



**Universidad Católica, Facultad de Física
Charla, Academia Chilena de Ciencias.**



James Clerk Maxwell.

***James Clerk Maxwell:
Una celebración a
175 años de
su nacimiento.***

**Rafael Benguria,
Miércoles 27 de Septiembre, 2006.**

Bosquejo

1. Biografía

2. Trayectoria Académica

3. Principales Descubrimientos Científicos:

- Los Anillos de Saturno.

- El Campo Electromagnético

- Visión en Colores

- Teoría Cinética de Gases.

- Contribuciones a Ingeniería.

4. Otros.

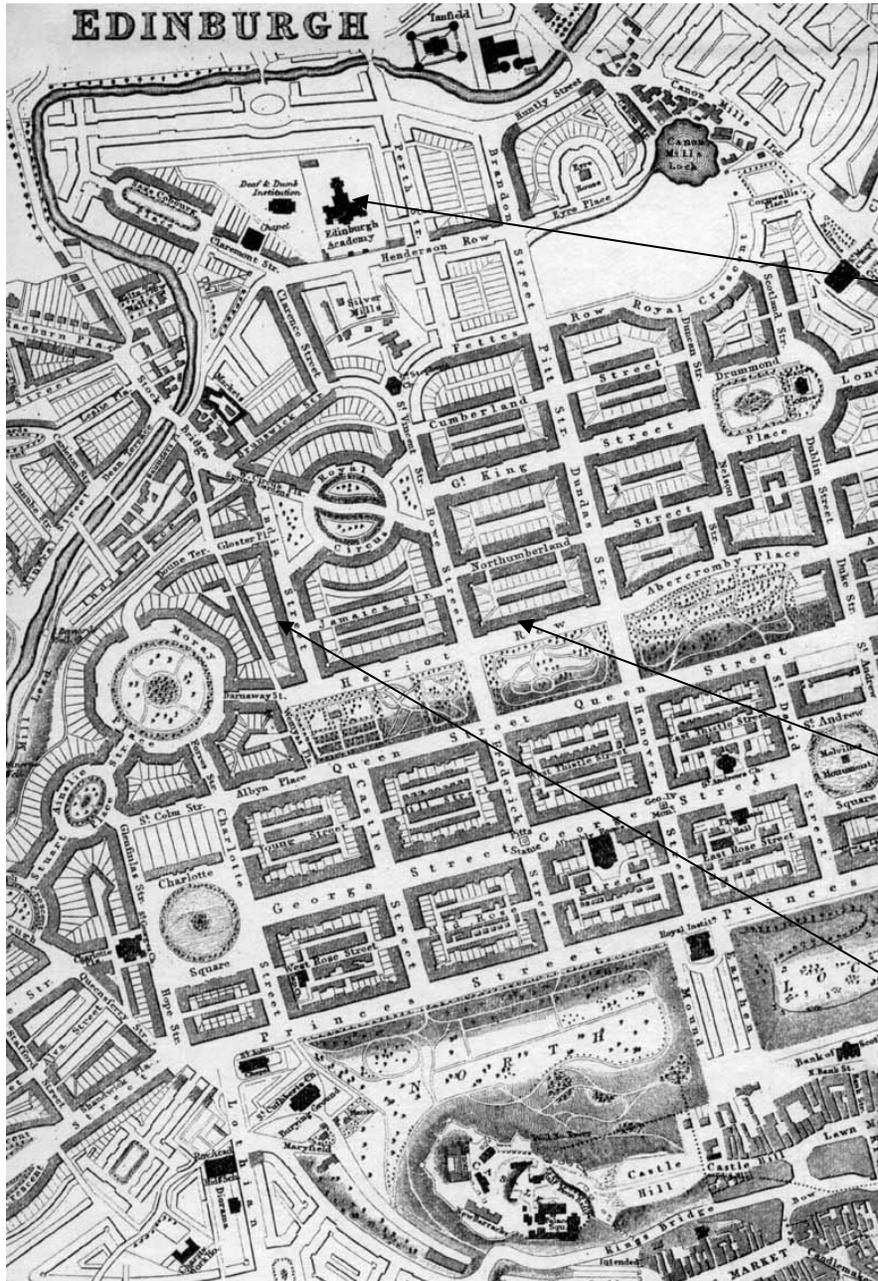
EDINBURGO, 1830's:





Maxwell nació en esta casa en 14 India Street, el 13 de Junio De 1831.





Edinburgh Academy

Heriot Row

14 India Street



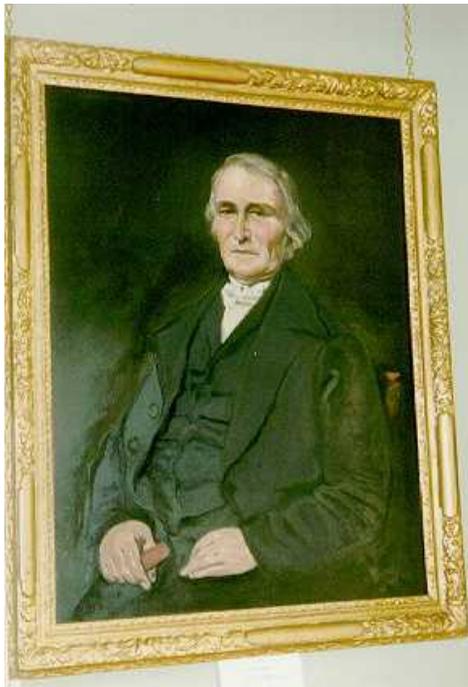
*Hoy la casa de Maxwell
es la sede de la*

*“James Clerk Maxwell
Foundation”,*

*Un instituto de investigación
en Física Matemática en
la ciudad de Edinburgo.*



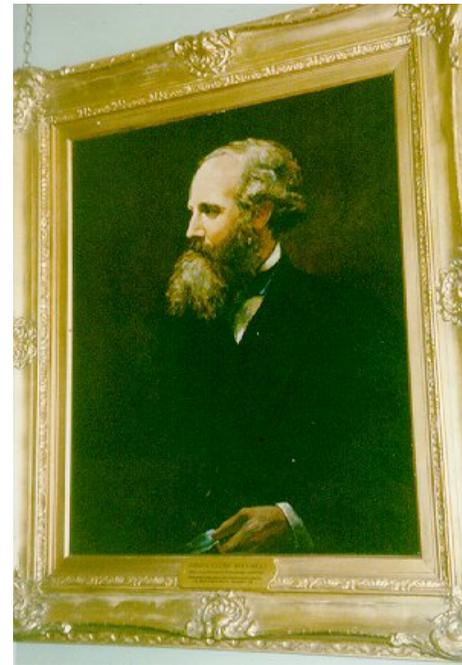
La entrada de la casa de James Clerk Maxwell en Edinburgo, tal como aparece hoy.



John Clerk Maxwell



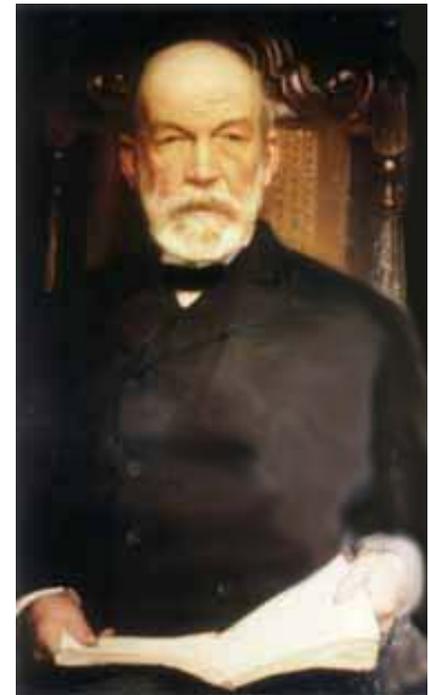
*Jane and Frances
Cay*



James Clerk Maxwell



Comedor



Peter G. Tait (1831-1901).



James Clerk Maxwell, niño, con su mamá, Frances Cay.

El niño Maxwell.

He is a very happy man, and has improved much since the weather got moderate; he has great work with doors, locks, keys etc., and 'Show me how it doos' is never out of his mouth. He also investigates the hidden course of streams and bell-wires, the way the water gets from the pond through the wall and a pend or small bridge and down a drain ...





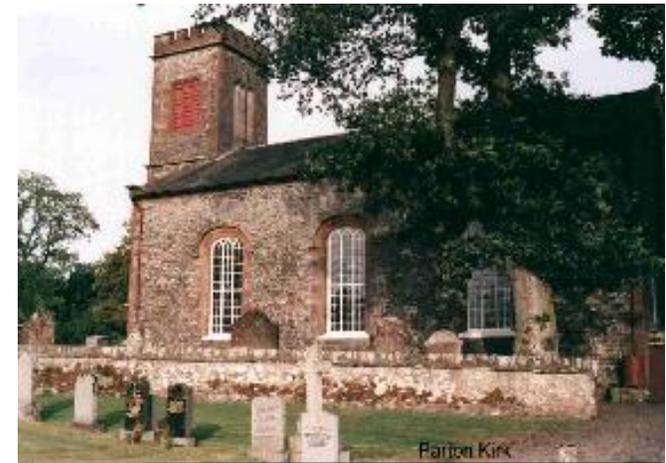
GLENLAIR HOUSE

en 1880

**Luego de haber sido
arreglada y mejorada
por James Clerk
Maxwell in 1867**

*John Clerk Maxwell y su familia
se trasladaron a Glenlair tan pronto
Maxwell nació. La mamá de Maxwell,
Frances Cay murió cuando su hijo
tenía 8 años.*

*Maxwell vivió en Glenlair entre 1831
y 1841.*



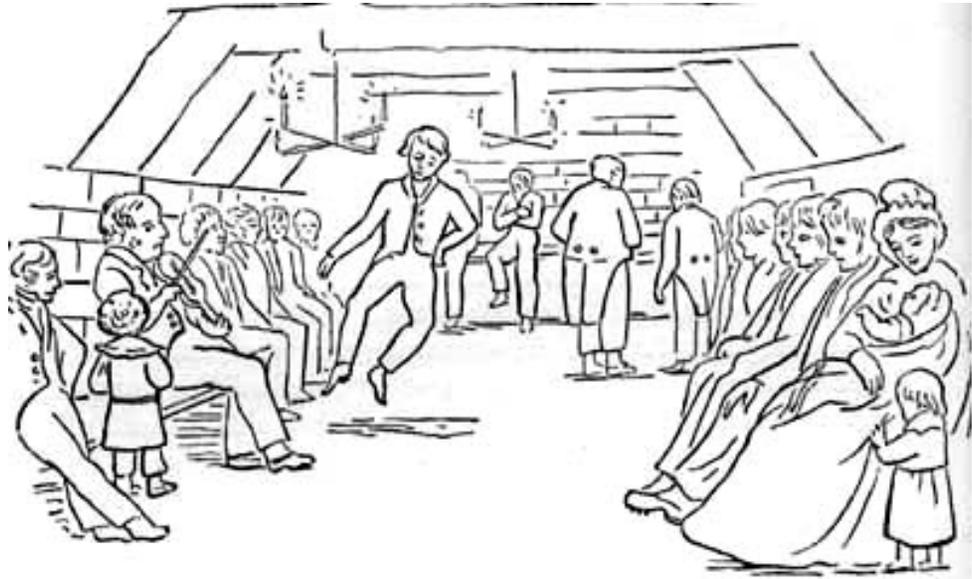
Parroquia de Parton

Las láminas y grabados hechos por la prima de James Clerk Maxwell (Jemima Wedderburn).

Hay muchas ilustraciones de la niñez de Maxwell, hechas por su prima J. Wedderburn.



Jemima Blackburn (née Wedderburn)
(cousin of JCM)





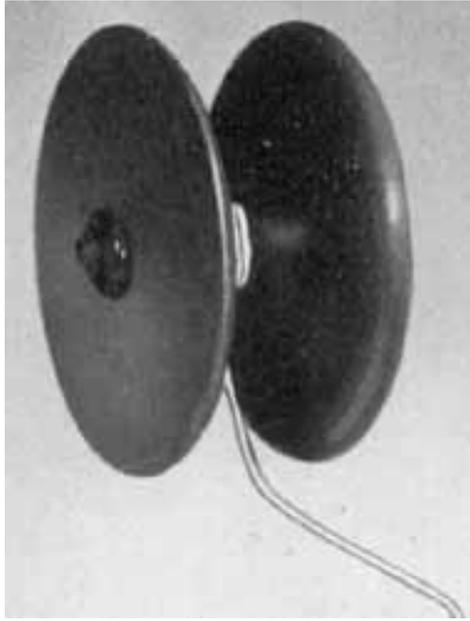
James con su perro Toby



James siguiendo a su padre en un caballo.



James jugando en Glenlair in 1841 con Jemima y su tutor.





Zoetrope de James con secuencias de dibujos hechos por el mismo.

1841



Acuerela de Jemima Wedderburn.
Nótese la Osa Mayor en el cielo.



Parada en Newton, 13 de Noviembre de 1841 (regresando a Edinburgo).



Llegada a 31 Heriot Row, Edinburgo, 18 November 1841



18th Nov^r 1841

Edinburgh



La casa de 31 Heriot Row, tal como aparece hoy.

Esta es la casa de la hermana de John Clerk Maxwell, Isabella Wedderburn.

Aquí vivió Maxwell luego de regresar a Edinburgo.

James Clerk Maxwell estudió en la Academia de Edinburgo, entre Noviembre de 1841 y Junio de 1847.



**Academia de Edinburgo en 1828
(fue co-fundada por Sir Walter Scott en 1824).**

*El siguiente es un comentario de **Peter Tait**, sobre Maxwell una vez en la Academia de Edinburgo:*

.....At school he was at first regarded as shy and rather dull. he made no friendships and spent his occasional holidays in reading old ballads, drawing curious diagrams and making rude mechanical models. This absorption in such pursuits, totally unintelligible to his school fellows, who were then totally innocent of mathematics, of course procured him a not very complimentary nickname...

...DAFTY



James y Jemima "tubbing" en el río en Glenlair en 1843







La casa de la tía Jane:

**James haciendo sus tareas
en 6 Great Stuart Street
en 1844.**



The highest position he achieved in class was fourteenth - until he reached Mr Gloag. Then it became obvious that this boy had a brain for mathematics, and his self-confidence grew so much that he also began to do well in Latin and Greek.

James Gloag fue el Profesor de Aritmética y Geometría de Maxwell y de Tait en la Academia de Edinburgo.

En Julio de 1845 Maxwell ganó la Medalla de Matemáticas en La Academia de Edinburgo, y de acuerdo a Tait:

...About the middle of his school career however he surprised his companions by suddenly becoming one of the most brilliant among them, gaining prizes and sometimes the highest prizes for scholarship, mathematics, and English verse composition. From this time forward I became very intimate with him, and we discussed together, with schoolboy enthusiasm, numerous schoolboy problems, among which I remember particularly the various plane sections of a ring or tore, and the form of a cylindrical mirror which should show one his own image unperverted.

En abril de 1846, a los 14 años, J.C. Maxwell publicó su primer trabajo. sobre óvalos multifocales, en Transactions of the Royal Society of Edinburgh: Oval curves, and those having a plurality of Foci.

Entre Noviembre de 1847 y Junio de 1850, Maxwell estudió en la Universidad de Edinburgo.



Engraving from [Modern Athens](#) - published 1829



Edinburgh University - South Bridge Street



Entre 1850 y 1854, J.C. Maxwell fue alumno en el Trinity College, Cambridge.

En 1854 se graduó como Second Wrangler, y compartió el premio Smith, con el Senior Wrangler, Edward Routh.

En 1855 y 1856 fue fellow del Trinity College.

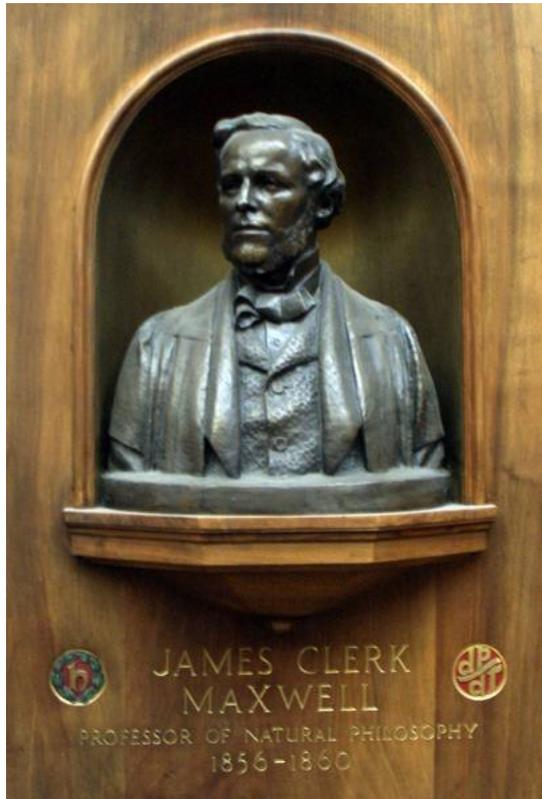
En esa época escribió dos artículos:

i) Experiments on Colour, as perceived by the eye, with remarks on Colour Blindness (1855),

ii) On Faraday's line of forces (1855-1856).

En este último artículo, Maxwell interpreta los resultados de inducción de Faraday como:

$$\varepsilon = -\frac{d}{dt} \int \vec{B} \cdot d\vec{S}.$$



En noviembre de 1856, Maxwell se traslada a la Universidad de Aberdeen (Marischal College).

El papá de Maxwell muere en Abril de 1856.



FROM PROFESSOR J. D. FORBES.

Bridge of Allan, 30th April 1856.

MY DEAR SIR—I have just seen in the newspaper that you have been appointed to the Chair in Marischal College, on which I beg sincerely to congratulate you.

I regret much that it should at the same time be my lot to express my sympathy on the occasion of the recent death of your father. Such a loss occurs but once in a lifetime. In your case I am sure that it has the greatest alleviation which it admits of—I mean the consciousness that you have been an affectionate and dutiful son, and that your excellent conduct relieved your father's mind from every shade of anxiety regarding you.—Believe me always, yours very sincerely,

JAMES D. FORBES.

En junio de 1859, Maxwell se casa con Katherine Mary Dewar.



*En 1860 es despedido
del Marischal College.*

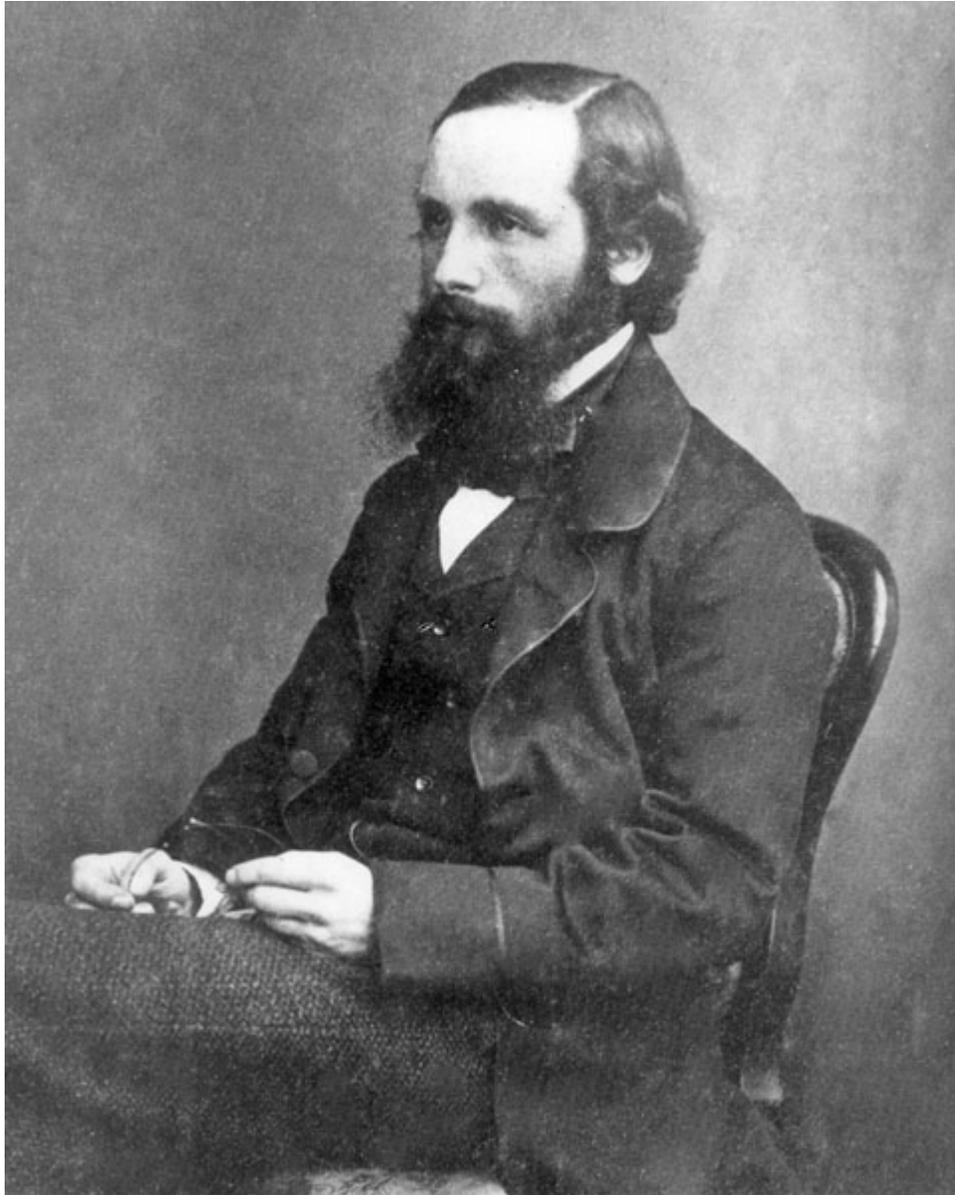
*Trata de obtener un puesto
vacante en Edinburgo, pero
este es ocupado por Tait.*

Entre 1860 y 1865, es el Director del Departamento de Natural Philosophy en King's College, London.





Maxwell is the bearded figure on the left, surrounded by children
This is taken from a watercolour by Jemima Wedderburn.



*Maxwell de aproximadamente
30 años.*

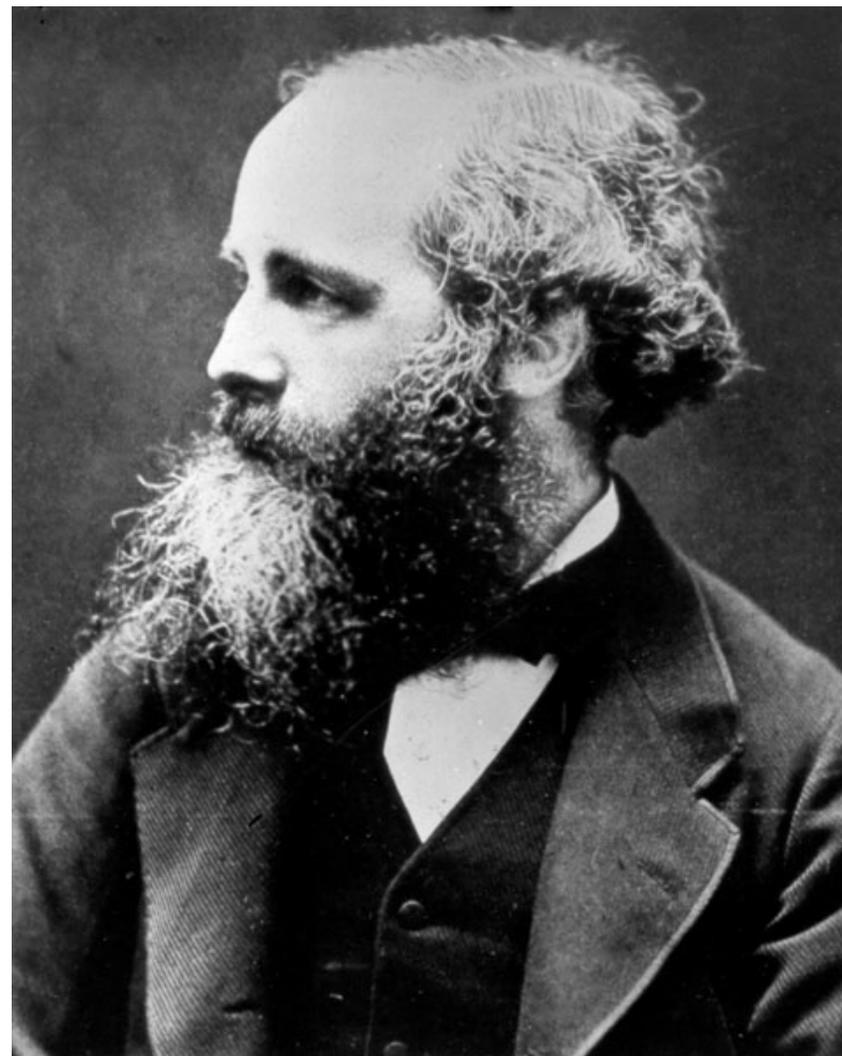
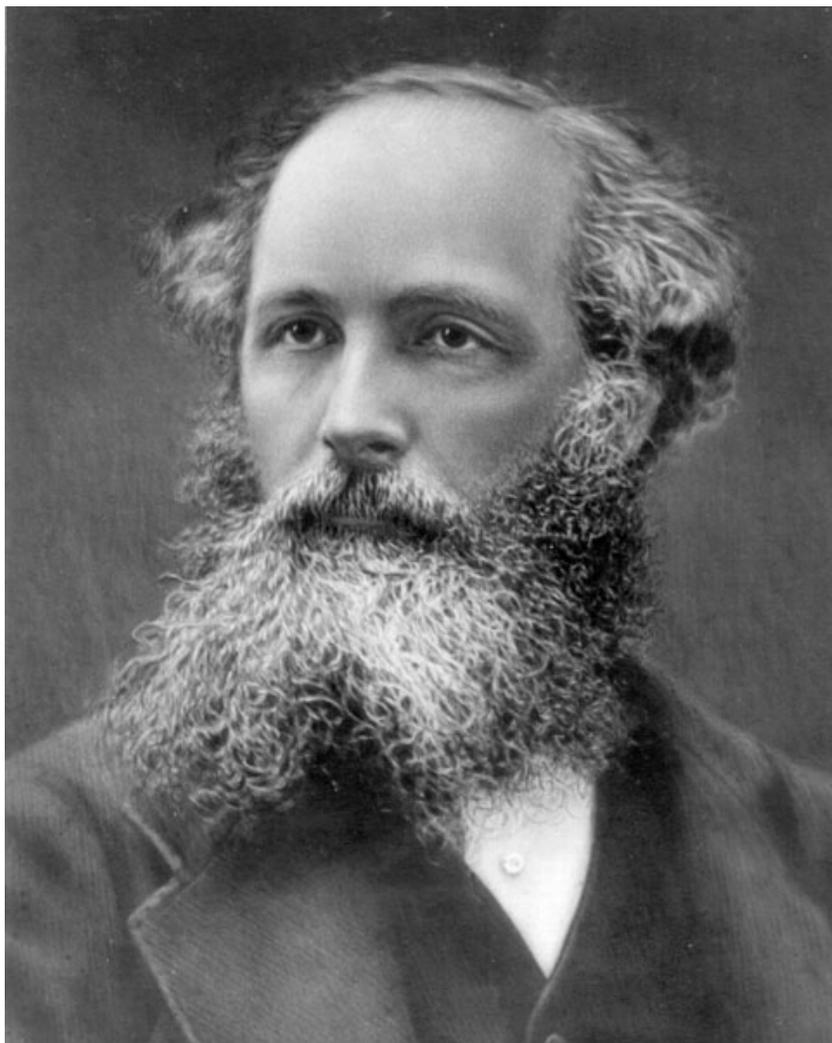


30

Entre 1865 y 1871 retorna a su cas de campo en Glenlair.



Maxwell a los 40 años.



En 1871 es nominado Profesor de Física Experimental del Laboratorio Cavendish, en Cambridge, donde permanece hasta su muerte.





*Tumba de James Clerk
Maxwell en la Parroquia de
Parton, cerca de Glenlair.*

Descubrimientos Científicos:

Estructura de los Anillos de Saturno.

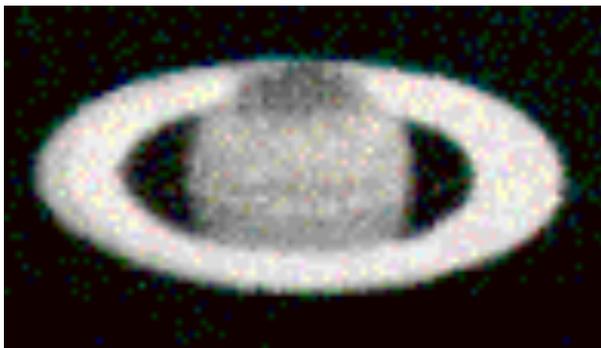
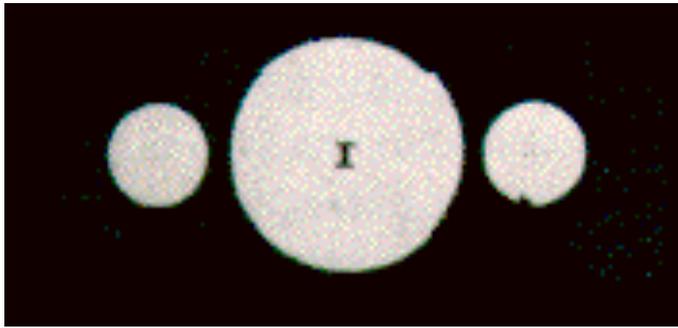
Visión en Colores.

Electromagnetismo.

Teoría Cinética de Gases.

Control Automático.

Calculo Estructural.



John Couch ADAMS: “The Adams Prize”

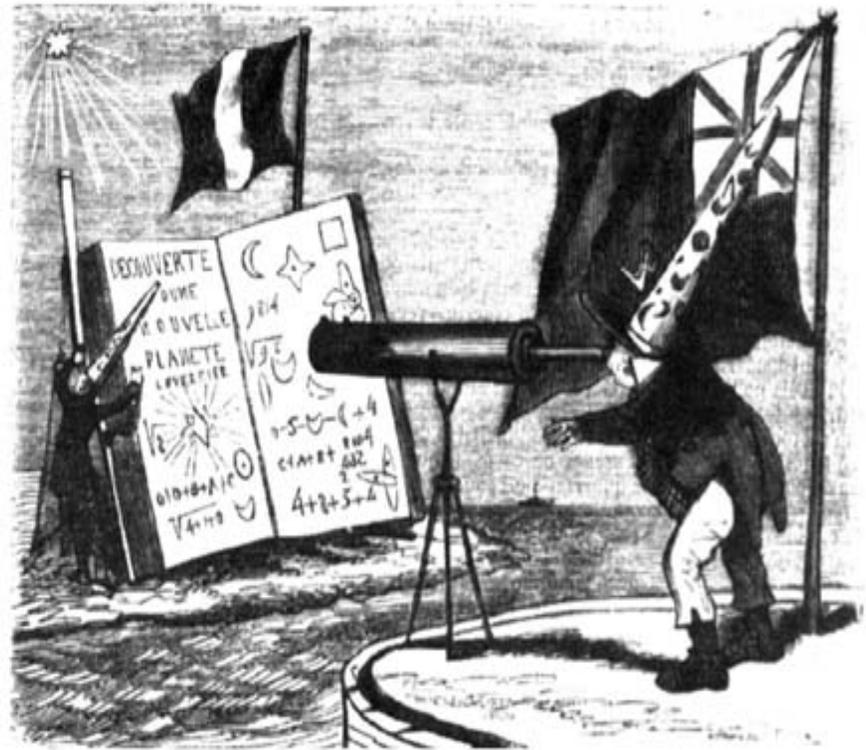
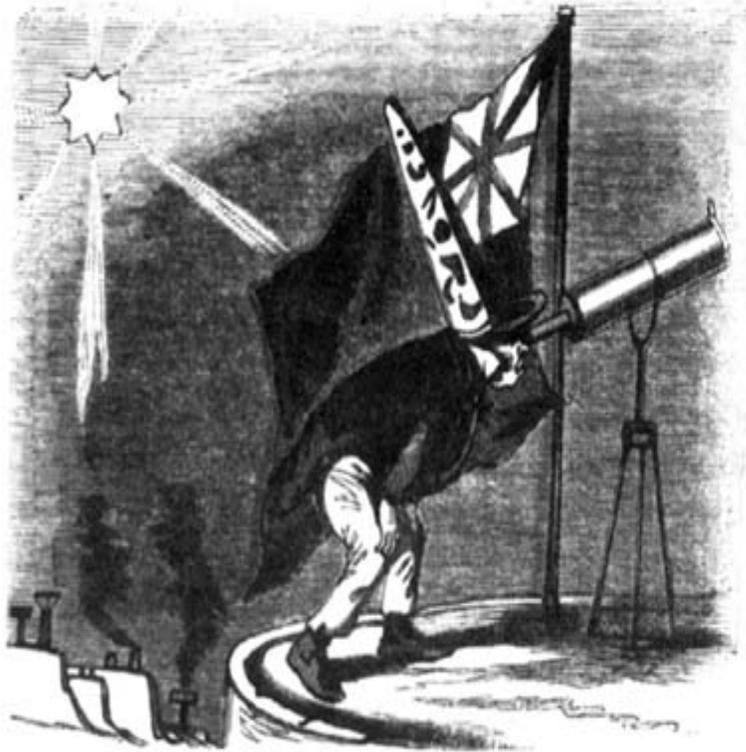
On 3 July 1841, while still an undergraduate, Adams made a note that he had decided to investigate:-

... the irregularities of the motion of Uranus...in order to find out whether they may be attributed to the action of an undiscovered planet beyond it.

In September 1845 Adams gave accurate information on the position of the new planet to James Challis, director of the Cambridge Observatory. Challis gave

Adams a letter of introduction to [Airy](#), the Astronomer Royal at Greenwich. Adams twice called at Greenwich during October attempting to see [Airy](#), but he had not made an appointment and was unsuccessful. He did leave the data giving his predicted position which [Airy](#) received and sent a letter to Adams with what he considered a vital question. Adams felt that [Airy](#)'s question was trivial and so did not reply. Action was not taken by the Cambridge Observatory.

Sampson writes [[5](#)]:-



[Urbain Le Verrier](#)'s prediction was published in June 1846 while Adams' prediction was still only known to Challis and [Airy](#). Despite this published prediction being close to that of Adams, he still made no claim regarding his precedence. Strangely, [Airy](#) wrote to [Le Verrier](#) with the same question he had posed to Adams, but still did not mention Adams' prediction (in fact Adams' name was not mentioned). It was [Le Verrier](#)'s prediction which led to the discovery of Neptune on 23 September 1846 by Galle at the Berlin Observatory.

Hutchins writes in [3]:-

The questions which are suggested by the appearance of Saturn's Rings cannot, in the present state of Astronomy, call forth so great an amount of labour among mathematicians. I am not aware that any practical use has been made of Saturn's Rings, either in Astronomy or in Navigation. They are too-distant, and too insignificant in mass, to produce any appreciable effect on the motion of other parts of the Solar system; and for this very reason it is difficult to determine those elements of their motion which we obtain so accurately in the case of bodies of greater mechanical importance.

But when we contemplate the Rings from a purely scientific point of view, they become the most remarkable bodies in the heavens, except, perhaps, those still less useful bodies - the spiral nebulae.

When we have actually seen that great arch swung over the equator of the planet without any visible connection, we cannot bring our minds to rest. We cannot simply admit that such is the case, and describe it as one of the observed facts in nature, not admitting or requiring explanation. We must either explain its motion on the principles of mechanics, or admit that, in the realms of Saturn, there can be motion regulated by laws which we are unable to explain ...

We know, since it has been demonstrated by Laplace, that a uniform solid ring cannot revolve permanently about a planet. We propose in this Essay to determine the amount and nature of the irregularity which would be required to make a permanent rotation possible. We shall find that the stability of the motion of the ring would be ensured by loading the ring at one point with a heavy satellite about four and one-half times the weight of the ring, but this load, besides being inconsistent with the observed appearance of the rings, must be far too artificially adjusted to agree with the natural arrangements observed elsewhere, for a very small error in excess or defect would render the ring again unstable.

We are, therefore, constrained to abandon the theory of a solid ring, and to consider the case of a ring, the parts of which are not rigidly connected, as in the case of a ring of independent satellites, or a fluid ring.

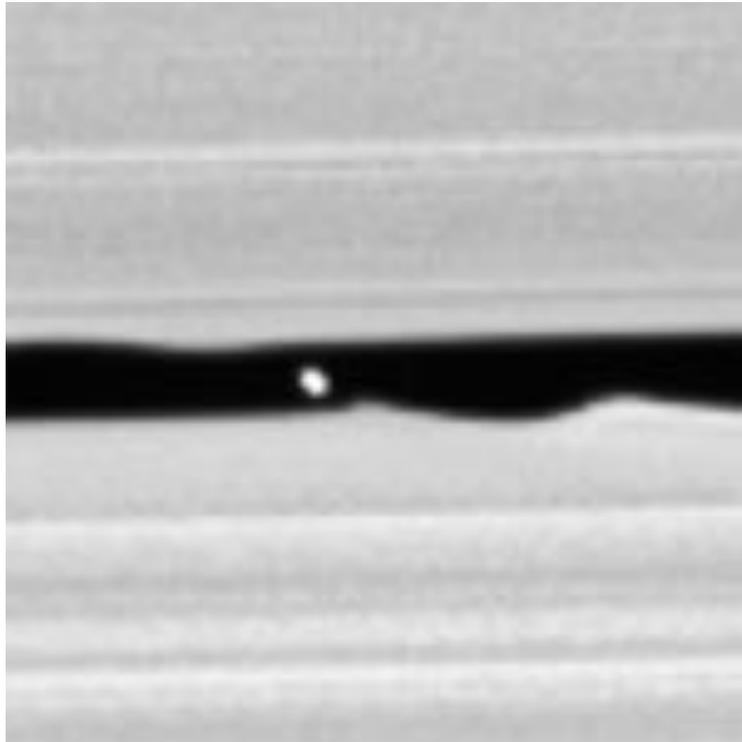
The final result, therefore, of the mechanical theory is, that the only system of rings which can exist is one composed of an indefinite number of unconnected particles, revolving round the planet with different velocities according to their respective distances. These particles may be arranged in series of narrow rings, or they may move through each other irregularly. In the first case, the destruction of the system will be very slow, in the second case, it will be more rapid, but there may be a tendency towards an arrangement in narrow rings, which may retard the process.

In 1895, Keeler spectroscopically measured the rotation speeds at different parts of the rings of the Saturn, at the Allegheny Observatory in Pittsburgh. He verified the effects mathematically predicted by James Clerk Maxwell in 1857. The velocities of rotation varied from 20 kilometers per second at the inner edge of the B ring to just under 16 kilometers per second at the outer edge of the A ring. This confirmation of Maxwell's hypothesis brought Keeler worldwide fame.

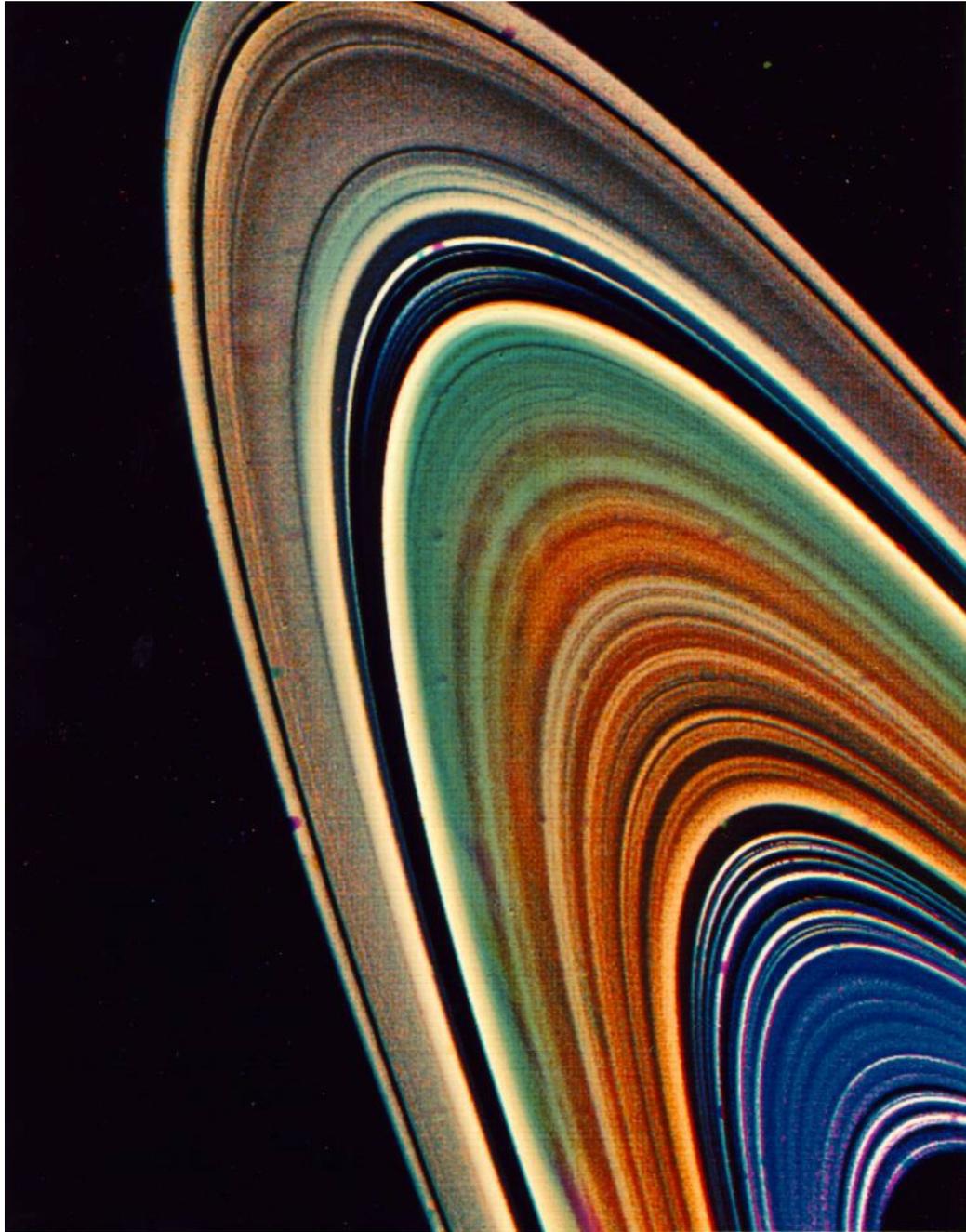


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James Edward Keeler (1857-1900), American astronomer, late 1890s.

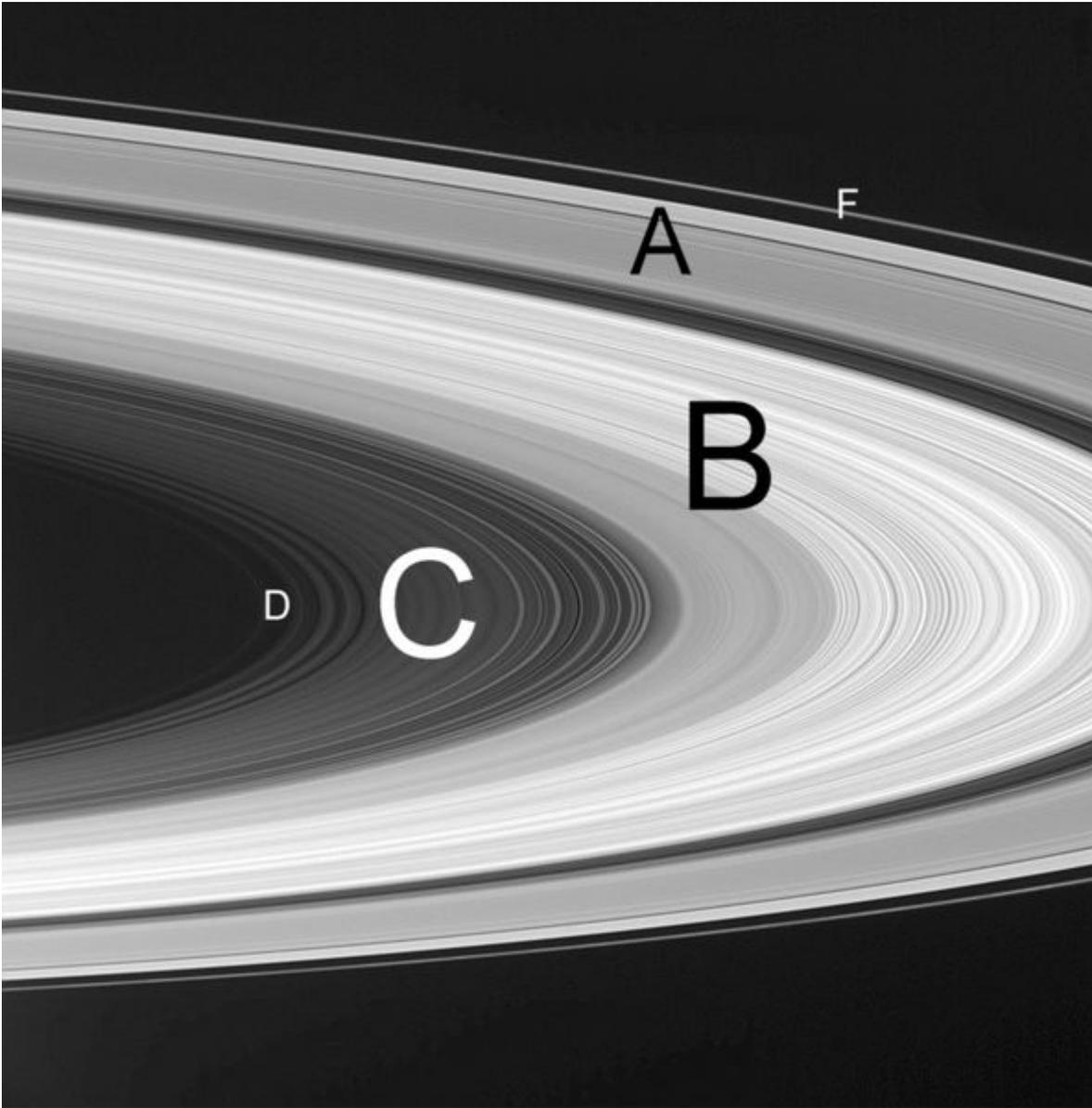


*La brecha de J. Keeler,
vista por la sonda Cassini,
en 2005.*



The planet Saturn is surrounded by several concentric flattened rings, which appear to be quite free from any connection with each other, or with the planet, except that due to gravitation.

The outer diameter of the whole system of rings is estimated at



*Division
de Maxwell
entre los anillos
B y C*



**Un modelo de los Anillos de Saturno,
Hecho por James Maxwell.**

Visión en Colores (1861).



Maxwell hizo varios trabajos sobre la percepción de los colores, y produjo la primera fotografía a color (introdujo el método RGB).

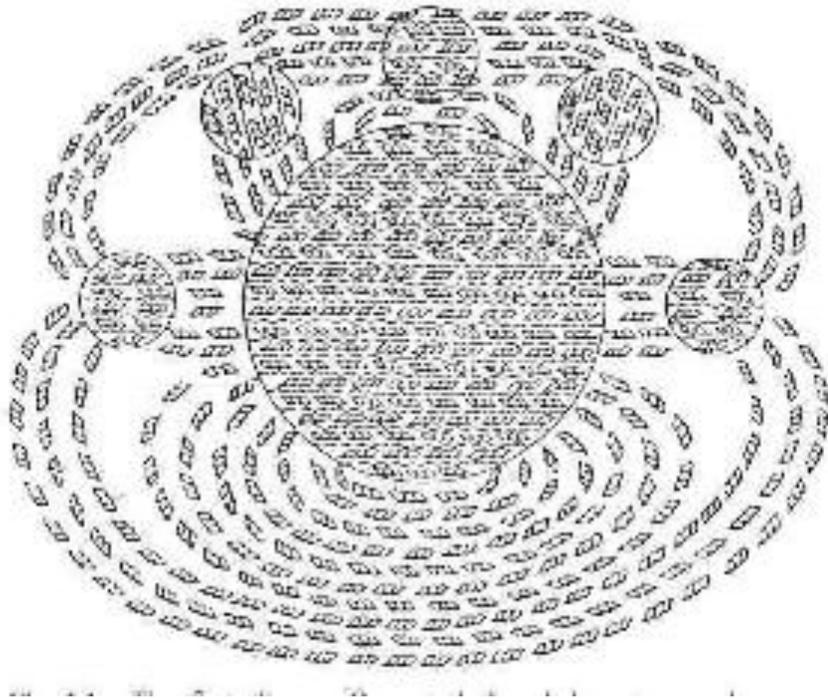


FIRST COLOUR PHOTOGRAPH
EVER MADE

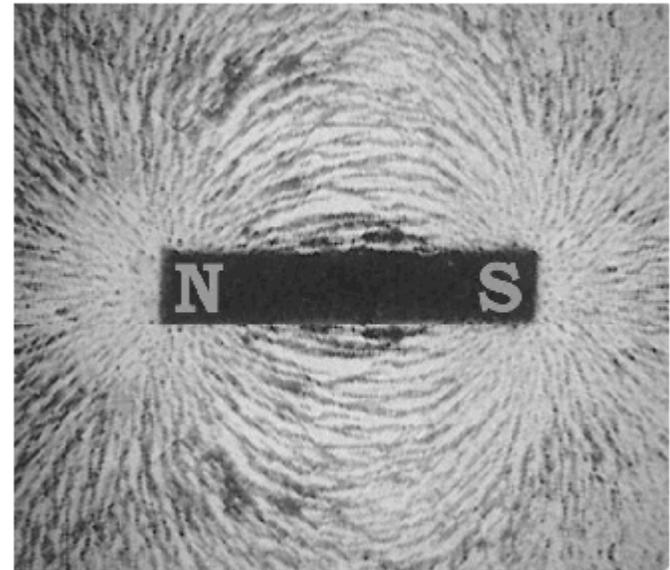
NEGATIVES BY
CLERK MAXWELL IN 1861

Primera fotografia a color (J. Clerk Maxwell, 1861).

*Lineas de Fuerza: Petrus Peregrinus, William Gilbert, Descartes,
Michel Faraday, Maxwell.*



*Lineas de Fuerza del Campo
Magnetico, según Descartes.*



*Lineas de Campo Magnético,
Experimentos de Faraday.*

INTRODUCCIÓN DE LA CORRIENTE DE DESPLAZAMIENTO:

...electromotive force acting on a dielectric produces a state of polarization of its partsIn a dielectric under induction, we may conceive that electricity in each molecule is so displaced that one side is rendered positively, and the other negatively electrical, But that the electricity remains entirely connected with the molecule, and does not pass from one molecule to another.

The effect of this action on the whole dielectric mass is to produce a general displacement of the electricity in a certain direction. This displacement does not amount to a current, because when it has attained a certain value it remains constant, but it is the commencement of a current, and its variations constitute currents in the positive or negative direction, according as the displacement is increasing or diminishing. The amount of the displacement depends on the nature of the body, and on the electromotive force...

J.C. Maxwell, "On Physical Lines of Force", Phil. Mag. 161-175, 281-291, 338-348 (1861).

LA LUZ, UN FENOMENO ELECTROMAGNÉTICO (ca. 1862):

*...the velocity of light in air, as determined by M. Fizeau, is ...195.647 miles per second. The velocity of transverse undulations in our hypothetical medium ... agrees so exactly with the velocity of light calculated from the optical experiments of M. Fizeau, that **we can scarcely avoid the inference that lights consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena.***

James Clerk Maxwell, “A dynamical theory of the electromagnetic field”, Phil. Transactions of the Royal Society (London) 155 (1865).

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \qquad \nabla \cdot \vec{D} = \rho$$

$$\vec{D} = \epsilon_0 \vec{E} + \vec{P}$$

$$\nabla \times H = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

Teoría Cinética de Gases:

*J.C. Maxwell, “Illustrations of the Dynamical Theory of Gases”
Phil. Mag. 19 (1860), pp. 19-32;*

*J.C. Maxwell, “On the results of Bernoulli’s theory of gases as
applied to their internal friction, their diffusion, and their
Conductivity for heat”, Report of the 30th Meeting of the British
Association for the Advancement of Science, part 2 (1860): 15-16.*

*J.C. Maxwell, “Viscosity of internal friction of air and other gases”,
Phil. Transactions of the Royal Society of London 156 (1866), 249-268.*

Aportes cruciales a la ingeniería:

1. J. Clerk Maxwell, “On governors”, Proc. Royal Society, 100 (1868).

Sentó las bases del **Control Automático.**

2. Desarrollo también las bases del **cálculo estructural.**

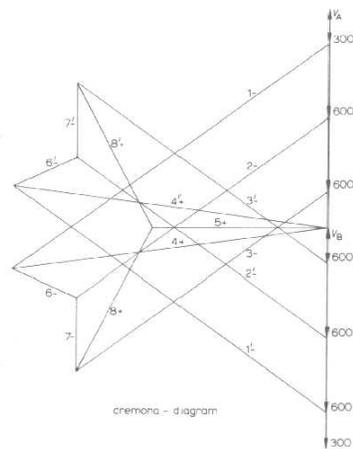
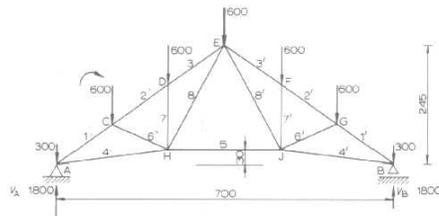
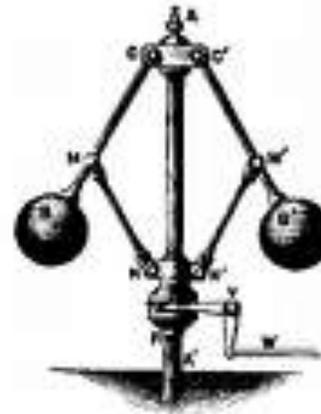


Diagrama de Maxwell-Cremona.



That this House notes the 175th anniversary of the birth in Edinburgh on 13th June 1831 of the great Scottish scientist James Clerk Maxwell; notes that by discovering the nature of electromagnetic waves he paved the way for radio, television, radar and the mobile telephone; acknowledges the tributes paid to him by Max Planck who described his theory as 'one of the greatest triumphs of human intellectual endeavour' and Einstein who said 'One scientific epoch ended and another began with James Clerk Maxwell'; congratulates the James Clerk Maxwell Foundation on preserving his birthplace in Edinburgh and promoting the study of science by young people; further notes the programme of events to honour Maxwell in this anniversary year; and encourages all who wish to learn more to visit the website at www.maxwellyear2006.org.

*Bill passed by the UK parliament, 27 de Abril de 2006.
Also, 28/6/06*

James Jeans (1931): Celebración del centenario de Maxwell.

... many think that Maxwell's study of the particles of Saturn's rings led him directly and inevitably into the realm of the kinetic theory of gases, in which so much of his life was spent. However this may be, when he crossed the bridge from Astronomy to Physics he left behind him for ever the prospect of becoming a great astronomer - but only to become the greatest mathematical physicist the world has seen since Newton.

Max Planck (1931): Celebración del centenario de Maxwell.

... it was his task to build and complete the classical theory, and in so doing he achieved greatness unequalled. His name stands magnificently over the portal of classical physics, and we can say this of him: by his birth, James Clerk Maxwell belongs to Edinburgh, by his personality he belongs to Cambridge, by his work he belongs to the whole world.



James Clerk Maxwell.

THE LIFE
OF
JAMES CLERK MAXWELL

WITH A SELECTION FROM HIS CORRESPONDENCE

AND OCCASIONAL WRITINGS

AND

A SKETCH OF HIS CONTRIBUTIONS TO SCIENCE

BY

LEWIS CAMPBELL, M.A., LL.D.

PROFESSOR OF GREEK IN THE UNIVERSITY OF ST. ANDREWS

AND

WILLIAM GARNETT, M.A.

LATE FELLOW OF ST. JOHN'S COLLEGE, CAMBRIDGE
PROFESSOR OF NATURAL PHILOSOPHY IN UNIVERSITY COLLEGE, NOTTINGHAM

WITH THREE STEEL PORTRAITS, COLOURED PLATES, ETC.

London

MACMILLAN AND CO.

1882



$$\nabla \cdot \vec{E} = 4\pi\rho \quad \nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

175
JAMES
CLERK
MAXWELL

$$\nabla \times \vec{B} = \frac{4\pi}{c}\vec{j} + \frac{1}{c}\frac{\partial \vec{E}}{\partial t} \quad \nabla \cdot \vec{B} = 0$$