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Ursula B. Marvin

KOVALEVSKAIA, SOFIA

SEE **Kovalevskaya, Sofya Vasilyevna**.

KOVALEVSKAYA, SOFYA VASILYEVNA (SONYA)

(*b.* Moscow, Russia, 15 January 1850; *d.* Stockholm, Sweden, 10 February 1891), *mathematics.* For the original article on Kovalevsky (the variant of her name used in that article) see *DSB,* vol. 7.

Interest in Kovalevskaya's life and work has increased considerably since the appearance of the original *DSB* article on her. As a result a number of new works about her have appeared in English and German, and a French work was completed in 2006, but has not yet appeared. Views of her position among late nineteenth-century mathematicians have altered slightly, and it seems that when she was mentioned among them, it was her talent rather than her gender that first came to mind. Her use of hyperelliptic functions to solve a complicated case of the equations of motion of a rigid body introduced techniques that found additional applications during the 1980s and thereby increased in importance, while the Cauchy-Kovalevskaya theorem in partial differential equations remains a standard result that everyone who works in this area must know.

Kovalevskaya's work in differential equations was so well respected that the name *Cauchy–Kovalevskaya theorem* was coined by Jacques Hadamard in his 1910 lectures. In the mid-1920s Felix Klein devoted a small amount of space to her work in his lectures on the development of nineteenth-century mathematics, unfortunately with a rather negative tone. Klein had a strong influence over Western European and American mathematical opinion, and the effect of his dismissal of Kovalevskaya was to put her in Karl Theodor Wilhelm Weierstrass's shadow for a generation. This low period in her posthumous reputation was reflected in the patronizing portrait of her painted by Eric Temple Bell in his 1937 book *Men of Mathematics,* who implied that she used her sex appeal to persuade Robert Bunsen to admit one of her friends to his laboratory, and went on to say that after returning to Russia and being unable to find work, "her sex had got the better of her ambitions."

Sofya Kovalevskaya. **SPL / PHOTO RESEARCHERS, INC.**

In the Soviet Union, however, the centenary of Kovalevskaya's birth in 1950 and the 125th anniversary of her birth in 1975 led to a host of new publications, providing both basic information and inspiration for further studies of her life and work. These publications brought her to the attention of mathematicians and historians around the world, and studies of her life and work began to appear outside the Soviet Union in the early 1980s.

Studies of Kovalevskaya's Life. Kovalevskaya's life is of interest from a number of points of view. She was part of the radical youth movement in Russia during the 1860s known as nihilism. A biography of Kovalevskaya as nihilist and scientist was published by Ann Hibner Koblitz in 1983. This work remains the definitive study of this aspect of Kovalevskaya's life. On a less political level, Kovalevskaya is deservedly a hero of the feminist movement. In her day there was determined opposition to careers for women, and if a woman defied expectation and discrimination and attempted to enter a career, she certainly found herself squeezed between the professional demand to work like the men in her field and the social demand to behave like other women in relation to her family and friends. For Kovalevskaya, such conflicts arose constantly.

Studies of Kovalevskaya's life include several scientific and personal biographies and a novel in which a decade of Kovalevskaya's life is depicted in fictionalized form. In addition, a highly inaccurate version of her years in Stockholm forms the subject of the 1983 Swedish film *Berget på månens baksida* (A mountain on the far side of the moon).

Studies of Kovalevskaya's Mathematical Work. Both of the major works that established Kovalevskaya's reputation in her lifetime were still regarded as outstanding achievements a century after her death and were still leading to new research. The fundamental place of the result known as the Cauchy-Kovalevskaya theorem in the theory of differential equations in the complex domain was established early, and this theorem remains a pillar of the subject.

Interest in her work on the equations of motion of a rotating rigid body continues for two reasons. First, it represents an exactly solvable case of the system of equations, that is, a set of parameters for which a complete set of "conservation laws" can be found to describe the motion. Second, to express the parameters of motion explicitly as functions of time, it is necessary to use theta functions of two variables.

The two exactly solvable cases of rigid-body motion that had been studied earlier by Leonhard Euler, Joseph-Louis Lagrange, and others were both important in that they covered the familiar cases of rotating heavenly bodies and gyroscopes. Sufficiently general to be of physical interest, they were also sufficiently symmetric that the motion could be described using, at worst, elliptic functions. For the Kovalevskaya case the degree of symmetry is less, so that physical cases where these equations apply are harder to find. At the same time, the computations are much more complicated. As a result, physicists paid little attention to this case for nearly a century. The late twentieth century, however, saw a revival of interest in this case as an exactly solvable model. Detailed studies of the phase portrait of the corresponding differential equations have been published, including one that was turned into a video.

Meanwhile new uses were found for theta functions in solving differential equations. The differential equations that describe comparatively simple mechanical systems, such as the motion of a pendulum, require elliptic functions for a closed-form solution. Mathematicians developed an intricate theory of more complicated algebraic functions as the natural extension of elliptic functions. Carl Jacobi introduced theta functions of one variable in the study of elliptic functions, and an analogous theory of theta functions of several variables was used to study more complicated algebraic functions. In developing this magnificent theoretical edifice, mathematicians had moved ahead of physical applications. For that reason, applications of theta functions of two variables were virtually nonexistent in mechanics during the nineteenth century. Some mathematicians went looking for such applications, notably Carl Neumann, who, in his 1856 dissertation, studied the motion of a point confined to a sphere and moving under a potential that is constant on ellipsoids. He found a system of two integrals of the type that occur in what is known as the Jacobi inversion problem, as stated by Weierstrass. This problem was solved by Weierstrass and Bernhard Riemann using theta functions of several variables. Although the problem is somewhat artificial, it does show that higher algebraic functions can be applied in mechanics.

Weierstrass had suggested that Kovalevskaya work along the same lines as Neumann in connection with the motion of a rigid body, and it was precisely by following this line of attack that she discovered and solved her case of the spinning top. Indeed, the system of equations that she finally developed was of exactly the same form as the system that Neumann had produced. But Neumann had not followed through with a thorough investigation of the solution. Kovalevskaya carried the solution through to completion using theta functions of two variables, thereby proving that theta functions could be useful in a "classical" problem of mechanics. This aspect of her work brought the highest praise from the Paris Academy.

In the 1970s and 1980s theta functions of two variables arose in connection with the Korteweg–de Vries equation describing the motion of a wave in a channel and in connection with George William Hill's equation for lunar motion. Due to modern computers, the complexity of an equation is not the barrier to study that it once was, and extensions of Kovalevskaya's work are once again being undertaken.

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Roger Cooke

KOVALEVSKY, SONYA

SEE **Kovalevskaya, Sofya Vasilyevna.**

KOWALEVSKY, SONJA

SEE **Kovalevskaya, Sofya Vasilyevna**.

KROPOTKIN, PETR ALEKSEYEVICH

(*b.* Moscow, Russia, 9 December 1842; *d.* Dimitrov, U.S.S.R., 8 February 1921), *geography, natural history, evolution.* For the original article on Kropotkin see *DSB,* vol. 7.

It is interesting to note that the original entry on Kropotkin concludes with a 1912 congratulatory address from the Royal Geographical Society of London in honor of Kropotkin's seventieth birthday. The address cited; "service in the field of natural sciences … contribution to geography and geology," and most importantly for this entry, "amendments to Darwin's theory." Kropotkin's contributions to geography and geology are well covered in the original entry by Oleg Naumov. This supplement focuses on Kropotkin's reassessment of Charles Darwin's theory, which he developed in response to what he saw as the excesses of some of evolution's most ardent supporters.

Kropotkin was attracted to natural history from a young age and developed that fascination throughout his young life as a member of a number of geographical expeditions and as a contributing member of various professional societies. After completing his studies in the corps of pages in 1862, he spent the next five years traveling through Siberia studying the geography and geomorphology of eastern Siberia. In the course of these travels,