



Софья Васильевна Ковалевская

# Sonya Kovalevsky

**A brilliant  
mathematical physicist,  
her life and work**

Rafael Benguria

Villa Pauli, Djursholm  
December 3, 2012

“Hamiltonians in Magnetic Fields”,  
Institut Mittag Leffler,  
Fall Semester 2012.



Gabrielle Émilie Le Tonnelier de Breteuil,  
marquise du Châtelet (1706-1749)



First woman to have a  
university chair.

Professor of Anatomy,  
University of Bologna  
(1732).

Professor of  
Experimental Physics,  
Science Institute,  
Bologna (1776).

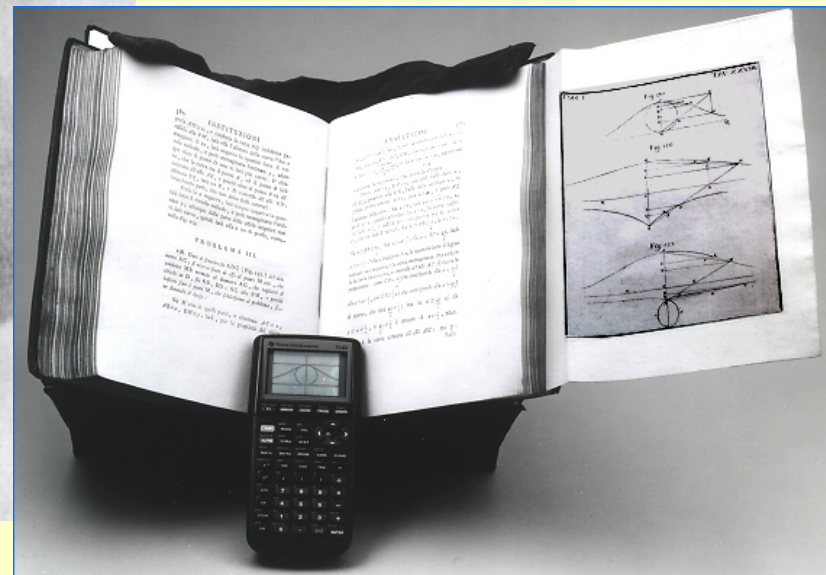


Laura Bassi (1711-1778):



# María Gaetana Agnesi (1718-1799)

Instituzioni analítiche ad uso  
della gioventù italiana (1748)





“Sophie Germain at 14”,  
painting of Auguste E. Leray

## Sophie Germain (1776-1831)

In 1816 wins the Prize of the  
French Academy of Sciences, Paris  
for explaining the Chladni figures.

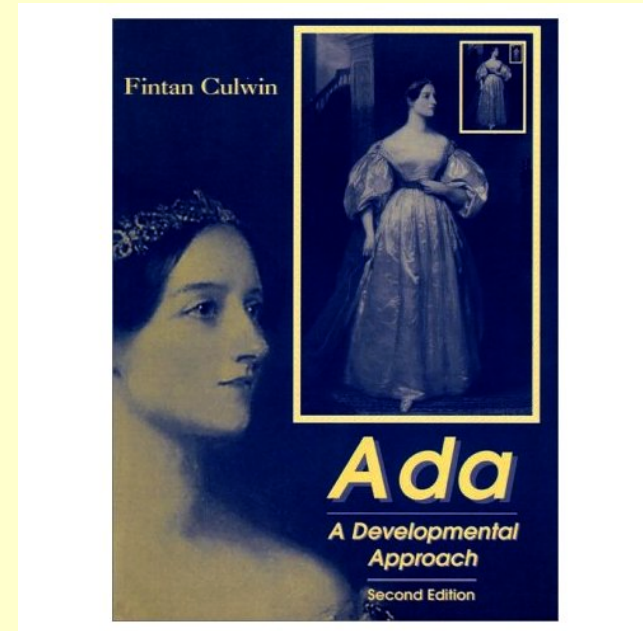
Creates the Theory of Elasticity.  
Makes important contributions  
in Number Theory





## Lady Ada Byron (1815-1852)

Writes the “first computer program”:  
(calculation of the Bernoulli numbers).



Monograph on the computer programming  
language “ADA”, introduced in 1983.



# Marie Skłodowska Curie (1867-1934)

Nobel Prize in Physics, 1903  
Nobel Prize in Chemistry, 1911

“...for her services in the advancement of chemistry by the discovery of the elements radium and polonium, by the isolation of radium and the study of the nature and compounds of this remarkable element.”  
--1911 Nobel Citation





# Maria Goeppert Mayer (1906-1972)

Discovered the shell structure of  
Atomic Nuclei

Nobel Prize in Physics, 1963



Lisa Meitner  
(1878-1968)

Discovered Nuclear Fission  
with Otto Hahn, and Otto Frisch  
in 1938.





**Sonya Kovalevsky  
(1850-1891)**

## Periods in the life of Sonya Kovalevsky:

Childhood: 1850-1868 (Moscow, Kaluga, Palibino, San Petersburgo)

University Years: 1869-1874 (Heidelberg and Berlin)

Intermediate Period: 1875-1883 (Moscow, etc.)

Academic Career: 1883-1891 (Stockholm)

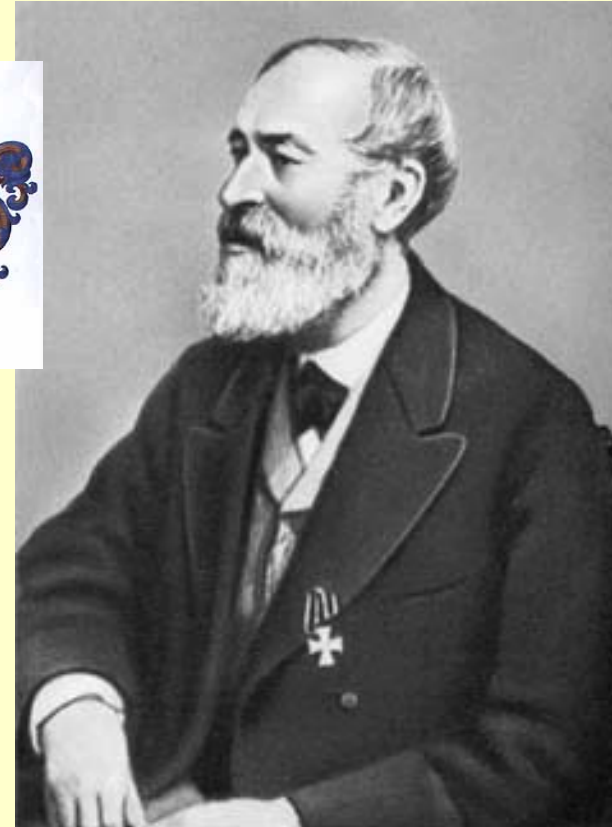
## Childhood (1850-1868)



Sophia Vasilevna Korvin-Krukovsky, age about 16



## Sonya Kovalevsky's parents



Elizaveta Shubert (1820-1879),  
granddaughter of Theodor Shubert,  
mathematician and astronomer

Vasilii V. Kryukovskoi (1800-1874),  
artillery official.



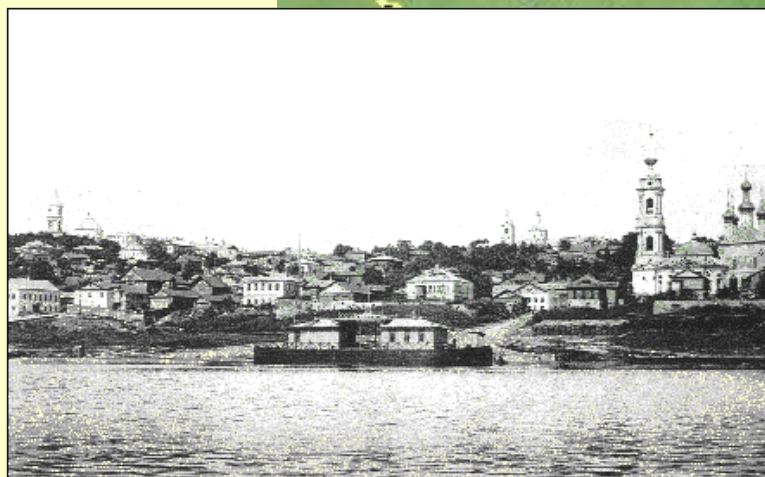
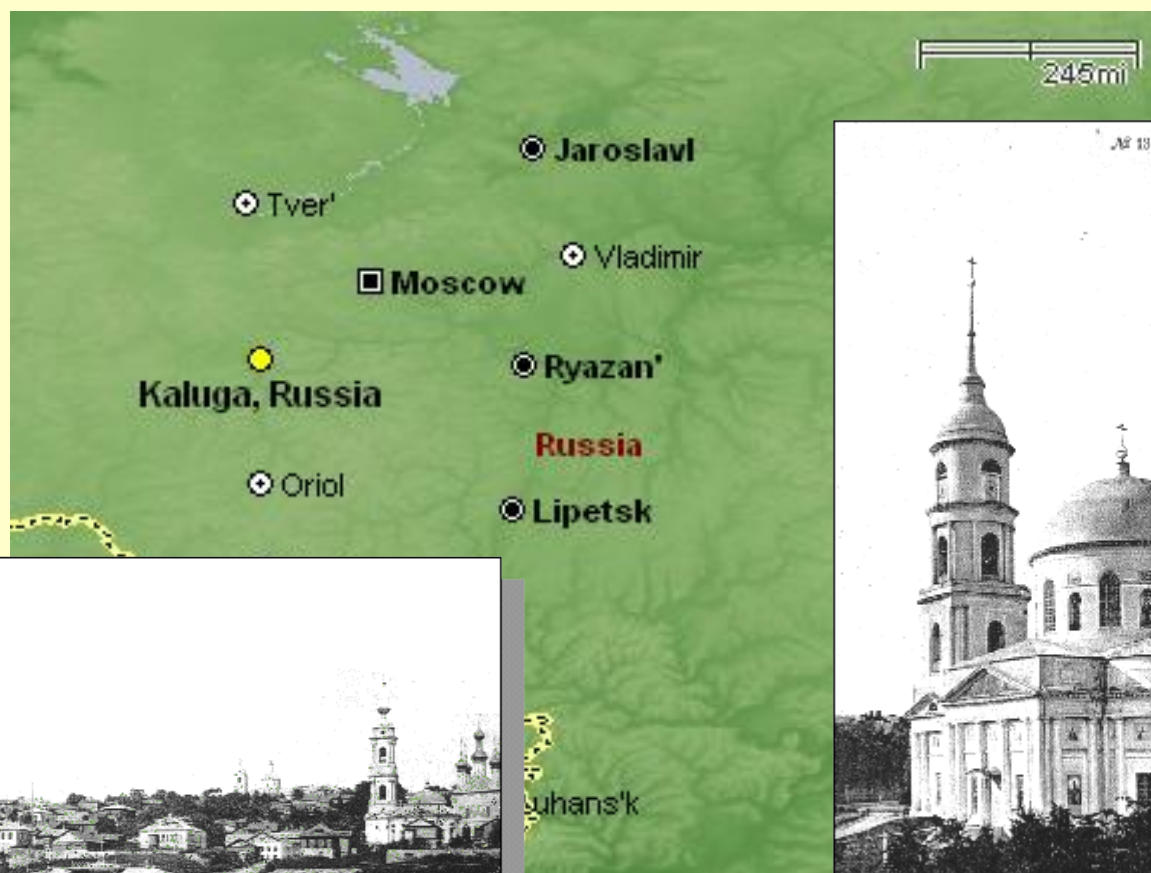
Moscow (ca. 1850)

Sonya was born in Moscow  
on January 15, 1850.

Her parents were married in 1843,  
and had three children:

1844	Ana (Anyuta)
1850	Sofia (Sonya)
1855	Fyodor

In 1853 the family moves to Kaluga (on the Oka River).  
They lived there during the period 1853-1858.





Views of Kaluga, and its surroundings.





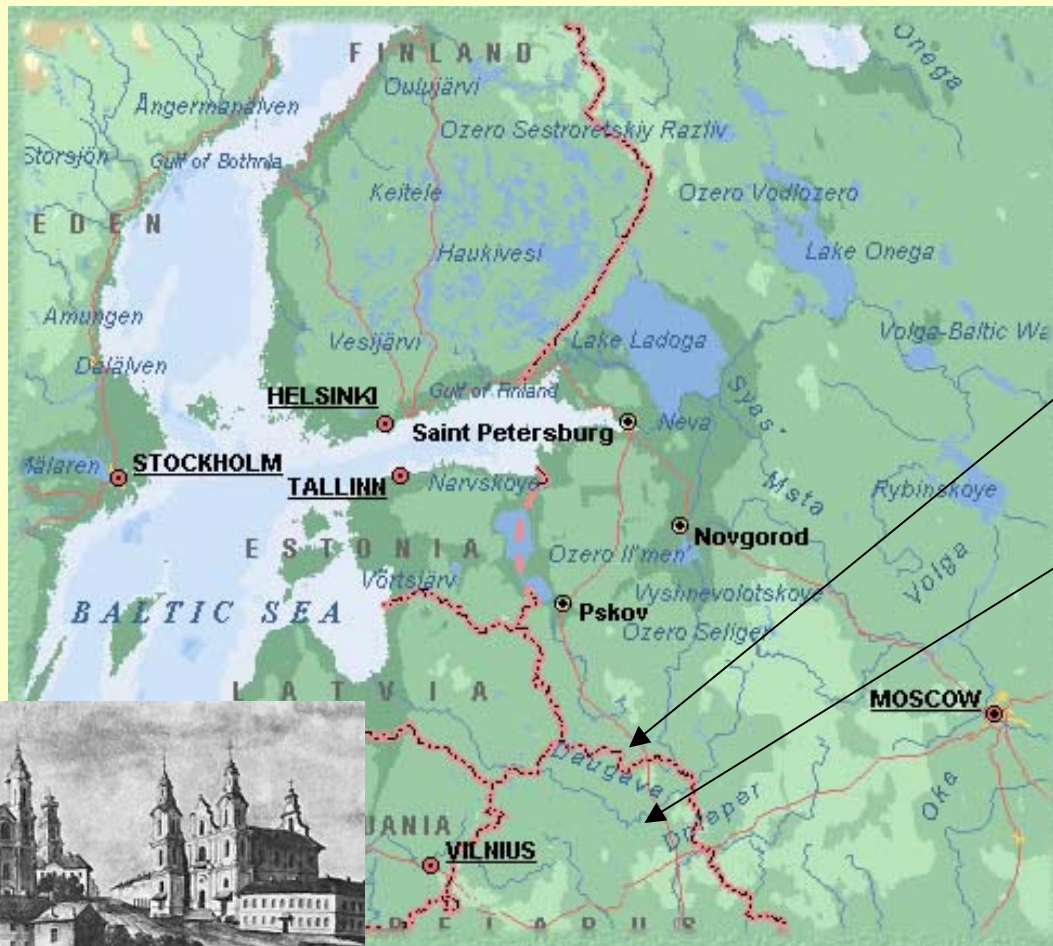
THE FALL OF SEBASTOPOL.  
CAPTURE OF THE MALAKOFF TOWER.

### Crimean War:

The Battle of Balaclava (1854); the Siege of Sevastopol (1854-55)



In 1858 her father retires and the family moves to Palibino.



Palibino,  
near  
Velikiye Luki

Vitebsk

Her father hires  
Margaret Smith  
as governess, and  
Joseph Malevich  
as tutor (1858).



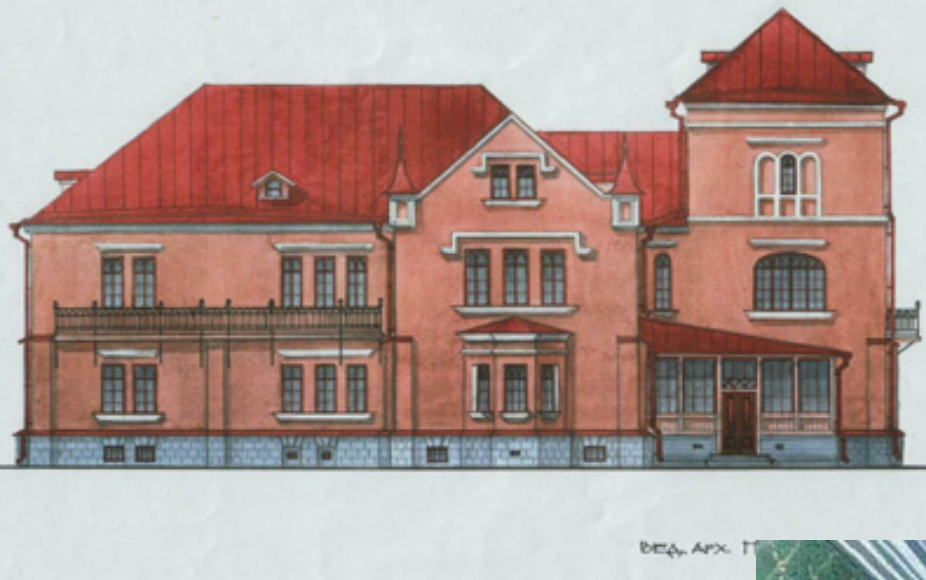


Anyuta  
SK's oldest sister



Margaret Smith,  
SK's governess

ИМЕНИЕ ПОЛИБИНО. ДОМ-МУЗЕЙ С.В. КОВАЛЕВСКОЙ. СЕВЕРНЫЙ ФАСАД.



Exterior and interior of the home of Sonya Kovalevsky's family in Palibino.

Now, this house is a Russian Museum dedicated to SK.







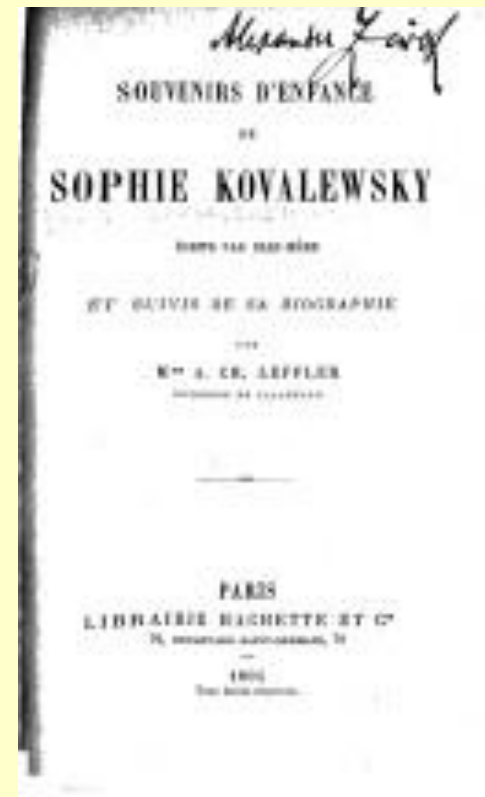
Sophia Vasilevna Korvin-Krukovsky, age about 16

The life of Sonya and Anyuta in Palibino is the subject of the book “Recollections of Childhood”, by SK.

It was originally published in Swedish, and later translated to many languages.

*Gösta Mittag-Leffler  
från hans lillgifna o. trofasta vän  
Sonya Kovalevsky*

Dedicatory to Gösta Mittag-Leffler by Sonya Kovalevsky, on the Swedish Edition of this book





Joseph Ignatovich Malevich

## Early influences:

Her uncle,  
Pyotr Vasilievich Krukovsky

Her tutor,  
Joseph I. Malevich

Her Physics Professor,  
Nicolás P. Tirtov (1864)

Her Mathematics Professor,  
Alexander N. Strannolyubskii (1839-1903)



Alexander Nikolayevich Strannoliubsky



## Intellectual Circles



Anyuta, sister of Sonya  
Published “The Dream”, in “**время**”,  
in 1863 (as Yuri Obryeloff)



Fedor Dostoevsky

Фёдор Миха́йлович Достоёвский  
(1821-1881)



## Ivan Turgenev (1818-1883)

In his novel “Fathers and Sons” popularized the term “Nihilist”.

With the popularizing of the word nihilism by Turgenev, a new Russian political movement called the Nihilism movement adopted the term. They supposedly called themselves nihilists because nothing "that then existed found favor in their eyes."

On September 15, 1868 Sonya got married with the paleontologist (1842-1883).

Sonya helped him translating the book “Variations of Animals and Plants”, by Charles Darwin. The first russian edition appear in 1868.



V. O. Kovalevski

SK and her husband move to Saint Petersburg, where Sonya meets Chebyshev, the famous russian mathematician.

On April 16, 1869, Sonya, Anyuta and Vladimir travel to Vienna, and later to Heidelberg.

# Correspondence with Charles Darwin

**Letter from Vladimir to Darwin:**

**St Petersburg**

**22 December 1868**

*“.....During this long time of silence I have changed my former state, and am now a married man; my young wife is a woman of quite an exceptional turn and, not being what You call strong minded at all, has a passion for natural science, especially mathematics & natural Philosophy (Physik) - this induced me also to leave for a time my editioneering and to become student myself; we go together in April in some small German university and will live there for two or three years to prepare ourselves for a long scientific travel in Siberia or in Central Asia, I hope you will help me in this with your large experience and knowledge...”*



There exist approximately 50 letters from the correspondence between Vladimir Kovalevsky and Charles Darwin.

Among them:

**Kovalevsky, V. O. to Darwin:**

**Letter 6890, 13 Sept 1869, Paris:**

Since March has been living in Heidelberg,  
where his wife is studying mathematics and physics.  
The Russian translation of Variation has been printed  
in his absence; he will bring a copy to Down if  
he receives one from Russia.

**Letter 9257, 27 Jan 1874, Berlin:**

On obtaining Clerk Maxwell's memoir on Saturn for his wife, Sofya.

Jan. 24<sup>7</sup> [1884]

Down,  
Beckenham, Kent.

My dear Sir

I have ordered by bookseller

to send (last Maxwell's)  
published by Macmillan & Co

book to you & I suppose it

will reach you in a few

days. - Please present it from

me to Mr. Kowalevsky.



Down Beckenham, Kent,  
Charles Darwin's Home.

Letter from Darwin to Vladimir,  
referring his sending the book  
by Maxwell to Sonya.

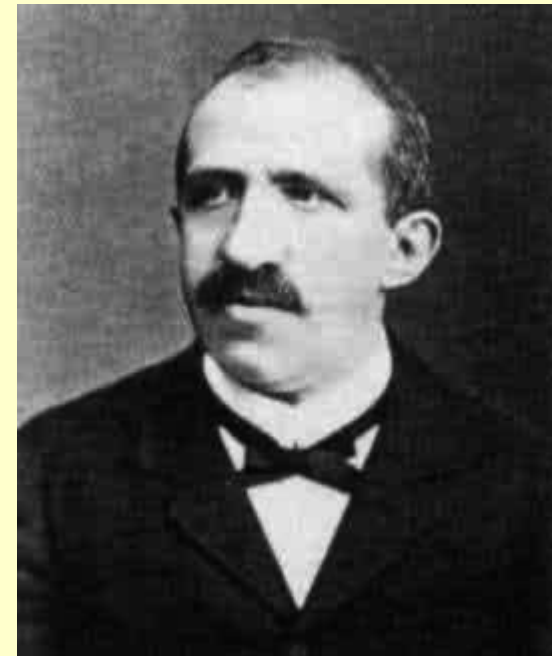
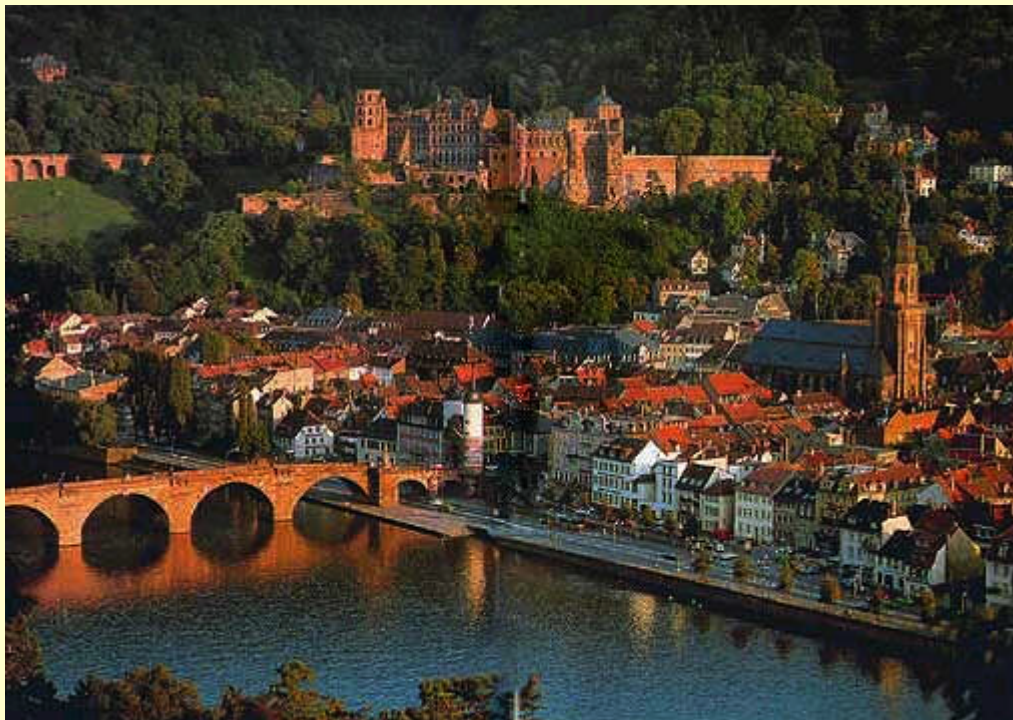
Yours truly  
Ch. Darwin

## University Years (1869-1874)



## Notes from the dary of Thomas Hirst:

....(27 July 1869) I attended Königsberger's lecture on the theory of determinants. He introduced me to a young Russian lady [Sofia Kovalevskaya] who attends his lectures and is at home in elliptic functions. She belongs to the mathematically gifted family of Schuberts. She is pretty and exceedingly modest.



Leo Königsberger (1837-1921)

Mathematics Professor  
Heidelberg University

Heidelberg and the river Neckar





## Julia V. Lermontova (1847-1919).

Юлия Всеволодовна Лермонтова



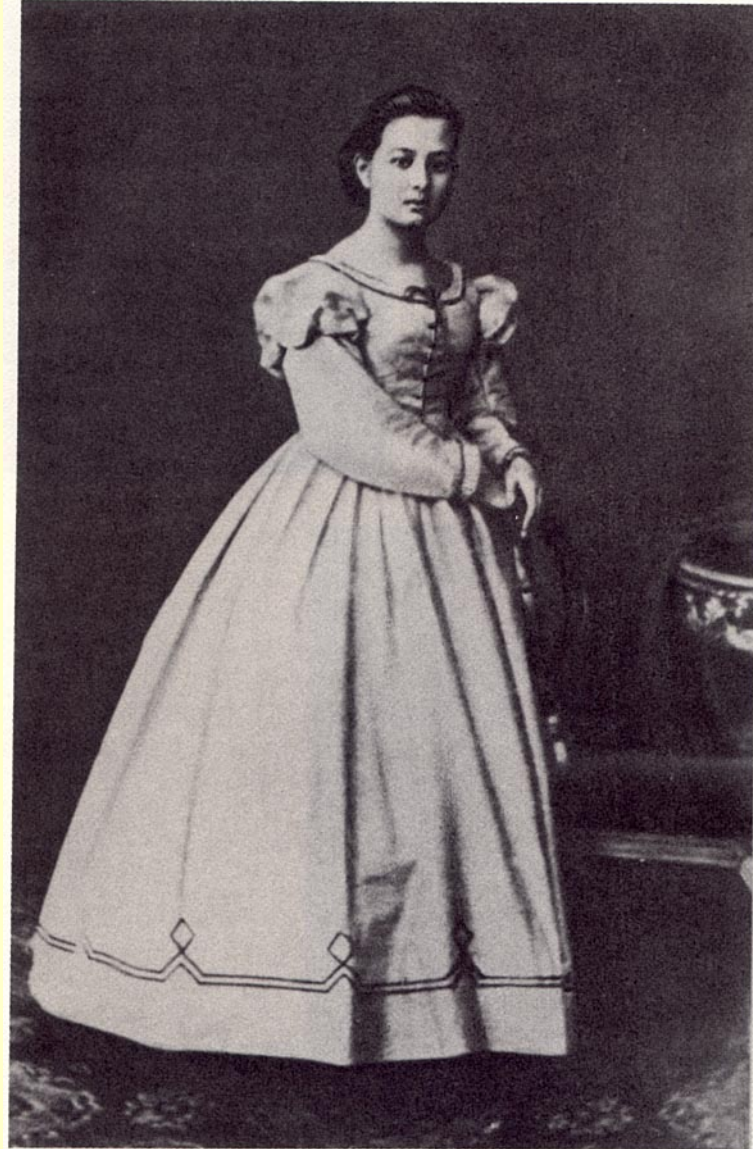
Sonya first corresponded with Julia, and later she meets her in Moscow.  
SK convinces her to study abroad. Julia also went to Heidelberg.  
Julia Lermontova became the first woman with a Ph.D. in Chemistry.  
She was a friend and played a very important role in the life of SK

In the summer of 1870, Sonya moves to Berlin, with the hope that she can enter the University of Berlin.

At the same time, Anyuta travels to Paris where she met Victor Jaclard.

In 1871, during the “Paris Comune” Sonya and Vladimir travel to Paris.

Vladimir gets his Ph.D. in Paleontology (U. Jena) in 1872.



Sofia Kovalevskaja in her mid-twenties.

# LA PRISE DE PARIS.

(MAI 1871)



*Reynard & Co. sc. 101. Rue de la Harpe, 101.*

La barricade de la place Blanche défendue par des Femmes.





Karl Weierstrass  
(1815-1897)

Ph.D. advisor of  
Sonya Kovalevsky  
University of Berlin





In 1874, Sonya Kovalevsky gets her Ph.D. (in absentia) from Göttingen University.

Her Ph.D. thesis consisted of three different research topics:

- i) On the solutions of Partial Differential Equations (published in the “Journal für die reine und angewandte Mathematik” [CRELLE’s]).
- ii) Properties of Abelian Integrals.
- iii) Stability of the Rings of Saturn.

In September 1874 Sonya goes back to Moscow. Vladimir, Sonya and Julia have all gotten their respective Ph.D.'s.



# Zur Theorie der partiellen Differentialgleichungen \*).

(Von Frau *Sophie von Kowalevsky*.)

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## E i n l e i t u n g.

Es sei eine algebraische Differentialgleichung

$$(1.) \quad G\left(x, y, \frac{dy}{dx}, \dots \frac{d^n y}{dx^n}\right) = 0$$

vorgelegt, wo ***G*** eine ganze rationale Function der unabhängigen Veränderlichen ***x***, der **als** Function derselben zu bestimmenden Grösse ***y*** und der Ableitungen **derselben** nach ***x*** bis zur ***n*<sup>ten</sup>** Ordnung hin bedeutet.

Article of Sonya Kovalevsky (based on her Ph.D. thesis)  
published in the “Journal für die reine und angewandte Mathematik”  
vol. 80, pp. 1-32 (1875). [CRELLE’s Journal].

Abelian Integrals, also called hyperelliptic integral, is an integral of the form:

$$\int_0^x \frac{dt}{\sqrt{R(t)}},$$

where  $R(t)$  is a polynomial of degree greater or equal to 4.

## **Monsieur Le Blanc: Sophie Germain.**

*During the first decade of the XIXth century, Gauss had an extensive scientific correspondence on Number Theory with, supposedly a French Mathematician, Monsieur Le Blanc. In 1806, after the defeat of Ferdinand by Napoleon, the Duchy of Braunschweig was occupied by the French troops. “M. Le Blanc” worried about sending a personal protection to Gauss. Due to this, Gauss finally realized that “M. Le Blanc” was indeed the french mathematician **SOPHIE GERMAIN***



***Sonya Kovalevsky,***  
*Got her Ph.D. “in absentia”  
at Göttingen University*

***Emmy Noether,***  
*Professor,  
Göttingen University*





## INTERMEDIATE PERIOD (1874-1883)



Back in Russia Sonya cannot find an academic position.

Participated in some mathematical conferences in Saint Petersburg.

In several occasions she contributes to Novoe Bremia (New Times)

1874 Sonya's father dies.

1878 In Octobre, Sofia Vladimirovna (Fufa, Foufie) (1878-1951), the daughter of Sonya and Vladimir is born.

1879 Sonya's mother dies.



Notes of Gösta Mittag-Leffler's diary (written in retrospective in 1923)  
on his encounter with Sonya Kovalevsky in Saint Petersburg on February 1876.

What interested me most in Saint Petersburg was making the acquaintance of Madame Kovalevsky. I spent several hours with her today. She is a delightful woman. She is beautiful and when she talks her face lights up with an expression of feminine good will and superior intelligence that one cannot help being dazzled by. Her manners are simple and natural with no trace of pedantry or affectation. In short, a "high society woman" in all respects. As a scholar she is distinguished by a rare clarity and a precision of expression, as well as an extraordinarily quick perception. It is also easy to see the degree of profundity to which she has pursued her studies, and I understand perfectly why Weierstrass regards her as the most talented of his students.



Gösta Mittag-Leffler (1846-1927)

With the purpose of retaking her research career, in October 1880, Sonya travels to Berlin to work with Weierstrass.

She comes back to Berlin the next year, 1881 (this time with Fufa).

In the fall of 1881, she moves to Paris (at first with Fufa), but in April 1882, Fufa goes back to Moscow.

On April 27, 1883, her husband Vladimir O. Kovalevsky commits suicide, overburdened by severe economic problems.



## ACADEMIC CAREER (STOCKHOLM) 1883-1891



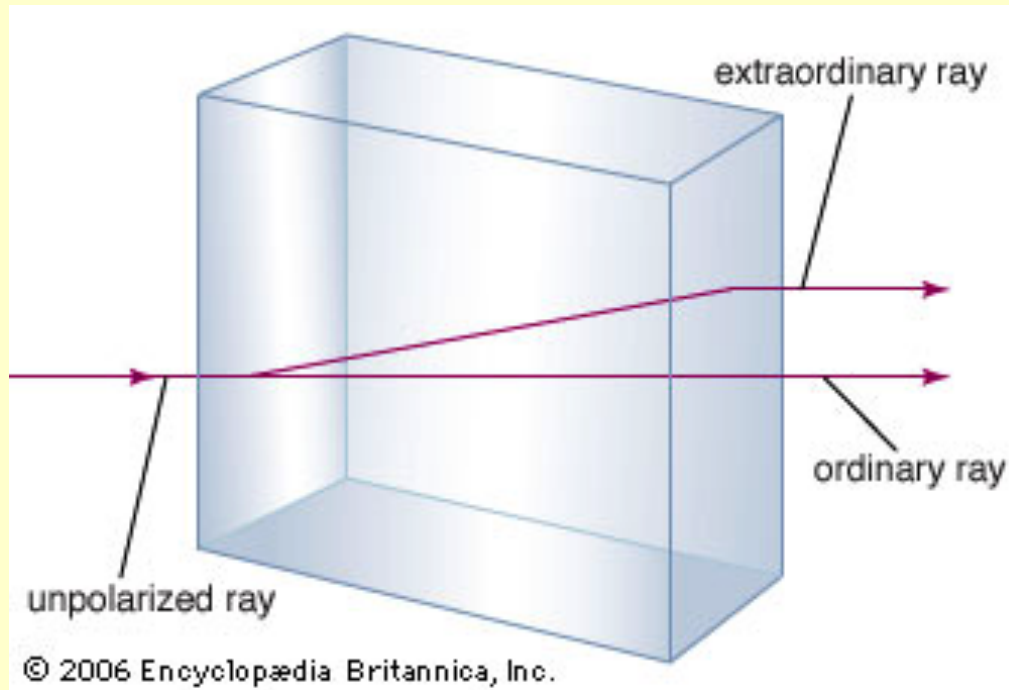


En 1884, Sonya Kovalevsky obtains the right to teach at the University of Stockholm. Her first lecture was on January 30, 1884.

The same year she is named “Professor Extraordinarius” for a period of five years.

In 1889, she is finally promoted to Full Professor and she becomes the third woman to obtain a chair in mathematics or physics in a European University.

## Sonya Kovalevsky's work on the Iceland Crystals



Between 1881 and 1883 she works on the problem of the double refraction of light by anisotropic materials. She published three articles, among them:

Über die Brechung des Lichtes in kristallinen Mitteln,  
Acta Mathematica, vol. 6, 219-304 (1883).



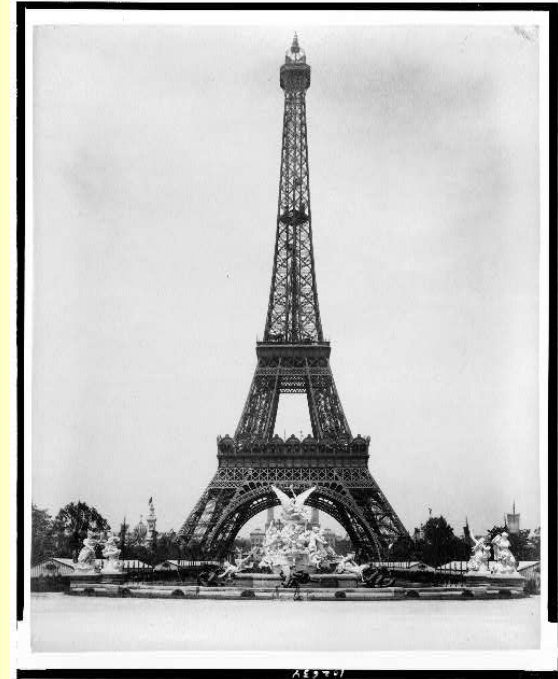
Sonya and Foufie

Stockholm, ca. 1886



## PRIX BORDIN:

In 1888, Sonya gets the “Bordin Prize” of the French Academy of Sciences for her work on the dynamics of the top. Her work is considered so outstanding that the jury decides to double the amount of money awarded with the prize.



*Integrar las ecuaciones del movimiento de un cuerpo sólido que gira alrededor de un punto fijo, sobre el que no actúa ninguna fuerza externa salvo la gravitatoria, mediante series que representen explícitamente como funciones del tiempo todas las cantidades requeridas para determinar el movimiento.*

Her fame in France, and in the rest of Europe reaches its highest point. She is invited as a guest of honor to the Paris Exposition of 1889. en 1889.

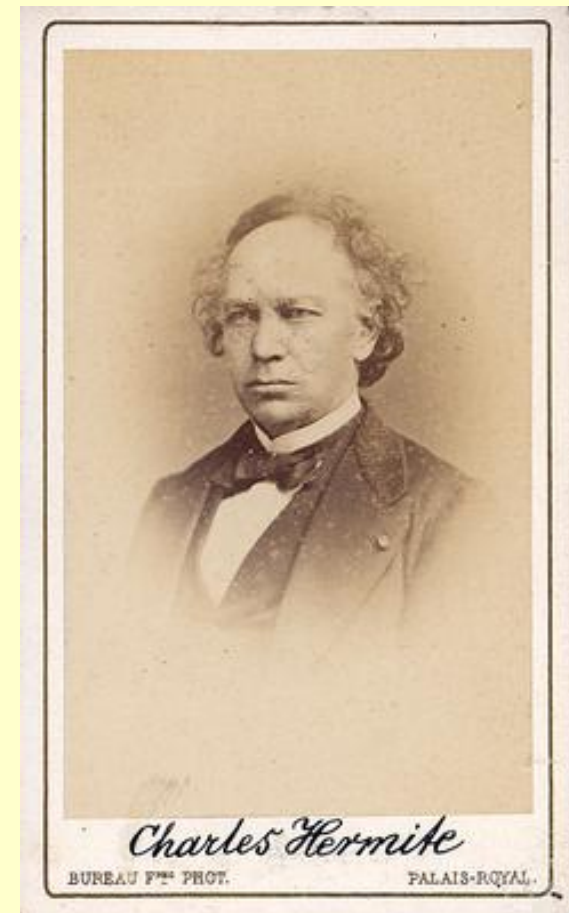
**Final paragraph of the recommendation of Charles Hermite  
supporting the promotion of Sonya Kovalevsky to Full Professor:**

“...pour déclarer hautement, que par  
l'ensemble de ses oeuvre j'estime  
que Mme. de Kowalevski, c'est  
placée dans l'élite des Analystes  
de notre temps...”

Charles Hermite

Paris, 21 Mai 1889

Several other letters of support, including  
one by Beltrami.



Article on the motion of the rigid solid, published in  
Acta Mathematica vol. 12, pp. 177-232 (1889).

SUR LE PROBLÈME DE LA ROTATION  
D'UN CORPS SOLIDE AUTOUR D'UN POINT FIXE <sup>1</sup>

PAR

SOPHIE KOWALEVSKI  
À STOCKHOLM.

§ 1.

Le problème de la rotation d'un corps solide pesant autour d'un point fixe peut se ramener, comme on sait, à l'intégration du système d'équations différentielles suivant:

$$A \frac{dp}{dt} = (B - C)qr + Mg(y_0 r'' - z_0 r'), \quad \frac{dr}{dt} = r r' - q r'',$$



Starting in the 1960's, with the interest raised by the study of exactly integrable systems, the solution of Sonya Kovalevsky to the “rigid top”, attained great relevance. See, for example, the article,



**The Kowalewski top 99 years later: a Lax pair, generalizations and explicit solutions**

A. I. Bobenko, A. G. Reyman and M. A. Semenov-Tian-Shansky

Source: [Comm. Math. Phys.](#) Volume 122, Number 2 (1989), 321-354.



Mittag-Leffler Villa in Djursholm (Now Institute Mittag-Leffler).





## SONIA KOVALEVSKY

WHAT I KNOW ABOUT HER FROM  
PERSONAL ACQUAINTANCE  
AND WHAT SHE TOLD ME ABOUT HERSELF

BY  
ANNA CARLOTTA LEFFLER  
DUCHESS OF CAJANELLO



Anna Charlotta Leffler (1849-1892): sister of Gösta Mittag-Leffler.



Kovalevskaya at age about 37

In 1888 she meets  
Maxim Kovalevsky,

In 1890 travels to the French  
Riviera and the North of Italy.



Jag mår inte bra. Jag har fått influensa och dumt nog besökte jag Gyldéns igår kväll. På natten hostade jag mycket och hade hög feber. Nu har jag så ont i bröstet och känner mig så sjuk att en läkare bör tillkallas. Skicka bud efter din läkare så han kan komma så fort som möjligt.



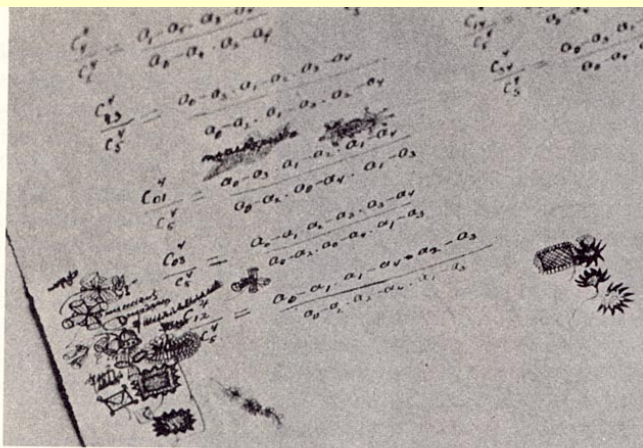
Swedish Astronomer Hugo Gylden (1841-1896)



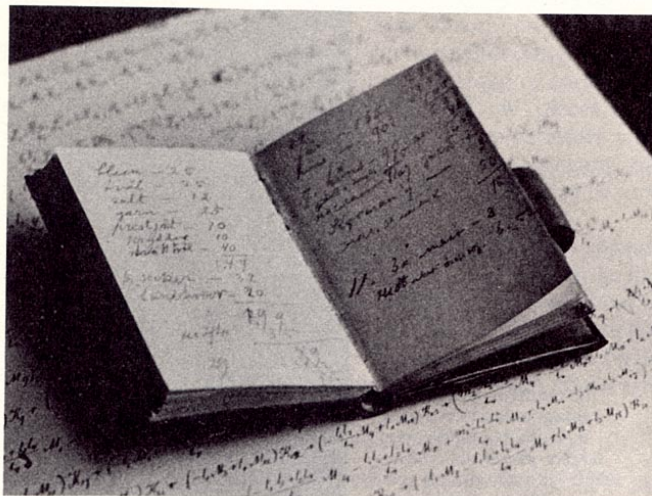
Sonya Kovalevsky's  
grave at the  
Norra Begravningsplatsen  
cemetery in Stockholm



Robiliz photo



Typical page of Kovalevskaia's mathematical computations, complete with doodles. (Institut Mittag-Leffler archives—Angela Wängler photo)



Kovalevskaia's household account book (she kept track of every penny, since she was always in straightened financial circumstances) lying on top of a page of intricate computations. (Institut Mittag-Leffler—Angela Wängler photo)





Alexander O. Kovalevsky  
(1840-1901),

Russian embryologist,  
brother of Vladimir Kovalevsky



Пришло ли раз вам безразлично  
Безразлично среди толпы гулять  
И вдруг какой то песни страстной  
Случайно звуки услышать

На вас мурдашного вальса  
Нахнула память преданных лет  
И <sup>это то</sup> ~~столько~~ <sup>се</sup> ~~милых~~ <sup>родных</sup>  
Вздумать откликнулось в субботу.

Казалось вам что эти звуки  
Вам в детстве слышались не раз  
Так много счастья, юности, смеха  
В них вспоминалось для вас.

Слышим вы привлекательный звук  
Нам в знакомый уловив.  
Копьёсь вам за казённым звуком  
За казённым словом уловив



## Nostalgie (?)

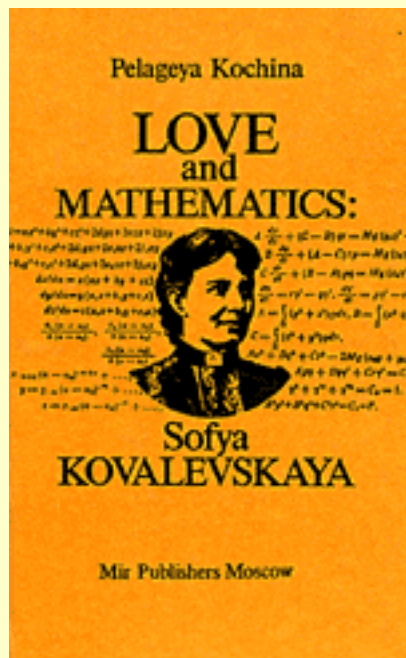
Vous est-il déjà arrivé d'errer indifféremment dans la foule, sans intention, ,  
Et d'être surpris par un chant vibrant de passion?

Déferlante, la vague des souvenirs d'antan s'abat sur vous,  
Et murmure à votre coeur un sentiment familier et doux.

Cette mélodie, comme surgissant de l'enfance,  
Vous rappelle tant de joies, et de souffrances.

Impatient de faire vôtre cette bouleversante chanson,  
Vous vous appliquez à en vivre chaque mot, chaque son.

A translation from the original Russian by Elena Farlova (U. Montreal)  
Corrected and adapted by Nicolas Raymond (U. Rennes)

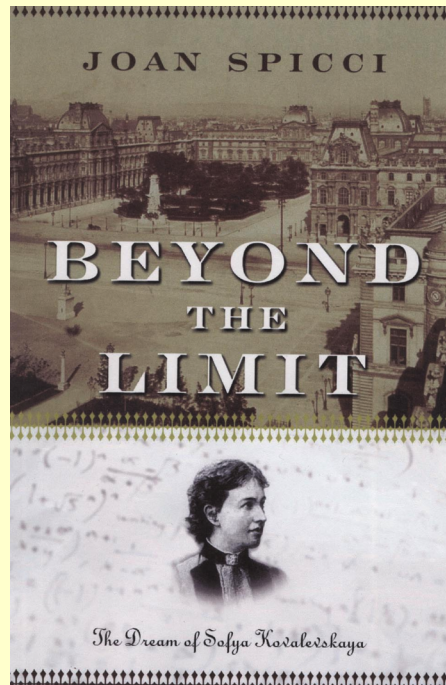


There are many books on the life of Sonya. One of the best knowns is the book by Pelageya Kochina: “Love and Mathematics”.

For the mathematical work of Sonya, see, e.g.,

Roger Cooke, “The Mathematics of Sonya Kovalevskaya”, Springer-Verlag, NY, 1984.





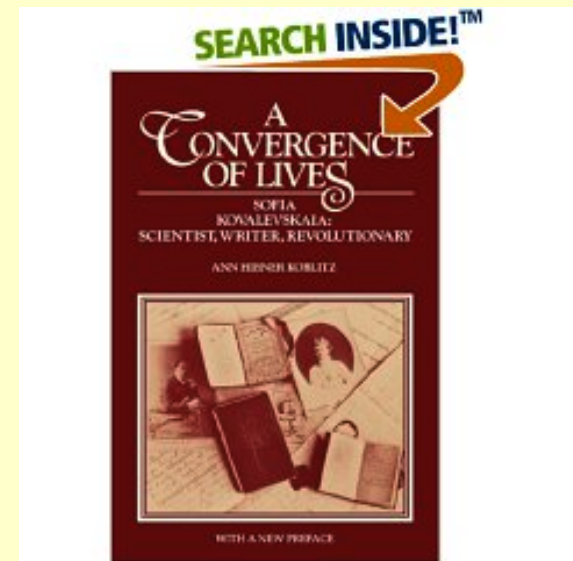
## Film:

**Berget på månens baksida (1983)**

(a mountain on the other side of the Moon)

Director: Lennart Hjulström.

*Le cas de Sophie K.* (pièce de théâtre), texte et mise en scène de Jean-François Peyret (2006).



## Special thanks to:

Mikael Rågsted (Librarian, Institut Mittag-Leffler)

Elena N. Polyakhova (Sobolev Astronomical Inst. St Petersburg State Univ.),

Tatiana Lindener (IML),

Claudia Urzua,

Elena Farlova (U. Montreal),

Nicolas Raymond (U. Rennes),

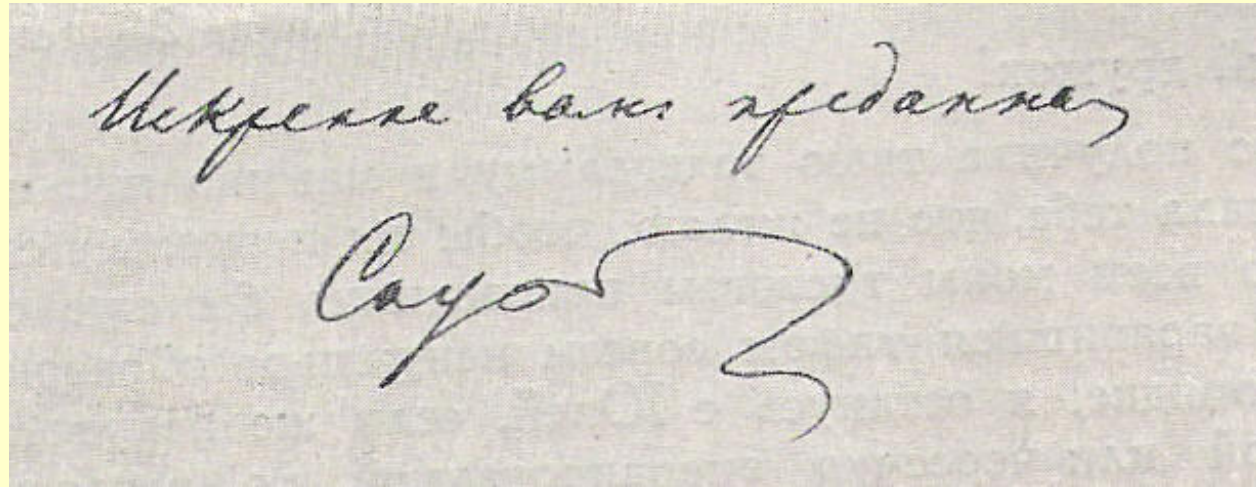
M. Soledad Benguria,

Aldo Rampioni (Springer Verlag),

Lev Kapitanski (U. Miami),

and many others!!





Никогда вам преданна,  
Саша

“Truly devoted to you,...Sonya”

The End