UC | Chile

WELCOME TO THE 17TH

LATIN AMERICAN WORKSHOP ON PLASMA PHYSICS

LAWPP 2025

BOOK OF ABSTRACTS

SANTIAGO, CHILE | JANUARY 20TH - JANUARY 23RD

INSTITUTO DE FÍSICA
FACULTAD DE FÍSICA

Comisión Chilena de Energía Nuclear
Ministerio de Energía
Gobierno de Chile

THORLABS

U.S.ARMY DEVCOM

1 Committee

1.1 International Advisory Committee

- Julio Herrera - Universidad Nacional Autonoma de Mexico
- Luis Felipe Delgado-Aparicio - Princeton University
- Salvador Portillo - University of New Mexico
- George Morales - University of California Los Angeles
- Anthony Peratt - Los Alamos National Laboratory
- Bruno Soares - Universidade de Lisboa
- Ibere Caldas - Univesidade de São Paulo
- Luis Bilbao - Universidad de Buenos Aires
- Leopoldo Soto - Comisión Chilena de Energía Nuclear
- Daniel Lopez-Bruna - CIEMAT España
- Carlos Hidalgo - CIEMAT España
- Edbertho Leal-Quiroz - Universidad de Santander
- Pablo Martin - Universidad de Antofagasta
- Leandro Prevosto - Universidad Tecnológica Nacional
- Ivan Vargas-Blanco - Tecnológico de Costa Rica
- Angel Gonzalez-Lizardo - Universidad Politécnica de Puerto Rico
- Diana Rojas - Universidad Nacional Autónoma de México
- Eduardo Orozco - Universidad Industrial de Santander
- Marquidia Pacheco - Instituto Nacional de Investigaciones Nucleares
- Henry Riascos - Universidad Tecnológica de Pereira
- Marco Ridenti - Instituto Tecnológico de Aeronáutica
- Victor Muñoz - Universidad de Chile

1.2 Local Organizing Committee

- Felipe Veloso (Chairman) - P. Universidad Católica de Chile
- Julio Valenzuela - P. Universidad Católica de Chile
- Germán Vogel - P. Universidad Católica de Chile
- Heman Bhuyan - P. Universidad Católica de Chile
- Gonzalo Avaria - Universidad Técnica Federico Santa María
- Cristían Pavez - Comisión Chilena de Energía Nuclear
- Pablo Moya - Universidad de Chile
- Leopoldo Soto - Comisíon Chilena de Energía Nuclear
- Victor Muñoz - Universidad de Chile

2 Prologue

Welcome to the 17th Latin American Workshop on Plasma Physics!
It is a great honor to present to you this Book of Abstracts for the 17th edition of the Latin American Workshop on Plasma Physics. This gathering, a cornerstone of scientific exchange in the field of plasma physics within Latin America, reflects our region's strong and growing presence in this essential area of research. With the participation of internationally recognized scientists and experts, this conference serves as a dynamic platform for fostering collaboration, advancing scientific inquiry, and encouraging the exchange of knowledge across national borders.
Plasma physics is a vast and rapidly evolving field, with profound implications for several cutting-edge areas of research, including nuclear fusion, space plasmas, high energy density physics, and the diverse applications of cold plasmas. By bringing together more than 100 presentations—comprising 10 invited talks, 35 oral contributions, and over 70 poster presentations—we aim to cover the full spectrum of these exciting topics, showcasing the latest advancements and promoting the exchange of ideas and perspectives.
One of the core purposes of this conference is to create a space where researchers from Latin American countries can engage in meaningful dialogue with the global scientific community. It is vital to highlight the importance of regional meetings like this one, which not only promote local expertise but also create invaluable opportunities for collaboration, joint research initiatives, and the sharing of resources across borders. By encouraging the formation of these connections, we can leverage the collective strength of our region to tackle some of the most complex and important challenges in plasma physics today.
At the same time, we are committed to offering an inclusive, friendly, and intellectually stimulating environment for all attendees. This conference provides a unique opportunity for early-career scientists, students, and professionals to interact with leaders in the field, exchange ideas in an informal setting, and build lasting relationships. We strongly believe that fostering a collaborative spirit in this friendly academic environment will not only advance the field of plasma physics but also contribute to the development of science and technology across Latin America.
I encourage all participants to take full advantage of the diverse scientific program, and I sincerely hope that the discussions, debates, and partnerships formed here will lay the groundwork for future innovations in plasma research, benefiting not just Latin America, but the global scientific community as a whole.
Thank you for being part of this important event, and I look forward to a fruitful and inspiring conference.
Sincerely,

Professor Felipe Veloso
17th Latin American Workshop in Plasma Physics - Chile 2025
Pontificia Universidad Católica de Chile

PROGRAM SCHEDULE

17TH LATIN AMERICAN WORKSHOP IN PLASMA PHYSICS

LAWPP CHILE 2025

<table>
<tr><th></th><th></th><th>Monday 20</th><th>Tuesday 21</th><th>Wednesday 22</th><th>Thrusday 23</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>9:00</td><td>9:10</td><td rowspan="3">Register</td><td rowspan="4">IN-M1 (Morales)</td><td rowspan="4">IN-W1 (Delgado-Aparicio)</td><td rowspan="4">IN-J1 (Delahaye)</td></tr>
<tr><td>9:10</td><td>9:20</td></tr>
<tr><td>9:20</td><td>9:30</td></tr>
<tr><td>9:30</td><td>9:40</td><td rowspan="3">Opening</td></tr>
<tr><td>9:40</td><td>9:50</td><td rowspan="3">Coffee Break</td><td rowspan="3">Coffee Break</td><td rowspan="3">Coffee Break</td></tr>
<tr><td>9:50</td><td>10:00</td></tr>
<tr><td>10:00</td><td>10:10</td><td rowspan="4">IN-L1 (Allain)</td></tr>
<tr><td>10:10</td><td>10:20</td><td rowspan="4">IN-M2 (Chittenden)</td><td rowspan="4">IN-W2
(Paganini Canal)</td><td rowspan="4">IN-J2 (Gupta)</td></tr>
<tr><td>10:20</td><td>10:30</td></tr>
<tr><td>10:30</td><td>10:40</td></tr>
<tr><td>10:40</td><td>10:50</td><td rowspan="3">Coffee Break</td></tr>
<tr><td>10:50</td><td>11:00</td><td rowspan="2">OR-AM-M1</td><td rowspan="2">OR-AM-W1</td><td rowspan="2">OR-AM-J1</td></tr>
<tr><td>11:00</td><td>11:10</td></tr>
<tr><td>11:10</td><td>11:20</td><td rowspan="4">IN-L2 (Diallo)</td><td rowspan="8">Poster Session 1</td><td rowspan="8">Poster Session 2</td><td rowspan="2">OR-AM-J2</td></tr>
<tr><td>11:20</td><td>11:30</td></tr>
<tr><td>11:30</td><td>11:40</td><td rowspan="2">OR-AM-J3</td></tr>
<tr><td>11:40</td><td>11:50</td></tr>
<tr><td>11:50</td><td>12:00</td><td rowspan="2">OR-AM-L1</td><td rowspan="2">OR-AM-J4</td></tr>
<tr><td>12:00</td><td>12:10</td></tr>
<tr><td>12:10</td><td>12:20</td><td rowspan="2">OR-AM-L2</td><td rowspan="2">OR-AM-J5</td></tr>
<tr><td>12:20</td><td>12:30</td></tr>
<tr><td>12:30</td><td>12:40</td><td rowspan="11">Lunch</td><td rowspan="11">Lunch</td><td rowspan="11">Lunch</td><td rowspan="11">Lunch</td></tr>
<tr><td>12:40</td><td>12:50</td></tr>
<tr><td>12:50</td><td>13:00</td></tr>
<tr><td>13:00</td><td>13:10</td></tr>
<tr><td>13:10</td><td>13:20</td></tr>
<tr><td>13:20</td><td>13:30</td></tr>
<tr><td>13:30</td><td>13:40</td></tr>
<tr><td>13:40</td><td>13:50</td></tr>
<tr><td>13:50</td><td>14:00</td></tr>
<tr><td>14:00</td><td>14:10</td></tr>
<tr><td>14:10</td><td>14:20</td></tr>
<tr><td>14:20</td><td>14:30</td><td rowspan="4">IN - L3
(Koga Ito + do Nascimento)</td><td rowspan="4">IN-M3 (Niembro)</td><td rowspan="2">OR-PM-W2</td><td rowspan="2">OR-PM-J6</td></tr>
<tr><td>14:30</td><td>14:40</td></tr>
<tr><td>14:40</td><td>14:50</td><td rowspan="2">OR-PM-W3</td><td rowspan="2">OR-PM-J7</td></tr>
<tr><td>14:50</td><td>15:00</td></tr>
<tr><td>15:00</td><td>15:10</td><td rowspan="2">OR-PM-L3</td><td rowspan="2">OR-PM-M2</td><td rowspan="2">OR-PM-W4</td><td rowspan="2">OR-PM-J8</td></tr>
<tr><td>15:10</td><td>15:20</td></tr>
<tr><td>15:20</td><td>15:30</td><td rowspan="2">OR-PM-L4</td><td rowspan="2">OR-PM-M3</td><td rowspan="2">OR-PM-W5</td><td rowspan="2">OR-PM-J9</td></tr>
<tr><td>15:30</td><td>15:40</td></tr>
<tr><td>15:40</td><td>15:50</td><td rowspan="2">OR-PM-L5</td><td rowspan="2">OR-PM-M4</td><td rowspan="2">OR-PM-W6</td><td rowspan="2">OR-PM-J10</td></tr>
<tr><td>15:50</td><td>16:00</td></tr>
<tr><td>16:00</td><td>16:10</td><td rowspan="3">Coffee Break</td><td rowspan="3">Coffee Break</td><td rowspan="3">Coffee Break</td><td rowspan="2">OR-PM-J11</td></tr>
<tr><td>16:10</td><td>16:20</td></tr>
<tr><td>16:20</td><td>16:30</td><td rowspan="2">Closure</td></tr>
<tr><td>16:30</td><td>16:40</td><td rowspan="2">OR-PM-L6</td><td rowspan="2">OR-PM-M5</td><td rowspan="2">OR-PM-W7</td></tr>
<tr><td>16:40</td><td>16:50</td><td rowspan="5"></td></tr>
<tr><td>16:50</td><td>17:00</td><td rowspan="2">OR-PM-L7</td><td rowspan="2">OR-PM-M6</td><td rowspan="2">OR-PM-W8</td></tr>
<tr><td>17:00</td><td>17:10</td></tr>
<tr><td>17:10</td><td>17:20</td><td rowspan="2">OR-PM-L8</td><td rowspan="2">OR-PM-M7</td><td rowspan="2">OR-PM-W9</td></tr>
<tr><td>17:20</td><td>17:30</td></tr>
<tr><td></td><td></td><td></td><td>Meeting - CLAF: Nuclear Fusion Unit</td><td></td><td></td></tr>
<tr><td>20:00 ...</td><td></td><td></td><td></td><td>DINNER</td><td></td></tr>
</table>

3 Presentations Schedule

3.1 Monday - January 20th

- 09:00 - 09:20 : Register
- 09:20 - 10:00 : Opening
- 10:00 - 10:40 : Jean Paul Allain - Building bridges: A vision for Fusion Energy and Plasma Science in the U.S. Department of Energy
- 10:40 - 11:10 : Coffee Break
- 11:10 - 11:50 : Ahmed Diallo - Advancing First Wall Materials for Sustainable Fusion Power Systems
- 11:50 - 12:10 : Reinaldo R. Rosa - Machine Learning-Based Disruption Diagnosis: From Solar Plasma to Tokamaks
- 12:10 - 12:30 : Arturo Dominguez - Public engagement and workforce development activities at the Princeton Plasma Physics Laboratory
- 12:30 - 14:20 : Lunch
- 14:20 - 15:00 : Cristiane Koga Ito + Fellype do Nascimento - Exploring the medical applications of cold atmospheric plasma jets and plasma activated liquids
- 15:00 - 15:20 : Aníbal Concha-Meyer - Atmospheric cold plasma treatments to ensure safety and quality of salmon and cheese
- 15:40 - 16:00 : Diego Morais da Silva - Optimizing E. Coli inhibition with cold atmospheric plasma jet delivery protocol
- 16:00 - 16:30 : Coffee Break
- 16:30 - 16:50 : Felipe A. Asenjo - Induced supersymmetric structure of electromagnetic plasma waves by dispersive gravitational waves
- 16:50 - 17:10 : Roberto E. Navarro - Multiple BGK-like Structures by Electro-Acoustic Waves in Vlasov-Poisson Plasmas
- 17:10 - 17:30 : Maricarmen A. Winkler - Accelerating solutions of the Korteweg-de Vries equation

3.2 Tuesday - January 21st

- 09:00 - 09:40 : Laura Morales - Waiting time for forecasting solar flares with avalanche & MHD models
- 09:40 - 10:10 : Coffee Break

- 10:10 - 10:50 : Jeremy Chittenden - Magnetic Reconnection in Radiatively Cooled, Wire Array Z-pinch Plasmas
- 10:50 - 11:10 : Felipe Veloso - Shocks induced by laser-produced plasmas in conical wire array Z-pinch outflows: An experimental platform to study astrophysical objects in the laboratory
- 11:10 - 12:30 : Poster Session 1
- 12:30 - 14:20 : Lunch
- 14:20 - 15:00 : Tatiana Niembro - The solar wind complexity during the Parker Solar Probe era
- 15:00 - 15:20 : Vicente Valenzuela-Villaseca - Exploring our magnetized universe on the world's most energic lasers: magnetic reconnection, collisionless shocks, and accretion disks
- 15:20 - 15:40 : Tobias Dornheim - Towards highly accurate diagnostics of extreme states of matter with x-ray Thomson scattering
- 15:40 - 16:00 : Julio Valenzuela - Advancing Plasma Diagnostics at PUC: Recent Results from Thomson Scattering
- 16:00 - 16:30 : Coffee Break
- 16:30 - 16:50 : José Alejandro Franco Altamirano - Calorimetry of keV to MeV X-rays from GeV plasma-based wakefield accelerators
- 16:50 - 17:10 : Miranda, R. A. - The role of coherent structures in intermittent plasma turbulence
- 17:10 - 17:30 : Joaquín Díaz Peña - Effects of E-region plasma turbulence on a 3D simulation of an extreme SAID/STEVE
- 17:30 - ... : Centro Latinoamericano de Física: Unidad de Fusíon Nuclear

3.3 Wednesday - January 22nd

- 09:00 - 09:40 : Luis Felipe Delgado-Aparicio - Energy-sensitive X-ray Cameras for Thermal and Non-Thermal Plasmas: A 12-Year Journey Towards Real-Time Solutions
- 09:40 - 10:10 : Coffee Break
- 10:10 - 10:50 : Gustavo Paganini Canat - The current status of the upgrade of TCABR
- 10:50 - 11:10 : José Roberto Fernandes Junior - Modeling separatrix splitting and magnetic footprints in TCABR

- 11:10 - 12:30 : Poster Session 2
- 12:30 - 14:20 : Lunch
- 14:20 - 14:40 : Iberê L. Caldas (Lucas N. A. Amaral) - Shearless Bifurcations In Tokamaks
- 14:40 - 15:00 : Cesar Clauser - Modeling of Vertical Displacement Events in Alcator C-Mod and SPARC
- 15:00 - 15:20 : Maia Brodiano - Study of 1/f Spectrum in Pristine Solar Wind Turbulence: Observation data vs numerical simulations
- 15:20 - 15:40 : Alejandro Lara - Interaction of energetic particles and large scale magnetic fields in the interplanetary medium
- 15:40 - 16:00 : Victor A. Pinto - Analysis of Solar Wind Properties Associated With Relativistic Electron Enhancement Events at Geostationary Orbit
- 16:00 - 16:30 : Coffee Break
- 16:30 - 16:50 : Rodrigo A. López - The role of plasma instabilities in collisionless plasmas
- 16:50 - 17:10 : Maximilian P. Boehme - Evidence of free-bound transitions in Warm Dense Matter
- 17:10 - 17:30 : Ishay Pomerantz - Undepleted Direct Laser Acceleration
- 20:00 - ... : Dinner

3.4 Thursday - January 23rd

- 09:00 - 09:40 : Franck Delayahe - Opacity for Astrophysics: Theory & Experiments
- 09:40 - 10:10 : Coffee Break
- 10:10 - 10:50 : Suryakant Gupta - ESD and its detrimental effects on the spacecraft charging and arc mitigation techniques
- 10:50 - 11:10 : Nicolas Vargas - Overview: Diamond Like Carbon (DLC) ablators for fusion energy
- 11:30 - 11:50 : Noely Zully Calderon Ipanaque - Analysis and simulations of cold plasmas generated by Magnetron Sputtering
- 11:50 - 12:10 : Biswajit Bora - Supersonic Thermal Plasma Expansion Process for Nanoparticle Production: Synthesis of Lithium-Based Nanoparticles

- 12:10 - 12:30 : Leopoldo Soto - Nuclear fusion research using a repetitive tabletop plasma focus of 2 Joules: Materials under extreme radiations conditions
- 12:30 - 14:20 : Lunch
- 14:20 - 14:40 : Pablo S. Moya - First Principles Description of the Solar Wind Expansion Using the Expanding Box Model
- 14:40 - 15:00 : Mayer Merino - Long-term trends at the geomagnetic equator: New results from Jicamarca Radio Observatory
- 15:00 - 15:20 : Mariana Stepanova - Role of the MHD turbulence in the stability and transport of plasma in the magnetosphere of the Earth
- 15:20 - 15:40 : Victor Muñoz - Community Structure Of Earth's Magnetic Field Measurements
- 15:40 - 16:00 : Sergio Davis - Kappa distributions in the language of Superstatistics
- 16:00 - 16:20 : Gonzalo Avaria - Ultra-High-Frequency Characterization of a Plasma Focus Device: Is There Something Hidden in the Complexity of the Signal?
- 16:20 - 16:40 : Closure

4 Posters Index

4.1 Poster Session 1

PO-M-1 Lautaro Alvear

PO-M-2 Macarena Cádiz

PO-M-3 Manuel Bravo

PO-M-4 Marco Antonio Ridenti

PO-M-5 Guilherme T. Irumé

PO-M-6 Tristan Bachmann

PO-M-7 J.P. Velásquez

PO-M-8 Igor Golovkin

PO-M-9 Viktoriya Golovkina

PO-M-10 Luan Bottin De Toni

PO-M-11 Gabriel Medel

PO-M-12 Komal

PO-M-13 Ricardo de Ávila Mesquita

PO-M-14 Lucas Nedeff Assub Amaral

PO-M-15 Felipe Paes Bekman

PO-M-16 Germán Vogel

PO-M-17 Lady Daiane Pereira Leite

PO-M-18 PEDRO WILLIAM PAIVA MOREIRA JUNIOR

PO-M-19 Rafael Resende Lucas

PO-M-20 Ivan Morales

PO-M-21 Homero Fonseca Santiago Maciel

PO-M-22 Claudio Andrés Téllez Zepeda

PO-M-23 Gonzalo Avaria

PO-M-24 Cristian Pavez

PO-M-25 Abiam Tamburrini

PO-M-26 Camilo Vásquez-Wilson

PO-M-27 Valentina D. Calderón

PO-M-28 Daniel A. S. Mendes

PO-M-29 Alejandro Zamorano

PO-M-30 Claudio Aravena

PO-M-31 Nicolás Villarroel Sepúlveda

PO-M-32 Yulissa Espitia

PO-M-33 Sebastián Echeverría-Veas

PO-M-34 Josefina Muñoz

PO-M-35 Isaac Gallegos

4.2 Poster Session 2

PO-W-1 Nathan Fabeliano Altaras

PO-W-2 Fernando A. F. Albuquerque

PO-W-3 JC Sánchez

PO-W-4 Ricardo Antonio De Levante Rodriguez

PO-W-5 Júlia Rodriguez Richieri

PO-W-6 B. B. Leal

PO-W-7 Luan Bottin De Toni

PO-W-8 M. V. Coello

PO-W-9 Maximiliano Correa Gazmuri

PO-W-10 Martín Quijada

PO-W-11 Marco Ribeiro

PO-W-12 Daniel Hermosilla Pizarro

PO-W-13 Astor Sandoval

PO-W-14 Nicolás Villarroel Sepúlveda

PO-W-15 Martín Astete

PO-W-16 Sebastián Saldivia

PO-W-17 Adetayo V. Eyelade

PO-W-18 Javier Fuentes

PO-W-19 Noala Vicensoto Moreira Milhan

PO-W-20 Nilton F. Azevedo Neto

PO-W-21 Jose Carlos Palomares Amado

PO-W-22 José Moreno

PO-W-23 Maximiliano Benitez

PO-W-24 Michaela Shiotani Marcondes

PO-W-25 Florencia Díaz

PO-W-26 Fellype do Nascimento

PO-W-27 Brayan Ponciano Leyva

PO-W-28 Felipe Miranda

PO-W-29 Christian Mendoza Benitez

PO-W-30 Alexsandra Cordero

PO-W-31 Azul Gabriela González Hernández

PO-W-32 José Leonardo Ferreira

PO-W-33 José Leonardo Ferreira

PO-W-34 Ana P. Aragon Rodriguez

PO-W-35 Consuelo Mimica

PO-W-36 Pelayo Phillips

5 Invited Speakers

- Jean Paul Allain - Associate Director Office of Fusion Energy Sciences U.S. Department of Energy
- Ahmed Diallo - Princeton Plasma Physics Laboratory Program Director ARPA-E
- Cristiane Koga Ito - Professor São Paulo State University
- Fellype do Nascimento - Research fellow São Paulo State University
- Laura Morales - Professor Universidad de Buenos Aires
- Jeremy Chittenden - Professor Imperial College of London
- Tatiana Niembro - Smithsonian Astrophysical Observatory Parker Solar Probe Scholar committee member Center for Astrophysics — Harvard & Smithsonian
- Luis Felipe Delgado-Aparicio - Head of Advanced Projects Princeton Plasma Physics Laboratory
- Gustavo Paganini Canal - Associate Professor Universidade de São Paulo
- Franck Delayahe - Astronome adjoint Observatoire de Paris
- Suryakant Gupta - Professor Institute for Plasma Research, India

Presentations: Monday, January 20th 2025

Advancing First Wall Materials for Sustainable Fusion Power Systems

Ahmed Diallo

In fusion power systems, the first wall is critical for containing reactions, bearing loads, and shielding components from extreme conditions. However, exposure to high-energy neutrons (>1 MeV) and intense heat fluxes (up to 10 MW/m^2) severely compromises its integrity. As fusion energy progresses toward commercialization, enhancing the durability and maintainability of first-wall materials is crucial for economic viability. While thermal effects on materials are well-understood, the synergistic impact of heat and high neutron flux introduces complex, nonlinear phenomena that challenge current predictive capabilities. Radiation damage, primarily through atomic displacements and transmutations, leads to material degradation. Measured in displacements per atom (dpa), first-wall materials in fusion plants may experience over 50 dpa during a 40-year lifespan, with embrittlement observed at merely 5 dpa. This presentation will explore:

1. The multifaceted challenges in developing radiation-resistant materials
2. Innovative approaches to discover materials capable of withstanding 50 dpa
3. Implications for the economic and environmental sustainability of fusion power.

The talk will conclude with an overview of the CHADWICK program developed and launched at ARPAE as well as highlights of recent projects selected to tackle the first wall for fusion system's challenge

Affiliations

Ahmed Diallo	Princeton Plasma Physics Laboratory

E-mail

adiallo@pppl.gov

Machine Learning-Based Disruption Diagnosis: From Solar Plasma to Tokamaks

Reinaldo R. Rosa, Rubens A. Sautter, Luan O. Baraúna, Jiro Kawamura, Pablo Medina, Juan A. Valdivia

Plasma instabilities can exhibit a variety of structural patterns known as loops, kinks, constrictions, wrinkles, and disruptions. When disruptions occur, a small disturbance in the magnetic field can amplify, increasing the instability. In the case of solar plasma, this instability can trigger a flare and associated extreme events. In the tokamak, these instabilities can complicate plasma confinement and can lead to energy losses and serious damage to the vacuum vessel by releasing significant amounts of energetic particles from the plasma column toward the vessel wall. A special type of disruption are those called edge-localized modes (ELMs), which are almost always associated with a filament-like structure. Based on data generated randomly by a ballooning instability model [1] (about a thousand extreme discharges of the order of 80-120μs), we test the performance of a disruption prediction algorithm (DPA) based on machine learning models from the CyMorph library [2]. Our results present a probability mapping associated with the forecasts and discuss the achievements and delays of disruption prediction in terms of triggering performance, simulating alarms in each discharge in a plasma control system. We discuss what levels of forecast performance should be met to predict disruptions that may occur in the ITER experiment scheduled to enter test operation in the next decade. We extend the methodology to predict possible successive flares that may occur on the Sun within a space weather perspective. In solar physics, the analysis is accompanied by the characterization of filaments in the MHD turbulence pattern observed in the SDO images [3].

[1]https://doi.org/10.1103/PhysRevLett.92.245002

[2]https://github.com/rsautter/CyMorph

[3] https://doi.org/10.3389/fspas.2024.1383746

Affiliations

Reinaldo Roberto Rosa	INPE-MCTI
Rubens Andreas Sautter	edital nº 002/2024-ps-pb - resultado final preliminar Universidade Tecnológica Federal do Paraná
Luan Orion Baraúna	INPE-MCTI
Jiro Kawamura	ITER
Pablo Medina	CeiBa Complexity Center, Bogotá, Colombia
Juan Alejandro Valdivia	Departamento de Física, Facultad de Ciencias, Universidad de Chile

E-mail

reinaldo.rosa@inpe.br

Exploring the medical applications of cold atmospheric plasma jets and plasma activated liquids

Cristiane Yumi Koga Ito, Noala Vicensoto Moreira Milhan, Felipe de Souza Miranda, Fellype do Nascimento, Nilton Francelosi Azevedo Neto, Rodrigo Savio Pessoa, Konstantin Georgiev Kostov

Cold atmospheric plasmas (CAP) can generate various active agents, such as reactive oxygen and nitrogen species, as well as charged particles. The interaction of CAP and living tissues induces a diverse array of simultaneous biological effects, including antimicrobial, anti-inflammatory, tissue-repairing, and antineoplastic, positioning plasma as a promising therapeutic tool. Our research group has dedicated over a decade to exploring CAP applications in the medical field, with a particular emphasis on dentistry. CAP is especially noteworthy for its potential in treating infectious diseases. We have determined the effective parameters of CAP applications using in vitro, ex vivo, and in vivo methodologies. Notably, helium-CAP (He-CAP) has shown effectiveness in inhibiting biofilms associated with dental caries, periodontitis, and endodontic infections. Additionally, the potentials to control biofilms formed inside tracheal endoprosthesis and to treat oral mucositis lesions have been explored. Interestingly, antifungal effect was also detected, suggesting that CAP could serve as a viable therapeutic option for persistent fungal infections, such as oral candidiasis. Our studies have also demonstrated that CAP exhibits low cytotoxicity and genotoxicity against various mammalian cell lines, providing further evidence for its clinical application. Based on these protocols, we developed and tested a cost-effective plasma jet device for clinical use. Recently, the applications of plasma-activated liquids (PAL) have been also explored and offer several advantages for clinical use. The PALs were prepared using different liquids and plasma systems, producing solutions with different chemical compositions. The antimicrobial efficacy of PALs, both in direct and nebulized forms, has been explored, aiming a myriad of medical applications.
Acknowledgments: Funded by The São Paulo Research Foundation (FAPESP) 2019/05856-7, 20/09481-5, 20/10450-7, 21/00046-7, 21/14181-3, 23/02268-2; Research fellowships - National Council for Scientific and Technological Development (CNPq) 309762/2021-9 (CKI), 310608/2021-0 (KK) and 313482/2021-7 (RP).

Affiliations

Cristiane Yumi Koga Ito	São Paulo State University (UNESP)
Noala Vicensoto Moreira Milhan	São Paulo State University (UNESP)
Felipe de Souza Miranda	São Paulo State University (UNESP)
Fellype do Nascimento	São Paulo State University (UNESP)
Nilton Francelosi Azevedo Neto	Aeronautical Technology Institute (ITA)
Rodrigo Savio Pessoa	Aeronautical Technology Institute (ITA)
Konstantin Georgiev Kostov	São Paulo State University (UNESP)

E-mail

cristiane.koga-ito@unesp.br

Atmospheric cold plasma treatments to ensure safety and quality of salmon and cheese

Concha-Meyer, A.; González-Esparza, A.; Muñoz-Fariña, O.; Carrillo-López, B.; Artunduaga, A.; Obando, J.L.; Loaiza, D.; Delgado, K.

Foodborne illnesses (FBIs) are a significant global health issue. The World Health Organization (WHO) estimates that these diseases result in around 600 million cases and 420,000 deaths each year. In the United States, one in six people is affected by FBIs annually, with an estimated cost of USD $77.7 billion. In Chile, 605 outbreaks of FBIs were reported in 2019, involving 3,040 people. Ready to eat (RTE) foods, like cheese and salmon, are popular due to their convenience, quality, and health appeal. However, contamination at any stage of the production chain is a concern, particularly from Listeria monocytogenes, a pathogen that can survive on food surfaces throughout their shelf life. Effective non-thermal methods are needed to inhibit pathogens without compromising the sensory properties of RTE foods.
The research proposes using Cold Atmospheric Plasma (CAP) as an innovative, non-thermal technology for food surface decontamination that can inactivate bacteria, yeasts, molds, spores, and biofilms on food contact surfaces in salmon and cheese plants. Results show CAP's efficacy in reducing pathogenic and non pathogenic microorganisms on food and surfaces. Furthermore, sensory analysis of CAP-treated cheese and salmon fillets revealed no significant differences in color, texture, flavor, or appearance, confirming that CAP does not affect these characteristics.

Affiliations

Aníbal Concha-Meyer	Universidad Austral de Chile

E-mail

anibal.concha@uach.cl

Sterilization of Bacteria with Low-Pressure Low-Temperature Plasma Discharge

Angel González-Lizardo, Jairo Rondón

The study investigates the effectiveness of using low-pressure oxygen plasma, generated by microwave discharge, to sterilize bacterial spores of \emph{Bacillus Stearothermophilus} and \emph{Bacillus Subtilis}. Plasma, a highly ionized state of matter consisting of positive ions and free electrons, is created by applying high temperatures or accelerating electrons through an electric field. This method provides an innovative alternative to traditional sterilization techniques, particularly beneficial for heatsensitive materials. In the experiments, microwave at 2.45 GHz with 1000 W and 500 W intensities (990 W and 495 W) were applied in a vacuum chamber at a pressure of 10^{-3} Torr. Spores were exposed to the plasma using two types of holders: Petri dishes and centrifuge tubes, for 1, 5, and 10 minutes. The findings revealed that direct exposure to oxygen plasma at a 1000 W microwave power effectively inactivated spores in Petri dishes, especially for \emph{B. Subtilis}. Conversely, centrifuge tubes did not allow sufficient plasma exposure, leading to the survival of bacteria posttreatment. The inactivation process involves UV induced DNA damage and the erosion of spores' protective layers by oxygen radicals. The study concludes that low-pressure oxygen plasma is a promising technology for sterilizing heat-sensitive materials. Optimal conditions identified include a 1000 W microwave power and exposure times of at least 5 minutes for B. stearot-hermophilus and 1 minute for \emph{B. Subtilis}. Petri dishes proved more effective than centrifuge tubes due to the closer and more direct plasma contact. This method offers a safe and efficient alternative to traditional sterilization techniques, with significant potential for applications in the sterilization of medical devices and other delicate materials.

Affiliations

Angel Gonzalez-Lizardo	Universidad Politecnica de Puerto Rico

Figure Caption PUPR Plasma Laboratory

E-mail

agonzalez@pupr.edu

OPTIMIZING E. COLI INHIBITION WITH COLD ATMOSPHERIC PLASMA JET DELIVERY PROTOCOL

Diego Morais da Silva, Augusto Stancampiano, Sébastien Dozias, Pablo Escot Bocanegra, Konstantin Georgiev Kostov, Cristiane Yumi Koga-Ito, Eric Robert

Cold atmospheric plasma jets (CAPJ) have been studied as a tool for microbial decontamination in different fields, such as the food industry and the medical environment. CAPJ produces oxygen and nitrogen reactive species (RONS) that interact with the microorganism structure, leading to inhibition. Its efficacy is correlated to the plasma parameters [1]. In this work, we studied the influence of the number of discharges, i.e. plasma pulses, on Escherichia coli inhibition.
The inhibition halo test was performed using the E. coli CIP54117 strain. The inoculum containing 1.106 CFU/mL was standardized using a spectrophotometer (OD=0.068, λ=600 nm). Then, 3 mL of the inoculum was transferred to a Luria-Bertani (LB) agar plate distributed all over the surface. After 15 min of contact, the suspension was removed, and the plates were kept inside a laminar flow until wholly dried (15 min). The plasma reactor used was described elsewhere [2]. The helium gas flow of 1.5 SLM was set to the treatment. Ten or one hundred plasma pulses were delivered as burst at 10 or 20 kHz, with various duty cycles and treatment times, as summarized in Table 1. The used parameters are described in Table 1. The voltage was set to 10 kV for all the experiments.

After 300s treatment, the Base parameter resulted in an area of 0.59 ± 0.06 cm2 of inhibition (Fig 1). Using parameter 10x, it delivered the same nº of pulses as the Base parameter in a shorter time (30s), showing an inhibition zone of 0.6±0.04 cm2. Duty cycle modulation is thus a convenient way to achieve the same inhibition but with a much shorter treatment time, which could be an essential protocol for medical applications. Similar behavior was observed during the second test, with more pulses delivered. Ten times more pulses were delivered compared to the previous test. The treatment of 300s using the parameter 10x resulted in an area of 2.76±0.1 cm2, and using the parameter 20x for 150s, the inhibition of 2.17±0.04 cm2 was observed. Discharge frequency is a second way to improve inhibition performance with again reduced treatment time. In conclusion, a strong correlation was observed between the number of pulses and even shorter treatment times.

References

[1] Do Nascimento, Fellype, et al. IEEE Trans Radiat Plasma Med Sci. 8 (3), 307–322 (2024)
[2] Omran, A.V., et al. Plasma Sources Sci Technol. 29 (10), (2020)

Acknowledgements
This work was supported by FAPESP (grant no. 2023/02432-2, 2021/02680-5, 2019/05856-7).

Affiliations

Diego Morais da Silva	São Paulo State University (UNESP), Brazil.
Augusto Stancampiano	GREMI-CNRS/Université d’Orléans, France
Sébastien Dozias	GREMI-CNRS/Université d’Orléans, France
Pablo Escot Bocanegra	GREMI-CNRS/Université d’Orléans, France
Konstantin Georgiev Kostov	São Paulo State University (UNESP), Brazil.
Cristiane Yumi Koga-Ito	São Paulo State University (UNESP), Brazil.

Eric Robert GREMI-CNRS/Université d’Orléans, France

Parameter	N° of pulses/second	Internal frequency (kHz)	N° of pulses	Time off (ms)	Duty cycle (%)
Base	500	10	10	19	5%
10x	5000	10	100	10	50%
20x	10000	20	100	5	50%

Figure Caption

Table 1. CAPJ parameters were used for the inhibition halo test.

E-mail

diego.m.silva@unesp.br

Induced supersymmetric structure of electromagnetic plasma waves by dispersive gravitational waves

Felipe A. Asenjo

We explore the electromagnetic plasma wave dynamics in the curved spacetime background composed by a dispersive gravitational wave. It is shown that gravitational waves induce a supersymmetric structure on polarizations of plasma waves, each polarization being the superpartner of each other. Besides, this supersymmetry occurs in spacetime (not in space nor time), in the speed-cone coordinate defined by the gravitational wave propagation. This supersymmetric form is the classical analogue of supersymmetric quantum mechanical theories. For this to happen, the dispersive behavior of the gravitational wave is essential, which couples to the dispersive nature of electromagnetic plasma waves. We explore several implications of possible measurements.

Affiliations

Facultad de Ingeniería y Ciencias	Universidad Adolfo Ibáñez

E-mail

felipe.asenjo@uai.cl

Multiple BGK-like Structures by Electro-Acoustic Waves in Vlasov-Poisson Plasmas

Danilo M. Rivera, Hugo A. Carril, Jaime A. Araneda, Roberto E. Navarro

In non-collisional electrostatic plasmas, exact non-linear solutions of the Vlasov-Poisson equations known as Bernstein-Greene-Kruskal (BGK) states, can be found. These states correspond to asymptotic states characterized by the formation of traveling large-scale vortices in phase-space, with speeds that are approximately in accordance with Langmuir resonance [1]. However, due to wave-wave and wave-particle interactions, energy can be transferred to smaller scales in a process analogous to electrostatic turbulence [2]. This process results in the formation of persistent, multiple small-scale vortices that gradually fill the phase-space while reducing filamentation [3].

Furthermore, the excitation of electro-acoustic waves may also occur under the appropriate conditions. These waves can potentially influence the properties of BGK states, which in turn can affect the characteristics of the aforementioned energy cascade to smaller scales. In this study, the impact of electro-acoustic waves on the formation of small-scales vortices within the electron phase-space is investigated. For this purpose, high-resolution Vlasov-Poisson simulations are performed on a one-dimensional, non-collisional plasma comprising massive ions, and core-halo distributed electrons. The stability and formation times of these vortices are systematically investigated as a function of the initially perturbed mode and the relative density of the core and halo electrons.

[1] I. B. Bernstein, J. M. Greene, and M. D. Kruskal, Phys. Rev. 108, 546 (1957).
[2] H. Schamel, D. Mandal, and D. Sharma, Phys. Plasmas 24, 032109 (2017).
[3] H. A. Carril, J. A. Gidi, R. E. Navarro, and J. A. Araneda, Phys. Rev. E 107, 065203 (2023).

Affiliations

Danilo M. Rivera	Universidad de Concepción
Hugo A. Carril	Universidad de Concepción
Jaime A. Araneda	Universidad de Concepción
Roberto E. Navarro	Universidad de Concepción

E-mail

roberto.navarro@udec.cl

Accelerating solutions of the Korteweg-de Vries equation

Maricarmen A. Winkler and Felipe A. Asenjo

The Korteweg-de Vries (KdV) equation is widely recognized as a fundamental tool for describing nonlinear wave phenomena across various scientific disciplines with the solitary wave, or soliton, being one of its notable closed-form solutions with constant velocity. In our study we show that this equation also presents accelerated wavepacket solutions.

This accelerated wave train is obtained by reducing the KdV equation into a Painlevé I equation, in terms of an accelerated coordinate system. Thus, the new solution for the KdV equation describes a wavepacket following a parabolic trajectory that is susceptible to changes due to different parameters, specifically the acceleration and the dispersion coefficient from the KdV equation. In this work, these accelerated waveform solutions are explored numerically showing their behavior explicitly.

This solution for the KdV equation belongs to a new class of accelerated solutions for nonlinear dynamics systems, that could have interesting applications, specially in plasma physics. These results contribute to a novel understanding on the KdV equation's versatility, and its relevance in modern theoretical and applied physics.

Affiliations

Maricarmen A. Winkler	Universidad Adolfo ibáñez
Felipe A. Asenjo	Universidad Adolfo ibáñez

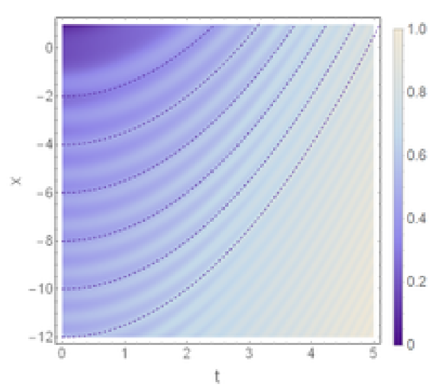


Figure Caption

Density plot for the accelerates solution of the KdV equation. Dashed lines represent parabolic trajectories for different initial conditions.

E-mail

ma.winkler822@gmail.com

Presentations: Tuesday, January 21st 2025

Waiting time for forecasting solar flares with avalanche & MHD models

Laura F. Morales

The solar corona hosts some of the most impulsive events in the Solar System: solar flares. In a nutshell, a solar flare is an impulsive, intermittent, and localized event that can cause the solar temperature to increase up to 10^7 K. Moreover, the spatial coincidence of flares with magnetic structures on the solar surface clearly indicates that their energy originates from the Sun's magnetic field, with magnetic reconnection being one of the possible physical mechanisms behind the phenomenon.

Systematic studies of flares observed from the EUV to soft X-rays revealed (Dennis, 1985; Aschwanden, 2011 and references there in) that the frequency distribution of solar flare energy release follows a well-defined power law, spanning 8 orders of magnitude in flare energy.

Between 1983 and 1988, Parker developed a simple model to explain energy liberation in the corona: stochastic photospheric fluid motions of convective origin shuffle the footpoints of magnetic coronal loops. The high electrical conductivity of the coronal plasma implies that the magnetic field is "frozen-in," leading to subsequent dynamical relaxation within the loop. This process results in a complex, tangled magnetic field that is essentially force-free everywhere except in numerous small electrical current sheets, which form spontaneously in highly stressed regions and, eventually will be the places where magnetic reconnection takes place.

To numerically explore this idea, two different approaches have been developed over the past decades: avalanche models (ranging from simple 2D models, such as Lu & Hamilton's model, to anisotropic versions where the "field lines" represent strands of the coronal loop) and, assuming the plasma is a fluid magnetohydrodynamic (MHD) models in 2D or 3D.

I will present several avalanche models and and MHD model developed in 2.5D, focusing on the temporal characteristics of all the models. Specifically, I will introduce three different definitions of waiting time, as well as the statistics of onset and release times, to evaluate their potential for forecasting solar flares.

Affiliations

Laura F. Morales	Universidad de Buenos Aires, Argentina

E-mail

lmorales@df.uba.ar

Magnetic Reconnection in Radiatively Cooled, Wire Array Z-pinch Plasmas

Jeremy Chittenden, Niki Chaturvedi, Aidan Crilly, Rishabh Datta, Jack Hare

Magnetic reconnection occurs in a variety of plasmas, ranging from magnetic fusion experiments, the solar surface and Earth's magnetosphere. Reconnection is often characterised by counter propagating flows containing opposing magnetic fields. Realignment of the magnetic fields by reconnection gives rise to accelerated perpendicular outflows and, in some instances, non-thermal high energy particles. Non-uniformity within the high current density reconnection layer can also result in the formation of localised flux ropes or 'plasmoids' moving along the layer with the outflow. In high energy density plasmas, such as occur in proximity to the accretion disks of black holes, the development of the reconnection layer as well as the presence of plasmoids are affected by strong radiation cooling within the plasma.

In this presentation we show results from magneto-hydrodynamic simulations of experiments designed to explore the transition from non-radiative to radiatively cooled regimes in magnetic reconnection. The experiments were performed on the 'Z' pulsed power facility at Sandia National Laboratory under the Z Fundamental Science Program for academic access. Two cylindrical exploding wire arrays were used to generated counter propagating super-Alfvénic flows forming a reconnection layer with a lifetime of several hundred nanoseconds. Simulation results are used to highlight the importance of radiative cooling in determining the temperature and magnetic field of the plasma entering the reconnection layer. Shortly after formation the reconnection layer is weakly radiating with high temperatures leading to plasmoid formation. After around 100ns however the increasing density in the reconnection layer leads to stronger radiative cooling and compression of the layer which extinguishes the plasmoids. Further analysis reveals the importance of radiation transport in preheating the plasmas as they converge on the layer. Detailed comparisons of the simulation results with experimental data are used to determine the radiative properties of the plasma within the experiments.

Affiliations

Jeremy Chittenden	Centre for Inertial Fusion Studies, Imperial College
Niki Chaturvedi	Centre for Inertial Fusion Studies, Imperial College
Aidan Crilly	Centre for Inertial Fusion Studies, Imperial College
Rishabh Datta	Plasma Science and Fusion Center, MIT
Jack Hare	Plasma Science and Fusion Center, MIT

E-mail

j.chittenden@imperial.ac.uk

Shocks induced by laser-produced plasmas in conical wire array Z-pinch outflows: An experimental platform to study astrophysical objects in the laboratory

Felipe Veloso, Luisa Izquierdo, Miguel Escalona, Julio Valenzuela

To investigate collisional effects in plasma-plasma interactions within a controlled environment, an experimental platform has been developed that enables the generation and characterization of the interaction between a plasma jet and a background plasma plume produced by a laser [1].

The plasma jet is generated using a conical array of 16 aluminum wires (each 40 μm in diameter) as the load for the Llampudken generator (~400kA, ~350ns) [2]. The laser-produced plasma plume is created by focusing a laser pulse of ~2×10^10 W/cm² onto an aluminum target, positioned parallel to the propagation axis of the jet. The interaction occurs in the region where the two plasmas intersect. This region is studied using various diagnostic techniques aligned transversely to the interaction. The primary diagnostics employed include interferometry using a pulsed Nd:YAG laser (532nm, 6ns FWHM) and self-emission imaging captured by a Micro Channel Plate (MCP) camera.

Our experimental results indicate that, in the absence of the laser-generated plasma plume, neither the X-rays emitted by the array nor the plasma jet alone causes significant photoionization of the aluminum target. However, when both plasma sources are present, a new structure emerges in the interaction region, with a thickness corresponding to the mean free path calculated for ion-ion collisions. This finding suggests the formation of a collisional structure resulting from the interaction. Further details and potential applications to laboratory astrophysics will be presented and discussed in our work.

This work has been partially funded by FONDECYT/Regular 1231286

[1] L Izquierdo et al, Results in Physics 37, 105476 (2022)
[2] H Chuaqui et al, Laser and Particle Beams 15, 241 (1997)

Affiliations

Felipe Veloso	Pontificia Universidad Catolica de Chile
Luisa Izquierdo	Pontificia Universidad Catolica de Chile
Miguel Escalona	Pontificia Universidad Catolica de Chile
Julio Valenzuela	Pontificia Universidad Catolica de Chile

E-mail

fveloso@uc.cl

The solar wind complexity during the Parker Solar Probe era

Tatiana Niembro

On Christmas' Eve, Parker Solar Probe made history as the spacecraft flying at the closest distance to the Sun, 3.8 million miles (6.1 million km) and as the fastest one reaching a speed of 430,000 miles per hour (692,000 km/h). Its mission is to surf the solar wind in early stages of evolution so we can improve our understanding on the energy transfer and dissipation, the magnetic field connectivity and, the acceleration and particle transport mechanisms happening from Sun to any other distance in the heliosphere, particularly at Earth with space weather relationship and forecasting. In this talk, I will be presenting Parker Solar Probe observations and analysis which are connected to interesting physical processes and phenomena at different temporal and spatial scales (turbulence, magnetic loops, magnetic flux ropes, magnetic field reconnection processes, etc) as well as its correlation with observations from other spacecraft and observatories located at different heliospheric distances use to reconstruct the solar wind conditions back to its source at the surface of the Sun.

Affiliations

Tatiana Niembro	Smithsonian Astrophysical Observatory, Center for Astrophysics | Harvard & Smithsonian

E-mail

tniembro@cfa.harvard.edu

Exploring our magnetized universe on the world's most energic lasers: magnetic reconnection, collisionless shocks, and accretion disks

Vicente Valenzuela-Villaseca

Fundamental plasma processes are key to understanding complex systems in the cosmos, such as instability and turbulence in magnetized accretion disks, energy transport in magnetic reconnection, and particle heating in supernova remnants and planetary magnetospheres.
In this talk, I will give an overview of recent results from magnetized laboratory experiments, led by Princeton University, conducted on the Omega laser (Laboratory for Laser Energetics, University of Rochester) and the National Ignition Facility (Lawrence Livermore National Laboratory). NIF experiments using elongated self-magnetized inflows have shown that the onset of magnetic reconnection at Alfvenic Mach numbers ~ 5 narrows the current sheet down to the electron gyro-radius [1] and that electron-ion collisions can produce significant electron heating in a background of weakly collisional ions [2]. Experiments on Omega have shown the unprecedented formation of fully-developed, quasi-perpendicular magnetized collisionless shocks in conditions relevant to the Earth's bow-shock, providing first measurements of compression ratio and energy partition in controlled conditions [3]. The Omega laser system has also been used to create magnetized, high-Pm, quasi-Keplerian rotating plasmas relevant the inner regions of black holes accretion disks [4]. Preliminary particle-in-cell simulations show the fast formation of Weibel filaments which are warped and twisted by differential rotation.

[1] W. Fox, et al. Fast magnetic reconnection in highly-extended current sheets at the National Ignition Facility (2025; in review at Physical Review Letters)
[2] V. Valenzuela-Villaseca, et al., X-ray imaging and electron temperature evolution in laser-driven magnetic reconnection experiments at the National Ignition Facility, Physics of Plasmas (2024)
[3] V. Valenzuela-Villaseca, et al., Electron heating and compression ratio measurements in laboratory perpendicular magnetized collisionless shocks at planetary bow-shock conditions (in preparation for Physical Review Letters)
[4] V. Valenzuela-Villaseca, et al., Formation of high-Pm, quasi-Keplerian, differentially rotating plasma flows driven by lasers (in preparation for Physical Review Letters)

Affiliations

Department of Astrophysical Sciences	Princeton University

E-mail

v.valenzuela@princeton.edu

Towards highly accurate diagnostics of extreme states of matter with x-ray Thomson scattering

Tobias Dornheim

Matter under extreme densities, temperatures and pressures is ubiquitous throughout our universe and naturally occurs in a variety of astrophysical objects, including giant planet interiors. On Earth, such extreme states are important for technological applications such as inertial fusion energy (IFE), where both the fuel capsule and the ablator material have to traverse this warm dense matter regime in a controlled way to reach ignition. In the laboratory, warm dense matter is created in large research facilities such as the European XFEL in Germany using a variety of techniques. Here, a key challenge is given by the accurate diagnostics of the created samples due to the extreme conditions and the ultrafast time scales. Over the last years, the X-ray Thomson scattering (XRTS) technique---also known as inelastic X-ray scattering---has emerged as a promising method of diagnostics as it is, in principle, capable of giving microscopic insights into the probed sample in the form of the electronic dynamic structure factor [1]. In practice, however, the interpretation of XRTS measurements has relied on theoretical models that are based on a number of de-facto uncontrolled assumptions. Consequently, the quality of the thus inferred system parameters has remained unclear. Here, I present an overview of a new approach that allows for the model-free interpretation of XRTS spectra in the imaginary-time domain [2,3]. The latter naturally emerges in Feynman's celebrated path integral formulation of statistical mechanics and, by definition, contains the same information as the usual spectral epresentation, only in an a-priori unfamiliar representation. At the same time, working in the imaginary-time allows one to deconvolve the physical nformation from effects due to the X-ray source and the detector. This, in turn, opens up the way for the model-free extraction of important system parameters such as the temperature [2] without the need for any
approximations or simulations.

[1] S. H. Glenzer and R. Redmer, X-ray Thomson scattering in high energy density plasmas, Rev. Mod. Phys. 81, 1625 (2009)
[2] T. Dornheim et al., Accurate temperature diagnostics for matter under extreme conditions, Nature Commun. 13, 7911 (2022)
[3] T. Dornheim et al., Physical insights from imaginary-time correlation functions, Matt. Radiat. Extremes 8, 056601 (2023)

Affiliations

CASUS	Helmholtz-Zentrum Dresden-Rossendorf

E-mail

t.dornheim@hzdr.de

Calorimetry of keV to MeV X-rays from GeV plasma-based wakefield accelerators

J. A. Franco Altamirano, A. Hannasch, I. Pagano, J. Brooks, C. Aniculaesei, M. C. Downer

Plasmas can support electric field gradients (~100GeV/m) three orders of magnitude larger than the ones used in convectional RF accelerators (~100 MeV/m), making plasma-based accelerators an atractive alternative to reduce the size and cost of the next generation of colliders and radiation-generation sources (i.e. synchrotrons and XFEL).

Here, we reconstruct spectra of x-rays from a GeV laser wakefield electron accelerator driven by the Texas Petawatt Laser. We measure from single-shot x-ray depth-energy measurements in a compact (7.5 x 7.5 x 10 cm), modular x-ray calorimeter made of alternating layers of absorbing materials and plastic scintillators. Geant4 simulations of energy deposition of single-energy X-rays in the stack generate an energy-vs-depth response matrix for a given stack configuration. An iterative reconstruction algorithm based on photon energy distributions of physical models was used to unfold X-ray spectra. The unfolded X-ray spectra agree with GEANT4 simulations using independently-measured electron spectra. The results demonstrate the viability of stack calorimetry for unfolding spectra of secondary plasma-accelerator-based x-rays of photon energies.

Affiliations

Department of Physics	The University of Texas at Austin

E-mail

josefranco@utexas.edu

The role of coherent structures in intermittent plasma turbulence

Miranda, R. A., Costa, S. G. S. P., Piragibe, A. L., Chian, A. C.-L.

Turbulence is ubiquitous in fusion, space and astrophysical plasmas, and can be regarded as a complex distribution of coherent structures coexisting with random fluctuations. For example, the magnetic field turbulence in the solar wind is characterized by power spectra with power-law scaling and spectral indices nearly -5/3, non-Gaussian fluctuations at small scales, and amplitude-phase synchronization among scales. In fusion plasmas, plasma density fluctuations are also characterized by power spectra with spectral indices nearly -5/3, and non-Gaussian statistics of fluctuations.

We discuss the role of coherent structures in turbulent plasmas. We demonstrate that coherent structures are responsible for a decrease of disorder and an increase of complexity of magnetic field fluctuations observed within a magnetic reconnection exhaust detected in the solar wind at 1 AU. We also show that coherent structures are responsible for decreasing the entropy of the turbulent magnetic field in numerical simulations of a model of Keplerian shear flows in astrophysical plasmas. In addition, we discuss the role of coherent structures in numerical simulations of a simplified model of turbulence induced by drift waves in tokamak plasmas. These results can be relevant for understanding the complex relationship between coherent structures and plasma turbulence.

Affiliations

Miranda, R. A.; Costa, S. G. S. P.	University of Brasilia
Piragibe, A. L.	Kyoto University
Chian, A. C.-L.	University of Adelaide, Australia, and National Institute for Space Research, INPE

E-mail

rmiracer@gmail.com

3D simulation of an extreme SAID/STEVE: Effects of E-region plasma turbulence

Joaquín Díaz Peña, Joshua L Semeter, Matt Zettergren

Observations from space highlight how the signatures linked with STEVE might correspond to a more intense variant of a SAID channel. Data indicates velocities exceeding 4 km/s, temperatures above 4,000 K, and significant current density drivers reaching up to 1 μA/m². This phenomenon is localized within a small latitude range, less than a degree, but extends over a broad longitudinal area.
In our research, we leverage the GEMINI model to recreate an extreme SAID/STEVE scenario. We start with a FAC density from the magnetosphere as the primary driver, letting all other factors adjust accordingly. Our goals are threefold: to demonstrate how an extreme SAID can achieve velocities like or exceeding those of STEVE, study the impacts of E-region instabilities since most of the current will close through the small area in the ionosphere, and to highlight the limitations and missing physics due to the high temperature and velocity values. Adjustments to GEMINI were necessary due to extreme conditions, particularly some neutral-collision frequencies.
We discuss the critical temperature threshold at which some collision frequencies deviate beyond their limits, as well as the importance of the energies that lead to inelastic collisions and impact ionization. We present complex structures and behaviors, underscoring the necessity of 3D simulations to capture these phenomena accurately. Longitudinal structure receives attention, as the channel's development varies with MLT. However, these simulations should be considered approximations due to limited observational data to constrain the model inputs and the assumptions needed to achieve plausible results.

Affiliations

Joaquín Díaz Peña	Universidad de Chile
Joshua L Semeter	Boston University
Matt Zettegren	Embry-Riddle Aeronautical University

E-mail

joaquindiaz@uchile.cl

Presentations: Wednesday, January 22nd 2025

Energy-sensitive X-ray Cameras for Thermal and Non-Thermal Plasmas: A 12-Year Journey Towards Real-Time Solutions

Luis F. Delgado-Aparicio

Versatile multi-energy soft and hard X-ray (SXR & HXR) pinhole cameras have been developed, calibrated, and deployed at MST, Alcator C-Mod, and WEST tokamaks with metal walls. These cutting-edge instruments, serving as enabling technologies, have facilitated investigations into a wide array of phenomena including particle, impurity, and thermal transport, heating and RF current-drive mechanisms, equilibria, MHD physics, and the diagnosis of non-Maxwellian effects such as runaway electrons (RE). This innovative imaging diagnostic leverages a pixelated X-ray detector capable of independently adjusting the lower energy threshold for photon detection on each pixel. Through meticulous trimming and calibration of the lower energy thresholds, our team has successfully mitigated contributions from radiative recombination and line emissions from medium to high-Z impurities like Al, Mo, and W. Central electron temperature values are derived by modeling the slope of continuum radiation, extracted from ratios of inverted radial emissivity profiles across multiple energy ranges, without relying on a-priori assumptions of plasma profiles, magnetic field reconstructions, high-density limitations, or shot-to-shot reproducibility. Recent breakthroughs include the temporal evolution measurement of central electron temperature during the C9 campaign at WEST, encompassing long-pulse L-modes lasting up to 364 seconds with 1.14 GJ of injected energy. Additionally, novel applications for diagnosing non-Maxwellian tails have been demonstrated, such as observing the birth, exponential growth, and saturation of runaway electrons (Ee~100×Te,0) as well as characterizing fast-electron losses near the W strike point and emission anisotropies at the edge and core in LHCD plasmas at WEST. Several applications and potential collaborations will be discussed.

Affiliations

Luis F. Delgado-Aparicio	Princeton Plasma Physics Laboratory

E-mail

ldelgado@pppl.gov

The current status of the upgrade of TCABR

G.P. Canal, A.O. Santos, A.S. Bouzan, F.M. Salvador, J.R. Fernandes Jr., F.P. Bekman, V.L.L. Cunha, M.C. Silva, F.A.F. Albuquerque, G.A.P. Vaccani, F.C. Romano, D.O. Novaes, A.S. de Souza, V.D. Sarkis, P.P. Corrêa, L.P.G. Oliveira, D. Cecara, J.V.A.K. de Sousa, N.F. Altaras, J.R. Richieri, R.A. Mesquita, R.M.E. Neto, R.A.O. Nalesso, V.M. Neto, V.B. Dalvi, A.N.R. Costa, R. Ramos Jr., F. Kassab Jr., P.S.P. da Silva, W. Komatsu, J.Y. Saab Jr., M.S. Mathias, F.T. Degasperi, E.M. Ozono, R. Schirru, A. Kleiner, N.M. Ferraro, A. Nagy, E.S. Seol, D.M. Orlov, W.P. de Sá, J.I. Elizondo, J.H.F. Severo and R.M.O. Galvão

A significant upgrade of the Tokamak à Chauffage Alfvén Brésilien (TCABR) is under design to make it capable of creating a well controlled environment where the impact of applied magnetic perturbations on edge localized modes (ELMs), can be addressed over a wide range of (i) plasma shapes, (ii) divertor configuration, (iii) ELM control coil geometries and (iv) perturbed magnetic field spectra. The core of this upgrade is the installation of an innovative set of ELM control coils composed of 108 independently powered in-vessel coils: 54 on the high field side and 54 on the low field side. These coils will operate with AC and DC currents up to 2 kA and with frequencies varying continuously from 0 up to 10 kHz. This will allow for the application of magnetic perturbations with toroidal mode number n

Affiliations

Gustavo Paganini Canal	Institute of Physics of the University of São Paulo
Alessandro de Oliveira Santos	Institute Mauá of Technology
André Salgueiro Bouzan	Polytechnic School of the University of São Paulo
Felipe Machado Salvador	Institute of Physics of the University of São Paulo
José Roberto Fernandes Jr.	Institute of Physics of the University of São Paulo
Felipe Paes Bekman	Polytechnic School of the University of São Paulo
Victor Lusis Lassance Cunha	Institute of Physics of the University of São Paulo
Matheus da Cruz Silva	Polytechnic School of the Federal University of Rio de Janeiro
Fernando Antonio Felicio Albuquerque	Nuclear and Energy Research Institute
Gustavo Antonio Pires Vaccani	Aeronautics Institute of Technology
Fernando Carlos Romano	Institute of Physics of the University of São Paulo
Douglas Oliveira Novaes	Federal University of Rio Grande
Adson Soares de Souza	Institute of Physics of the University of São Paulo
Vanessa Dib Sarkis	Polytechnic School of the University of São Paulo
Pedro Pinho Corrêa	Institute of Physics of the University of São Paulo
Lucas Porta Grecco Oliveira	Institute of Physics of the University of São Paulo
Danilo Cecara	Polytechnic School of the University of São Paulo

João Vitor Araya Kobayashi de Sousa	Institute of Physics of the University of São Paulo
Nathan Fabeliano Altaras	Institute of Physics of the University of São Paulo
Júlia Rodriguez Richieri	Institute of Physics of the University of São Paulo
Ricardo de Ávila Mesquita	Institute of Physics of the University of São Paulo
Rodolpho Marques Evangelista Neto	Institute of Physics of São Carlos - University of São Paulo
Ryan Augusto de Oliveira Nalesso	Institute of Physics of the University of São Paulo
Vinicius Maia Neto	Institute of Physics of the University of São Paulo
Virgínia Boina Dalvi	Polytechnic School of the University of São Paulo
Ari Nelson Rodrigues Costa	Institute Mauá of Technology
Roberto Ramos Jr.	Polytechnic School of the University of São Paulo
Fuad Kassab Jr.	Polytechnic School of the University of São Paulo
Paulo Sérgio Pereira da Silva	Polytechnic School of the University of São Paulo
Wilson Komatsu	Polytechnic School of the University of São Paulo
Joseph Youssif Saab Jr.	Institute Mauá of Technology
Marlon Sproesser Mathias	Polytechnic School of the University of São Paulo
Francisco Tadeu Degasperi	São Paulo State Technological College
Edson Moriyoshi Ozono	São Paulo State Technological College
Roberto Schirru	Polytechnic School of the Federal University of Rio de Janeiro
Andreas Kleiner	Princeton Plasma Physics Laboratory
Nathaniel M. Ferraro	Princeton Plasma Physics Laboratory
Alexander Nagy	Princeton Plasma Physics Laboratory
Ellen Seegyoung Seol	Rensselaer Polytechnic Institute
Dmitri M. Orlov	University of California San Diego
Wanderley Pires de Sá	Institute of Physics of the University of São Paulo
Juan Iraburu Elizondo	Institute of Physics of the University of São Paulo
José Helder Facundo Severo	Institute of Physics of the University of São Paulo
Ricardo Magnus Osório Galvão	Institute of Physics of the University of São Paulo

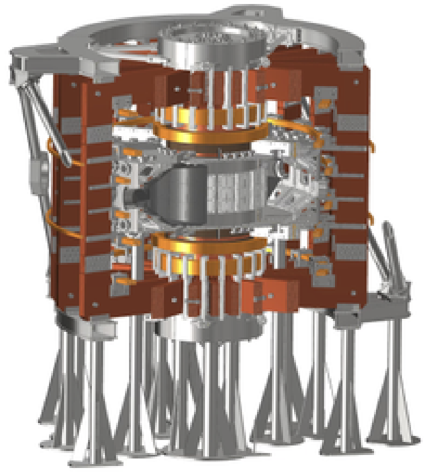


Figure Caption

3D CAD model of TCABR showing the in-vessel ELM control coils and graphite protection tiles that will be installed inside the vacuum vessel.

E-mail

canal@if.usp.br

Modeling separatrix splitting and magnetic footprints in TCABR

J. R. Fernandes Jr., G. P. Canal, J. R. Richieri, F. M. Salvador, D. Ciro

Plasma instabilities remain a significant concern when thermonuclear conditions are approached, as they can impose severe constraints on the maximum achievable plasma performance. When operating in the so-called high confinement mode (H-mode), a very steep plasma pressure profile forms at the plasma edge, leading to repetitive instabilities known as edge localized modes (ELMs) [1]. The crash of these modes results in high transient heat fluxes onto the divertor plates [2], significantly reducing the lifetime of their components. Experiments have demonstrated that externally applied resonant magnetic perturbations (RMPs) can control plasma edge stability, providing a way to trigger ELMs prematurely [3]. When field lines from inside the perturbed plasma volume connect to the divertor targets, structures termed magnetic footprints appear on the plates, delimiting the spots over which most of the exhausted heat and particles are deposited. A significant upgrade of the Tokamak à Chauffage Alfvén Brésilien (TCABR) is being designed to make it capable of creating a well controlled environment where the physics basis behind the effect of RMP fields on ELMs can be addressed. The core of this upgrade corresponds to the design and construction of an innovative set of 108 in-vessel ELM control coils, installed both on the high field side and on the low field side. Controlling the intersection of magnetic lobes with divertor target plates is an important issue to maintain the integrity of the plasma facing components as it controls the levels of heat and particle deposition on the target plates surface. In this project, various perturbed TCABR plasma scenarios are simulated using the MHD code M3D-C1 [4, 5] to obtain the plasma response over different modes of operation of the RMP coils. A specific algorithm is structured to follow the perturbed magnetic field lines, compute their connection length, and track the magnetic flux surfaces they cross, allowing for the modeling of the magnetic footprints on the divertor plates. Furthermore, a second code is implemented to trace the stable and unstable manifolds that compose the perturbed separatrix of the plasma magnetic surfaces, revealing the underlying topology of the magnetic lobes.

[1] H. Zohm. DOI 10.1088/0741-3335/38/2/001
[2] A. Loarte et al. DOI 10.1088/0741-3335/45/9/302
[3] T.E. Evans et al. DOI 10.1103/PhysRevLett.92.235003
[4] Ferraro, N. M. DOI 10.1063/1.3694657
[5] G.P. Canal. DOI 10.1088/1741-4326/aa6e10

Affiliations

José Roberto Fernandes Junior	Universidade de São Paulo
Gustavo Paganini Canal	Universidade de São Paulo
Julia Rodriguez Richieri	Universidade de São Paulo
Felipe Machado Salvador	Universidade de São Paulo
David Ciro Taborda	Universidade Federal de Santa Catarina

E-mail

ojrfernandes@usp.br

Shearless Bifurcations In Tokamaks

B. B. Leal, M. Mugnaine, M. J. Lazarotto, A. M. Ozório de Almeida, R. L. Viana, I. L. Caldas

Shearless Bifurcations in Tokamaks

B. B. Leal1, M. Mugnaine1, M. J. Lazarotto1, A. M. Ozório de Almeida2, R. L. Viana3, I. L. Caldas1

1- Institute of Physics, University of São Paulo, Brazil
2- Brazilian Center for Research in Physics, Rio de Janeiro, Brazil
3- Department of Physics, Federal University of Paraná, Brazil

In nontwist Hamiltonian systems, primary shearless invariant curves are robust barriers to chaotic transport. Surprisingly, secondary shearless invariant curves have also been identified in some twist Hamiltonian systems1, 2. This work presents secondary shearless bifurcations in a twist symplectic Two-Harmonic Ullmann Map that describes chaotic field lines in tokamaks perturbed by two sets of ergodic limiters3, 4. We identify the onset of shearless bifurcations around elliptic fixed points within the island of stability by examining numerical profiles of the internal field line rotation number5. The onset of shearless curves is related to periodic point bifurcations. Furthermore, depending on the bifurcation, these shearless curves can emerge alone or in pairs and, in some cases, deform into separatrices.

1- C. Abud, I. L. Caldas. Chaos 22, 033142 (2012).
2- C. Abud, I. L. Caldas, Nuclear Fusion 54, 064010 (2014).
3- Ullmann K. and Caldas I. L. Chaos Solitons, and Fractals 11, 2129 (2000).
4- B. B. Leal, I. L. Caldas, M. C. de Sousa, R. L. Viana, A. M. Ozorio de Almeida. Physical Review E 109, 014230 (2024).
5- B. B. Leal, M. J. Lazarotto, M. Mugnaine, A. M. Ozório de Almeida, R. L. Viana, I. L. Caldas. Arxiv 2408.10930v1 (2024).

Affiliations

Institute of Physics	University of São Paulo

E-mail

ibere@if.usp.br

Modeling of Vertical Displacement Events in Alcator C-Mod and SPARC

C. Clauser, R. Sweeney, R. Granetz, N. Ferraro, S. Jardin, C. Rea

Vertical displacement events (VDEs) will pose major challenges future in tokamak operations. During these events, the vertical control is lost and the plasma column drift vertically, generating large electromagnetic loads in the vacuum vessel and surrounding conducting structures. Hot VDEs, in which the plasma drifts vertically without losing its thermal energy, might be the most concerning type of VDE. However, cold VDEs (in which the plasma is quenched at the midplane before drifting vertically) will be the most common due to fast mitigation techniques. In SPARC, despite substantial efforts on disruption prediction, avoidance, and mitigation, unmitigated disruptions and VDEs are expected. Therefore, appropriate modeling is critical to better assess their consequences. M3D-C1, a 3D nonlinear MHD code, has become an important high-fidelity modeling tool to help inform SPARC design and operation as well as to provide guidance for ARC design. As part of the effort in building confidence in the modeling, we conducted a validation exercise with Alcator C-Mod VDE data, showing that the overall dynamic is well captured. Then, we employed M3D-C1 to simulate 2D hot and cold VDEs on the SPARC primary reference discharge to assess electromagnetic loads and to determine the critical current that can trigger vertical displacement when the current quench time scale is much shorter than the vessel L/R time. We performed scans over different parameters of interest, covering different magnitudes of halo currents, finding that its magnitude has a stabilizing role on the plasma vertical displacement.

Affiliations

Plasma Science and Fusion Center	Massachusetts Institute of Technology

E-mail

cclauser@psfc.mit.edu

Study of 1/f Spectrum in Pristine Solar Wind Turbulence: Observation data vs numerical simulations

Maia Brodiano, Facundo Pugliese, Davide Manzini, Nahuel Andrés, Lina Hadid, Fouad Sahraoui; Pablo Dmitruk

The magnetic power spectrum in the solar wind is known to be characterized by a double power law at scales much larger than the proton gyroradius (from intermediate to large scales), with flatter spectral exponents close to -1 found at the lower frequencies below an inertial range with indices closer to [-1.5, -1.67]. This double power law is usually found in fast solar wind, in very long intervals of slow wind, and also in extremely long intervals without regard to wind speed. The low frequency range of the spectrum has been considered the energy reservoir that facilitates the turbulence cascade in the solar wind.

The origin and formation mechanism of the 1/f range is still not well understood and is under active debate [1, 2, 3]. Some studies suggested that the 1/f scaling is produced at the sun as a result of uncorrelated samples of fluctuations originating from different regions of the solar surface [1]. While other authors have attributed the 1/f scaling in the fast solar wind to turbulent dynamics within the solar wind [2, 4].

We studied the presence of the 1/f spectrum using observational data from PSP and direct numerical simulation of MHD turbulence. We compare two regimes between having a strong and weak magnetic field. For the simulations, this implies fixing the value of the mean magnetic field guide, and for in-situ data, this translates into having measurements with greater (aphelion case) or lesser (perihelion) heliocentric distance and therefore, weak and strong mean magnetic field, respectively. In all observational cases, we used fast solar wind events. We compared these results by using a moving window so as to fit and determine (and quantify) the slope and range of 1/f of the magnetic energy spectra. We observed a range of one decade of 1/f spectrum for the strong magnetic field regime, which is larger than the weak magnetic field case in numerical simulations. As for the observational data, no significant 1/f range has been found. Moreover, the break between the two different scaling laws is only observed in the perihelion case.

[1] Matthaeus, W. H., & Goldstein, M. L. 1986, PhRvL, 57, 495.
[2] Velli, M., Grappin, R., & Mangeney, A. 1989, PhRvL, 63, 1807.
[3] Dmitruk, P., & Matthaeus, W. H. 2007, PhRvE, 76, 036305.
[4] Verdini, A., Grappin, R., Pinto, R., & Velli, M. 2012, ApJL, 750, L33.

Affiliations

Maia Brodiano	CONICET - Universidad de Buenos Aires, Instituto de Física Interdisciplinaria y Aplicada (INFINA). Buenos Aires, Argentina.
Facundo Pugliese	CONICET - Universidad de Buenos Aires, Instituto de Física Interdisciplinaria y Aplicada (INFINA). Buenos Aires, Argentina.
Davide Manzini	Laboratoire de Physique des Plasmas (LPP), CNRS, École Polytechnique, Sorbonne Université, Université Paris-Saclay, Observatoire de Paris, 91120 Palaiseau, France

Nahuel Andrés	CONICET - Universidad de Buenos Aires, Instituto de Física Interdisciplinaria y Aplicada (INFINA). Buenos Aires, Argentina.
Lina Hadid	Laboratoire de Physique des Plasmas (LPP), CNRS, École Polytechnique, Sorbonne Université, Université Paris-Saclay, Observatoire de Paris, 91120 Palaiseau, France
Fouad Sahraoui	Laboratoire de Physique des Plasmas (LPP), CNRS, École Polytechnique, Sorbonne Université, Université Paris-Saclay, Observatoire de Paris, 91120 Palaiseau, France
Pablo Dmitruk	CONICET - Universidad de Buenos Aires, Instituto de Física Interdisciplinaria y Aplicada (INFINA). Buenos Aires, Argentina.

E-mail

mbrodiano@df.uba.ar

Interaction of energetic particles and large scale magnetic fields in the interplanetary medium

Alejandro Lara

The interplanetary medium is permeated by a quasi-constant and quasi-isotropic flux of particles, mainly protons, in a wide range of energies (form 103 to 1020 eV) originated outside of the solar system (galactic cosmic rays, GCR). Similarly, a wind of plasma and magnetic field is constantly blowing by the Sun. The effect (modulation) of the solar wind over the low energy GCR is well known, resulting on an anti-correlation between the number of GCR and the solar activity at long time scales (~22 years) and on shorter time scales (days), the Forbush decreases caused by solar storms.

Recently, short time scale (hours) enhancements of GCR have been observed by very sensitive detectors, as the High Altitude Water Cherenkov (HAWC) array, during the passage of large scale magnetic helical structures. These structures are transported by the interplanetary coronal mass ejections (ICMEs) which transport the magnetic flux ropes originated in the solar interior to the outer heliosphere and its dimension at the Earth distance are approximately of half of an astronomical unit.

We propose that the observed enhancements as well as other GCR fluctuations are due by the Effect of the Lorentz force exerted by the helicoidal large scale magnetic field, resulting in GCR flux anisotropies which depend on the position of the observer inside the ICME and the energy of the GCR. In this work we present some observations as well as the simulations carried out to test our model

Affiliations

Instituto de Geofísica	Universidad Nacional Autónoma de México

E-mail

alara@igeofisica.unam.mx

Analysis of Solar Wind Properties Associated With Relativistic Electron Enhancement Events at Geostationary Orbit

Victor A. Pinto, Bea Zenteno-Quinteros, Pablo S. Moya, Marina Stepanova

Radiation belt electrons of ultra-relativistic energies can vary several orders of magnitude in periods as short as hours. For this reason, they are considered a threat to the infrastructure in space, as they can penetrate the dielectric materials in satellites and cause malfunctions. Several studies have been devoted to understanding the physical processes that lead to changes in the electron's population, and by far, the most studied phenomena have been the response of the radiation belt to geomagnetic storms. Despite this, there have been reported cases of relativistic electron enhancements where it is unclear if the geomagnetic conditions correspond to a traditional geomagnetic storm. In this work, we use in-situ measurements from the Geostationary Operational Environmental Satellite (GOES) 5-12 Energetic Particle Sensor (EPS) and GOES 13-15 Energetic Proton, Electron, and Alpha Detectors (EPEAD) instruments to identify >2 MeV relativistic electron enhancement events during the period between 1 December 1984 and 31 December 2020. Additionally, we use solar wind parameters and geomagnetic indices from the OMNI database to determine solar wind conditions and geomagnetic activity associated with the enhancements. We classified the events and found that around 30% of relativistic electron enhancement events can be characterized as no-storm events and that those events are typically associated with high-speed streams in the solar wind produced by corotational interaction regions (CIR) which are not geoeffective enough to trigger a geomagnetic storm. We also found significant differences in the solar wind speed and density profiles associated with the different geomagnetic drivers of the events. Our results suggest that for studies that focus on data analysis of the radiation belt dynamics, it is not enough to study storm time to have a complete characterization of the evolution of the electron fluxes in the belt.

Affiliations

Victor A. Pinto	Departamento de Fisica, Universidad de Santiago de Chile
Bea Zenteno-Quinteros	Departamento de Fisica, Universidad de Santiago de Chile
Pablo S. Moya	Departamento de Fisica, Facultad de Ciencias, Universidad de Chile
Marina Stepanova	Departamento de Fisica, Universidad de Santiago de Chile

E-mail

victor.pinto@usach.cl

The role of plasma instabilities in collisionless plasmas

Rodrigo A. López

Many space and astrophysical systems, such as accretion flows, intracluster medium of galaxy clusters, the solar wind, and some laboratory environments, are found to be weakly collisional or even collisionless magnetized plasmas. In these weakly collisional systems, the collisional timescales and space scales are much larger than the typical scales of the collective processes in these systems. In the absence of particle-particle Coulomb collisions, deviations from thermodynamic equilibrium can not be relaxed, and a series of non-thermal features appear in the particle distribution functions, such as temperature anisotropies, beam populations, phase space gradients, or suprathermal high-energy populations. These non-thermal features are a source of free energy, which triggers various
plasma micro-instabilities and supports a certain level of wave fluctuations and turbulence in the plasma system. The continuous local energy exchange between waves and particles shapes the particle distributions and prevents further deviations from the thermodynamic equilibrium, making them essential for the overall evolution of these plasmas.
This work will discuss the recent progress on theoretical and numerical tools dedicated to studying various electron and proton-driven instabilities relevant to many astrophysical plasmas, particularly the solar wind and planetary environments. We apply the fundamental kinetic theory and a series of analytical and numerical tools from linear and quasi-linear
Vlasov-Maxwell approaches to hybrid and fully kinetic particle simulations.
We will focus on our different advances in formulating a more general velocity-moment-based quasilinear theory that allows the incorporation of oblique instabilities or solves the velocity space diffusion equation under the assumption of a separable perpendicular and parallel velocity distribution function.
These enable us to understand the role of these instabilities in the plasma evolution and contribute to the ongoing efforts toward a self-consistent global multi-scale model for the heliospheric plasmas.

Affiliations

Research Center in the intersection of Plasma Physics, Matter, and Complexity (P^2mc)	Comisión Chilena de Energía Nuclear

E-mail

rodrigo.lopez@cchen.cl

Evidence of free-bound transitions in Warm Dense Matter

Maximilian P Böhme, Luke B Fletcher, Tilo Döppner, Dominik Kraus, Andrew D Baczewski, Thomas R Preston, Michael J MacDonald, Frank R Graziani, Zhandos A Moldabekov, Jan Vorberger, Tobias Dornheim

Warm dense matter (WDM) is now routinely created and probed in laboratories around the world, providing unprecedented insights into conditions achieved in stellar atmospheres, planetary interiors, and inertial confinement fusion experiments. However, the interpretation of these experiments is often filtered through models with systematic errors that are difficult to quantify. Due to the simultaneous presence of quantum degeneracy and thermal excitation, processes in which free electrons are de-excited into thermally unoccupied bound states transferring momentum and energy to a scattered x-ray photon become viable. Here we show that such free-bound transitions are a particular feature of WDM and vanish in the limits of cold and hot temperatures. The inclusion of these processes into the analysis of recent X-ray Thomson Scattering experiments on WDM at the National Ignition Facility and the Linac Coherent Light Source significantly improves model fits, indicating that free-bound transitions have been observed without previously being identified. This interpretation is corroborated by agreement with a recently developed model-free thermometry technique and presents an important step for precisely characterizing and understanding the complex WDM state of matter.

Affiliations

Maximilian P. Boehme	Lawrence Livermore National Laboratory

E-mail

boehme4@llnl.gov

Undepleted Direct Laser Acceleration

Itamar Cohen, Talia Meir, Kavin Tangtartharakul, Lior Perelmutter, Michal Elkind, Yonatan Gershuni, Assaf Levanon, Alexey V Arefiev and Ishay Pomerantz

Intense lasers have supported new schemes for generating high-energy particle beams in university-scale laboratories. With the direct laser acceleration (DLA) method, the leading part of the laser pulse ionizes the target material and forms a positively charged ion plasma channel into which electrons are injected and accelerated. In this work, we demonstrate that for efficient DLA to prevail, a target material of sufficiently high atomic number is required to maintain the injection of ionization electrons at the peak intensity of the pulse.
Using the high-contrast 20 TW laser system at Tel-Aviv University, we generated, for the first time, electron beams from high-atomic-number plasma plumes created by pre-exploding foils of Au. We compared their properties with DLA from low-atomic-number plasmas created from foils of CH. The plasma plume density profile was tailored by setting the pre-pulse energy and the pre-pulse to main-pulse delay interval to optimize the generated electron beam charge and energy.
Using Particle-In-Cell simulations, we observed highly efficient acceleration of electrons injected from a specific range of ionization levels into the DLA channel.
Applying this new understanding to experiments on multi-petawatt laser facilities now coming online is expected to increase the electron energy overlap with the neutron production cross-sections of any material. These increased neutron yields are required to enable a wide range of research and applications, such as investigation of nucleosynthesis in the laboratory, performing non-destructive material analysis, and industrial applications.

Cohen, I., et. al, Undepleted direct laser acceleration, Science Advances 10, eadk1947(2024)

Cohen, I., et. al, Multi-scale analytical description of an expanding plasma slab, Phys. Plasmas 2024; 31 (1): 013103

Cohen, I., et al, Accumulated laser-photoneutron generation, The European Physical Journal Plus 139.7 (2024): 1-7

Meir, T., et. al, Plasma guided Compton source, Phys. Rev. Applied (accepted, 9/2024)

Affiliations

Ishay Pomerantz	Tel Aviv University

E-mail

ipom@tauex.tau.ac.il

Presentations: Thursday, January 23rd 2025

Opacities for Astrophysics: Theory and Experiments

Franck Delahaye, Connor Ballance, Frederique Perez, Shinsuke Fujioka et al.

Trying to understand the underlying differences between the measured Fe opacities at the Sandia National Laboratory (Bailey et al. 2015) and prior theoretical calculations, a new set of monochromatic opacities for key Fe ion stages have been calculated. These ion stages are important contributors to the Rosseland opacities for the physical conditions characterizing the base of the Solar convection zone, and have been calculated in the framework of the Opacity Project approach. These new data sets are being tested on solar models. In parallel, while exploring all possible uncertainties and missing processes in theoretical calculations, we are developing 2 new platforms to measure opacities at 2 facilities, GEKKO XII (ILE-Osake University-laser ns + probe ps) and APOLLON (LULI - Ecole Polytechnique-lasers fs). I will present here the status and preliminary results on both part Theory and Experiment.

Affiliations

Observatoire de Paris	Sorbonne Universite

E-mail

franck.delahaye@observatoiredeparis.psl.eu

Overview: Diamond Like Carbon (DLC) ablators for fusion energy

N. M. Vargas, K.C. Chen, P. Raman, M. Hoppe, and F. Elsner

On December 5, 2022, after 4 decades of technical improvements, NIF reached "ignition" for the first time, achieving a 150% energy yield and with it unlocking the promise of unlimited energy supply for human society. This historical achievement was enabled by the many esoteric and ultra-high precision Inertial Confinement Fusion (ICF) components General Atomics manufactures and assembles into complex target assemblies, which are subsequently fielded, on national facilities such as the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL). Each target assembly has an ablator capsule at its center. HDC (high-density carbon), a form of nanocrystalline diamond, is the current choice for the ablator in these experiments. However, as NIF laser power scales up, Diamond Like Carbon (DLC) ablators are looking increasingly attractive.

Diamond Like Carbon (DLC) material has captured the interest of the laser fusion community due to its unique properties. DLC's amorphous microstructure, high density, and ability to be doped makes it an attractive choice for ablator material. At General Atomics, we developed a Hollow Cathode Radio Frequency Plasma Assisted Chemical Vapor Deposition (HC RF PACVD) system to deposit DLC coatings on both flat and spherical substrates.
Our DLC capability, with precisely tuned hydrocarbon and carrier gas compositions, enables the deposition of thick, dense, and smooth Diamond-Like Carbon coatings for experiments in Inertial Fusion Technology. In this presentation, we will provide an overview of our major results to create free-standing DLC capsules, including the fabrication, characterization and post processing techniques.
This work performed under the auspices of General Atomics under Internal Research and Development.

Affiliations

Nicolas M. Vargas	General Atomics
Kuo-Chun Chen	General Atomics
Priya Raman	General Atomics
Martin Hoppe	General Atomics
Fred Elsner	General Atomics

E-mail

nicolas.vargas@ga.com

A study of an Argon-Helium parallel plate discharge structure using optical diagnostics

Stephen Muhl, Omar Alejandro Soto Cabral, Marco Antonio Martínez-Fuentes

Glow discharges (GD) are probably the most common forms of cold plasma and are widely used in both industry and research.
In this study, experiments were conducted in a cylindrical vacuum chamber with two parallel plate electrodes: a copper anode and a graphite cathode, separated by 21 cm. Several combinations of Argon (Ar) and Helium (He) mixtures were used, 100%, 75%, 50%, 25%, and 0%. For pure Ar (100%), six pressures from 60 mtorr to 250 mtorr were tested at 600V, while for pure He (100%), five pressures from 190 to 450 mtorr were tested at 700V. For the mixtures, pressures of 150, 200, and 250 mtorr were used at 600V.
The primary diagnostic tools were Optical Emission Spectroscopy (OES) and analysis of high-resolution photographs. Spectra from the discharge were obtained using an Avantes AvaSpec-DUAL spectrometer, which provided UV spectra from 200 nm to 470 nm with a resolution of 0.12 nm, and visible spectra from 400 nm to 940 nm with a resolution of 0.24 nm. Measurements were taken along the axis of the cylinder in 2 mm steps away from the cathode, observing light from a rectangular area of 20 mm × 1 mm. Additionally, analysis of photographic images was conducted which provided a good general view of color distribution.
It was found that the structure and behavior of the GDs differed significantly as function of the gas mixture and pressure. For pure Ar the presence of He modified the intensity of certain Ar emission lines, and was accompanied by an increase in discharge current suggesting a higher plasma density. Conversely, in pure He the introduction of Ar caused the emission intensity of He I lines to increase, shortened the negative glow zone, shifted the peak emission closer to the cathode, and drastically increased the discharge current.

Affiliations

Instituto de Investigaciones en Materiales	Universidad Nacional Autónoma de México

E-mail

muhl@unam.mx

Analysis and simulations of cold plasmas generated by Magnetron Sputtering

Michael Stuber, Sven Ulrich , Rolf Grieseler

This work investigates an analysis and simulations of cold plasma generated by Magnetron Sputtering. Comprehensive diagnostic study of the plasma at MatER PUCP laboratory employing a combination of Finite Element Method (FEM), Electron Energy Probability Function (EEPF), Langmuir probe, and Optical Emission Spectroscopy (OES). The investigation involves systematic variations in RF power from 20 W to 90 W, accompanied by incremental adjustments in pressure from 6.00×10^{-3} mbar to 9.00×10^{-2}mbar. Remarkably, the data consistently exhibit analogous behaviors throughout this range of parameters.

This work explains the plasma parameters for each technique. FEM results show that the maximum values of ion and electron density are 1.24×10^{16} m^{-3}, and electron temperature 4.09 eV at 90 W with 1.00×10^{-2} mbar. Langmuir probe results show 1.17×10^{16} m^{-3} for electron density, 1.67×10^{16} m^{-3} ion density, and an kT_e of 2.72 eV. EEPF results show 1.17×10^{16} m^{-3} and an kT_e of 3.42 eV. OES demonstrated kT_e values of 2.99 eV obtained with the Aluminum target. The results with pressure variations show that RF magnetron sputtering systems can obtain plasma stability from 7.00×10^{-3} mbar to 5.00×10^{-2} mbar.

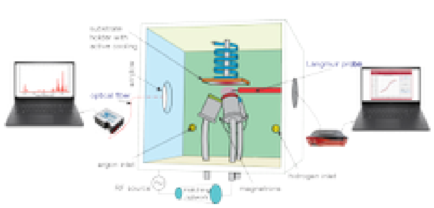
A crucial aspect of this study is the correlation of plasma parameters with variations in power and pressure for Ti, Al and C targets. The results confirm the reproducibility of the data and provide an understanding of the underlying mechanisms governing the plasma behavior. This knowledge is indispensable for achieving precise control over the deposition process in the laboratory's sputtering system.

The practical significance of this research extends outside the confines of the laboratory. The acquired understanding of plasma parameters is a foundation for reproducing thin films with identical properties in different sputtering systems. By comprehensively documenting the plasma characteristics, this work facilitates the transfer of knowledge to other sputtering systems, facilitating the process of obtaining films with desired properties.

This research advances plasma diagnostics and applies the groundwork for controlled thin film deposition. The understandings gained deepen our understanding of plasma behavior and hold implications for enhancing the reproducibility of thin films in diverse sputtering environments.

Affiliations

Pontificia Universidad Católica del Perú	PUCP
Karlsruhe Institute of Technology	KIT



E-mail

noely.calderon@pucp.edu.pe

Supersonic Thermal Plasma Expansion Process for Nanoparticle Production: Synthesis of Lithium-Based Nanoparticles

Biswajit Bora[1,2†], Jalaj Jain[1,2], Jose Moreno[1,2], Sergio Davis[1,2], Cristian Pavez[1,2], Rodrigo Lopez[1,2], and Leopoldo Soto[1,2]

This study explores the synthesis of lithium-based nanoparticles using the supersonic thermal plasma expansion process, utilizing a direct current (dc) plasma torch. The setup comprises a tungsten rod cathode and a water-cooled copper anode, functioning as a nozzle to generate a high-temperature, high-velocity plasma jet. By introducing gas into the electrode gap, we establish a dc arc that facilitates the effective synthesis of lithium sulfide (Li_2S) nanoparticles. Characterization techniques, including scanning electron microscopy (SEM), high-resolution transmission electron microscopy (HRTEM), and X-ray diffraction (XRD), reveal the formation of core-shell structures that enhance stability and performance for energy storage applications. Additionally, electrochemical testing indicates the potential of these nanoparticles as anode materials in lithium-ion batteries. This research highlights the efficiency and scalability of the supersonic thermal plasma expansion process, paving the way for advancements in nanotechnology and energy storage solutions.

Affiliations

	1Center for Research on the Intersection in Plasma Physics, Matter and Complexity, P2mc, Comisión Chilena de Energía Nuclear, Casilla 188-D, Santiago, Chile.
	2Universidad Andres Bello, Departamento de Ciencias Físicas, Republica 220, Santiago, Chile. †biswajit.bora@cchen.cl

E-mail

biswajit.bora@cchen.cl

First Principles Description of the Solar Wind Expansion Using the Expanding Box Model

Pablo S. Moya, Sebastián Echeverría-Veas, Sebastián Saldivia, Marian Lazar, Stefaan Poedts, and Felipe Asenjo

Due to the combined effect of pressure gradients and the gravitational field, the Sun and the stars release a continuous flow of particles known as the solar (or stellar) wind. The solar wind represents a natural plasma physics laboratory to study and unravel several unsolved problems about the microscopic and macroscopic physics of expanding poorly collisional turbulent plasmas. In-situ observations have shown that the solar wind is hotter and faster than predicted by the Chew–Goldberger–Low (CGL) adiabatic theory. This poses several questions about the heating and acceleration of the solar wind that still resist being fully answered; yet, there is ample evidence about the active role that the magnetic field and electromagnetic turbulence must play. In this context, the Expanding Box Model (EBM) provides a valuable framework to mimic plasma expansion in a non-inertial reference frame, co-moving with the expansion but in a box with a fixed volume, which is especially useful for numerical simulations. Here, fundamentally based on the Vlasov equation for magnetized plasmas and the EBM formalism for coordinates transformations, for the first time, we develop a first-principles description of radially expanding plasmas in the EB frame. From this approach, we aim to fill the gap between simulations and theory at microscopic scales to model plasma expansion at the kinetic level. Our results show that expansion introduces non-trivial changes in the Vlasov equation, especially affecting its conservative form through non-inertial forces related to the expansion. Moreover, we have used EBM to revisit the CGL description including plasma expansion. We developed a CGL-like description in which the expansion modifies the conservation of the double adiabatic invariants. Our results show that the double adiabatic equations are no longer conserved if plasma cooling is introduced through the EBM, with explicit dependence on expanding parameters, magnetic field profiles, and velocity gradients. Solving the equations for different magnetic field and density profiles (obtained self-consistently through the equations), we compute the evolution of temperature anisotropy and plasma beta, which deviates from CGL predictions and empirical observations. This deviation is attributed to the plasma cooling effect induced by the plasma expansion. These results suggest that heating mechanisms play an even major role in counteracting plasma cooling during the expansion of the solar wind

Affiliations

Pablo S Moya	Departamento de Física, Facultad de Ciencias, Universidad de Chile
Sebastián Echeverría-Veas	Departamento de Física, Facultad de Ciencias, Universidad de Chile
Sebastián Saldivia	Departamento de Física, Facultad de Ciencias, Universidad de Chile
Marian Lazar	Centre for mathematical Plasma Astrophysics, Department of Mathematics, KU Leuven
Stefaan Poedts	Centre for mathematical Plasma Astrophysics, Department of Mathematics, KU Leuven
Felipe Asenjo	Facultad de Ingeniería y Ciencias, Universidad Adolfo Ibáñez

E-mail

pablo.moya@uchile.cl

Long-term trends at the geomagnetic equator: New results from Jicamarca Radio Observatory

Meyer Merino, Ana G. Elias and Enrique Rojas

It is well known that trends in ionospheric plasma depend on location. In addition, trend values seem to depend also on the solar proxy used to filter solar activity effects previous to the trend assessment. Furthermore, at low and equatorial latitudes, the secular variations of the geomagnetic field have comparable effects on ionospheric trends as greenhouse cooling. These complexities may require a more comprehensive analysis of several ionospheric parameters and how they are related. This work assesses long-term trends of ionospheric parameters in the equatorial region above the Jicamarca Radio Observatory. First, we will revisit the long-term trends in the foF2, hmF2, and h'F time series from the local digisonde. We propose a linear model that accounts for the geomagnetic field and plasma convection to analyze the trends present in these parameters. Then, we will present our first results in constructing proxies from sounding data that capture the long-term evolution of neutral temperature. Finally, we analyze the trend of a 20-year-long time series of electron densities from the Valley region (around 150 km), estimated from coherent echoes from plasma turbulence.

Affiliations

Meyer Merino	Peruvian University of Applied Sciences
Ana G. Elias	Universidad Nacional de Tucuman
Enrique Rojas	MIT Haystack Observatory

E-mail

meyer.merino@upc.edu.pe

Role of the MHD turbulence in the stability and transport of plasma in the magnetosphere of the Earth

Marina Stepanova, Vctor Pinto, Cristóbal Espinoza

Interaction between a turbulent plasma flow like solar o stellar wind and a magnetic field as an obstacle is very common for space and astrophysical plasmas. The magnetosphere of the Earth is formed precisely as a result of such interaction, and there is a vast amount of evidence suggesting that the geomagnetic tail is like a turbulent wake behind an obstacle. These solar wind turbulent fluctuations are strongly amplified after crossing the bow shock, forming the plasma flows in the magnetosheath. At the same time, the geomagnetic tail contains the plasma sheet filled by dense and turbulent plasmas and tail lobes filled by a rare quasi-laminar plasmas. The large-scale vortices in the wake are able to generate turbulent transport that takes place both along the plasma sheet, in the X and Y directions, and across the plasma sheet, in the Z direction. Thus, turbulent fluctuations in all directions should be taken into consideration when analyzing plasma transport in the plasma sheet, and stability of the plasma sheet itself. The interaction between the turbulent plasma sheet and the inner magnetosphere regions is important for understanding of the key magnetospheric processes such as geomagnetic storms and substorms. At the same time, the variations in the solar wind density, velocity, and interplanetary magnetic field consonantly change the plasma conditions both in the plasma sheet and the inner magnetosphere, but due to different and not fully understood mechanisms. Data from CLUSTER, Themis, and MMS satellites are used to analyse the stability of turbulent plasma sheet and turbulent transport for different solar wind conditions and geomagnetic activity. The results obtained show that the level of turbulence in the plasma sheet, characterized by the eddy diffusion, correlates with the dawn-dusk electric field, and depends of the solar wind and IMF parameters for both quiet and disturbed geomagnetic conditions.

Affiliations

Physics Department	Universidad de Santiago de Chile
Center for Interdisciplinary Research in Astrophysics and Space Science	Universidad de Santiago de Chile

E-mail

marina.stepanova@usach.cl

Community Structure Of Earth's Magnetic Field Measurements

Víctor Muñoz, Sebastián de la Maza

The Earth's magnetic field has variations both in the time and spatial domains, which are due to the internal dynamics of the Earth's core, the forcing by external sources like the solar wind, or fluctuations induced by coupling between neighbouring regions. This leads to various levels of correlations between magnetic field readings on the Earth's surface, which map the interplay of these factors across multiple time and space scales. In this work, we propose to describe and study this complex dynamics of spatiotemporal correlations by means of tools derived from graph theory and complex networks, which have shown to be useful to describe the behavior of various systems of geophysical interest [1, 2, 3]. In particular, we study the evolution of magnetic field measurements on the Earth's
surface along the 23rd solar cycle.

Based on records by 59 magnetometers during the 23rd solar cycle, we define a complex network where nodes are points on the Earth's surface (magnetometers), and their connections represent the degree of similarity between the time series observed at those points. Our results show that there is a correlation between the evolution of network community structure and geomagnetic activity. In addition, we study the dependence of the results of the methods used to define the similarity between time series (and, therefore, to define the connection between nodes), in order to establish the best possible sensitivity for the community structure with respect to the geomagnetic activity, as measured by the Dst index and the sunspots number. We show that the choice of similarity method is not as relevant as the choice of the correlation threshold which determines whether two nodes are actually connected or not. Our work suggests that analysis of the Earth's magnetic field variations using complex network and
community structure analyses, can be useful to understand the geomagnetic activity along the solar cycle.

[1] L. Orr, S. C. Chapman, J. W. Gjerloev, and W. Guo, Network community structure of substorms using SuperMAG magnetometers, Nature Commun. 12, 1842, 2021.
[2] S. Lu, H. Zhang, X. Li, Y. Li, C. Niu, X. Yang, and D. Liu, Complex network description of the ionosphere, Nonlinear Proc. Geophys. 25, 233–240, 2018.
[3] A. Najafi, A. H. Darooneh, A. Gheibi, and N. Farhang, Solar flare modified complex network, Astrophys. J. 894, 66, 2020.

Affiliations

Departamento de Física, Facultad de Ciencias	Universidad de Chile
Facultad de Ciencias Físicas y Matemáticas	Universidad de Chile

E-mail

vmunoz@macul.ciencias.uchile.cl

Kappa distributions in the language of Superstatistics

Sergio Davis

In certain nonequilibrium plasmas, including space and laboratory plasmas, electron and ion velocities are no longer well described by the Maxwellian distribution common in systems under thermal equilibrium, but rather by using a generalization of this known as the kappa distribution. This distribution is characterized by the so-called spectral index kappa, which takes positive values such that in the limit of kappa -> infinity the Maxwellian distribution is recovered. In order to explain the origin of these non-Maxwellian distributions, several theoretical frameworks have been proposed, including non-extensive (Tsallis) statistics and superstatistics, the latter based on the idea of superpositions or mixtures of canonical distributions at different temperatures.

In this work we are focused on the superstatistical description of non-collisional plasmas, explicitly showing the assumptions under which the kappa distribution emerges. We also discuss the proper statistical methodology for fitting the parameters of the kappa distribution using experimental or observational data. Additionally, we present methods for extracting useful predictions from this kind of statistical-mechanical models.

Affiliations

Sergio Davis	Comisión Chilena de Energía Nuclear

E-mail

sergio.davis@cchen.cl

Ultra-High-Frequency Characterization of a Plasma Focus Device: Is There Something Hidden in the Complexity of the Signal?

Gonzalo Avaria, Luis Orellana, Jorge Ardila-Rey, Sergio Davis, Cristian Pavez, Leopoldo Soto

Pulsed plasma devices are well-known sources of high-intensity radiofrequency emissions, spanning a broad frequency range from High Frequency to Ultra High Frequency. These emissions exhibit considerable complexity in their signals, particularly during the various stages of the current pulse evolution.

The emitted signals carry critical information about plasma dynamics and are closely linked to phenomena such as pulsed X-ray emissions from the plasma device. To effectively measure UHF emissions, various antenna designs optimized for specific frequency ranges can be employed.

This study presents three experiments investigating the use of UHF signals for the remote characterization of a Plasma Focus device. These experiments employ diverse antenna designs alongside machine learning algorithms to analyze and interpret the signals. The first experiment utilized a Vivaldi antenna to capture UHF signals emitted by the PF-400J device, while a scintillator/photomultiplier tube detector acquired X-ray pulses. The data were processed using a Convolutional Neural Network, achieving 85% accuracy in classifying UHF signals and estimating hard X-ray pulse intensity.

The second experiment compared various antenna designs, including Monopole, Helical, and Vivaldi antennas, with the inductive sensors integrated into the PF-400J device. Time and frequency analyses revealed that the Vivaldi antenna effectively captured key features observed in the inductive sensor, such as distinct phases of the current pulse evolution, including breakdown and pinch. This finding demonstrates that UHF antennas could serve as economical and effective remote sensors for monitoring pulsed plasma devices.

The third experiment used a neural network classifier to examine correlations between electrical signals from the plasma focus device, such as those from the voltage divider and Rogowski coil, and UHF emissions captured with the Vivaldi antenna. The findings indicated that UHF signals provided comparable information to electrical signals for estimating hard X-ray pulse intensity, with no significant differences observed.

These results highlight the promising potential of UHF emissions for remote sensing applications in pulsed plasma devices. This approach offers a cost-effective and efficient method for monitoring and analyzing plasma behavior in real time.

The authors gratefully acknowledge financial support from ANID FONDECYT Regular 1211131 and FONDEF IDeA ID22I10153.

Affiliations

Gonzalo Avaria	Universidad Técnica Federico Santa María
Luis Orellana	Karlsruhe Institute of Technology
Jorge Ardila-Rey	Universidad Técnica Federico Santa María

Sergio Davis	Comisión Chilena de Energía Nuclear
Cristian Pavez	Comision Chilena de Energía Nuclear
Leopoldo Soto	Comisión Chilena de Energía Nuclear

E-mail

gonzalo.avaria@usm.cl

Posters 1: Tuesday, January 21st 2025

Activity and Cumulative Entropy in MHD Simulations of the GOY Shell Model with Different Types of Forcing

Lautaro Alvear, Víctor Muñoz

In the study of magnetohydrodynamics (MHD), one of the proposed models is the GOY Shell Model, which solves the usual MHD equations via coupled shells in the Fourier space for the velocity and magnetic field of the fluid, correctly reproducing nonlinear effects and statistical properties of turbulence such as power-law distribution of dissipative events. Previous studies performed with this model showed a relation between the fractal dimension of the magnetic dissipation and activity parameters of the time series with a Langevin-type forcing.

In this work, we seek to study if the Cumulative Entropy, proposed as an alternative to Shannon Entropy, shows a correlation with any of the activity parameters proposed in the literature and the effect of varying the fractal dimension of the forcing. For this, we solved the GOY Shell Model equations under different types of forcing in the velocity and magnetic field. The forcings used were antipersistent Fractional Brownian Motion (FBM) time series, in at least one of the dynamic fields (velocity or magnetic field), and Langevin or Gaussian noise in the other. After this, we calculated the magnetic dissipation rate of the time series, studied its cumulative entropy for sliding windows along the time series, and calculated the cumulative entropy of the whole time series.

We have compared the cumulative entropy of the whole series with four activity parameters previously used in the literature. Early results show that for three of the five types of simulations, the cumulative entropy is well correlated with the average magnetic dissipation.

Affiliations

Departamento de Física, Facultad de Ciencias	Universidad de Chile

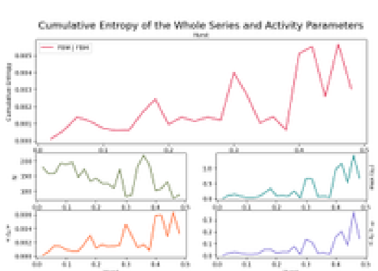


Figure Caption Cumulative entropy and the four usual activity parameters plotted against the hurst coefficient of the forcings for a simulation which used FBM forcing in both dynamic fields.

E-mail

lautaro.alvear@ug.uchile.cl

Using Complex Networks to Characterize Light Curves of Blazars

Macarena Cádiz, Walter Max-Moerbeck, Pablo S. Moya and Denisse Pastén

Blazars are a particular type of active galactic nuclei (AGN), which are galaxies that present strong non-stellar emission. These non-stellar emissions are the product of the accretion of matter to a supermassive black hole in its center, forming plasma jets when they rotate and their accretion disk is strongly magnetized. Blazars have the particularity that their plasma jet is moving at relativistic velocities oriented close to our line of sight [1]. Regarding their optical spectrum, we find two types of blazars: BL Lacertae (BL Lac) and Flat-Spectrum Radio Quasar (FSRQ). The former have weak or featureless emission lines, while the latter have prominent ones.
A common problem in the study of objects through astronomical observations, such as blazars, is the small amount of data obtained. In this context, complex networks appear to be a natural approach to the study of astronomical observations, as shown in the work of Acosta-Tripailao et al. [2]. In this work, we study blazars through complex networks to characterize time series of blazars emissions obtained from the OVRO 40 m Telescope [3]. We model each blazar light curve as a complex network through the Visibility Graph algorithm [4]. Thus, we are looking to determine the type of correlation among time series of blazar emissions, presenting this approach as a new perspective to the analysis of astrophysical systems.

Acknowledgments: This research was funded by FONDECyT grant number 1240281 (P.S.M.) and supported by ANID MSc grant number 22240809 (M.C.). We are grateful to OVRO Telescope data supplied.

References:
[1] Blandford, R.; Meier, D.; Readhead, A. Relativistic Jets from Active Galactic Nuclei. Annu. Rev. Astron. Astrophys. 2019, 57, 467–509.
[2] Acosta-Tripailao, B.; Max-Moerbeck, W.; Pastén, D.; Moya, P.S. Assigning Degrees of Stochasticity to Blazar Light Curves in the Radio Band Using Complex Networks. Entropy 2022, 24, 1063.
[3] Richards, J.L.; Max-Moerbeck, W.; Pavlidou, V.; King, O.G.; Pearson, T.J.; Readhead, A.C.; Reeves, R.; Shepherd, M.C.; Stevenson, M.A.; Weintraub, L.C.; et al. Blazars in the FERMI Era: The OVRO 40 m telescope monitoring program. Astrophys. J. Suppl. Ser. 2011, 194, 29.
[4] Lacasa, L.; Luque, B.; Ballesteros, F.; Luque, J.; Nuno, J.C. From time series to complex networks: The visibility graph. Proc. Natl. Acad. Sci. USA 2008, 105, 4972–4975.

Affiliations

Macarena Cádiz	Departamento de Física, Facultad de Ciencias, Universidad de Chile
Walter Max-Moerbeck	Departamento de Astronomía, Facultad de Ciencias Físicas y Matemáticas
Pablo S. Moya	Departamento de Física, Facultad de Ciencias, Universidad de Chile
Denisse Pastén	Departamento de Física, Facultad de Ciencias, Universidad de Chile

E-mail

macarena.cadiz@ug.uchile.cl

Simulations of the dynamics of Equatorial Ionization Anomaly crests during Solar Eclipses

Manuel Bravo, Miguel Martínez-Ledesma, Jonas de Souza, Blas de Haro Barbás, Valentin Venchiarutti

The ionosphere is a cold magnetized plasma that surrounds the Earth. This is of very low density, reaching less than 0.1% of the total mass of the Earth's atmosphere, however, it is sufficient to affect the propagation of radio waves. In its equatorial zone the called Equatorial Ionization Anomaly (EIA) is characterized by enhanced ionization around the magnetic equator, forming two crests at approximately ±15 degrees geomagnetic latitude due the “fountain effect” (vertical drift E x B). Solar eclipses alter solar radiation, affecting ionospheric electron density and revealing the dynamics of the EIA. Ionospheric models have simulated the response of eclipses around the globe. In particular, the SUPIM-INPE model has been modified by our group to simulate the ionospheric response over America during geomagnetic storm and solar eclipses of the last 5 years, obtaining good results. Observations suggest that not only one of the EIA crests is modified but both of them are impacted. This work attempts to reproduce these observations by simulating the solar radiation reduction (as in previous studies) but also by modifying the input of the thermospheric meridional neutral wind. The results of this research will enhance our understanding of ionospheric behavior in relation to solar activity and thermospheric conditions, contributing to improved predictions of space weather phenomena and the stability of technologies reliant on ionospheric conditions.

Affiliations

Manuel Bravo	Centro de Instrumentación Científica, Universidad Adventista de Chile, Chillán, Chile
Miguel Martínez-Ledesma	Geospace Physics Laboratory, NASA Goddard Space Flight Center, Greenbelt MD, USA; Catholic University of America, Washington DC, USA
Jonas de Souza	Instituto Nacional de Pesquisas Espaciais, Sao Jose dos Campos SP, Brazil
Blas de Haro Barbás	Departamento de Física, Universidad Nacional de Tucumán, Tucumán, Argentina
Valentin Venchiarutti	Departamento de Física, Universidad Nacional de Tucumán, Tucumán, Argentina

E-mail

manuelbravo@unach.cl

A Generalization of Bohm Velocity for Multicomponent Electronegative Plasmas

Marco Antonio Ridenti, David Arruda Toneli, Rodrigo Sávio Pessoa, Marisa Roberto

In this study, we explore how varying assumptions regarding the velocity distribution of negative ions in electronegative plasmas influence the Bohm criterion and the resulting Bohm velocities in the presheath region of a collisionless plasma. We derive a generalized expression for the Bohm criterion in a multi-component electronegative plasma, applicable to non-collisional sheaths, where the electron and negative ion velocity distributions are modeled as $f(v)=A\exp{(-Bv^{2\xi})}$, with ξ being a positive real number greater than 0.5. Furthermore, we demonstrate how the Bohm criterion can be calculated for any given negative ion velocity distribution function. For a three-component plasma consisting of electrons, positive ions, and negative ions, we find that when the ion velocity distribution is convex ($\xi_i > 1.0$), the Bohm velocity is lower than that predicted by a Maxwellian distribution, whereas for concave distributions ($0.5 < \xi_i < 1.0$), the Bohm velocity is higher. Our results show that deviations from the conventional Bohm velocity arise not only due to the plasma's electronegativity but also due to the shape of the ion velocity distribution.

Affiliations

Marco Antonio Ridenti	Aeronautics Institute of Technology
David Arruda Toneli	Aeronautics Institute of Technology
Rodrigo Sávio Pessoa	Aeronautics Institute of Technology
Rodrigo Sávio Pessoa	Aeronautics Institute of Technology
Marisa Roberto	Aeronautics Institute of Technology

E-mail

aridenti@ita.br

Langmuir Turbulence Generated by Electron Beams of Arbitrary Intensity

Guilherme T. Irumé, Joel Pavan and Rudi Gaelzer

This study begins by reviewing the basic concepts of the Kinetic Theory of Plasmas and the Weak Turbulence Theory. The Klimontovich formulation of the Weak Turbulence Theory is then applied to the beam-plasma system according to the single-mode model with the quasi-thermal emission as the initial condition of the beam-mode wave dynamics.

The use of quasi-thermal emission as an initial condition for the wave spectrum is justified for kinetic systems with a characteristic thermal emission spectrum, which can serve as seeds for the excitation of new normal oscillating modes.

Numerical solutions of the kinetic equations are presented for different values of beam parameters (velocity and density).
We observed that the behavior of the beam-plasma system with a high-intensity beam resembles that of the system with low-intensity beams. The results found for the beam-plasma system according to the single-mode model corroborate the consistency of the Weak Turbulence Theory, in the sense that, in both cases, involving beams of low or high intensity, the dynamics of the system do not change significantly.

Future research possibilities are considered based on improvements to the single-mode model, including more normal modes to the dynamics of the beam-plasma system, and implementing a two-dimensional numerical code.

Affiliations

Guilherme Thomas Irumé	Universidade Federal do Rio Grande do Sul

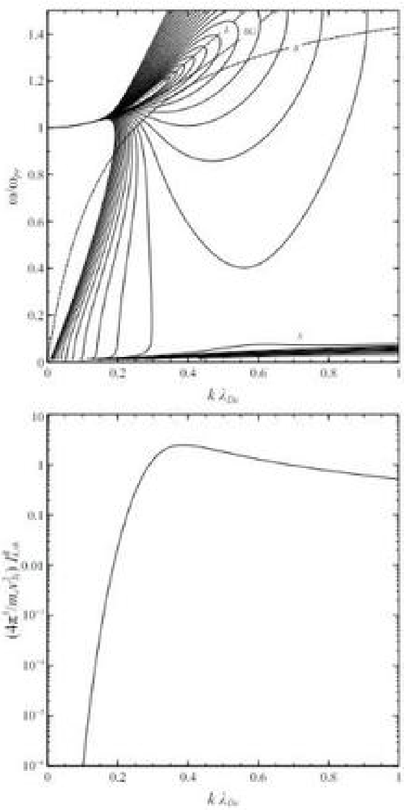


FIG. 5. Top panel: Contour plots of the quasi-thermal emission $(2\pi^3\omega_{pe}/T)\langle\delta E_{\parallel}^2\rangle_{\mathbf{k},\omega}$. The dashed curves correspond to the dispersion relations of the Langmuir mode (L), Bohm-Gross (BG) and beam mode (B), with $\alpha v_b = 10\sqrt{2}v_{te}$ and $b = 0.6\omega_{pe}^{-1}$. Bottom panel: the normalized thermal spectral intensity along the dispersion relation of the mode B.

E-mail

gui.irume@gmail.com

Laboratory Exploration of Early Universe Magnetogenesis with High Repetition Rate Experiments and FLASH Simulations

Tristan Bachmann, Jessica Pilgram, Marissa Adams, Mario Manuel, Carmen Constantin, Haiping Zhang, Lucas Rovige, Peter Heuer, Robert Dorst, Sofiya Ghazaryan, Marietta Kaloyan, Derek Schaeffer, Christoph Niemann, Petros Tzeferacos

Magnetic fields are pervasive on cosmological and galactic scales, and understanding their formation and evolution is essential to our understanding of modern cosmology. One of the predominant proposed mechanisms for the origin of these fields is via the Biermann battery effect, which describes the spontaneous generation of magnetic fields due to non-parallel density and temperature gradients in plasmas. Though the effect is difficult to observe directly in the intergalactic medium, due to its relatively small magnitude and the large spatial scales along which measurements are made, advancements in the field of laboratory astrophysics in recent decades now allows us to use scaling relations to investigate these phenomena on laboratory scales. Using FLASH, a high-performance radiation-hydrodynamics code with extended magnetohydrodynamic terms, we collaborate with experimentalists at UCLA to model the generation of Biermann-driven fields in such a laboratory setting, using high repetition rate laser produced plasmas at a frequency of ~1 Hz. We validate the FLASH code in new spatiotemporal regimes, and we use these newly validated capabilities to assist in the modeling and design of ongoing laboratory astrophysics experiments that introduce a nitrogen fill to the target chamber to facilitate shocks in the system. We also perform large scale simulations to investigate the generation and subsequent amplification of seed fields and their impact on large scale structure.

Affiliations

Tristan Bachmann	University of Rochester
Jessica Pilgram	UCLA
Marissa Adams	Sandia National Laboratory, University of Rochester
Mario Manuel	Laboratory for Laser Energetics
Carmen Constantin	UCLA
Haiping Zhang	UCLA
Lucas Rovige	UCLA
Peter Heuer	University of Rochester,
Robert Dorst	UCLA
Sofiya Ghazaryan	UCLA
Marietta Kaloyan	UCLA
Derek Schaeffer	UCLA
Christoph Niemann	UCLA
Petros Tzeferacos	University of Rochester

E-mail

tbachma2@ur.rochester.edu

Simulating Electromagnetic Waves in Low Altitude Space Plasmas: Applications to solar flares, neutral waves, and tomography

J.P. Velásquez, G. Rosadio, J. Samanés, E. Rojas.

The ionosphere's D region results from the interaction of solar ionization, highly complex chemistry, and neutral dynamics. With its low concentration of electrons and ions, this region significantly affects the propagation of very low-frequency (VLF) radio waves. VLF signals are highly sensitive to changes caused by solar flares, geomagnetic activity, and gravity waves, making them an effective tool for studying the D region.

In this project, we focused on developing new ionospheric modeling capabilities of the D-region of the ionosphere by utilizing recent tools for D-region simulation and VLF propagation. First, we replaced an empirical statistical model with a physics-based model for simulating electron density profiles and explored GEANT4 to model plasma-enhanced ionization from solar flares. We then used the LongwaveModePropagator.jl library to estimate the plasma characteristics of perturbations caused by solar flares, gravity waves, and day-night transitions using synthetic data and preliminary results with experimental measurements. Finally, we will present the initial results of our efforts to extend the applicability of plasma-neutral dispersion relations to include D region physics.

Affiliations

Comisión Nacional de Investigación y Desarrollo Aeroespacial	Peruvian Space Agency
Pontificia Universidad Católica del Perú	

E-mail

jpvelasquez@pucp.edu.pe

Consistent Treatment of Dense Plasma Effects on Atomic Structures, Collisions, and Spectral Signatures

I. E. Golovkin, M. F. Gu, J. J. MacFarlane

Many existing models for dense plasma effects on the atomic structure often rely on ad-hoc ionization potential depression formulas. However, these models do not capture the entire influence of the plasma screening effects at high densities. We report on development of a complete and consistent atomic database, with all atomic parameters required for collisional radiative modeling computed from appropriate plasma screening potentials. A grid of models depending on plasma temperature and density will be calculated with the Flexible Atomic Code (FAC), and new capability in the suite of Prism modeling codes will be developed to utilize such a database. We will explore several different forms of plasma screening potentials, such as ion-sphere, Stewart-Pyatt, and those based on the average atom models. The resulting spectral models will not only address the modification of ionization balance due to the continuum lowering, but also shifts of spectral lines from the altered energy level structures, as well as the effects of screening potentials on other collisional and radiative process, such as radiative transition, electron impact excitation, photo-ionization, autoionization, and collision ionization. The new development required in FAC, and the resulting atomic data from this project will be made publicly available and hosted in the GitHub repository for FAC.

Affiliations

Prism Computational Sciences, Inc.

E-mail

golovkin@prism-cs.com

Radiation-Hydrodynamics code HELIOS-CR: improved models for dense plasma effects and IFE simulations

V. N. Golovkina, I. E. Golovkin , M. F. Gu and J. J. MacFarlane1

HELIOS-CR is a 1-D radiation-magnetohydrodynamics code that is used to simulate the dynamic evolution of plasmas created in high energy density physics (HEDP) experiments. The energy sources include lasers, radiation sources, electric currents (in cylindrical geometry), and particle beams. It has been extensively used for modelling low-yield ICF experiments. We will discuss several model improvements that makes HELIOS more suitable for IFE simulations including accounting for burned fuel, improved fusion cross-sections, more accurate and efficient charged particle transport algorithms, and support for non-monoenergetic particle beam specifications. We will also discuss new models that account for dense plasma effects on atomic structures and their effect on the results of hydrodynamics simulations with inline collisional-radiative atomic kinetics.

Affiliations

Prism Computational Sciences, Inc.

E-mail

vgolovkina@prism-cs.com

Influence of plasma particle flow on dust grain charging and on particle number density

Luan Bottin De Toni, Luiz Fernando Ziebell, Rudi Gaelzer

This study explores the dynamic evolution of dust electrical potential and plasma particle number densities with a focus on the charging of dust grains through electron and ion absorption, as described by the orbital motion limited (OML) theory. The initial model, which does not account for plasma particle sources and sinks, predicts that dust grains could eventually absorb all plasma particles, leading to a null electrical potential. To address this, we introduced source and sink terms considering a finite region of space in order to simulate real conditions. Our findings indicate that, with the inclusion of plasma particle flow into and out of the region, dust grains reach a stable, non-zero equilibrium potential and the electron and ion densities reach an equilibrium value. This equilibrium is dependent on the size of the region; larger regions result in lower plasma densities and more negative equilibrium potentials. For extensive regions, the dust potential initially mirrors the scenario without sources or sinks but eventually deviates, showing increasing negative values as the region size grows. This behavior is attributed to the electron source term surpassing the combined sink and absorption terms at certain intervals along time evolution.

Affiliations

Luan Bottin De Toni	Universidade Federal do Rio Grande do Sul
Luiz Fernando Ziebell	Universidade Federal do Rio Grande do Sul
Rudi Gaelzer	Universidade Federal do Rio Grande do Sul

E-mail

luan.toni@ufrgs.br

Parametric Decays of Electromagnetic Waves in Electron-Positron Nonextensive Plasmas

Gabriel Medel, Victor Muñoz, Roberto Navarro

Wave propagation in relativistic plasmas is a subject of interest in many astrophysical and space systems, where electromagnetic fields may accelerate particles up to relativistic velocities, which in turn modifies the physics of wave propagation. Besides, kinetic effects further modify the dispersion properties of waves and their nonlinear interactions with the plasma particles. Thus, it is of interest to study wave propagation, and its nonlinear decays, considering both relativistic and kinetic effects.
However, the traditional approach of equilibrium statistics, where kinetic effects are described by Maxwellian velocity distributions, is not satisfactory in several environments where long range correlations, or memory effects, may lead the distributions to deviate from the Maxwellian case. Here, the proposal to describe plasma distribution functions in terms of nonextensive distribution functions, either of the Tsallis (where deviation from the Maxwellian case is given by a parameter q) or the kappa type (where deviations are parametrized by a kappa factor), allows to extend the traditional formalisms, to study wave linear and nonlinear propagation for systems out of thermodynamical equilibrium.
Following these ideas, in this work, parametric decays of an electromagnetic wave in an electron-positron plasma are studied. Kinetic effects are considered by means of the collisionless Vlasov equation, which is coupled to Maxwell equations. Relativistic effects on the particle motion are also taken into account.
In the weakly relativistic case, although some of the instabilities involve strongly damped, electroacoustic pseudomodes, instabilities found using fluid theory are present as well in the kinetic regime. We study in detail the dependence on kappa of the dispersion relation, the growth rate, and the phase velocity of the waves. As expected, results reduce to the Boltzmann-Gibbs statistics for kappa tending to infinity.

Affiliations

Departamento de Física, Facultad de Ciencias, Universidad de Chile, Santiago	Universidad de Chile

E-mail

gabriel.medel@ug.uchile.cl

Investigating The Effect Of Impurity Seeding On The Magnetic And Electrostatic Edge Fluctuations In ADITYA-U Tokamak

Komal, H. Raj, I. Hoque, S. Banerjee, A. Kumawat, B. Hegde, A. Kumar, K. Singh, S. Dolui, S. Aich, R. Kumar, K. A. Jadeja, K. M. Patel, R. L. Tanna, J. Ghosh

The edge fluctuations play a crucial role in controlling the transport of particles and energy in a tokamak plasma and hence modify the plasma confinement. However, the magnetic fluctuations, above a threshold value have been observed to affect the edge electrostatic fluctuations, which in turn contribute to the modifications in plasma confinement [1].

Several studies have shown that the edge fluctuations can be suppressed by puffing of the working gas, leading to an improvement in plasma confinement [2] [3]. However, gas puffing with impurity gases like Argon, Neon etc. i.e. impurity seeding can affect the edge fluctuations and magnetic fluctuations in a different way [4]. Impurity seeding plays a crucial role in achieving stable and efficient conditions for plasma confinement. Therefore, it is important to investigate the effect of impurity seeding on the edge electrostatic and magnetic fluctuations, in order to attain suitable conditions to improve the plasma confinement for large scale fusion devices like ITER. In this work, a detailed investigation of the effect of impurity seeding on the edge electrostatic and magnetic fluctuations in ADITYA-U tokamak will be presented.

References :

[1] Origin of Harmonics of Drift Tearing Modes by Harshita Raj IAEA FEC - 2018
[2] R Jha et al 2009 Plasma Phys. Control. Fusion 51 09501.
[3] M Dreval et al 2013 Plasma Phys. Control. Fusion 55 035004.
[4] Shrish Raj et al 2022 Nucl. Fusion 62 036001.

Affiliations

Institute for Plasma Research	Homi Bhabha National Institute

E-mail

komal@ipr.res.in

Simulation of Emissivity Profiles in the TCABR Tokamak

Ricardo de Ávila Mesquita, José Helder Facundo Severo

In tokamaks, plasma impurities are a significant source of energy loss. At the TCABR tokamak, located at our institute, carbon is one of the most relevant impurities due to the graphite limiter employed. This study aims to characterize the emissivity behavior of various carbon ions (C^{0+}, C^{1+}, C^{2+}, C^{3+}, and C^{5+}).

We first calculated the excitation and recombination Photon Emissivity Coefficients (PECs) for the selected ions. Key resources included the Open-ADAS database, which provided the necessary PEC data, and Cherab, a Python library originally developed for optical diagnostics in the JET programme. The results align well with theoretical predictions and previous experimental measurements from our laboratory, as demonstrated by the excellent agreement for the CVI spectral lines (468.52 nm, 529.05 nm, and 620.06 nm). However, limitations in the Open-ADAS database prevented the inclusion of charge exchange PECs in this analysis, and Cherab did not support direct analysis of the CIV line at 580.65 nm.

Regarding emissivity profiles, based on the estimated PECs, it was observed that the emissivity peaks of more highly ionized species are located near the center of the plasma column, while less ionized species peak closer to the edge. Specifically for the CVI line, excitation PECs dominate near the core, whereas recombination PECs are more significant toward the edge. The emissivity reaches a maximum at the plasma center and decreases progressively outward.

Among the three analyzed CVI lines, the 529.05 nm line exhibited the highest intensity.

These findings validate the employed methodology and contribute to a more comprehensive understanding of carbon ion emissivity profiles in the TCABR tokamak. They also hold importance for the development of new optical diagnostics and the enhancement of existing systems.

Affiliations

Laboratório de Física de Plasmas - LFP	Universidade de São Paulo

E-mail

ricardo.av.mesquita@usp.br

Hamiltonian Map for a Double-Null Divertor Tokamak

Lucas Nedeff Assub Amaral, Iberê Luiz Caldas

The magnetic field lines in a tokamak can be modeled as a single-degree-of-freedom Hamiltonian system. This descriptions allows the construction of simple area-preserving maps, useful for investigating general plasma phenomena. One such map is the Simple Double-Null Divertor Map, which captures the fundamental properties of a diverted plasma with two X-points.

In this work, the Simple Double-Null Divertor Map was applied to determine the magnetic footprints on divertor plates and to examine transport characteristics in this type of magnetic configuration.

Affiliations

Institute of Physics of University of Sao Paulo	University of Sao Paulo

E-mail

l.amaral@usp.br

Development of an Active Cooling System for ELMs Control Coils of the TCABR

Felipe Paes Bekman, Marlon Sproesser Mathias, Gustavo Paganini Canal

An innovative system of resonant magnetic perturbation (RMP) coils for the Tokamak à Chauffage Alfvén Brésilien (TCABR) is being developed. The system will be comprised of 108 coils operating in two modes: direct current (DC), with maximum current of 2 kA, and alternating current (AC), with maximum current of 1 kA and maximum operating frequency of 10 kHz. Initial simulations in DC mode showed that, at maximum current, the RMP coils will reach temperatures exceeding 200 °C. This significantly increases the copper resistivity, which further degrades the surrounding electrical insulation and weakens the coil mechanical structure. The objective of this work is to evaluate the thermal loading of the RMP coils through finite element analysis. While thermal loading in DC mode can be straightforwardly analyzed, AC operation introduces additional complexities to the analysis, such as skin and proximity effects inside the winding and on the coil structure. For the simulations, a coupled electro-thermal workflow is employed using the Ansys software to account for the material properties change with the increasing temperature of the components. The active cooling system is being designed based on the amount of heat produced during a pulse, which must be removed before the next pulse. The active cooling system parameters must the chosen such that the temperature of the coils before a pulse must be low enough to guarantee that the temperature right after the pulse do not exceed the limit of 200 °C.

Affiliations

Felipe Paes Bekman	Polytechnic School of the University of São Paulo
Marlon Sproesser Mathias	Polytechnic School of the University of São Paulo
Gustavo Paganini Canal	Institute of Physics of the University of São Paulo

E-mail

felipe.bekman@usp.br

Estudio de Impurezas en el Tokamak GOLEM mediante Diagnósticos Espectroscópicos

Germán Vogel, Theo Reinoso, Catalina Vásquez y Vojtech Svoboda

Durante 2023-2024 hemos desarrollado un proyecto aprovechando la operación remota del tokamak GOLEM. GOLEM es un tokamak compacto de sección transversal circular utilizando un limitador de Mo (sin divertor) operando con calentamiento óhmico. Sus principales parámetros de operación son un campo magnético toroidal de 0.5 T, corriente de plasma de hasta 10 kA, tiempo de descarga entre 10-20 ms, densidades electrónicas de 10-18 partículas/m3 y la posibilidad de utilizar H y He como gas principal. Aunque GOLEM es principalmente una plataforma educacional, estudios recientes y la incorporación de nuevos sistemas de diagnósticos, incluida la primera observaciónde una barrera espontánea en plasmas circulares, destacan su relevancia para la investigación relacionada al proyecto ITER.

La colaboración UC-GOLEM ha aprovechado la instalación de una nueva suite de diagnósticos espectroscópicos, cubriendo el rango UV, H-alpha, visible e IR. Con esta herramienta hemos podido monitorear y estudiar el comportamiento de las impurezas en el tokamak en plasmas de H y He, las cuales se originan de la erosión de la cámara de vacío (acero), el limitador de Mo y otros componentes expuestos. En particular, se han monitoreado las líneas de impurezas durante las descargas con una resolución de ms, obteniendo datos sobre la evolución de impurezas en cada descarga.

En total se realizaron cerca de 100 descargas, más de la mitad de cuales incluyen datos espectroscópicos, además de los diagnósticos esenciales de GOLEM como la interferometría para medir la densidad, así como suites de sondas electrostáticas y bobinas que informan sobre las propiedades MHD del plasma, y la temperatura y densidad electrónica en regiones específicas del plasma. Experimentos iniciales se enfocaron en optimizar las condiciones del plasma, particularmente en maximizar el tiempo de confinamiento de energía, alcanzando valores del orden de los ms. Adicionalmente, se han identificado regímenes de operación con acumulación mínima de impurezas, algo esencial para GOLEM que cuenta con una configuración de limitador y sección transversal circular. También se ha explorado si la suite de espectrómetros puede utilizarse para complementar los diagnósticos de rutina de GOLEM, utilizándolos para estimaciones de temperatura y densidad electrónica. Los espectrómetros se han calibrado absolutamente para intensidad con el uso de lámparas de Mg y Ne que expande las posibilidades de análisis de emisiones de impurezas.

Affiliations

Germán Vogel	Pontificia Universidad Católica de Chile
Theo Reinoso	Pontificia Universidad Católica de Chile
Catalina Vásquez	Pontificia Universidad Católica de Chile
Vojtech Svoboda	Czech Technical University in Prague

E-mail

gvogel@uc.cl

Antibiofilm Properties of Poly(Methyl Methacrylate) Coated with Al_2O_3 by Atomic Layer Deposition

Lady Daiane Pereira Leite; Júlia Karnopp; William Chiappim Júnior; Rodrigo Sávio Pessoa; Cristiane Yumi Koga Ito

Antibiofilm Properties of Poly(Methyl Methacrylate) Coated with Al_2O_3 by Atomic Layer Deposition
Introduction: The development of biomaterials with antibiofilm properties is crucial in the medical field. Poly(methyl methacrylate) (PMMA) is widely used in dentistry for its biocompatibility and mechanical properties but is susceptible to microbial colonization, leading to infections. Adhesion of Candida albicans to surfaces is the initial step toward colonization and biofilm formation. This study evaluated the antibiofilm properties of PMMA coated with aluminum oxide (Al_2O_3) using Atomic Layer Deposition (ALD). The use of plasma-activated water (PAW) as a precursor in the deposition process was also investigated.
Methodology: Colorless thermosetting acrylic resin was prepared according to the manufacturer's recommendations. The specimens were 2 mm in height and 9 mm in diameter. After polymerization, samples were sanded and polished. Al_2O_3 films were deposited using a crossflow ALD reactor at 80 °C. The following groups were studied: untreated control, Al_2O_3-coated (250 and 500 cycles), and Al_2O_3/PAW-coated (250 and 500 cycles). For PAW depositions, distilled water was activated with a pin-to-liquid system. Microstructural characterization was performed using scanning electron microscopy (SEM). The reference strain C. albicans ATCC 18804 was used to evaluate antibiofilm properties. Experiments were conducted in triplicate on three occasions (n=9). Data were analyzed using one-way ANOVA followed by Tukey's test (5%).
Results: SEM characterization showed successful Al_2O_3 deposition, altering the surface topography and chemical composition. The control group presented an average of 2.44×10^6 CFU/mL adhered cells after 24 hours. Samples coated with Al_2O_3 (250 cycles), Al_2O_3 (500 cycles), and Al_2O_3/PAW (500 cycles) showed significant reductions in fungal adhesion compared to the control ($p < 0.05$). After 48 hours, these groups also exhibited significantly lower fungal counts (Table 1). SEM analyses (Figure 1) confirmed lower cell densities in biofilms on coated samples.
Conclusion: ALD effectively modified the PMMA surface, both topographically and chemically, reducing C. albicans biofilm formation. Al_2O_3 coatings deposited via ALD, especially with PAW, show potential for reducing microbial colonization on PMMA-based biomaterials.
Acknowledgments
Funded by The São Paulo State Research Foundation (FAPESP), grants 2019/05856-7 and 2022/00266-0.

Affiliations

Lady daiane	Universidade Estadual Paulista (Unesp)
Júlia Karnopp	Universidade do Estado de Santa Catarina
William Chiappim Júnior	Universidade Estadual Paulista (Unesp)
Rodrigo Sávio Pessoa	Instituto Tecnológico de Aeronáutica (ITA)
Cristiane Yumi Koga Ito	Universidade Estadual Paulista (Unesp)

E-mail

lady.leite@unesp.br

Influence of Thermal Pre-Treatment of Sewage Sludge for Plasma Processing in a DC-Transferred Arc Reactor

Pedro Moreira Júnior, Felipe Miranda, Nilton Azevedo Neto, Lincoln Silva, Antônio Cruz, Alexei Essiptchouk, Gilberto Petraconi Filho

Wastewater treatment is essential to prevent contaminants from entering the environment and managing by-products like sewage sludge. Population and industrialization have led to a proportional increase in sewage sludge production. This sludge contains organic and inorganic matter and pollutants such as heavy metals, dioxins, furans, and pathogenic microorganisms. Traditional treatment methods like incineration do not fully eliminate harmful components and produce ash-containing pollutants. In contrast, thermal plasma technology offers a promising alternative. It uses extremely high temperatures to destroy hazardous organic compounds and pathogens, significantly reducing the volume of sludge while generating valuable by-products, like syngas and vitrified inert slag, that immobilize toxic substances and can be safely stored or reused in construction. This study focuses on the thermal plasma treatment of sewage sludge as an alternative waste management solution. Samples were collected from a sewage treatment facility in São Paulo, Brazil, and first subjected to thermal treatments using a furnace at temperatures 400, 600, 800, and 900ºC. The main goals were to assess moisture content, determine mass losses during drying, and evaluate ash content. Following thermal treatments, the samples underwent thermal plasma processing in a DC-transferred arc reactor designed for sewage sludge treatment, operating at an average power of 30 kW. Characterization of the samples was comprehensive, employing techniques like X-ray fluorescence, X-ray diffraction, and FT-IR spectrometry. Initial results revealed the presence of oxides, particularly those related to K, Ca, and Fe elements, which are known to influence material melting points. The plasma treatment notably reduced the sewage sludge's volume and mass, reaching weight losses of up to 72% and volume reductions of up to 90%. The gases produced during the plasma treatment analyzed using an industrial gas analyzer presented up to 67% (CO 43% + H_2 24%) of syngas volumetric fraction, reaching a high heating value of 9.05 MJ/m3. Leaching and solubility tests were carried out, and the treated material proved inert. Chemical and structural analyses showed that the vitrified material mainly comprises SiO_2. Therefore, this research highlights the effectiveness of thermal and plasma treatments in valorizing and inertizing sewage sludge, presenting a promising approach to waste management.

Affiliations

Pedro William Paiva Moreira Júnior	Laboratório de Plasmas e Processos - LPP, Instituto Tecnológico de Aeronáutica – ITA/DCTA, São José dos Campos, SP, Brazil
Felipe de Souza Miranda	Laboratório de Plasmas e Processos - LPP, Instituto Tecnológico de Aeronáutica – ITA/DCTA, São José dos Campos, SP, Brazil
Nilton Francelosi Azevedo Neto	Laboratório de Plasmas e Processos - LPP, Instituto Tecnológico de Aeronáutica – ITA/DCTA, São José dos Campos, SP, Brazil
Lincoln Burckhart Santos Silva	Laboratório de Plasmas e Processos - LPP, Instituto Tecnológico de Aeronáutica – ITA/DCTA, São José dos Campos, SP, Brazil
Antônio Carlos da Cruz	Laboratório de Plasmas e Processos - LPP, Instituto Tecnológico de Aeronáutica – ITA/DCTA, São José dos Campos, SP, Brazil

Alexei Mikhailovich Essiptchouk	São Paulo State University - Unesp, Instituto de Ciência e Tecnologia, São José dos Campos, SP, Brazil
Gilberto Petraconi Filho	Laboratório de Plasmas e Processos - LPP, Instituto Tecnológico de Aeronáutica – ITA/DCTA, São José dos Campos, SP, Brazil

E-mail

pedro_kcond28@hotmail.com

Morphological and chemical characterization of the AA2024-T3 (Alclad) alloy treated by Plasma Electrolytic Oxidation (PEO)

Rafael Resende Lucas, Luís Felipe Barbosa Marques, Tuane Stefania Reis dos Santos, Edson Cocchieri Botelho, Luís Rogério de Oliveira Hein, Rogério Pinto Mota

In this study, the AA2024-T3 (Alclad) aluminum alloy with the provided chemical composition was used. The samples, measuring 25x25 mm, were sanded and cleaned by ultrasonic cleaning in deionized water and isopropyl alcohol. The treatment was conducted in an experimental system at 200 V for 900 seconds, using a sodium tetraborate solution homogenized by ultrasound. The anodized samples were characterized using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) to quantify the elements in the coating. The molecular structure of the formed oxides was analyzed with an ATR-FTIR spectrometer, covering functional groups from 1000 to 650 cm^{-1}.
The morphology of the sample subjected to the PEO process revealed distinct microstructures, including a coral-like configuration with irregularly shaped pores formed by high-intensity electrical discharges during the procedure. Additionally, microcracks were noted, resulting from the rapid cooling of the formed oxide layer. Circular protrusions were also observed, characteristics previously reported by other researchers [1]. The identified pores had an average diameter of 0.22 ± 0.04 µm. The EDS analysis revealed the following chemical composition of the generated oxide coating: aluminum (Al) accounting for 58.8%, oxygen (O) for 40.0%, chlorine (Cl) for 0.8%, silicon (Si) for 0.3%, iron (Fe) for 0.2%, and sulfur (S) with a minimal presence of 0.1%. Chlorine and sulfur are considered contaminants originating from the environment and the manufacturing process, respectively [2].
The FTIR analysis of the untreated alloy revealed weak bands from hydroxyl groups and CO_2 bonds (2286 to 1981 cm^{-1}) and groups at 1237 cm^{-1} from its composition. Si-O-Si/Si-O-H groups (1096 and 938 cm^{-1}), while the Al-O group at 736 cm^{-1} indicated a nanometric alumina (Al_2O_3) layer formed by passivation. For the PEO-treated alloy, a range of 3600 to 3290 cm^{-1} signified stretching vibrations of hydroxyl, indicating partially hydrated oxide, and notable changes below 1000 cm^{-1} showed increased Al-O, Al-O-Si, and Al-O-H bonds after treatment [2].

[1] Jadhav, P. et al. A review of process characteristics of plasma electrolytic oxidation of aluminium alloy. In Journal of physics: conference series (Vol. 1854, No. 1, p. 012030). IOP Publishing.

[2] Lucas, R. et al. Characterization of oxide coating grown by plasma electrolytic oxidation (PEO) at different times on aluminum alloy AA2024-T3. MRS Communications, 12(2), 266-271.

Affiliations

Rafael Resende Lucas	São Paulo State University (UNESP), School of Engineering and Sciences, Guaratinguetá, São Paulo 12516-410, Brazil
Luís Felipe Barbosa Marques	São Paulo State University (UNESP), School of Engineering and Sciences, Guaratinguetá, São Paulo 12516-410, Brazil
Tuane Stefania Reis dos Santos	São Paulo State University (UNESP), School of Engineering and Sciences, Guaratinguetá, São Paulo 12516-410, Brazil

Edson Cocchieri Botelho	São Paulo State University (UNESP), School of Engineering and Sciences, Guaratinguetá, São Paulo 12516-410, Brazil
Luís Rogério de Oliveira Hein	São Paulo State University (UNESP), School of Engineering and Sciences, Guaratinguetá, São Paulo 12516-410, Brazil
Rogério Pinto Mota	São Paulo State University (UNESP), School of Engineering and Sciences, Guaratinguetá, São Paulo 12516-410, Brazil

E-mail

rr.lucas@unesp.br

Implementation of the Faraday Rotation Technique for Current Measurement in Low-Energy Plasma Focus Devices

Iván Morales, Cristian Pavez, José Pedreros, José Moreno, Jalaj Jain, Leopoldo Soto, Gonzalo Avaria, Julio Valenzuela, Miguel Escalona, Felipe Veloso

Among pulsed plasma generators, Z-pinch discharges are characterized by their high efficiency in producing pulsed fields of radiation and particles. Plasma Focus (PF) discharges stand out in this class due to their high efficiency in fusion neutron production, the simplicity of their electrical design, and the similarity in plasma dynamics. From the set of reported measurements for generators operating at different current ranges, a scaling law for neutron production with the pinch current is obtained, in the form $Y_n \sim I_p^{4.4}$, with I_p in kA [1]. The I_p values reported by various groups correspond to the total current at the moment of the pinch. In PF generators with currents above 200 kA, it is estimated that between 70\% and 90\% of the total current flows through the pinch [2,3]. For studies with currents below 200 kA, no evidence has been reported of current leakage outside the pinch region. This work presents a feasibility study for current measurement in the pinch phase of low-energy, low-current PF discharges, using the Faraday Rotation technique.

The analytical evaluation of the rotation angle will be calculated for PF devices with currents of 100 kA and 140 kA, with parabolic density profiles, with maximum density values and pinch (plasma column) dimensions following the scaling observed in PF discharges and a laser wavelength of 1064 nm. For the previously defined plasma conditions and the calculated rotation angle for different pinch radii, the effect of polarization rotation of the scene beam will be evaluated in the intensity recording of a synthetic polarogram for a 16-bit recording system, according to the techniques proposed in references [4] and [5]. Preliminary results of the technique's implementation on a 120 kA PF device will be presented.

Acknowledgments: The authors thank FONCEDYT Project No. 1211885 for financial support.

References:

[1] A. Tarifeno-Saldivia and L. Soto, Phys. Plasmas \textbf{19}, 092701 (2012).\newline
[2] J. Malir and D. Klir \textit{et al.}, Phys. Plasmas \textbf{29}, 092704 (2022).\newline
[3] T. Oppenlander and G. Pross \textit{et al.}, Plasma Phys. \textbf{19}, 1075 (1977).\newline
[4] M. Tatarakis and R. Aliaga-Rossel \textit{et al.}, Phys. Plasmas \textbf{5}, 682 (1998).\newline
[5] G.F. Swadling and S.V. Lebedev et al., Rev. Sci. Instrum. \textbf{85}, 11E502 (2014).

Affiliations

Ivan Morales	Facultad de Ciencias Exactas, Universidad Andrés Bello, Sazié 2212, 837-0136, Santiago, Chile
Cristian Pavez	Comisión Chilena de Energía Nuclear, Nueva Bilbao 12501, Las Condes, Santiago, Chile.

Cristian Pavez	Facultad de Ciencias Exactas, Universidad Andrés Bello, Sazié 2212, 837-0136, Santiago, Chile
José Pedreros	Facultad de Ciencias Exactas, Universidad Andrés Bello, Sazié 2212, 837-0136, Santiago, Chile
José Pedreros	Space and Planetary Exploration Laboratory (SPEL), FCFM,University of Chile, Santiago 8370448, Chile
José Moreno	Comisión Chilena de Energía Nuclear, Nueva Bilbao 12501, Las Condes, Santiago, Chile.
Jalaj Jain	Comisión Chilena de Energía Nuclear, Nueva Bilbao 12501, Las Condes, Santiago, Chile.
Leopoldo Soto	Comisión Chilena de Energía Nuclear, Nueva Bilbao 12501, Las Condes, Santiago, Chile.
Gonzalo Avaria	Departamento de Física, Universidad Técnica Federico Santa María, San Joaquín, Santiago
Julio Valenzuela	Instituto de Física, Pontificia Universidad Católica de Chile, Santiago 7820436, Chile
Miguel Escalona	Instituto de Física, Pontificia Universidad Católica de Chile, Santiago 7820436, Chile
Felipe Veloso	Instituto de Física, Pontificia Universidad Católica de Chile, Santiago 7820436, Chile

E-mail

i.moraleshernndez@uandresbello.edu

Characterization of Plasma-Sprayed EBCs Under Controlled Thermal Conditions: Insights into Stability and Performance

Homero F S Maciel, Felipe S Miranda, Tiago M B Campos, Argemiro S Silva Sobrinho, Gilberto Petraconi Filho

Extreme aerothermodynamic conditions are encountered in hypersonic flight, space vehicle reentry, and modern gas turbines. Inconel superalloys, known for their good oxidation and erosion resistance, are limited by operational temperatures up to 700°C due to their surface oxide layers (JUDE; JAPPES; ADAMKHAN, 2022). Composite C/C materials, which are valued for their low weight and cost, degrade rapidly in high catalytic oxidizing environments such as atmospheric reentry, leading to a loss of mechanical and structural integrity (LYNAM et al., 2022). To address these challenges, Environmental Barrier Coatings (EBCs) are employed to protect against highly reactive, high-temperature, and ablative environments. Next-generation EBCs must feature stable oxide phases, high density, homogeneity, thermal shock resistance, fracture toughness, and high thermal conductivity. Mullite ($3Al_2O_3.2SiO_2$), zirconia (ZrO_2), zircon ($ZrSiO_4$), and silica (SiO_2) are promising materials for this purpose due to their chemical stability, high melting points, low oxygen permeability, and self-healing capabilities. In this context, the study aims to deposit thick Environmental Barrier Coatings (EBCs) on carbon-carbon composites using a high-velocity plasma spray technique with hybrid precursors of alumina and zircon (MIRANDA et al., 2017). The hybrid precursor, consisting of an aluminum nitrate alcohol solution with dispersed zircon silicate in a 3:2 molar ratio, was applied by mass at a 10% solids concentration. The coatings were annealed until 1250°C to illustrate critical operational environment. Comprehensive characterizations were conducted both before and after thermal exposure, including X-ray diffraction (XRD), Raman spectroscopy, Fourier-Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), and Scanning Electron Microscopy (SEM) analyses. The results offer valuable insights into the thermal stability, phase transformations, and degradation mechanisms of the EBCs under high-temperature conditions. This study contributes to developing more resilient EBCs for advanced aerospace and turbine applications.

Affiliations

Homero F S Maciel	ITA
Felipe S Miranda	ITA
Tiago M B Campos	ITA
Argemiro S Silva Sobrinho	ITA
Gilberto Petraconi Filho	ITA

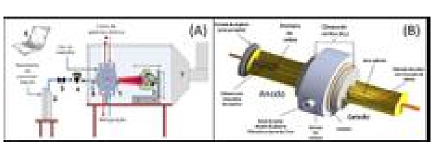


Figure Caption	High-velocity plasma spray system

E-mail

maciel.homero@gmail.com

Atmospheric Argon Plasma-Induced Defects in Monoclinic α-Bi_2O_3: Insights from DFT and Vibrational/Electronic Spectroscopic Analysis

Claudio Andrés Téllez Zepeda, Helen Caroline de Souza Barros, Michaela Shiotani Marcondes, Clodomiro Alves Jr., André Luis de Jesus Pereira, Rodrigo Sávio Pessoa

Metal oxides, particularly bismuth oxide (α-Bi_2O_3), have garnered significant attention for their diverse applications in optoelectronics and photonics due to their unique properties, such as high chemical, thermal, and mechanical stability. Despite numerous reports on plasma-based defect generation in materials similar to α-Bi_2O_3, studies directly addressing the plasma treatment of this material remain limited. In this work, we synthesized monoclinic α-Bi_2O_3 via the solvothermal method, then dispersed it in deionized water and subjected it to atmospheric argon (Ar) plasma treatment for varying durations of 5, 10, 15, 30, 45, and 60 minutes to induce defects and enhance surface activity. Experimental vibrational and electronic spectroscopic analyses were conducted to characterize the structural and electronic modifications induced by the plasma treatment. Complementing the experimental findings, we performed a comprehensive theoretical and computational study using Density Functional Theory (DFT) with both Gaussian and plane-wave approaches. This allowed us to investigate the vibrational modes and electronic structure of α-Bi_2O_3 and analyze the effects of induced defects on the material's properties. We observed shifts in key spectral bands, changes in the projected density of states (PDoS), and alterations in the band structure, revealing modifications in the electronic environment around Bi and O atoms. The synergy of experimental and theoretical analyses provides a robust understanding of the structural and electronic changes induced by plasma treatment, opening new avenues for optimizing α-Bi_2O_3 for advanced technological applications.

Affiliations

Claudio Andrés Téllez Zepeda	Aeronautics Institute of Technology (ITA)
Helen Caroline de Souza Barros	Aeronautics Institute of Technology (ITA)
Michaela Shiotani Marcondes	Aeronautics Institute of Technology (ITA)
Clodomiro Alves Jr.	Universidade Federal do Rio Grande do Norte (UFRN)
André Luis de Jesus Pereira	Aeronautics Institute of Technology (ITA)
Rodrigo Sávio Pessoa	Aeronautics Institute of Technology (ITA)

E-mail

tellez.ca@gmail.com

Measurements of the radial phase magnetic field on the MPG discharge with Zeeman Splitting spectroscopy

Gonzalo Avaria, Miguel Escalona, Cristian Pavez, Julio Valenzuela, Paulina Carrasco, Matheo Escobar, Pedro Retamales, Leopoldo Soto

Current measurements in Plasma Focus discharges are typically conducted with inductive sensors like Rogowski coils. However, these probes have a limitation: they cannot isolate the current passing specifically through the plasma column. This ambiguity complicates the estimation of plasma properties, such as the column's temperature, which is often calculated using the Bennett relation. Zeeman splitting, which leverages the spectral separation of emission lines, offers a method to estimate the magnetic field within the plasma column when high currents are present. The emitted photons exhibit distinct polarizations, known as sigma+ and sigma-, which can be separated with a λ/4 polarizing plate.
This study introduces preliminary magnetic field measurements in the plasma column of the MPG (Multipurpose generator) discharge under a high current density setup (anode diameter of 6.0 mm, and effective length between 14 to 17 mm), utilizing Zeeman splitting spectroscopy of the Ar III emission at 330.18 nm. Radial spatial resolution is achieved by combining a polarizing crystal, a λ/4 plate, and a bifurcated fiber optic bundle aligned with the entrance of a 0.5 m spectrometer equipped with a 2400 lines/mm grating.
With this experimental setup, a magnetic field below 1.5T is observed at the pinch volume when the current peaks around 100 kA.

Affiliations

Cristian Pavez	Centro de Investigación en la intersección de Física de Plasma, Materia y Complejidad (P2mc), Comisión Chilena de Energía Nuclear, Chile
Leopoldo Soto	Centro de Investigación en la intersección de Física de Plasma, Materia y Complejidad (P2mc), Comisión Chilena de Energía Nuclear, Chile
Gonzalo Avaria	Departamento de Física, Universidad Técnica Federico Santa María, Chile
Julio Valenzuela	Instituto de Física, Pontificia Universidad Católica de Chile, Chile
Miguel Escalona	Instituto de Física, Pontificia Universidad Católica de Chile, Chile
Pedro Retamales	Instituto de Física, Pontificia Universidad Católica de Chile, Chile
Paulina Carrasco	Departamento de Ingeniería Mecánica, Universidad Técnica Federico Santa María, Chile
Matheo Escobar	Departamento de Física, Universidad Andrés Bello, Chile

E-mail

gonzalo.avaria@usm.cl

Measuring Plasma Parameters in a Small Plasma Focus Using Collective Thomson Scattering

Cristian Pavez, Miguel Escalona, Julio Valenzuela, Gonzalo Avaria, José Pedreros, Edmund Wyndham, José Moreno, Leopoldo Soto, Felipe Veloso

In this work, experimental results of study radial dynamics and plasma parameters of a low-energy, low-current plasma focus discharge using refractive optical techniques and Thomson scattering (TS) are presented. The experiment was conducted under high-pressure deuterium conditions (13 mbar), resulting in high neutron production. The interferometric technique provided density profiles showing a plasma sheet with densities reaching 4×10^{24} m^{-3} in the radial phase and up to 2.5 $\times 10^{25}$ m^{-3} at the pinch apex in the compressed phase. Simultaneous schlieren and TS measurements in collective scattering regime, yielded ionic and electronic temperatures (T_i and T_e), as well as radial and axial velocity profiles. The data revealed average T_i and T_e values around 300 eV and 100 eV respectively in the compressed phase, with peak values of approximately 400 eV and 150 eV. The Doppler shift from TS measurements confirmed the presence of the "zipper effect," characterized by axial momentum transfer during the stagnation phase. The study demonstrates the effectiveness of combined optical and TS diagnostics in characterizing the dynamic behavior of a plasma focus discharge, providing valuable data for validating sophisticated plasma simulation codes.

Affiliations

Center for Research in the Intersection of Plasma Physics, Matter and Complexity, P2mc	Comisión Chilena de Energía Nuclear
Departamento de Ciencias Físicas, Facultad de Ciencias Exactas	Universidad Andres Bello
Instituto de Física	Pontificia Universidad Católica de Chile
Departamento de Física	Universidad Técnica Federico Santa María
Departamento de Ingeniería Eléctrica, Facultad de Ciencias Físicas y Matemáticas	Universidad de Chile

E-mail

cristian.pavez@cchen.cl

Unifying Kappa Distribution Models for Non-Equilibrium Space Plasmas: A Superstatistical Approach Based on Moments

Abiam Tamburrini, Pablo S. Moya, Sergio Davis.

From the perspective of non-equilibrium statistical mechanics, modeling the velocity distribution of particles in non-equilibrium, steady-state plasmas present a significant challenge. Under this context, a family of kappa distributions has been widely used to capture the high-energy tails in space plasmas. These distributions deviate from canonical Maxwell-Boltzmann statistics and vary significantly in their interpretation of the temperature of an out-of-equilibrium system. In this letter, we establish the validity of any kappa distribution from the standpoint of superstatistics. This study unifies these models by introducing a new kappa distribution based on superstatistical parameters, providing a more general and fundamental framework to connect these distributions and the fundamental temperature of a system. We demonstrate that the general distribution depends on the thermal characteristics of the modeled temperature distribution population. Furthermore, we present a moment-based velocity distribution that bypasses the traditional temperature debate, relying on the velocity moments. Our findings enhance the understanding of kappa distributions and offer a robust model for non-equilibrium space plasmas.

Affiliations

Abiam Tamburrini	Physics Department, Faculty of Science, University of Chile
Pablo S. Moya	Physics Department, Faculty of Science, University of Chile
Sergio Davis	Research Center in the Intersection of Plasma Physics, Matter and Complexity (P^2mc), Chilean Nuclear Energy Commission.

E-mail

abiamtamburrini@gmail.com

Plasma Focus-Based Pulsed Plasma Thruster for Nanosatellites: Design, Characterization, and Thrust Measurement System

Camilo Vásquez-Wilson, Cristian Pavez, José Moreno, Jalaj Jain, Biswajit Bora, Marcos Diaz, Felipe Asenjo, Luis Altamirano and Leopoldo Soto.

The formation of plasma shocks and jets makes plasma focus (PF) devices ideal candidates for space propulsion applications. For instance, in a 400 J PF device, the ejected plasma has been observed to have a mass of approximately 10^{-10} kg and moves at velocities around 10^5 m/s [1]. Furthermore, the Plasma Physics Group of the Chilean Nuclear Energy Commission has extensive experience in scaling and miniaturizing PF devices to extremely low energies (0.1 J of operation) [2], which allows for the exploration of this technology as the basis for a pulsed plasma thruster (PPT) to control the orientation of SUCHAI nanosatellites [3]. Based on theoretical models and scaling estimations, it is expected that a PPT with these characteristics, operating at 1 J of energy, would generate thrust in the range of fractions of µNs to a few µNs per pulse [2]. Consequently, developing a system capable of characterizing the thrust is essential. To achieve this, a load cell previously used to measure forces in continuous plasma thrusters has been adapted, allowing for the design of a smaller device tailored to PPT characterization [4]. This work presents the construction and characterization of a plasma gun with PF electrodes, the design of a thrust measurement system using a thrust stand based on a single-point load cell, the analysis and calibration of the load cell, which relates its oscillations to the generated impulse, and the integration of the PPT assembly.

References
[1] “Characterization of the axial plasma shock in a table top plasma focus after the pinch and its possible application to testing materials for fusion reactors”. L. Soto, C. Pavez, J. Moreno, M. J. Inestrosa-Izurieta, F. Veloso, G. Gutiérrez, J. Vergara, A. Clausse, H. Bruzzone, F. Castillo, and L. F. Delgado-Aparicio, Physics of Plasma 21, 122703 (2014)
[2] L. Soto, C. Pavez, J. Pedreros, J. Jain, J. Moreno, P. San Martín, F. Castillo, D. Zanelli and L. Altamirano, Micromachines 15, 1123 (2024)
[3] M. Díaz, J. Zagal, C. Falcon, et al., Advances in Space Research 58, 2134 (2016)
[4] L. Conde, M. D. Lahoz, J. Grabulosa, R. Hernández, J. González, M. Delgado, J. Damba, Review of Scientific Instruments 91, 023308 (2020)

Affiliations

Camilo Vásquez-Wilson	Universidad Adolfo Ibáñez, Chile.
Cristian Pavez	Center for Research on the Intersection in Plasma Physics, Matter and Complexity, P2mc Comisión Chilena de Energía Nuclear, CCHEN, Casilla 188-D, Santiago, Chile; Universidad Andres Bello, Departamento de Ciencias Físicas, Chile.
José Moreno	Center for Research on the Intersection in Plasma Physics, Matter and Complexity, P2mc Comisión Chilena de Energía Nuclear, CCHEN, Casilla 188-D, Santiago, Chile; Universidad Andres Bello, Departamento de Ciencias Físicas, Chile.

Jalaj Jain	Center for Research on the Intersection in Plasma Physics, Matter and Complexity, P2mc Comisión Chilena de Energía Nuclear, CCHEN, Casilla 188-D, Santiago, Chile; Universidad Andres Bello, Departamento de Ciencias Físicas, Chile.
Biswajit Bora	Center for Research on the Intersection in Plasma Physics, Matter and Complexity, P2mc Comisión Chilena de Energía Nuclear, CCHEN, Casilla 188-D, Santiago, Chile; Universidad Andres Bello, Departamento de Ciencias Físicas, Chile.
Marcos Diaz	Space and Planetary Exploration Laboratory (SPEL), Universidad de Chile.
Felipe Asenjo	Universidad Adolfo Ibáñez, Chile.
Luis Altamirano	Dicontek Ltda., Chile.
Leopoldo Soto	Center for Research on the Intersection in Plasma Physics, Matter and Complexity, P2mc Comisión Chilena de Energía Nuclear, CCHEN, Casilla 188-D, Santiago, Chile; Universidad Andres Bello, Departamento de Ciencias Físicas, Chile.

E-mail

Camvasquez@alumnos.uai.cl

Characterizing the Velocity Distribution of a Turbulent Plasma through the study of a Langevin-type System and its relationship with Kappa Distributions

Valentina D. Calderón, Iván Gallo-Méndez, Simón Poblete, Pablo S. Moya

Turbulence is a complex phenomenon that manifests itself in a variety of physical systems with a high number of degrees of freedom. Its effects are especially prominent in systems characterized by strong spatio-temporal correlations, revealing universal patterns in their dynamics. Collisionless space plasmas, such as the solar wind or plasmas in planetary environments, are in a turbulent state of disequilibrium, so a model that characterizes their behavior is essential to their understanding. The Langevin equation is mathematical tool that is frequently used to achieve this.

In this work, we consider a Langevin-type coupled network [1,2] to model the relationship of a turbulent system with its dynamic spatial scale and the number of elements that make up the system. From this, we generate the steady-state velocity distribution for a turbulent fluid at the different spatial scales that compose it. In this way, we can study how the obtained distribution depends on macroscopic parameters.

To achieve the above, we will use the theoretical framework proposed by Tsallis & Tirnakli-Jensen [3], which provides an adjustment for the probability distribution of a system when the number of elements is limited. We will analyze the correspondence between the model and the simulations obtained by varying the number of simulation elements, to analyze the behavior of the stationary distributions when varying the number of particles. We will evaluate the quality of kappa-like fits, in particular, a regularized kappa and kappa function in terms of macroscopic parameters, which will help us understand finite-size effects in our system. Finally, we will make an analysis of the moments of the numerically obtained distributions, and of the fitting functions to test their validity.

References:

[1] I. Gallo-Méndez, and P. S. Moya, Nature Scientific Reports 12 , 2136 (2022).
[2] C. Beck, Physical Review E, 49(5), 3641–3652 (1994).
[3] C. Tsallis and U. Tirnakli, Journal of Physics: Conference Series, 201, 012001 (2010).

Affiliations

Valentina Daniela Calderón Hevia	Universidad de Chile
Pablo Sebastián Moya Fuentes	Universidad de Chile
Iván Andrés Gallo Méndez	Universidad San Sebastián
Simón David Poblete Fuentes	Universidad San Sebastián

E-mail

valentina.calderon@ug.uchile.cl

Fine-Grained Comparative Classification of Equivalent MHD and HD Turbulence Patterns in an Entropic Informational Parameter Space

Daniel A. S. Mendes, Dalton N. Oliveira, Reinaldo R. Rosa, Erico L. Rempel, Rubens A. Sautter, Luan O. Baraúna, Juan A. Valdivia

Characterization of spatiotemporal patterns of turbulent fluids in both hydrodynamics (HD) and magnetohydrodynamics (MHD) is crucial for the refinement of theoretical and computational approaches to the various processes where turbulence plays an important role in nature. In space physics, such characterizations are critical in situations where the magnetic Reynolds number is not so high (1 G). In this work, we revisit the same technique to classify equivalent spatiotemporal patterns generated from DNS for MHD [3] and HD[4] in a 128x128x128 grid with 1700 timesteps. Our results provide a complementary study to the previous work [2] by refining the characterization of processes that are critically equivalent but with fine differences in Re (10 to 100) and ($0 < B < 1$ Gauss). We discuss the importance of this approach, through the space of entropic parameters, within a possible automatic characterization of turbulent patterns and coherent structures in plasmas and fluid dynamics based on machine learning methods.

[1] Pothérat, A.; Dymkou, V. , 2010, https://doi.org/10.1017/S0022112010000807

[2]Baraúna, L. et al., 2024, https://doi.org/10.3390/e26060508

[3]Rempel, E.L. et. al, 2013, doi:10.1017/jfm.2013.290

[4]Mortesen, M., Langtangen, H.P., 2016, https://doi.org/10.1016/j.cpc.2016.02.005

Affiliations

Daniel A. S. Mendes	INPE-MCTI
Dalton N. Oliveira	Departamento de Matemática, ITA
Reinaldo Roberto Rosa	INPE-MCTI
Erico Luiz Rempel	Departamento de Matemática, ITA
Rubens Andreas Sautter	edital nº 002/2024-ps-pb - resultado final preliminar Universidade Tecnológica Federal do Paraná
Luan Orion Baraúna	INPE, MCTI
Juan Alejandro Valdivia	Universidade de Chile

E-mail

daniel.mendes@inpe.br

Solar flare model over a rewired magnetic field network

Alejandro Zamorano[1], Laura Morales[2,3], Denisse Pastén[1], Víctor Muñoz[1]

The Lu-Hamilton model is a sandpile model which was proposed to study the dynamics of solar flares. In this work, the centroids of the regions affected by the simulated flares are considered as nodes of a growing complex network, using the Suzuki-Abe method, which has been extensively used to study seismic sequences. Results show that the Lu-Hamilton model yields Gaussian distributions for the degree distribution of the network, which is consistent with a random process, where the probability of all locations to be centers of energy release is the same. Lu \& Hamilton model managed to reproduce a large part of the main characteristics observed in solar eruptions but the physical interpretation of the elements constitutive of the system presented several difficulties. One way to solve this issues was presented by Morales and Charbonneau . We follow that idea and modify the Lu-Hamilton such that the main element of the cellular automaton is a strand of interconnected nodes that can reconnect when a certain condition is fulfilled.. Thus, we modify the Lu-Hamilton model, such that, instead of running over a regular grid as in a traditional cellular automaton, sites in the grid are reconnected, so that energy is released not to spatial neighbours, but to topological neighbours, as given by the grid network configuration. Rewiring of the grid network is done is such a way that energy release out of the system is always possible, and the number of network edges is conserved. In this case, the Lu-Hamilton model shows a SOC state different to the regular grid case, presenting structures where the appearance of solar flares has a higher probability. Both cases, the regular grid and the rewired grid, present a power-law distribution of released energy per event, which is consistent with previous findings on solar flare dynamics, but for the rewired grid, the total energy in the system is lower, due to the larger number of energy release paths that the reconnection of sites introduces. These results suggest a new approach to the simulational study of solar flares and magnetic reconnection, where the dynamics yielding energy release events occurs not over fixed paths, but along a complex network with reconnected paths, as expected during magnetic field line reconnection events in the solar surface

Affiliations

Alejandro Zamorano	Universidad de Chile
Víctor Muñoz	Universidad de Chile
Denisse Pastén	Universidad de Chile
Laura Morales	Universidad de Buenos Aires

E-mail

alejandro.zamorano@ug.uchile.cl

Modos Tensoriales tipo London y Airy en ondas gravitacionales cosmológicas

Claudio Aravena, Víctor Muñoz, Felipe A. Asenjo

En este trabajo hemos estudiado otras soluciones a las ecuaciones de Einstein para una perturbación de la métrica de fondo tipo FLRW, específicamente la ecuación para los modos tensoriales. Se sabe que las soluciones lineales de esta ecuación pueden ser escritas en términos de las ecuaciones de Bessel para ecuaciones de estado entre $w=1$ y $w=-1$, excepto $w=-1/3$. Para un escenario cosmológico con $w=-1/3$ pudimos obtener una ecuación tipo London, tal como la obtenida clásicamente para el fenómeno de superconductividad, por lo tanto presentamos una condición para el número de onda que permite observar soluciones atenuadas en escala temporal. Estudiando este mismo escenario y además para uno con $w=+1/3$ pudimos obtener modos acelerados, no difractantes del tipo Airy, cuya dirección de aceleración es un vector luz (ζ), tal como se observa en el Figura 1a. Además se obtiene a partir de estas últimas soluciones la posibilidad de construir otros paquetes de ondas gravitacionales a partir de una función espectral, un ejemplo de esto se representa en la Figura 1b para una función espectral tipo gaussiana.

Affiliations

Claudio César Aravena Plaza	Universidad de Chile

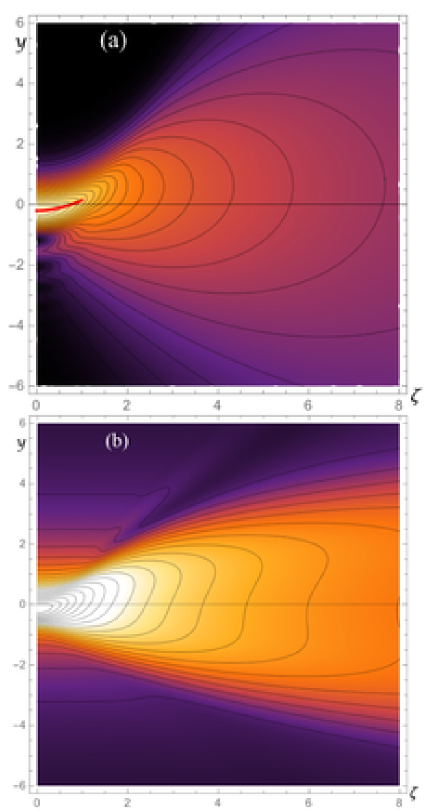


Figure Caption

a) Gráfico de densidad para la magnitud de la solución. En línea roja, la trayectoria parabólica de la máxima intensidad de la solución. b) Gráfico de densidad para la magnitud del paquete de ondas, dada para una cierta funcióń espectral $\varrho = \exp\left(-(k-k_0)^{2}\right)$ determinada.

E-mail

c_aravena@ug.uchile.cl

Wave-particle equilibrium with heavy ions

Nicolás Villarroel Sepúlveda, Daniel Verscharen, Pablo S. Moya and Rodrigo A. López

Positive ions in space plasmas are composed mainly of protons, but also of smaller populations of alpha particles, oxygen, nitrogen, carbon, and heavy metals in multiple ionisation stages. Although the concentration of these minor ion species is often small compared to that of protons, their large relative masses account for significant contributions to the overall ion momentum, and their signatures in the velocity distribution functions (VDFs) of ions have been observed since the early days of space exploration.

The study of space plasmas is also intrinsically linked to that of non-equilibrium thermodynamics and statistical physics. These systems are widely regarded as weakly collisional, that characteristic time scales related to Coulomb collisions are much larger than those of Larmor gyration or wave-particle interactions. Thus, wave activity is likely to be the cause some of the non-thermal features that are observed in space plasma ion distributions, such as temperature anisotropy, beam formation and skewness.
Minor ion constituents have often been overlooked in theoretical studies due to practical reasons, although their presence can significantly affect the propagation of electromagnetic waves in plasmas.
Therefore, an in-depth study of how wave-particle interactions may shape the VDFs of minor ions and how these ions and their statistical properties modify the dispersion relation of electromagnetic waves is of great relevance to our understanding of space plasmas.
To achieve this, we use the Boris algorithm to simulate test-particles forced by electromagnetic waves in solar wind-type plasmas. The forcing waves are solutions of the fully kinetic dispersion relation of electromagnetic waves in two-ion plasmas, obtained with the Arbitrary Linear Plasma Solver (ALPS). The test-particles, representing minor ions, are initially in thermal equilibrium, and their distribution evolves due to interactions with the waves. By solving the dispersion relation using the evolved distributions we
show that the system will evolve into a wave-particle equilibrium state. This state is characterised by a minimisation of the interaction and energy transfer between wave and test-particles.

Affiliations

Nicolás Villarroel Sepúlveda	Universidad de Chile
Nicolás Villarroel Sepúlveda	University College London
Daniel Verscharen	University College London
Pablo S. Moya	Universidad de Chile
Rodrigo A. López	Comisión Chilena de Energía Nuclear

E-mail

nicolas.villarroel@ug.uchile.cl

Radial Response to Geomagnetic Disturbances of Relativistic Electrons in the Outer Radiation Belt as a Function of Their Energy

Yulissa Espitia, Víctor Pinto, Beatriz Zenteno, Marina Stepanova

Recent studies have shown that an increase in relativistic electron fluxes (> 2 MeV) in geostationary orbit (GEO) can generate significantly different responses in the outer radiation belt, depending on the radial distance L. In this work, we have identified 60 events of increased relativistic electron fluxes in GEO, recorded between October 1, 2012, and December 31, 2017, with the aim of characterizing the response of the outer radiation belt, especially in regions with lower L (below 4). These events were studied using flux measurements from the Relativistic Electron-Proton Telescope of the Energetic Particle, Composition, and Thermal Plasma Suite (ETC-REPT) of the Van Allen probes, in the range 2.5<L<6.0, for different energy levels.

Our results indicate that, during flux enhancement events, the radiation belt response is consistent for L>5.0 and shows remarkable similarities for L>4.5. Furthermore, a strong correlation was observed in the post-increase peak fluxes for all regions with L>4.0. However, the predictability in the region 4.0<L<4.5 is influenced by the magnitude of pre-existing fluxes in the outer belt. In contrast, for L<4, fluxes show a low correlation with values observed in geostationary orbit and tend to exhibit less variability. Additionally, our analyses reveal that the magnitude of geomagnetic indices SYM-H, Kp, and AE provides a better quantification of the response in different parts of the outer belt, offering a comprehensive view of the evolution of electron fluxes as a function of radial distance. Specifically, for L<4, we observed that electron fluxes at different energy levels show variation patterns that suggest a complex and less predictable dynamic, highlighting the importance of detailed analysis in these regions.

Affiliations

Yulissa Espitia	Universidad de Santiago de Chile
Víctor Pinto	Universidad de Santiago de Chile, CIRAS
Beatriz Zenteno	Universidad de Santiago de Chile
Marina Stepanova	Universidad de Santiago de Chile, CIRAS

E-mail

yulissa.espitia@usach.cl

Quantifying the expanding and cooling effects into the CGL evolution through the Expanding Box Model.

Sebastián Echeverría-Veas, Pablo S. Moya, Marian Lazar, Stefaan Poedts & Felipe Asenjo

One of the fundamental problems in space physics is the solar wind expansion and its interaction with different physical processes, e.g., collisions, wave turbulence or self-generated instabilities, conditioning the plasma dynamics. The expansion of the solar wind has been commonly described by the double adiabatic invariants or CGL theory, including the approach with the so-called Expanding Box Model (EBM) [1]. Despite the contributions made in the last decades, much remains to be understood and a realistically model, which includes plasma cooling and heating effects due to expansion concurring with other physical processes, is still an open problem. Our study introduces a new theoretical formalism to solve the CGL equations in an expanding framework, a significant step towards understanding what the expansion of the plasma entails but also what it implies. Our primary objective is to isolate the expanding effects and how they affect the conservation of double adiabatic invariants, the key aspect of the CGL theory.

By following the same approximations and assumptions as in EBM and CGL theory, we developed a CGL-like description in which the expansion modifies the conservation of the double adiabatic invariants. Our results show that the double adiabatic equations are no longer conserved if plasma cooling is introduced through the EBM, with explicit dependence on expanding parameters, magnetic field profiles, and velocity gradients. Solving the equations for different magnetic field and density profiles (obtained self-consistently through the equations), we compute the evolution of anisotropy and plasma beta, which deviates from CGL predictions and empirical observations [2]. This deviation is attributed to the plasma cooling effect induced by the Expanding Box Model. Results suggest that heating mechanisms play an even major role in counteracting plasma cooling during expansion. Moreover, the dependence on the transverse velocity gradients may suggest a possible role of vorticity and its relations with turbulent flows. These gradients may be fundamental to include a source of plasma heating from a turbulent spectrum.

[1] Echeverría-Veas, S., Moya, P.S., Lazar, M., Poedts, S. Universe 2023, 9, 448.
[2] Echeverría-Veas, S., Moya, P.S., Lazar, M., Poedts, S., Asenjo, F. Quantifying the Expanding and Cooling Effects into the Double Adiabatic Evolution of the Solar Wind through the Expanding Box Model. Astrophys. J. (accepted)

Affiliations

Sebastián Echeverría Veas	Universidad de Chile
Pablo S. Moya	Universidad de Chile
Marian Lazar	KULeuven, Ruhr University Bochum
Stefaan Poedts	KULeuven, University of Maria Curie-Sklodowska
Felipe Asenjo	Adolfo Ibáñez

E-mail

s.echeverria@ug.uchile.cl

Study of collisions and perturbations in laser produced annular plasma

Felipe Veloso, Josefina Muñoz, Julio Valenzuela, Santiago Radrigán, Joaquín Espinosa

Annular plasmas can be produced by focusing over a solid target a laser beam in the shape of a ring by using a combination of axicon prism and convergent lens [1]. It has been recently demonstrated that the propagation of the laser produced plasma corresponds to a two-dimensional shock wave due to its interaction with the background medium [2]. Moreover, these shocks resemble the interaction of plasma emission from protostars (HH objects) in astrophysical environments. Nevertheless, these HH objects present perturbations in the shocks that could be mimicked in controllable laboratory experiments.

In this work, we present experimental results of annular plasmas propagating through an Argon gas background at near atmospheric pressure. The plasma is created by focusing a 30 ps (FWMH), 1mJ Nd:YAG laser (1064nm) onto a solid aluminium target. This target is intentionally machined with ~mm size perturbations in order to study the evolution of such perturbation in the propagating plasma shock. The plasma is diagnosed in the side-on direction using schlieren imaging.

Results indicate that plasma with initial perturbations has an overall propagation similar to those observed with unperturbed initial conditions in terms of shock dimensionality and Mach stem formation. Further discussion on similarities and differences between conditions will be shown and discussed.

This work is funded by Fondecyt/Regular 1231286 project.

[1] F. Veloso; H. Chuaqui; R. Aliaga-Rossel; M. Favre; I. H. Mitchell; E. Wyndham; "Laser produced annular plasmas" Rev Sci Instrum 77, 063506 (2006)

[2] F. Veloso, V. Rosales, M. Favre, J. Valenzuela, "Two dimensional shock propagation and Mach stem formation induced by a laser-produced annular plasma" submitted to Phys Rev E

Affiliations

Instituto de Física	Pontificia Universidad Católica de Chile

E-mail

josefina.muoz@uc.cl

Determination of the ionic temperature in a Gas-Puff Plasma via Xray Emission Spectroscopy.

Isaac Gallegos; Julio Valenzuela; Miguel Escalona; Marco Ribeiro

The investigation and application of the experiment consists of determining the real ionic temperature of a Z-pinch plasma, by detecting spectral lines that depend on the effects that occur, such as the Doppler Effect and the Stark Effect. What will be presented is the design and construction of an X-ray spectrometer that uses a cylindrical crystal and two spherical crystals for the analysis of spectral lines of the Ne H-like atom of a Gas-Puff plasma type. The applied methodology will consist of a theoretical scheme and a computational simulation, which will lead to the experimental setup in the Llampudkeñ pulsed power generator. The spectrometers are designed with spherical MICA crystals with a radius of curvature of ~500 mm, to observe spectral lines corresponding to the Lyman (Ly) series: Ly-δ and Ly-ε and, on the other hand, a cylindrical crystal with radius of 20mm to observe the Ly-α spectral line. As a result, a spectral resolution is determined to characterize the spectral lines and, in addition, an overestimation of the effective ionic temperature (Teff), which depends on the contribution of the Doppler effect. Likewise, the electron density is measured considering the contribution of the Stark effect, the ion-ion coupling parameter (Γii) and the local electric field.

Affiliations

Faculty of Physics	Pontifical Catholic University of Chile

E-mail

igallegosu@uc.cl

Posters 2: Wednesday, January 22nd 2025

Modeling the attenuation of RMP fields in TCABR plasmas due to eddy currents induced in the vacuum vessel

Nathan Fabeliano Altaras, Felipe Bekman, André Salgueiro Bouzan, Roberto Ramos Jr., José Helder Facundo Severo, Marlon Sproesser Mathias, Gustavo Paganini Canal

A significant upgrade of the Tokamak à Chauffage Alfvén Brésilien (TCABR) is being designed to make it capable of creating a well controlled environment where the physics basis behind the effect of externally applied magnetic perturbations on violent plasma instabilities, termed edge localized modes (ELMs), can be addressed over a wide range of (i) plasma shapes, (ii) divertor configuration, (iii) ELM control coil geometries and (iv) perturbed magnetic field spectra. The core of this upgrade corresponds to the design and construction of an innovative set of in-vessel ELM control coils composed of 54 coils on the high field side and 54 coils on the low field side (LFS), i.e. a total of 108 coils. These coils will operate with both direct current (DC) - up to 2 kA with 0 Hz - and alternating current (AC) - up to 1 kA with frequencies up to 10 kHz. During AC operations, Foucault/eddy currents will be induced in the surrounding structures causing a reduction of the amplitude of the perturbation fields in the plasma region. To properly model the thermo-electro-mechanical effects of the induced Foucault currents during AC operations, the ANSYS module Maxwell 3D was used. In this work, three different mechanical designs for the LFS coils were studied. Additionally, each coil design was studied under both DC and AC operation. A transient analysis was also carried out. The simulation with DC was used to validate the coil electrical parameters, i.e. mutual inductance and resistance, the simulation with AC was used to evaluate the impact of induced Foucault currents on the magnetic field attenuation into the plasma region and on the total power dissipation, and the transient model was used to simulate the coil current rise in 3 ms during DC operation and the power dissipation during this phase.

Affiliations

Gustavo Canal	University of São Paulo

E-mail

nathanaltaras@usp.br

Development of a Multi-Pass Cavity Optical System for Diagnosing Neutral Particle Density and Electronic Parameters in the TCABR Tokamak.

Fernando Antônio Felício Albuquerque, Niklaus Ursus Wetter and José Helder Facundo Severo

This work presents the design and simulation of an advanced optical system employing a multi-pass cavity mirror resonator to facilitate the Laser Induced Ionization (LII) technique for measuring neutral particle density. The optical system is developed utilizing paraxial optics principles and validated through detailed simulations using Zemax OpticStudio. The multi-pass cavity is engineered to amplify laser energy by enabling multiple reflections, thereby enhancing the interaction between the laser and the plasma. This increased interaction results in the ionization of excited particles and a subsequent reduction in their emissivity. Through simulations, we analyze the reduction in emissivity of spectral lines such as H_alpha and H_beta due to LII. This allows us to estimate the local population of neutral atoms throughout the plasma column, providing insights into the system's resolution capabilities. In addition, we explore the potential of extending the functionality of this multi-pass cavity to infer electronic density and temperature via Thomson Scattering. This extension aims to improve the diagnostic capabilities of the system and enhance its application in plasma research.

Affiliations

Center of Lasers and Applications	Instituto de Pesquisas Energéticas e Nucleares - IPEN/CNEN
Center of Lasers and Applications	Instituto de Pesquisas Energéticas e Nucleares - IPEN/CNEN
Institute of Physics	University of São Paulo

E-mail

fernandoalbuquerque@usp.br

Numerical study of the magnetohydrodynamic equilibrium of a fusion plasma confined in a tokamak.

JC Sánchez, JE López, EA Orozco

In thermonuclear fusion devices, the reactant gas is heated to very high temperatures, so much so that it is considered plasma, and it is essential to keep it stably confined long enough until the energy released by the fusion reactions is greater than that supplied; however, these systems are prone to develop a large number of instabilities due to their own dynamics, which strongly depends on the equilibrium conditions to which the system is subjected, for this reason, it is important to know the pressure, current and magnetic field profiles that confine the plasma. For this, from the force balance of a fluid element and under static and stationary equilibrium conditions arises the Grad-Shafranov equation, whose solution provides the equilibrium in magnetic confinement devices such as the tokamak, which, for practical cases is obtained numerically. Thus, in order to reduce the computational cost and to have control over the geometry of the plasma column, a code was developed to solve the Grad-Shafranov equation using finite differences of second order on a uniform rectangular mesh with fixed plasma boundary, defined by analytical expressions. This code was validated through direct comparison with the analytical solution of Solov'ev; thus obtaining the relation between error and convergence. Finally, different equilibrium profiles of experimental configurations with different values of current, pressure and geometrical parameters were recreated.

Affiliations

Juan Camilo Sánchez Mendoza	Universidad Industrial de Santander
Jesús Eduardo López Durán	Universidad Industrial de Santander
Eduardo Alberto Orozco Ospino	Universidad Industrial de Santander

E-mail

jcsanchez@correo.uis.edu.co

Investigation of HHFW Edge Plasma Interactions in NSTX-U using realistic density profiles in a 2D and 3D geometry.

R. A. De Levante Rodriguez, S-G. Baek, S. Shiraiwa, N. Bertelli, P. T. Bonoli

High Harmonic Fast Wave (HHFW) heating experiments in Princeton's NSTX have shown that up to 60% of the injected power can be lost in the Scrape-Off Layer (SOL) when the fast wave is able to propagate in front of the antenna [Hosea, PoP (2008)]. This poster discusses progress in modeling HHFW propagation and losses in the divertor region using more realistic SOL plasmas in the NSTX-U SOL 2D and 3D geometry. Previous models often assume exponentially decaying SOL density and temperature profiles, which may be insufficient to accurately describe the wavefield, especially in the divertor and high-field side regions. In this work, the temperature profile is first evaluated by solving the anisotropic Spitzer heat conduction equation using a finite element approach in the Petra-M workbench. The 2D axisymmetric functional form is implemented. A density profile is then evaluated by assuming pressure conservation on each flux tube. The work focuses on investigating the effect of the realistic SOL plasma on the fast wave cutoff layer position and the coaxial mode excitation [Green, PRL (2011)] at different antenna phasing. This model is also used to evaluate power losses resulting due to elastic electron-ion and electron-neutral collisions in the divertor region.

Work supported by DOE Contract DE-SC0021120.

Affiliations

R. A. De Levante Rodriguez	MIT - Plasma Science and Fusion Center
S-G. Baek	MIT- Plasma Science and Fusion Center
P. T. Bonoli	MIT - Plasma Science and Fusion Center
S. Shiraiwa	Princeton Plasma Physics Laboratory
N. Bertelli	Princeton Plasma Physics Laboratory

E-mail

RDLR@MIT.EDU

Separatrix splitting and magnetic footprints in TCABR

Júlia Rodriguez Richieri, José Roberto Fernandes Junior, Felipe Machado Salvador, André Salgueiro Bouzan, José Helder Facundo Severo and Gustavo Paganini Canal

In perfectly axisymmetric diverted plasmas, the equilibrium separatrix associated to an X-point is composed of a stable and an unstable manifold that perfectly overlay. When non-axisymmetric magnetic fields perturb such an axisymmetric configuration, the stable and unstable manifolds do not overlay anymore and complex topological structures, known as homoclinic tangles, arise from the intersection between these two manifolds. This process is usually referred to as separatrix splitting. These manifolds oscillate and increase their excursions as they asymptotically approach an X-point, forming structures commonly named magnetic lobes, which act as the plasma boundary of this new perturbed non-axisymmetric equilibrium. When field lines from inside the perturbed plasma volume connect to the divertor plates through intersections of the magnetic lobes with the first wall, structures termed magnetic footprints appear. Magnetic footprints consist of several stripes that are periodic in the toroidal direction. The shape of the magnetic footprints strongly depends on the amplitude of the magnetic lobes and harmonic content of the perturbation. Most of the exhausted heat and particles from the plasma are deposited in the first wall within the magnetic footprints and, depending on the plasma conditions, damaging hot spots can appear thus reducing its life time. Controlling the intersection of magnetic lobes with the first wall is, therefore, essential to maintain the integrity of the plasma facing components. This work presents the ongoing of writing a numerical code to compute separatrix splitting and magnetic footprints on the first wall of TCABR.

Affiliations

Gustavo Paganini Canal	Universidade de São Paulo

E-mail

julia@richieri.com.br

Isochronous islands bifurcations driven by resonant magnetic perturbations in tokamaks

B. B. Leal, I. L. Caldas, M.C. de Sousa, R. L. Viana and A. M. Ozorio de Almeida

Isochronous islands bifurcations driven by resonant magnetic perturbations in tokamaks

B. B. Leal and I. L. Caldas
(Instituto de Física, Universidade de São Paulo, Brazil)
M.C. de Sousa
École Polytechnique, Institut Polytechnique de Paris, France
R. L. Viana
Departamento de Física, Universidade Federal do Paraná, Curitiba, Paraná, Braszil
A. M. Ozorio de Almeida
Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil

Recent works with MHD simulations showed the appearance of heteroclinic bifurcations in magnetic islands [1, 2]. We propose that this type of bifurcation is driven by the coupling of resonant modes at the same magnetic surface [3]. Using a symplectic mapping to describe the magnetic field lines in a tokamak with a large aspect ratio, we impose double perturbations at a specific magnetic surface near the edge plasma column. The perturbations are generated by a magnetic ergodic limiter; a set of magnetic coils that produce two modes (m, n). Where m and n are, respectively, the poloidal and toroidal modes. When the parameters of the perturbation vary, isochronous bifurcations are produced. In this poster, we show examples of bifurcations, where we identify that between the dominant modes (m1, n1) and (m2, n2) there are intermediate cases. Additionally, we show the appearance of local shearless curves due to coupling modes.

[1] W. Wu, T. Evans, G. Canal, N. Ferraro, B. Lyons, and D. Orlov, Topological bifurcation of magnetic islands inNSTX-U, Nuclear Fusion 59, 066010 (2019).

[2] T. Evans, W. Wu, G. P. Canal, and N. Ferraro, Observations of heteroclinic bifurcations in resistive magnetohydrodynamic simulations of the plasma response to resonant magnetic perturbations, Physical Review E 103, 013209 (2021).

[3] B. B. Leal, I. L. Caldas, M. C. de Sousa, R. L. Viana, and A. M. Ozorio de Almeida, “Isochronous island bifurcations driven by resonant magnetic perturbations in tokamaks,” Physical Review E, vol. 109, no. 1, p. 014230, 2024.

Affiliations

Bruno Borges Leal	Instituto de Física, Universidade de São Paulo, Brazil
Meirielen Caetano de Sousa	École Polytechnique, Institut Polytechnique de Paris, France
Iberê Luis Caldas	Instituto de Física, Universidade de São Paulo, Brazil
Ricardo Luiz Viana	Universidade Federal do Paraná, Curitiba, Paraná, Braszil

Alfredo Miguel Ozorio de Almeida	Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil

E-mail

bruno.borges.leal@usp.br

Kinetic effects of dust size distribution on Alfvén waves in magnetized space plasmas

Luan Bottin De Toni, Rudi Gaelzer, Luiz Fernando Ziebell

Alfvén waves are low-frequency waves ubiquitous in space environments and are of great interest as they play important roles in the heating and transport of energy in laboratory and astrophysical plasmas. Some physical effects that these waves are known to be a part of are the heating and acceleration of stellar winds and acceleration of auroral electrons through the transport of magnetic energy. Since most of space environments are populated with dust particles, which will acquire an electrical charge and participate in the plasma's collective behavior, it is of paramount importance to study the modifications that the presence of charged dust particles imposes on the propagation and damping of Alfvén waves in space plasmas.
Dust populations in space plasmas are often described by a size distribution function, generally a power law distribution. In view of that, we include this feature in the kinetic description of a homogeneous magnetized dusty plasma with electrically charged immobile dust grains, in order to study its effects in the propagation and damping of Alfvén waves. The dispersion relation is numerically solved using parameters typically found in the dust-driven stellar winds of carbon-rich stars and in Earth's auroral acceleration region, two space systems with unalike plasma parameters and in which Alfvén waves are known to play important roles in the plasma acceleration and heating processes.
We show that the characteristics of the normal modes, namely the ion cyclotron and whistler modes, will change when one considers a power law distribution of dust sizes in the theory, as compared to a mono-sized dust population; and that these differences will depend on the exponent p of the power law, which alters the plasma charge imbalance between electrons and ions. We also notice that power law distribution functions will modify the waves' damping rate values. In particular, we show that in a stellar wind environment the ion cyclotron mode at very small wavenumber decreases with the reduction of p, while for higher wavenumber the damping of this mode increases with the reduction of p. For the Earth's magnetosphere, the results obtained show that the wave damping increases with the decrease of p for all wavenumbers, for the parameters considered in the analysis.

Affiliations

Luan Bottin De Toni	Universidade Federal do Rio Grande do Sul
Rudi Gaelzer	Universidade Federal do Rio Grande do Sul
Luiz Fernando Ziebell	Universidade Federal do Rio Grande do Sul

E-mail

luan.toni@ufrgs.br

Radial evolution of plasma parameters in the Solar Wind using measurements from Parker Solar Probe

M. V. Coello, V. A. Pinto, M. Stepanova, P. S. Moya

The Solar Wind (SW) is a fast, energetic plasma that radiates from the Sun at speeds between 300 and 800 km/s; it mainly comprises protons and electrons, with a small population of heavier ions. Relying on the fact that the SW expands radially, in the 50's the Chew-Goldberg-Low theory (CGL) modeled plasma with ideal magnetohydrodynamics (MHD) and adiabatic invariants, and deduced that magnetic field strength and particle density in the SW should decay like the inverse of the square of the distance to the Sun's surface. Despite its simplicity and elegance, many observations have refuted the CGL double-adiabatic theory, yielding instead that the SW plasma heats in a continuous, non-adiabatic process as it expands. Currently, the question of the heating and acceleration of particles in the Sun's corona remains open. Other models, such as Expanding Box or kinetic theory, account for other processes that could be happening in the SW, like small turbulences, and that could contribute to a more complex explanation of plasma heating and expansion.

Here, to scaffold theoretical modeling, we use in-situ measurements from the Parker Solar Probe (PSP) mission, which is currently at 0.1 UA of closeness to the Sun at perihelion, thus probing the outermost corona. Since we aim to gain insight into the microscopic and macroscopic processes that drive the acceleration and heating of particles in the expanding plasma, our inquiry starts characterizing magnetic field strength and proton density as a function of radial distance to the Sun's surface; we found an exponential decay as expected, that now includes previously unexplored regions near the Sun. Then, we characterize the spectral properties of magnetic field small fluctuations as a function of radial distance, comparing with results from kinetic theory, previously vetted only with simulations. In this way, we take a fundamental step towards connecting current space physics research efforts in Chile, bridging theory and simulations with spacecraft measurements.

Affiliations

Matilde Valentina Coello Guzmán	Universidad de Santiago de Chile
Víctor Alejandro Pinto Abarzúa	Universidad de Santiago de Chile
Marina Stepanova	Universidad de Santiago de Chile
Pablo Sebastián Moya Fuentes	Universidad de Chile

E-mail

matilde.coello@usach.cl

Characterizing the transmission of electromagnetic waves in a plasma with kappa distribution

Maximiliano Correa Gazmuri, Pablo Moya

In the context of space plasma, they have been observed to have a non-Maxwellian distribution function with high energy tails. One of the most used ways to describe this type of plasma is through the Kappa distributions. This distribution is characterized by a parameter κ, whose value is an indicator of how far from thermodynamic equilibrium the system is. In particular, in the limit, $\kappa \longrightarrow \infty$ the Maxwell-Boltzmann distribution is recovered.

To study this, we seek to characterize the properties of the transmission of electromagnetic waves with oblique incidence in a non-magnetized plasma (modeled by a Kappa distribution) through a flat interface. We use as a reference the works of T. Khokhar, et al. (2017) [1] and N. Rubab & G. Murtaza (2006) [2], studies in which the behavior of electromagnetic waves in plasmas modeled with Kappa distributions is analyzed. These studies mainly found that the Debye length is shorter in plasmas modeled with Kappa distributions compared to those modeled with Maxwellian distributions. They also observed that temperature anisotropy has a significant effect on wave transmission.

We will use the Vlasov and Maxwell equations to describe the plasma dynamics. A Kappa distribution function will be used to find the medium's permeability and conductivity, the refractive index, and the total internal refraction angle as a function of the κ parameter. At the same time, we will perform the calculations for a Maxwellian distribution and compare both results. We aim for these results to be relevant for studying wave propagation in space environments, particularly in understanding the changes that electromagnetic waves undergo when passing from one region to another in the solar wind, the Earth's magnetosphere, or other planetary magnetospheres.

Affiliations

Maximiliano Antonio Correa Gazmuri	Universidad de Chile
Pablo Sebastián Moya Fuentes	Universidad de Chile

E-mail

m.correa.2@ug.uchile.cl

Weakly Non-Linear Interaction Between Electromagnetic and Electrostatic Spectra in a Solar Wind-Type Plasma

M. Quijada and R. E. Navarro

The solar corona exhibits a seemingly anomalous heating to millions of degrees relative to the solar surface [1]. Numerous mechanisms have been proposed to explain the emergence of highly excited and hotter ions, including Coulomb relaxation, magnetic reconnection events, preferential ion heating by Alfvén waves, and electromagnetic turbulence through MHD or kinetic theory. Resonant heating by Alfvén waves is a robust candidate for elucidating the solar wind heating and acceleration [2]. For parallel wave propagation along a background magnetic field linear kinetic theory predicts that transverse electromagnetic waves (such as Alfvén waves) and electrostatic fluctuations (ion-acoustic or Langmuir waves) remain decoupled. However, due to the inherent non-linearity in resonance between particles and waves, coupling between electrostatic and Alfvén waves becomes inevitable [3, 4]. Our research seeks to understand the energy transfer mechanisms at Alfvénic scales when electrostatic fluctuations at corresponding scales coexist within the system. We have employed a quasilinear analytical approach based on the Vlasov-Maxwell equations to examine the weakly non-linear interaction between plasma particles and both electromagnetic and electrostatic waves [5, 6]. In this approach, an initially bi-Maxwellian velocity distribution function for a collisionless, solar wind-type plasma evolves adiabatically over time, where we have conducted quasilinear simulations to perform a parametric study on electrostatic fluctuations, aiming to determine their influence on the heating of magnetized solar wind-like plasmas and its competition with electromagnetic fluctuations related instabilities.

[1] Marsch, E. Living Rel Sol Phys 3, 1-100 (2006).
[2] Kasper, J. C., Lazarus, A. J., and Gary, S. P. Phys Rev E 101, 26 (2008).
[3] Vecchio, A., F. Valentini, S. Donato, V. Carbone, C. Briand, J. Bougeret, and P. Veltri. J Geophys Res-Space 119 (2014).
[4] Kellogg, P. J., Mozer, F. S., Moncuquet, M., Malaspina, D. M., Halekas, J., Bale, S. D., and Goetz, K. Astrophys J 964, 68 (2024).
[5] Yoon, P. Rev Mod Plasma Phys 1, 1- 69 (2017).
[6] Moya P. S and Navarro R. E. Front Phys 9 (2021).

Affiliations

Physics Department, Faculty of Physical Sciences and Mathematics	Universidad de Concepción

E-mail

mquijadabenavente@gmail.com

Turbulent plasma simulation using PIC to study the Thomson scattering spectrum

Marco Ribeiro, Julio Valenzuela, Miguel Escalona

This study aims to characterize the Thomson Scattering spectrum produced by non-equilibrium plasmas in order to verify the validity of applying this diagnostic technique to plasmas exhibiting turbulence. It has been reported [1,4] that particle density fluctuations of turbulent plasma produce asymmetries in the shape function S(k,w) of the scattered light spectrum, so data analysis obtained using this technique must take this phenomenon into account. In addition to this asymmetry, a broadening of the spectrum has also been observed [3], making it invalid to assume a Maxwell-Boltzmann velocity distribution for the corresponding fit. Therefore, performing simulations to determine the optimal distribution for different experimental conditions where turbulence is present becomes a useful tool, as distinguishing between broadening caused by thermal and non-thermal processes (such as turbulence) would allow us to determine the mechanism behind energy dissipation through turbulence. This is important in the formation of collisionless shocks in Gas-Puff Z-Pinch implosions [3], among other applications [5]. These simulations are performed using the open-source Particle-In-Cell (PIC) simulation code Smilei [2], due to its ease of implementation, parallelization, and the wide range of physical modules that allow for modeling various types of turbulent plasmas.

References:

[1] K. Sakai, T. Nishimoto, S. Isayama, S. Matsukiyo, Y. Kuramitsu; Ion-acoustic feature of collective Thomson scattering in non-equilibrium two-stream plasmas. https://doi.org/10.1063/5.0117812.

[2] J. Derouillat, A. Beck, F. Pérez, T. Vinci, M. Chiaramello, A. Grassi, M. Flé, G. Bouchard, I. Plotnikov, N. Aunai, J. Dargent, C. Riconda, M. Grech, SMILEI: a collaborative, open-source, multi-purpose particle-in-cell code for plasma simulation, Comput. Phys. Commun. 222, 351-373 (2018).

[3] E. S. Lavine et al., "Energetics of Triple-Nozzle Gas-Puff Z-Pinch Implosions on COBRA," in IEEE Transactions on Plasma Science, doi: doi.org/10.1109/TPS.2024.3379889.

[4] K. Sakai, S. Isayama, N. Bolouki, M. S. Habibi, Y. L. Liu, et. al; Collective Thomson scattering in non-equilibrium laser produced two-stream plasmas. Phys. Plasmas 1 October 2020; 27 (10): 103104. https://doi.org/10.1063/5.0011935.

[5] S. Davidovits and N. J. Fisch, “Sudden viscous dissipation of compressing turbulence,” Phys. Rev. Lett., vol. 116, no. 10, Mar. 2016, Art. no. 105004, doi: 10.1103/PhysRevLett.116.105004.

Affiliations

Marco Antonio Ribeiro Vega	Pontificia Universidad Católica de Chile

E-mail

maribeiro@uc.cl

Magnetic Spectra Comparison for Kappa-distributed Whistler Electron Fluctuations

Daniel H. P., Pablo S. Moya, Bea Zenteno-Quinteros, & Rodrigo López

Long-range charged particle interactions in the plasma of the heliosphere deviate from the idealized Gibbs-Boltzmann statistics, making it reasonable to consider non-thermal quasi-equilibrium scenarios, such as the Kappa distribution. This family of distributions is characterized by the parameter κ, which, at lower values, accounts for the contribution of high-energy charged particles often observed in the solar wind and magnetosphere. A Maxwellian distribution, in contrast, fails to capture these high-energy contributions, particularly relevant in the magnetized plasmas, where non-thermal and nonlinear processes are inherent. In this work, we use the Maxwellian and two observed models of Kappa velocity distribution functions in the heliosphere to describe non-thermal electromagnetic fluctuations and highlight their fundamental differences. Our main results show that in a magnetized plasma, across different regimes of β (the ratio of thermal to magnetic energy) and κ values, the energy obtained from magnetic spectra decays differently as κ decreases. This indicates that Kappa distributions allow the representation of the non-thermal process in different manners depending on the choice of the Kappa distribution function. We hope this work contributes to the space plasma community by providing a useful framework for interpreting data from upcoming missions related to non-thermal plasma environments.

Affiliations

Departamento de Física, Facultad de Ciencias, Universidad de Chile, Santiago, Chile.	Universidad de Chile
Departamento de Física, Facultad de Ciencias, Universidad de Santiago de Chile, Santiago, Chile	Universidad de Santiago de Chile
Center for Interdisciplinary Research in Astrophysics and Space Sciences, (CIRAS), USACH, Santiago, Chile	Universidad de Santiago de Chile
Research Center in the intersection of Plasma Physics, Matter, and Complexity (P^2mc), comisión Chilena de Energía Nuclear, Casilla 188-D, Santiago, Chile.	

E-mail

danielhermosillapizarro@gmail.com

Particle Acceleration in the magnetorotational instability

Astor Sandoval, Mario Riquelme, Anatoly Spitkovsky, and Fabio Bacchini

In low luminosity black hole accretion disks, the particle-particle collision time is much larger than the time it takes for the plasma to be accreted by the black hole, making the system effectively “collisionless”. Important examples of collisionless disks are those around the supermassive black holes Sgr A* and M87, which have been recently imaged by the Event Horizon Telescope, constituting unique laboratories for testing via observations gravitation and plasma physics under extreme conditions. The low collisionality of these systems maintains them out of local thermodynamic equilibrium, giving rise to several kinetic plasma effects. These include the existence of different temperatures of protons and electrons, and the occurrence of non-thermal particle acceleration, which challenge the interpretation of the observations.

One of the main mechanisms to transport angular momentum and dissipate energy in accretion disks is given by the turbulence driven by the magnetorotational instability (MRI). Previous studies show that the turbulence generated by the collisionless version of the MRI can accelerate particles to very high energies. However, the underlying mechanism and its efficiency is still unclear. We present results from 2D and 3D fully kinetic, ab-initio particle-in-cell (PIC) plasma simulations of the collisionless MRI aimed at studying its particle acceleration effect. Even though our simulations are local (they encompass a small piece of the disk), they include disk stratification, therefore capturing its expansion and the generation of particle and magnetic field outflows. We will discuss the main acceleration processes driven by the MRI and their possible observational manifestations.

Affiliations

Astor Sandoval	Universidad de Chile
Mario Riquelme	Universidad de Chile
Anatoly Spitkovsky	Princeton University
Fabio Bacchini	KU Leuven

E-mail

astor.sandoval@ug.uchile.cl

Heat flux battery processes near black hole event horizons

Nicolás Villarroel Sepúlveda, Felipe A. Asenjo and Pablo S. Moya

The presence of large-scale magnetic fields is ubiquitous in the known universe. The origin of these structures is a matter of great interest to our understanding of the physical universe. A likely mechanism for the creation of these fields involves the generation of a very small magnetic field, commonly referred to as a magnetic seed, that is later amplified by a dynamo.

Mechanisms that are capable of creating a seed from an initially null magnetic field have been proposed in theory and observed in laboratory plasmas. The simplest of these is called the Biermann battery. This battery appears in classical MHD when the magnetic vorticity equation, which determines the time evolution of the magnetic field, becomes nonhomogeneous. The condition for this non-homogeneity to exist, which can drive a non-zero time derivative of the magnetic field even if the field itself is 0 at that given instant, is that gradients in thermodynamic quantities of the magneto-fluid are non-parallel. This strongly restricts the systems in which the Biermann battery can act as a magnetic seed generator. It has also been shown that coupling MHD to special and general relativity gives rise to new magnetic seed generators, that can be more relevant than the Biermann battery. All of these cases, however, have been treated only in completely ideal plasmas.

In this work, we extend previous results by including heat flux in the stress-energy tensor of the system's magneto-fluid. By coupling fluid and electromagnetic equations in the 3+1 formalism for the foliation of space-time, we obtain new magnetic seed generators arising from the inclusion of heat flux coupled with general relativity. We show that, in a static and spherically symmetric space-time with a geometrically thin accretion disk that has full axial symmetry, only the new heat flux battery appears as a source for magnetic seed generation. In this configuration, all of the previously derived magnetic batteries vanish. This suggests that non-ideal fluid behavior may be relevant for the generation of small magnetic fields, that can later be amplified to produce the large-scale fields observed in astrophysical and cosmological environments.

Affiliations

Nicolás Villarroel Sepúlveda	Universidad de Chile
Pablo S. Moya	Universidad de Chile
Felipe A. Asenjo	Universidad Adolfo Ibáñez

E-mail

nicolas.villarroel@ug.uchile.cl

Synchrotron radiation from mirror instability in collissionless plasmas using PIC simulations

Mario Riquelme, Martín Astete, Astor Sandoval, Francisco Ley

Low-luminosity accretion disks around supermassive black holes are common in the local universe. Two paradigms of these systems are M87 and Sagittarius A*, for which the shadow of their respective black holes have been recently imaged by the Event Horizon Telescope (EHT). In these disks, the plasma does not reach thermal equilibrium, and it is characterized by the appearance of pressure anisotropies. These pressure anisotropies lead to the excitation of kinetic-scale plasma microinstabilities like the mirror and firehose instabilities. We focus on the mirror modes, where the perpendicular pressure with respect to the magnetic field is larger than the parallel pressure, producing 'magnetic traps' where low energy particles are confined. Given the energy dependence of this trapping effect, we are interested in the possible effect of the mirror modes on the emission spectrum of synchrotron radiation, which is the emission process observed by the EHT. We aim to calculate the radiation spectrum produced by electrons moving in mirror-like fields, and compare it to the emission in the case with isotropic pressure and homogeneous (without mirror modes) fields, which is what is usually assumed in theoretical models of emission from M87 and Sagittarius A*. To produce nonlinear mirror modes and electrons dynamics from first principles, we use particle-in-cell (PIC) plasma simulations, and calculate numerically the synthetic spectra using synchrotron radiation theory.

Affiliations

Mario Alejandro Riquelme Hernandez	Universidad de Chile
Martín Fabián Astete Moreno	Universidad de Chile
Astor Emar Sandoval Parra	Univesidad de Chile
Francisco Javier Ley Quinteros	University of Wisconsin

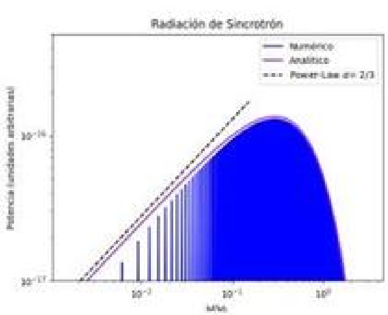


Figure Caption

Synchrotron spectrum of one electron in a constant magnetic field obtained with our code (arbitrary units))

E-mail

martin.astete@ug.uchile.cl

The effect of plasma expansion on the dispersion properties of MHD waves.

Sebastián Saldivia, Pablo S. Moya, Felipe Asenjo

The Sun and other stars release a continuous stream of charged particles, known as solar or stellar wind. This plasma permeates interplanetary space as it expands at high velocities, exhibiting turbulence, instabilities, and oscillations, such as Alfvén or magnetosonic waves. Although the solar wind has been extensively studied, it still presents fundamental challenges in plasma physics, particularly in understanding the dynamics of its expansion and the role played by the magnetic field, instabilities, turbulence, and electromagnetic waves in this process. In this context, the Expanding Box Model (EBM) provides a theoretical framework for studying plasma expansion in a non-inertial frame of reference that moves along with the plasma at a constant velocity, but at a fixed volume. The expansion can be described in this model because the transformation of the reference frame introduces time variations to the equations. By keeping the volume of the box constant, this approach has proven to be especially useful in numerical simulations, as it avoids memory problems.

Despite its extensive history of use as a useful tool for closing the gap between theory and observations, until the work of Echeverría-Veas et al. (2023)[2] the fluid equations modeling the plasma at the macroscopic scale in the framework of this model had not been derived from first principles, nor have the processes occurring in the plasma been theoretically characterized using this set of equations provided by the model. This is why in this study we investigate the effect of considering the plasma expansion through the framework offered by the EBM model, using the expanding fluid equations obtained by Echeverría-Veas et al. (2023) in the characterization of the electromagnetic waves characteristic of the plasma. We do this using the theoretical derivation of their dispersion relations. We focus on the normal magnetohydrodynamic modes of the plasma: the Alfvén mode and the fast and slow magnetosonic modes, obtained using the ideal magnetohydrodynamic equations.
Our results indicate a spatial dependence in the obtained dispersion relations, consistent with the literature and the widely known non-expanding case. With this work, we hope to reduce the gap between theory and observation in studying solar wind dynamics.

Affiliations

Sebastián Saldivia	Universidad de Chile
Pablo S. Moya	Universidad de Chile
Felipe Asenjo	Universidad Adolfo Ibañez

E-mail

sebastian.saldivia@ug.uchile.cl

Characterizing Solar Wind Electron Velocity Distributions: Analysis of the Core-Strahlo (CS) Model Using Wind-SWE-VEIS Observations

Adetayo V. Eyelade , Bea Zenteno-Quinteros , Javier I. Silva , Benjamin Urra , Pablo. S. Moya

In this study, we apply a novel heuristic Core-Strahlo (CS) model to analyze solar wind electrons. This model reproduces the behavior of a core-halo-strahl representation by employing solely two sub-populations: a bi-Maxwellian core and a modified Kappa distribution that introduces skewness. This modification effectively represents halo and strahl electrons within a single skew distribution. The CS model can reproduce the main features of electron velocity distribution functions (eVDFs) in the solar wind—thermal core, enhanced tails, and skewness—with the advantage that a single parameter controls the asymmetry. This work aims to demonstrate to the scientific community that the CS model can be utilized to model observations beyond theoretical contexts. We present a comprehensive statistical analysis of solar wind electrons at 1AU using the electron and solar wind plasma moments onboard NASA Wind SWE/VEIS instrument. This work uses a sophisticated algorithm developed to analyze and characterize separately the core and strahlo populations. We limited our effective energy range to 10 eV to 3 keV and fit the electron velocity distribution functions (eVDFs) measurements observed by the WIND satellite to the CS model. Our experimental measurements show good agreement with existing models of solar wind electrons, including those that account for core, halo, and strahl components, as the resulting values fall within the expected order of magnitude. The CS model not only achieves results comparable to previous studies but also offers the added capability of accounting for heat flux and the asymmetry of the electron velocity distribution through the delta (δ) parameter, which enhances our understanding of solar wind electron dynamics. Further, we confirm that the kappa parameter (κ) is independent of the skewness parameter (δ), which is consistent with findings from previous theoretical and numerical simulation studies. This present work serves as the first instance of the practical application of the Core-Strahlo model. We extend its relevance beyond theoretical contexts to the study of observational data. The results of our study emphasize the efficacy of the CS model as a robust tool for improving the scientific community's understanding of the dynamics of solar wind electrons.

Affiliations

Adetayo V. Eyelade	Departamento de Física, Facultad de Ciencias, Universidad de Chile, Santiago, Chile
Bea Zenteno-Quinteros	Departamento de Física, Facultad de Ciencias, Universidad de Santiago de Chile, Santiago, Chile.
Bea Zenteno-Quinteros	Center for Interdisciplinary Research in Astrophysics and Space Sciences (CIRAS), USACH, Santiago, Chile
Javier I. Silva	Departamento de Física, Facultad de Ciencias, Universidad de Santiago de Chile, Santiago, Chile.
Benjamin Urra	Centro de Instrumentacion Cientifica, Universidad Adventista de Chile, Chillan, Chile
Pablo. S. Moya	Departamento de Física, Facultad de Ciencias, Universidad de Chile, Santiago, Chile

E-mail

adetayo.eyelade@usach.cl

Characterization of the dynamics of a current sheet in a coaxial plasma accelerator: Simulations and experiments

Javier Fuentes, Cristian Pavez, Maximiliano Zorondo, Alejandro Clausse, Federico Casanova, Leopoldo Soto, José Moreno, Gonzalo Avaria, Julio Valenzuela.

It is widely known that, in coaxial plasma accelerators, such as plasma focus devices, the performance of the discharge is strongly determined by the formation phase of the current sheet and its subsequent axial acceleration. However, the characterization of the electrical, dynamic, and thermal parameters of the plasma sheet is limited both by the diagnostic capabilities and their resolution. In most cases, these parameters must be obtained indirectly, through self-consistent relationships, such as conservation principles and measurements reported by other authors.

This work presents the dynamic study of the current sheet in a coaxial plasma acceleratorin Hydrogen and Deuterium as fill gas, guided by the Multipurpose Generator ($C_{0} = 1.2 \mu F$, $L_{0} = 40nH$, $Z_{0} = 0.18\Omega$, $V_{c} = 23kV$, $E_{0} = 318J$, $I_{0} = 90kA$). The plasma dynamics are studied using ultra-fast optical-refractive images, for which a pulsed Nd:YAG laser in the second harmonic (532nm and pulse width of 170ps) is used. Additionally, the electrical behavior of the discharge is studied using high-voltage and current derivative monitors.

The experimental study is complemented by a 2-D numerical model, referred to by the developers as CSHOCK\cite{ref1, ref2}. In this model, the current sheet is represented by a discretization of axisymmetric conical segments, where the dynamics of each segment are governed by the Lorentz force and the temporal evolution of its mass, as the mass is swept up in its advance. The equation of motion is coupled to the circuit equation, considering the plasma sheet as a time-varying inductor. The agreement between the experimental results and those provided by CSHOCK establishes a self-consistent scenario, which allows us to calculate other variables considered in the model and thus estimate other properties of the plasma sheet, such as: temperature, mass, velocity, geometry, and energy per unit mass. The latter has been considered by some authors as a key parameter in the formation of filament-like structures observed in this type of discharge.

[1]C. Moreno, F. Casanova, G. Correa, and A. Clausse, Plasma Phys. Control. Fusion, vol. 45, no. 12 (2003).
[2]F. Casanova, C. Moreno, and A. Clausse, Plasma Phys. Control. Fusion, vol. 47, no. 8 (2005).

Affiliations

Javier Fuentes	Facultad de Ciencias Exactas, Universidad Andrés Bello, Sazié 2212, 837-0136, Santiago, Chile
Cristian Pavez	Comisión Chilena de Energía Nuclear, Nueva Bilbao 12501, Las Condes, Santiago, Chile. Facultad de Ciencias Exactas, Universidad Andrés Bello, Sazié 2212, 837-0136, Santiago, Chile
Maximiliano Zorondo	Università Cattolica del Sacro Cuore, Italia.

Alejandro Clausse	CNEA-CONICET and Universidad Nacional del Centro, 7000 Tandil, Argentina.
Federico Casanova	CNEA y Universidad Nacional del Centro, 7000 Tandil, Argentina.
Leopoldo Soto	Comisión Chilena de Energía Nuclear, Nueva Bilbao 12501, Las Condes, Santiago, Chile. Facultad de Ciencias Exactas, Universidad Andrés Bello, Sazié 2212, 837-0136, Santiago, Chile.
José Moreno	Comisión Chilena de Energía Nuclear, Nueva Bilbao 12501, Las Condes, Santiago, Chile. Facultad de Ciencias Exactas, Universidad Andrés Bello, Sazié 2212, 837-0136, Santiago, Chile.
Gonzalo Avaria	Departamento de Física, Universidad Técnica Federico Santa María, San Joaquín, Santiago.
Julio Valenzuela	Instituto de Física, Pontificia Universidad Católica de Chile, Santiago 7820436, Chile

E-mail

javier.fuentes101001@gmail.com

Antifungal property of Cold atmospheric pressure plasma associated with Vitamin C in a murine model of oral candidiasis

Noala Vicensoto Moreira Milhan, Ludmilla Oliveira Mantovani, Aline da Graça Sampaio, Fellype do Nascimento, Konstantin Georgiev Kostov, Cristiane Yumi Koga-Ito

Candida albicans is a commensal but also opportunistic fungus that commonly causes oral candidiasis in the presence of predisposing factors, such as immunosuppression. Previous in vitro and in vivo studies have indicated that cold atmospheric pressure plasma (CAP) may present antimicrobial activity against C. albicans and reduce the pathological findings of oral candidiasis, respectively. Other studies have demonstrated that Vitamin C (Vit C) also called ascorbic acid may inhibit and modulate virulence factors of C. albicans, in addition to present local anti-inflammatory properties. The objective of this study was to evaluate the synergistic antifungal effect of CAP associated with Vit C in a murine model of oral candidiasis. For this purpose, 21 male mice were submitted to immunosuppression with methylprednisolone and C. albicans inoculation on the lingual dorsum on alternate days. The animals were divided into four groups: 1) control (untreated), 2) Nystatin (standard treatment) 3) CAP and 4) CAP + Vit C. On the 8th and 9th days of the experiment the animals were exposed to helium CAP for 5 minutes at 1.5 cm, followed by the injection of 10 uL of Vitamin C (100 mg/mL). The treatment with the gas and injection of distilled water were performed in the groups that did not receive CAP or Vit C, respectively. The mice were euthanized on the 10th day and the tongues were sectioned into 3 fragments. The part destined to microbiological analysis were weighed, macerated and plated on selective agar for counting of colony forming units (CFU/mg). The results indicated that the highest fungal reduction was observed in the nystatin group, as expected, with statistical differences for untreated control group and CAP group (p0.05), the reduction was similar to the standard treatment with nystatin ($p>0.05$). In conclusion, the association between CAP and Vit C exhibits antifungal activity against C. albicans. Further analysis should investigate the tissue responses after this treatment, since this association may improve CAP potentialities previously observed in rodent models of oral candidiasis.

Affiliations

São Paulo State University (UNESP), Institute of Science and Technology, São José dos Campos, São Paulo, 12245-000, Brazil.	UNESP
São Paulo State University (UNESP), Guaratinguetá School of Engineering, Guaratinguetá, Brazil	UNESP

E-mail

milhan.noala@gmail.com

Enhanced Production of Reactive Oxygen and Nitrogen Species in Plasma-Activated Saline using a Serially Associated Hybrid Plasma Discharge System

Nilton F. Azevedo Neto, Felipe S. Miranda, Pedro W. P. Moreira Junior, Marcelo P. Gomes, Clodomiro Alves-Junior, Cristiane Y. Koga-Ito and Rodrigo S. Pessoa

Plasma-activated saline (PAS) has emerged as a promising therapeutic agent with diverse applications. This study presents a novel approach to enhance PAS production using a serially associated hybrid plasma discharge (HPD) system. The HPD system, combining dielectric barrier discharge (DBD) and gliding arc plasma jet (GAPJ), effectively amplifies the generation of reactive oxygen and nitrogen species (RONS) in saline water. Optical emission spectroscopy confirmed the increased production of RONS, characterized by unique emissions associated with nitrogen and oxygen ions. Significant physicochemical changes in the saline solution were observed, including pH reduction, oxidation-reduction potential (ORP) increase, and total dissolved solids (TDS) elevation. Real-time UV-Vis spectroscopy revealed the formation of key RONS such as hydrogen peroxide (H_2O_2), ozone (O_3), nitrite (NO_2^-), and nitrate (NO_3^-). Raman spectroscopy further elucidated the impact of plasma treatment on the molecular structure of saline, demonstrating a weakening of the hydrogen-bonding network. This research provides valuable insights into PAS production, paving the way for its potential applications in various therapeutic domains.

Affiliations

Nilton Francelosi Azevedo Neto	Instituto Tecnológico de Aeronáutica
Felipe Sousa Miranda	Universidade Estadual Paulista
Pedro William Paiva Moreira Junior	Instituto Tecnológico de Aeronáutica
Marcelo Pego Gomes	Instituto Tecnológico de Aeronáutica
Clodomiro Alves-Junior	Instituto Tecnológico de Aeronáutica
Cristiane Yumi Koga-Ito	Universidade Estadual Paulista
Rodrigo Savio Pessoa	Instituto Tecnológico de Aeronáutica

E-mail

nilton.azevedo@unesp.br

ELECTRICAL CHARACTERIZATION OF A PLANAR DOUBLE DIELECTRIC BARRIER DISCHARGE IN A MESH-TYPE CONFIGURATION AS WELL AS WITH DIFFERENT ELECTRODE GEOMETRIES.

C. Amado, P. G. Reyes, A. Gómez, J. Vergara, C. Torres, H. Martínez

Dielectric barrier discharges (DBD) are cold plasmas generated at atmospheric pressure with industrial applications such as: disinfection, material treatment, and ozone production, the latter being of great importance as it is a strong oxidizing and disinfecting agent. The study of electrode geometries in planar double discharges allows to understand which geometric and electrical characteristics produce a higher number of micro-discharges or a better density distribution during the discharge. Additionally, knowing the voltage and current applied, and consequently the electrical power consumed, it is possible to establish the efficiency and effectiveness of each experimental configuration for plasma generation. In this study, the formation of a mesh with copper electrodes on a quartz surface (used as a dielectric material) is electrically characterized. Additionally, three configurations to generate a DBD are analyzed, where the geometry of the copper electrodes is triangular, semicircular, and square, varying the gap between them until reaching 0.5 cm, with intervals of 0.1 cm. The electrical characterization is performed through charge-voltage diagrams based on experimentally obtained sinusoidal signals. The results show how the distribution, number of electrodes, and their geometric shape influence the frequency and voltage applied during the discharge to generate a DBD. The power consumption of the different configurations is directly related to the gap between the electrodes. For each geometric configuration, the gap between the electrodes is varied, yielding the following power range values: 2-5 W for the triangular geometry, 2-6 W for the semicircular geometry, and 3-7 W for the square geometry. In the study of mesh formation, the process is parametrized, starting from 2 parallel electrodes with a maximum distribution of 8 electrodes, to which 8 superimposed perpendicular electrodes are added, reaching a maximum of 16 electrodes to form the mesh.

Affiliations

Jose Carlos Palomares Amado	Universidad Autónoma del Estado de México
Pedro Guillermo Reyes Romero	Universidad Autónoma del Estado de México
Aarón Gómez Díaz	Universidad Autónoma del Estado de México
Josefina Vergara Sánchez	Universidad Autónoma del Estado de Morelos
Cesar Torres Segundo	Universidad Autónoma del Estado de Morelos
Horacio Martínez Valencia	Universidad Nacional Autónoma de México

E-mail

jcpalomaresa@uaemex.mx

Optimization of pulsed X-ray emission from a 2kJ Plasma Focus for application in biological areas

José Moreno, Jalaj Jain, Cristian Pavez, Valentina Verdejo, Analía Radl, Sergio Davis y Leopoldo Soto

A plasma focus discharge is produced by a pulsed electrical system, in a coaxial electrode configuration, and generates different types of emissions, both particles and electromagnetic radiation. This type of discharge has shown great potential as a pulsed source of radiation, with possibilities of being used in various application areas [1]. An important part in the study of this type of device is the characterization of the emissions produced, which is necessary to understand both the physical processes and their possible applications. A relevant point is to be able to know, given its variability between shots, how the conditions that produce good compression change, and therefore good radiation emission. An important condition is to be able to measure and characterize shot by shot the different parameters involved and among them is the effect on the detection elements or the irradiated ones. To achieve this, it is required that the emission level per shot be high enough to be able to differentiate the signal from the noise of the instruments and detectors used in the measurement. The main modification made to improve the emission level was in the geometry of the anode, increasing its length and decreasing its radius. This paper presents the results of the advances made in the optimization and improvement of a 1.2 kJ PF device (PF-2kJ) in order to determine both directly and indirectly the emission and its effects using different types of diagnostics and analysis. The radiation emission is determined directly by means of TLD100 thermoluminescent detectors and indirectly through a technique used to characterize the effects on biological material, cytogenetic markers, for the analysis of chromosomal aberrations of the dicentric and centric ring type, in peripheral blood lymphocyte cultures. The measurements are made for an anode geometry of an effective length of 53 mm and radius of 12 mm, determined based on design considerations using dynamic equilibrium criteria. Series of 1 and 5 shots were performed with and without a lead insert in the anode cavity. According to estimates, an increase in emission is expected for both conditions, with and without Pb, of about 30% and 50%, respectively, compared to previous campaigns [2].

This work is funded by ANID-FONDECYT projects, Regular 1240375, Regular 1211885 and Initiation 11230594.

[1] J. Jain et al. J. Appl. Phys. 130, 164902 (2021)
[2] Verdejo et al. J. Appl. Phys. 133, 163302 (2023).

Affiliations

José Moreno Martínez	Center for Research on the Intersection in Plasma Physics, Matter and Complexity, P2mc,Comisión Chilena de Energía Nuclear
José Moreno Martínez	Universidad Andres Bello, Departamento de Ciencias Físicas

E-mail

jose.moreno@cchen.cl

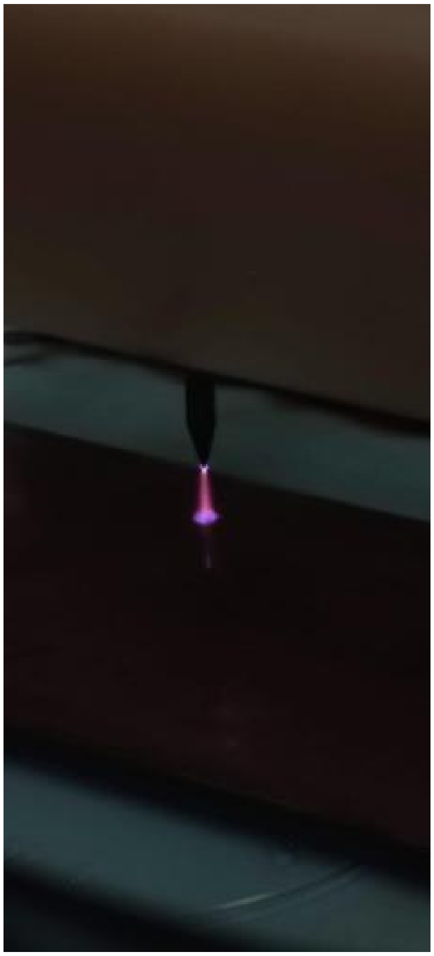
Design and construction of a corona discharge reactor for wastewater treatment.

Maximiliano Benitez

Within the new strategy that governs the global development programs adopted by the 2030 Agenda for Sustainable Development, an action plan in favor of people, plants and prosperity that includes 17 objectives in which it is intended to influence the following: objectives 6 clean water and sanitation, 13 action for the climate, 14 life below water, 15 life of terrestrial ecosystems and finally industry, innovation and infrastructure.
This particular project will focus on the textile production industry which is technologically one of the most complex, the expansion of the textile industry is extensive and it is considered the key to economic development with the growing demand for textile products, its waste water has been increasing proportionally causing a global pollution problem, the most common environmental problems around the world are associated with water pollution, this is caused by both the discharge of effluents as well as the use of toxic chemicals, this textile industry contributes to the release of dyes into the environment of 54% being the one that most pollutes our aquifers.
For decades, wastewater treatment using advanced oxidation methods such as Fenton, photo Fenton, ultrasonic ozonation, etc. has been investigated. Plasma treatment is currently being used as an innovative method seeking different configurations for the optimization of this environmentally friendly technique. In addition to nanotechnology, which offers numerous opportunities due to the ability of different nanoparticles to take advantage of their catalytic and oxidative properties, which can help promote the removal of contaminants, as well as their degradation.
Therefore, the main objective of this research is the degradation of the methanol yellow dye in wastewater by means of a corona discharge. For this purpose, an innovative reactor will be designed and built to optimize the treatment time. In order to propose a novel, efficient and ecological technique for the treatment of water contaminated by dyes. The development of the reactor will seek a way to systematize and innovate by integrating several modular pieces that will allow applying different forms of treatment to the plasma.

Affiliations

Horacio Martinez Valencia	Universidad Nacional Autonoma de Mexico
Pedro Guillermo Reyes Romero	Universidad Autonoma del Estado de Mexico



E-mail

benitezgmax@gmail.com

Cold Plasma Treatment: Efficacy and Selectivity in Cancerous (B16F10) and Healthy Cells (L929)

L. Lima, M. Shiotani, N. F. Azevedo Neto, F. S. Miranda, R. Queiroz, D. Tada, C. Alves Junior, R. Pessoa

Introduction: Cold atmospheric plasma (CAP) has recently emerged as a promising adjuvant therapy in cancer treatment [1-4]. This type of treatment stands out for its selective ability to induce cell death in cancer cells without significantly affecting healthy cells [3,4].

Methodology: In this study, a surface dielectric barrier discharge (SDBD) plasma source was developed with 24 electrode pairs, each designed for individual cell cultures. Plasma was directly applied to metastatic melanoma cells (B16F10) and healthy fibroblasts (L929) with exposure times of 1, 2, and 3 minutes. Cell viability was assessed using the MTT assay, with measurements taken 24 and 48 hours after plasma activation.

Results: A 1-minute exposure to CAP did not show significant cytotoxic levels in cancer cells. However, a 3-minute exposure resulted in a 30% reduction in B16F10 cell viability after 24 hours and 13% after 48 hours, suggesting that the reactions triggered by reactive oxygen and nitrogen species (RONS) continued in the medium even after the treatment ended. The L929 cells remained viable above 70% at all treatment times, demonstrating the selectivity of CAP.

Conclusion: Cold atmospheric plasma proved effective in reducing the viability of cancer cells without significantly compromising healthy cells. The selective effects can be attributed to the internal properties of cancer cells, such as high levels of reactive species and a higher number of aquaporins, combined with the action of short- and long-lived reactive species, as well as physical factors like UV radiation.

References

[1] Adachi, T., Tanaka, H., Nonomura, S., Hara, H., Kondo, S. I., & Hori, M. Free Radical Biology and Medicine, 79, 28–44 (2015).
[2] Yan, D., Sherman, J. H., & Keidar, M. In Oncotarget Vol. 8, Issue 9 (2017).
[3] Malyavko, A., Yan, D., Wang, Q., Klein, A. L., Patel, K. C., Sherman, J. H., & Keidar, M. In Materials Advances (Vol. 1, Issue 6, pp. 1494–1505). Royal Society of Chemistry (2020).
[4] Saadati, F., Mahdikia, H., Abbaszadeh, H. A., Abdollahifar, M. A., Khoramgah, M. S., & Shokri, B.. Scientific Reports, 8(1) (2018)

Affiliations

Michaela Shiotani Marcondes	Aeronautics Institute of Technology
Luan Gonçalves de Lima	Aeronautics Institute of Technology
Nilton Francelosi Azevedo Neto	Aeronautics Institute of Technology
Felipe de Souza Miranda	São Paulo State University
Rafaela Campos Queiroz	Federal University of São Paulo
Dayane Batista Tada	Federal University of São Paulo

Clodomiro Alves Junior	Aeronautics Institute of Technology
Rodrigo Sávio Pessoa	Aeronautics Institute of Technology

E-mail

marcondes.micaela5@gmail.com

Electric field effects in the formation of patterns at plasma-liquid interface

Felipe Veloso, Florencia Díaz, Josefina Muñoz, Francisco Castillo

Different studies [1-3] have shown that the interaction between plasmas and liquids produce complex phenomena that involve the interaction of charges in both phases. In this interaction, visible patterns are formed on the liquid surface whose shapes and structures vary depending on the saline concentration on the liquid as well as on the voltage and current of the plasma [2,3]. In this work, we studied the dynamic variation of the patterns formed that depend on the spatial geometry of the global electric field in the plasma region.
The experiments were made using a DC plasma at atmospheric pressure in contact with a H2O+NaClO4 solution. The plasma is formed at a point-plane configuration, with the point being a tungsten electrode acting as the cathode at high voltage and the plane anode being the aqueous surface. The system is located inside of a sealed chamber that allows the control of the gases that interact with the plasma and the liquid. The electric field is spatially modified with the use of a metallic aperture of different diameters located between the anode liquid and the cathode and connected to ground outside of the liquid. Diagnostics include current through the plasma and images of the plasma self-emission in the visible range.
The results show that using the metallic aperture the obtained plasma column can be larger with improved stability than without using it. In addition to that, patterns appear similar between different aperture diameters, but at different currents on each case. Effects of electric field and charged species in the dispersion relation of the liquid [3] are discussed as a possible explanation for the observed phenomena.

[1] P. Bruggeman, J. Liu, J. Degroote, M. G. Kong, J. Vierendeels, C. Leys. J. Phys. D: Appl. Phys. 41, 215201 (2008)
[2] P. Rumbach, A. E. Lindsay, D. B. Go. Plasma Sources Sci. Technol 28, 105014 (2019)
[3] O. Dubrovski, J. Yang, F. Veloso, D. B. Go, H-C. Chang, P. Rumbach. Phys. Rev. Lett. 133, 105301 (2024)

Affiliations

Felipe Veloso	Instituto de Física, Pontifica Universidad Católica de Chile
Florencia Díaz	Instituto de Física, Pontifica Universidad Católica de Chile
Josefina Muñoz	Instituto de Física, Pontifica Universidad Católica de Chile
Francisco Castillo	Instituto de Física, Pontifica Universidad Católica de Chile

E-mail

florencia.diazv@uc.cl

A low-cost plasma source aimed for medical applications using Ar as the working gas

Fellype do Nascimento and Konstantin Georgiev Kostov

Plasma medicine has become a research field of great interest in recent decades. Advances in equipment intended for medical applications have been quite significant. There are currently products commercially available and, in some cases, certified for medical use by health regulatory agencies in different countries. Most of the plasma sources employed in medical treatments produce cold atmospheric pressure plasmas (CAPPs). The beneficial effects of CAPP treatments are attributed to the reactive oxygen and nitrogen species (RONS) generated within the plasma discharges [1, 2].

When argon (Ar) is used as the working gas the plasma jets tend to present filamentary patterns. This occurs because the discharge channel becomes highly conductive and very narrow at the same time. Consequently, the resulting plasma jet exhibits higher discharge current (i_{dis}), gas temperature (T_g), and, crucially for medical applications, patient leakage current (PLC) compared to diffuse discharges. To avoid higher T_g values some plasma jet (PJ) devices employ gas flow rates between 5 and 10 slm. However, this solution has some disadvantages like faster dispersion of the RONS. Low i_{dis} and PLC values are typically achieved by increasing the distance between the plasma outlet and the target.

A previously reported low-cost plasma source device from our research group is already capable of operating with Ar as the working gas [3]. When configured for Ar, safety parameters like gas temperature and ultraviolet (UV) radiation emission fell within established limits for medical applications. The production of ozone and NOx gasses only slightly exceeded those limits. However, the PLC values significantly surpassed 100 µA, which is the value established as safe for applications in human tissues. In this work, a simple modification of the above mentioned device is proposed in order to employ an argon gas flow enriched with RONS formed within the PJ for biomedical applications. Thus, in this way, the resulting PLC values were shown to be negligible. Further experiments are required in order to check for antimicrobial efficiency.

[1] T.-W. Chen et al., ECS J. Solid State Sci. Technol., vol. 9, no. 11, p. 115002, Jun. 2020.
[2] C. Corbella, S. Portal, and M. Keidar, Plasma, vol. 6, p. 72, Mar. 2023.
[3] F. do Nascimento et al., IEEE Transactions on Radiation and Plasma Medical Sciences, vol. 8, no. 3, p. 307, Mar. 2024.

Affiliations

Fellype do Nascimento	Faculty of Engineering and Science in Guaratinguetá - São Paulo State University (UNESP)
Konstantin Georgiev Kostov	Faculty of Engineering and Science in Guaratinguetá - São Paulo State University (UNESP)

E-mail

fellype@gmail.com

Plasma electrolytic oxidation for coating formation

Brayan Ponciano Leyva, Fermín Castillo Mejía, Horacio Martínez Valencia, Jairo Radilla Bello

Plasma electrolytic oxidation (PEO) is a method used to form metal coatings on a substrate. Electrical breakdown in this system establishes a plasma state in which, under anodic polarization, the substrate material is converted into a compound, made of the substrate material itself, oxygen and the electrolyte components. In the PEO process, voltages of about 250 to 750 V are employed, usually in conjunction with an AC power supply, so that repeated dielectric breakdown occurs through the thickness of the growing oxide layer, in the form of many micro discharges that are distributed over the surface of the workpiece. PEO coatings contain relatively high levels of porosity, with a complex structure, but tend to be more wear resistant than anodized coatings and can also generally grow to micron thicknesses. This method is useful for depositing rGO on SiO2, which is a widely used material in energy storage devices such as batteries and supercapacitors, while rGO is a material that can significantly improve its electrical and energy storage properties due to the structure of this material. Therefore, in this work, the efficiency of the PEO technique as a method for deposition of rGO on SiO2 is studied.

Affiliations

Instituto de Ciencias Físicas	Universidad Nacional Autónoma de México

E-mail

brayan21.pole@gmail.com

The Influence of Temperature Process on RONS Formation in Plasma Activated Water Produced by Coaxial DBD Reactor.

Felipe S. Miranda, Nilton F. Azevedo Neto, Pedro W. P. Moreira Junior, Rodrigo Sávio Pessoa and Cristiane Y. Koga-Ito.

Plasma Activated Water (PAW) has garnered increasing attention in various research fields due to its potential in biological, medical, agricultural, and environmental applications. PAW is generated when a plasma source, such as a dielectric barrier discharge (DBD), interacts with water, leading to the formation of a variety of reactive oxygen and nitrogen species (RONS), such as hydrogen peroxide (H_2O_2), ozone (O3), nitrate ions (NO_3^-), and nitrite ions (NO_2^-)[2]. These species possess antimicrobial and oxidative properties, making PAW promising for use in areas ranging from surface disinfection to medical therapies and enhancing plant growth efficiency. The RONS present in PAW plays critical roles in many biochemical processes, such as inducing selective cell death in cancerous cells and improving plant resistance to pathogens. However, controlling and optimizing the composition of PAW is essential to ensure the effectiveness of these species for specific applications. Variables like the type of gas used in the discharge, the initial composition of the water, and especially the temperature directly impact the formation and concentration of RONS. In this context, the present study aims to use a coaxial DBD system employing post-discharge gas (compressed air), which is bubbled into a 40 mL volume of water to be activated, to understand the effect of temperature on RONS formation. Three experimental conditions were investigated: without temperature control of the water (which lowered the sample temperature from 22°C to 16°C) and with water temperature control maintained constant at 30°C and 60°C. Through characterizations involving thermal flow, temperature measurements, optical spectroscopy, UV-Vis spectrophotometry, and real-time monitoring of physicochemical parameters (pH, oxidation-reduction potential (ORP), conductivity, and total dissolved solids (TDS)), the optimal conditions for the formation of each RONS were determined. These findings allow for precise adjustments of the experimental conditions, enabling the tailored formation of specific RONS to meet the needs of applications in medicine, dentistry, or agriculture.

Affiliations

Felipe de Souza Miranda	Universidade Estadual Paulista - UNESP
Nilton Francelosi Azevedo Neto	Instituto Tecnológico de Aeronáutica
Pedro William Paiva Moreira Junior	Instituto Tecnológico de Aeronáutica
Rodrigo Sávio Pessoa	Instituto Tecnológico de Aeronáutica
Cristiane Yumi Koga-Ito	Universidade Estadual Paulista - UNESP

E-mail

mirannda.fs@gmail.com

Degradation of red and yellow azo dyes in an aqueous medium by corona discharge

Christian Mendoza Benitez, Horacio Martínez Valencia, Pedro Guillermo Reyes Romero

Atmospheric pressure plasma is an innovative technique for degradation of industrial dyes, red and yellow dyes are difficult to decompose due to its complex structure and persistence in a medium aqueous. These dyes, especially azo dyes, generate toxic waste. that contaminate water quality, affecting both marine biodiversity as well as human health.
In the present experiment, the red and yellow dyes in a solution of 300 mg/L were treated in a plasma reactor at atmospheric pressure. This plasma, generated by a high-voltage electrical current, creates species reactive substances such as hydroxyl radicals (•OH) and ozone (O_3), which oxidize and break down the dyes.
During the process, several parameters were measured such as dissolved oxygen, pH and electrical conductivity, which allowed the chemical characterization of the degradation. Additionally, a UV-visible spectrophotometer was used to monitor the dye concentration throughout the treatment, analyzing degradation kinetics.
The results showed a significant decrease in the concentration of dyes, confirming the effectiveness of pressure plasma treatment atmospheric. The generation of reactive species from plasma without the need for chemicals makes it a clean and sustainable option for treatment of contaminated effluents.
In summary, plasma at atmospheric pressure is a promising tool for the degradation of dyes, being capable of breaking down structures

complex molecular structures through reactive species generated under controlled, thus contributing to environmental remediation without generating waste additional.

Affiliations

Institute of physics cience	Nacional Autonomus University of México
Faculty of cience	Autonomus University State of México

E-mail

cbenitez@icf.unam.mx

SURFACE MODIFICATION OF POLYPROPYLENE SURGICAL POLYMER USING ARGON PLASMA AND CHITOSAN COATING FOR ANTIMICROBIAL SUTURES

Alexsandra Cordero, Rolf Grieseler

This work aims towards the investigation and the analyses of polypropylene sutures (PPs) superficially modified by argon direct current luminous discharge plasma and subsequent deposition of a chitosan coating to obtain antimicrobial sutures. In order to decrease the incidence of surgical site infections (SSIs), which affect the recovery of patients, generate high hospital costs, prolonged pain, and in severe cases, sepsis. One of the solutions currently proposed is the application of a material with intrinsic antimicrobial property on the suture.

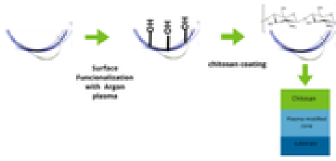
For the surface modification different plasma parameters that were used such as the time with plasma treatment, which was varied between 10 min and 30 min, On the other hand, the used power was between 1 W to 2 W with a pressure of 3 x 10-4 Torr.
After the plasma treatment different methods of chitosan deposition were investigated. The immersion time with the chitosan solution and the drying time were varied between 1 h to 2 h respectively.

With the different deposition parameters, it was possible to obtain an optimum to be able to cover the sutures with chitosan. To verify the successful chitosan deposition Raman spectroscopy was applied to show that the plasma treated sutures after the coating with chitosan had an increase of the representative bands due to the increase in the formation of polar bonds that are formed on the surface of the sutures. Good parameters were in this case a modification time with plasma of 30 min and a subsequent immersion time with chitosan of 2 hours. Likewise, the SEM results allowed the observation of the morphology of the treated sutures, which presented dark and granular areas that are indicators of chitosan adhesion. The amount of these features increased with larger immersion times and especially after plasma treatment. This is in good accordance to the results obtained by FITR, since a large number of oxygen-containing functional groups introduced by the surface modification of the plasma were presented in the spectra of the sutures in addition to the characteristic functional groups of chitosan, which confirms the formation of the chitosan layer on the surface of the sutures.

An important aspect of this study is the relationship between the parameters of power and exposure time during surface treatment with plasma. The respective results confirmed that at low powers, the coating of the sutures is less due to the small number of active sites on the suture surface.

Affiliations

Pontificia Universidad Católica del Perú	PUCP



E-mail

a20166068@pucp.edu.pe

Degradación de Metamizol sódico con plasma a presión atmosférica

Azul Gabriela González Hernández, DR. Álvaro Torres Islas, DR. Horacio Martínez Valencia

En esta investigación se presenta un nuevo sistema de degradación con plasma a presión atmosférica del medicamento Metamizol sódico con un enfoque en el campo de la catálisis heterogénea, centrado en la degradación de compuestos orgánicos utilizando películas delgadas de PLA. El catalizador se activó con plasma, produciendo especies activas de oxígeno en la interfase gas-liquido, así como en el medio acuoso. Las películas delgadas de PLA se sintetizaron utilizando PLA reciclado de impresiones 3D y se modificaron mediante un tratamiento de plasma a presión atmosférica. Las películas delgadas no tratadas y tratadas con plasma se analizaron utilizando, Raman, FTIR, XRD y AFM. Se ha alcanzado un porcentaje de degradación del 50%. Sin embargo, se esta trabajando en obtener un mejor resultado.

This study presents a novel atmospheric pressure plasma degradation system for sodium metamizole, focusing on the field of heterogeneous catalysis. The research focuses on the degradation of organic compounds using thin PLA films. The catalyst was activated by plasma, leading to the generation of active oxygen species at both the gas-liquid interface and within the aqueous medium. Thin PLA films, synthesized from recycled PLA obtained from 3D printing, were modified through atmospheric pressure plasma treatment. Both untreated and plasma-treated films were analyzed using Raman spectroscopy, FTIR, XRD, and AFM techniques. A degradation efficiency of 50% was achieved; however, further work is underway to improve this result.

Affiliations

Instituto de ciencias físicas	Universidad nacional autónoma de México

E-mail

azul.ggh.hgg@gmail.com

Hall Electric Thruster with RF Cathode for Small Satellites

Jhonatha W. S. Paula, Hudson M. Costa, Rodrigo A. Miranda, José L. Ferreira

Radiofrequency (RF) cathodes, commonly referred to as plasma cathodes, represent a cutting-edge innovation poised to advance Hall thruster technology by providing efficient, durable, and scalable electron sources. These devices utilize radiofrequency (RF) to ionize a neutral gas within a compact chamber, creating a high-energy plasma. A negative potential applied to a thin cylindrical electrode confines the electrons within the chamber, while a positive potential applied to an external anode plate enables controlled electron extraction through a precision-engineered orifice. This study documents the design, fabrication, and operational testing of an RF cathode prototype. Key contributions include the development of optimized geometrical and material configurations, ensuring stable plasma generation and efficient electron emission. Advanced numerical simulations predict critical performance metrics, including temperature distribution, electron density, electric potential, and plasma flux density, offering valuable insights into device behavior under varying operational conditions. Experimental validation is provided through extensive testing, demonstrating reliable operation, compatibility with Hall thruster requirements, and potential for extended lifespan compared to traditional hollow cathodes. The findings underscore the transformative role of RF cathodes in enhancing the performance and longevity of electric propulsion systems for next-generation space missions.

[1] M. Celik and H. Kurt, "Ferromagnetic enhanced inductively coupled plasma cathode for thruster ion neutralization," presented at the AIP Conf. Proc., vol. 2011, no. 1, Harlow, England, 2018.

[2] M. Celik, "Development of a prototype radio-frequency cathode with ferrite core for use in space propulsion applications as electron source," 2019, Grant FA9550-17-1-0143.

[3] Z. Xu, P. Wang, Z. Hua, S. Cong, and S. Yu, "Numerical simulation and experimental research on an inductively coupled RF plasma cathode," Plasma Sci. Technol., vol. 24, no. 1, pp. 015404, 2021.

[4] S. Jahanbakhsh and M. Celik, "Theoretical investigation and modeling of current extraction from a radio-frequency cathode," presented at the 50th AIAA/ASME/SAE/ASEE Joint Propulsion Conf., 2014, p. 3402.

[5] P. Smirnov et al., "Research and development of radio-frequency cathode neutralizer," presented at the 36th Int. Electr. Propulsion Conf., Vienna, Austria, Sept. 15–20, 2019, IEPC-2019-840.

Affiliations

Plasma Physics Laboratory (LFP)	University of Brasília (UnB)

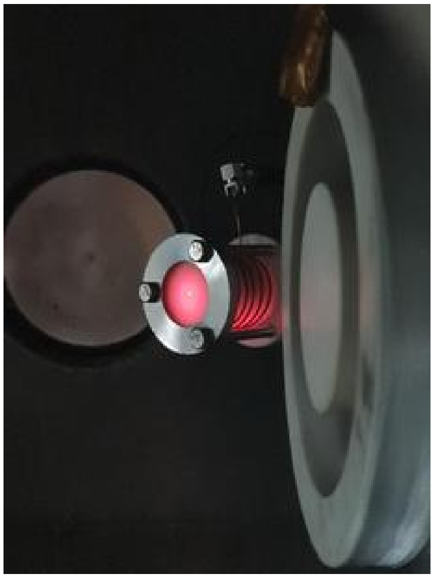


Figure Caption permanent magnet Hall thruster with RF hollow cathode

E-mail

jleonardoferreira@uol.com.br

"SPACE WEATHER" A PROJECT TO EXPERIMENTALY SIMULATE NEAR EARTH SPACE PLASMAS

José Leonardo Ferreira, João Gabriel Borges Aquino, Rodrigo Andrés Miranda Cerda

INTRODUCTION:
This work aims to develop a device capable of producing plasmas confined by magnetic fields in various configurations. The objective is to experimentally simulate the conditions of space plasmas near Earth and investigate phenomena such as waves and turbulence in the Earth's magnetospheric plasma, wave-particle interactions, plasma dynamics, and magnetic confinement. These experiments are being conducted at the Plasma Physics Laboratory of the University of Brasília (LFP-UnB). To achieve this, the experimental setup requires:

A uniform magnetic field to represent the interplanetary magnetic field (IMF),
A plasma source and acceleration system to effectively simulate the solar wind,
An obstacle with magnetic field emission capabilities for magnetosphere representation.

EXPERIMENTAL SETUP AND PROPOSED RESEARCH:

The vacuum chamber of the LFP-UnB has 0.5 m in diameter and 2.0 m in length. This vacuum chamber is made of stainsless steel and capable of reaching a pressure corresponding to 10-7 Torr already installed and fully operational, being mainly employed for testing plasma thrusters. The characterization of the plasma parameters inside the chamber - such as electron density and temperature, plasma potential, and instabilities - is carried out using Langmuir probes. Ion acceleration is determined by energy sensors, while ion dynamics in the acceleration channel is measured based on ion temperature, using the plasma spectroscopy technique. For the IMF representation a coil system was designed to generate the magnetic field. This field adopts an axial configuration, aligned with the main axis of the cylindrical vacuum chamber, and is produced by six coils. The system for plasma generation was implemented using a helical antenna with radio frequency in the vicinity of plasma frequency (13.6MHz). This system produced plasma, which was subsequently accelerated using polarized grids to replicate the dynamic behavior of the solar wind.

With this experimental set up we expec to perform experiments related to solar wind interaction with the earth magnestosphere such as Whistler Wave Generation, Auroral Emission and Magnetic Reconection.

REFERENCES:
[1]- Yur, G. et al. Laboratory facility for magnetospheric simulation. (1995).

[2]- SHAIKHISLAMOV, I. F. et al. Laboratory model of magnetosphere created by strong plasma perturbation with frozen-in magnetic field.Plasma Physics and Controlled Fusion , (2014).

Affiliations

João Gabriel Borges Aquino	Universidade de Brasília
José Leonardo Ferreira	Universidade de Brasília
Rodrigo Andrés Miranda Cerda	Universidade de Brasília

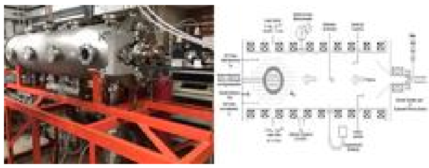


Figure Caption

PLASMA MACHINE FOR SPACE WEATHER PHENOMENA LABORATORY SIMULATION

E-mail

jleonardoferreira@uol.com.br

Spectral simulation of plasma bubbles: Sensitivity analysis of drivers

Ana P. Aragon Rodriguez, Enrique Rojas Villalba, Ana G. Elias

The equatorial plasma bubbles (EPBs) are produced by a combination of factors driven by plasma convection and are the known cause of spread F, which can significantly affect radio signals. Despite decades of study, the precise role of each of their drivers remains unknown. This affects our forecasting capabilities using numerical physics-based models, which are still limited in accuracy. This work will present preliminary results of attempts to model EPBs using spectral methods. Even though flux-preserving methods are usually the choice for systems showing strong gradients, we hypothesize that spectral methods can capture most of the physics relevant to the predictability of EPBs occurrence. We start reproducing a simplified two-dimensional fluid model and use this framework to test a sensitivity analysis methodology to evaluate the relative role of the various drivers. Then, we relax some of this model assumptions and repeat the sensitivity analysis. Furthermore, we will explore closures to capture the behavior reported with 3D simulations while keeping the 2D system.

Affiliations

Ana P. Aragon Rodriguez	Universidad Nacional de Tucuman, Facultad de Ciencias Exactas y Tecnologia, Departamento de Fisica
Enrique Rojas Villalba	MIT Haystack Observatory, Massachusetts
Ana G. Elias	Universidad Nacional de Tucuman, Facultad de Ciencias Exactas y Tecnologia, Departamento de Fisica

E-mail

anitaaragonrodriguez@gmail.com

Preliminary Design of an Experimental Platform for the Study of Turbulence in Laboratory Plasmas

Consuelo Mimica, Julio Valenzuela, Miguel Escalona

Three diagnostics have been implemented to characterize plasmas: refractometry, Thomson scattering, and visible emission spectroscopy, for the development of an experimental platform for the study of turbulence in laboratory plasmas. Using the Llampudkeñ pulsed power generator from the Pontificia Universidad Católica, supersonic plasma jets are generated from conical arrays of copper and tungsten wires, inducing turbulence externally with the insertion of a periodic aperture mesh of 829 µm. Refractometry shows a broadening in the deflection distributions for both copper and tungsten, but the formation of turbulence is not confirmed with certainty. Thomson scattering provides plasma parameters, identifying a slight increase in ion temperature of 16% for the tungsten plasma, related to the width of the scattering spectrum and possible turbulence evolution in the jet. Through spectroscopy, three lines corresponding to copper I are identified, showing a 244% broadening in one of them possibly relating to turbulence. It is concluded that the diagnostics are indeed sensitive to various variations in the generated plasma profiles, and optimization of the platform is suggested to improve the quality of the signals obtained in future studies.

Affiliations

Consuelo Mimica	Pontificia Universidad Católica
Julio Valenzuela	Pontificia Universidad Católica
Miguel Escalona	Pontificia Universidad Católica

E-mail

consuelo.mimica@uc.cl

Generation of magnetized plasmas in a Gas-puff Z-pinch configuration

Pelayo Phillips, Miguel Escalona, Julio Valenzuela

Gas-Puff Z-Pinches are of great interest for studies of magneto-inertial fusion, and they are known to be an efficient source of X-ray and neutron radiation. However, this configuration is susceptible to various instabilities, primarily magneto-Rayleigh-Taylor (MRT) instabilities, which can lead to axially non-uniform implosions that significantly reduce efficiency. Recently, it has been demonstrated that magnetizing these plasmas greatly mitigates these instabilities and improves pinch uniformity. However, the influence of this dynamics on the final energy balance of the pinch has not yet been studied in detail, which is essential for enhancing the fusion applications of these types of plasmas.

In this work, preliminary results will be presented regarding the application of an external magnetic field to an argon plasma in a Gas-Puff configuration produced by the Llampüdkeñ pulsed power generator, which generates currents of 400 kA in 350 ns. The plasma is pre-magnetized using a uniform axial field of 0.5-1 T, produced by two Helmholtz coils. To assess the compression efficiency, the evolution of magneto-Rayleigh-Taylor instabilities, X-ray emission, pinch rotation speed, and possible fluctuations in density and temperature, a set of simultaneous diagnostics will be employed. These include: MCP imaging for studying plasma homogeneity and the growth rate of MRT instabilities; diodes, PCD, and bolometers for X-ray production and radiation emission; and Thomson scattering spectroscopy for analyzing plasma parameters and dynamics. This will be compared with the parameters of the same plasma without magnetization to understand how stability and energy balance in the pinch change in response to this magnetic field.

Affiliations

Pelayo Phillips Pfenniger	Pontificia Universidad Católica de Chile
Miguel Escalona Álvarez	Pontificia Universidad Católica de Chile
Julio Valenzuela Ahumada	Pontificia Universidad Católica de Chile

E-mail

pelayo.phillips@uc.cl

UC | Chile

WELCOME TO THE 17TH

LATIN AMERICAN WORKSHOP ON PLASMA PHYSICS

LAWPP 2025

SANTIAGO, CHILE | JANUARY 20TH - JANUARY 23RD

INSTITUTO DE FÍSICA
FACULTAD DE FÍSICA