ALEXANDER LYAPUNOV   (June 6, 1857 – November 3, 1918)

by HEINZ KLAUS STRICK, Germany

ALEXANDER MICHAILOVICH LYAPUNOV was born in Yaroslavl, an important provincial town about 300 km north-east of Moscow, situated on the upper course of the Volga.

His father, the astronomer MIKHAIL VASSILYEVICH LYAPUNOV, had taken over the direction of the local lyceum a few months earlier – after 15 years as head of the observatory of the University of Kazan.

In 1864, his father also relinquished his post as headmaster and moved with the family to a country estate inherited by his wife SOFIA ALEXANDROVNA, and he devoted himself to the education and schooling of his three sons. All three showed special talents – ALEXANDER's brother SERGEI became known beyond Russia's borders as a pianist and composer and BORIS became a member of the *Soviet Academy of Sciences* as a linguist.

After the unexpected death of their father, the widow moved with her children to Nizhny Novgorod, where a relative, R M SETCHENOV, took over the lessons for the three boys – in addition to those for his own daughter NATALIA RAFAILOVNA.

From 1870 onwards ALEXANDER LYAPUNOV attended the local grammar school (from grade 3); in 1876 he passed the final examinations with brilliant grades.

Afterwards, he took up studies at the physical-mathematical faculty of *St Petersburg University*.

There he met ANDREI ANDREYEVICH MARKOV, who was only a few days younger, and together they attended the mathematics lectures of PAFNUTY LVOVICH CHEBYSHEV as well as of his students ALEXANDR NIKOLAEVICH KORKIN and IGOR IVANOVICH SOLOTAREV.

In addition to the compulsory courses, he attended the chemistry lectures of DMITRI IVANOVICH MENDELEEV, who had developed the periodic table of the chemical elements in 1869 – at the same time as the German chemist LOTHAR MEYER.
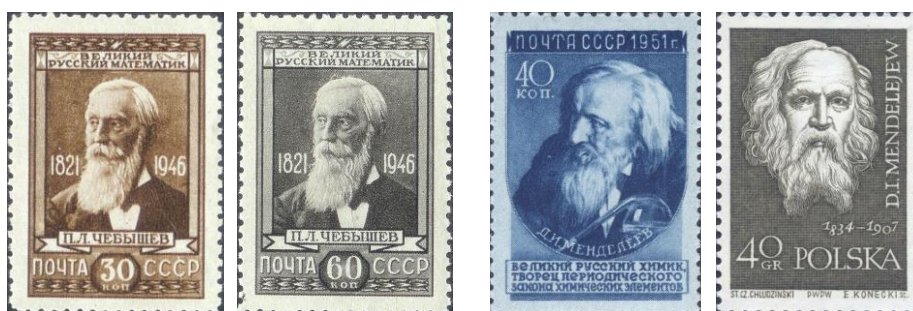
LYAPUNOV's physics professor DMITRI KONSTANTINOVICH BOBYLEV encouraged him to carry out research in the field of hydrostatics, which resulted in his first publications: *On the Equilibrium of Heavy Bodies in Dense Fluids Contained in Containers of Certain Shapes and On the Potential of Hydrostatic Pressure*.

For the first publication, he was awarded a gold medal by the faculty and the title of candidate of mathematical sciences (equivalent to a doctorate in Western Europe).

At the suggestion of CHEBYSHEV, LYAPUNOV then dealt with the question of what forms rotating liquids can assume at high rotational speeds and this led in 1884 to the writing of his master's thesis *On the Stability of Elliptical Equilibrium Forms of Rotating Liquids*.

The following year, LYAPUNOV lectured on theoretical mechanics at Kharkov University (kinematics, dynamics of point masses, dynamics of point-mass systems, theory of attractive forces, theory of deformation of solid bodies and hydrostatics).

VLADIMIR ANDREEVICH STEKLOV, one of his first students, his first doctoral student in 1893 and his successor to the chair at Kharkov in 1902, reports the breathless silence that fell shortly after Lyapunov's inaugural lecture began:

ALEXANDER MIKHAILOVICH won the respect of the auditorium in one hour – without knowing it himself – with the force of a natural talent rarely seen in such youth. From that day on, the students looked at him with different eyes and showed him special respect. Often they did not even dare to speak to him, lest they should show their ignorance.

After his *habilitation* (in Russian it is called a doctoral examination) at the University of Moscow in 1892 (topic: *A general problem on the theory of motion*), he was appointed full professor in Kharkov and from then on he also gave lectures on the integration of differential equations and on probability theory, among other things.

He gradually assumed important functions in the *Kharkov Mathematical Society*, as editor of the society's reports and finally as its president.

In 1901 he was appointed to the chair of applied mathematics at *St Petersburg University*, which had been vacant for seven years – LYAPUNOV succeeded his teacher CHEBYSHEV, who had died in 1894.

His reputation grew: after his admission to the Russian *Academy of Sciences* and honorary membership of the universities of St Petersburg, Kharkov and Kazan, honours from the *Accademia dei Lincei* (Rome) and the *Académie des Sciences* (Paris) followed over the years.

LYAPUNOV was involved in the editing of LEONHARD EULER's *Collected Works* (he was responsible for volumes 18 and 19.

So far 76 of the planned 81 volumes have been published).

In connection with his lectures on probability theory, he investigated under which conditions, as general as possible, the *law of the large numbers* or the *central limit theorem* apply, and thus – together with ANDREI MARKOV – continued the work of his highly revered teacher CHEBYSHEV.

Throughout his life, however, Lyapunov was primarily concerned with the above-mentioned question that Chebyshev had posed to his students:

- *Are there other forms of equilibrium for rotating bodies apart from the ellipsoids?*

Neither Solotarev nor Sofia Kovalevskaya had found satisfactory answers to this question.

In his master's thesis, Lyapunov had already referred to the investigations of Colin Maclaurin on ellipsoids and in 1742, he had concluded from the connection between the rotational speed and the flattening of the Earth that the Earth could not have a homogeneous structure.

In 1904, he wrote a contribution to Clairaut's equation, by which the French scientist had described the shape of the Earth.
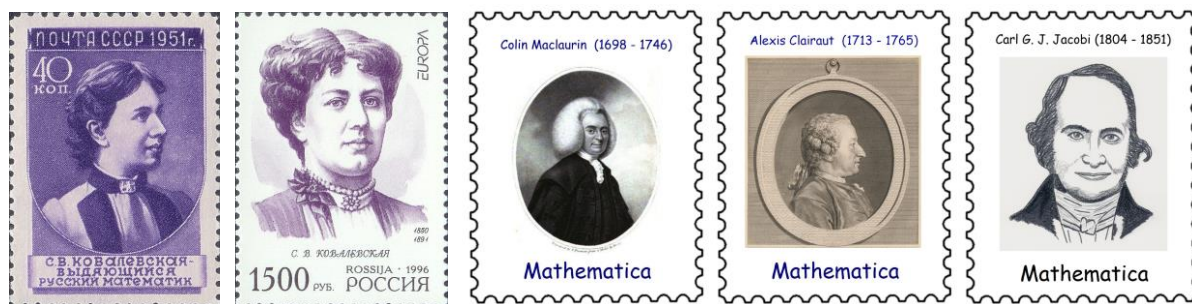
Carl Gustav Jakob Jacobi had also dealt with the underlying systems of differential equations and shown that stable triaxial ellipsoids can exist, i.e. ellipsoids with three semi-axes of different lengths (an example of this – as we know today – is the shape of the planet Mars).

The ingenious French mathematician, astronomer and theoretical physicist Henri Poincaré, in his attempts to find approximate solutions to the systems of equations in question, came to the conclusion that a pear-shaped form could also be a possible stable form of a rotating body, from which the British astronomer George Darwin (son of the famous biologist) developed the theory in 1898 that the Earth and the Moon were formed by the division of a previously pear-shaped mass.

Lyapunov considered Poincaré's solutions to be wrong – his calculations led to the conclusion that a pear-shaped form could not be stable, which Poincaré finally confirmed in 1911.

(Portuguese Millenium stamp: Mathematicians of the 20th century – Henri Poincaré, Kurt Gödel, Andrej Kolmogorov)

In the summer of 1917, Lyapunov travelled with his wife, who was suffering from tuberculosis (he had married his cousin Natalia Rafailovna in 1886), to visit his brother Boris in Odessa but his work was impaired by increasingly failing eyesight.

These personal problems and deteriorating living conditions due to the war, led him to depression. In September, he gave a last series of lectures on the equilibrium form of celestial bodies at the University of Odessa.

When his wife died on 31 October, he tried to shoot himself. Three days later he also died without having regained consciousness.

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