Pafnouti Lvovitch Chebyshev (1821-1894)

Pafnouti Lvovitch Chebyshev is the founder of the 19th century Russian mathematical school of Saint Petersburg. He contributed to number theory, probability, approximation theory, analysis, geometry, algebra, differential equations, abelian integrals, probability, cartography, and astronomy. His results on the distribution of prime numbers stand at the basis of analytic number theory. His work on probability includes significant extensions of the law of large numbers and of the central limit theorem and makes him one of the main founders of modern probability theory. He was the first mathematician to recognize the importance of a general theory of orthogonal polynomials. We owe to him fundamental results on the approximation of a real analytic function by polynomials. He had a very strong interest in mechanical engineering and he conceived several machines and devices. His work highlights the importance of mathematics in the applied sciences, and conversely, it shows how practical problems may act as a motivation for theoretical research.

Pafnouti Lvovitch Chebyshev was born on May 14, 1821 in the village of Okatovo, about 80 km south of Moscow, district of Borovsk, Kaluga province. The village was part of the property of his father, an ancient army officer of noble descent. Pafnouti received his education at home until the age of 11, from family members, and then from private tutors. In 1837, he enrolled in the faculty of physics and mathematics of Moscow University. One year later, he wrote a paper titled “Calculation of the roots of equations” in which he gave a method of approximation of the roots of an algebraic equation of degree \( n \). This was the first of a series of works he did in approximation theory, a topic in which he became engaged for the rest of his life.

At Moscow university, Chebyshev’s talents attracted the attention of N. D. Braschmann, his mechanics teacher who became his mentor, to whom Chebyshev always kept a profound respect, both as a mathematician and as a person. He graduated in 1841 with a candidate dissertation titled “On the numerical solution of algebraic equations of higher degree”. In 1843, he published the first of a series of 17 papers that appeared in Liouville’s journal. This paper is titled Note on a class of multiple definite integrals, and it attracted the attention of Catalan even before its publication, since the latter wrote a sequel to Chebyshev’s results which was published in the same issue of the journal. In 1843, Chebyshev published a paper in Crelle’s journal, titled Note on the convergence of Taylor’s series, in which he pointed out a gap in a statement by Cauchy involving the integration of a series of functions. In 1845, he defended a Magister thesis, titled “An attempt for an elementary analysis of the theory of probability”, opening up a series of works on a topic in which he became a world leader.

In 1847, Chebyshev settled in Saint Petersburg where he started to teach at the Imperial University. In 1847, he defended there a doctoral dissertation on number theory, titled “The theory of congruences” a topic in which he became interested after reading Euler’s works. According to Delone [Delone2005], this dissertation contained the first non-trivial results on the distribution of prime numbers since the works of Euclid, and their importance is only comparable to those obtained by Riemann on this topic. Part of this thesis was published in 1852 in Liouville’s journal under the title On the function which determines the totality of prime numbers smaller than a certain limit. It contains new results on the growth and the limiting behavior of the function \( \phi(x) \) of the number of primes less than \( x \) for large \( x \), incidentally invalidating several statements made by Legendre and giving alternative results and proofs. By that time, Chebyshev has become a highly respected mathematician in Europe, and his prestige and influence went on increasing.

In 1854, Chebyshev, motivated by the stream engine constructed by J. Watt in 1763, published a paper titled On the theory of mechanisms, known under the name of parallelograms. This was the first of circa 10 papers he wrote on the theory of mechanical linkages. Roughly speaking, Watt produced a mechanism which, from a combination of circular motions, produces a rectilinear one. Chebyshev was interested on this question, because it involves the conception of mechanical devices and approximation theory.
He also wanted to obtain an exact solution of the problem of transforming a rectilinear motion into a circular one, and not only approximations. The problem was solved in 1871 by L. Lipkin, one of his young collaborators, and two years later it was given another solution by the French engineer Peaucellier [Peaucellier 1873]. In his work on this topic, Chebyshev inaugurated the general study of transforming one motion into another one, through mechanical linkages. By the end of the 19th century, the interest in the theory of linkages declined, but it became very active again in the 1980s, under the impulse of William Thurston, see the survey by Sossinsky [Sossinsky 2016]. Among the devices that Chebyshev invented are mechanical linkages for a wheelchair and for a row boat. Incidentally, it is in his 1854 paper on linkages that the Chebyshev polynomials appeared for the first time.

Chebyshev was perfectly fluent in French, which was not unusual among 19th-century educated Russians. In the early 1840s, he started building contacts with renowned mathematicians in Western Europe and he established close friendship with Hermite, Bertrand, Catalan, Kronecker, Lucas and many others. Vassiliev [Vassiliev 1898] and Possé [Possé 1907] mention that he spent almost all his summers abroad, mostly in Paris. His Collected works edition contains a report on a 3-month stay he made in France in 1852, in which he records that he discussed with Bienaymé, Cauchy, Liouville, Hermite, Lebesgue, Pouignac, Serret, Poncelet, and other mathematicians. The meetings took place in the evening, since during the day he was busy visiting industrial plants. He noted his observations on the windmills in Lille, on the metallurgical plant in Hayange, on the paper mills in Coronne, on the foundry and the cannon factory in Ruelle, on a turbine in a windmill in Saint-Maur, on a water mill in Meaux, on an arms factory in Châtellerault, etc. From Paris he made a small trip to London where he discussed with Cayley and Sylvester and he visited the Royal Polytechnic Institute where he examined models of various machines. He also went to Brussels where he visited the museum of engines, and on his way back to Russia, he made a stop in Berlin and had several discussions with Dirichlet.

In 1856, Chebyshev was elected adjunct at the Saint Petersburg Academy of Sciences. His first task there was to assist Bouniakovsky, who noticed his strong working capacities, in the publication of an edition of Euler’s works on number theory. He became ordinary academician in 1859.

Since his childhood, Chebyshev was handicapped by a withered leg, he walked with the help of a stick and he was excluded with most of the children’s games. He was fascinated by mechanical devices, and kept this passion until the end of his life. One of his first realizations is a computing machine, which he constructed with his own hands. The machines he invented are displayed in the Conservatoire national des arts et métiers in Paris, and at Saint Petersburg University and at the Saint Petersburg Academy of Sciences and in other places.

Chebyshev was member of most European academies of sciences. In 1874, he was elected as a foreign member (the first Russian after Peter the Great) of the Paris Académie des sciences. He became member of the Association française pour l’avancement des sciences, a learned society created in 1872, whose aim was to promote relations between the various sciences. Chebyshev participated to 4 of its annual meetings : Lyon (1873), Clermont-Ferrand (1876), Paris (1878), and La Rochelle (1882), each time presenting several works on various topics (geographical maps, the cutting of garments, his calculating machine, etc.). Abstracts of his talks are reproduced in his Collected works.

In 1882, Chebyshev resigned from professorship and started dedicating all his time to research. One day a week, his house was open to young scientists who wished to discuss with him their results or to seek for advise. In the summer of 1893, he made his last extended visit to Paris. He died on November 26, 1894. His tomb can be visited in the basement of the Church of the Transfiguration in the village of Spas-Prognanye, 10 km from the science city of Obninsk. In the nearby village of Mashkovo, there is a school named after Chebyshev, which hosts a museum containing a collection of original photographs and objects that belonged to him, including an arithmetic machine he constructed. There are several biographies of Chebyshev, e.g. [Possé 1907] Vassiliev 1898] Youschkevitch 2008].

Athanase Papadopoulos
References


