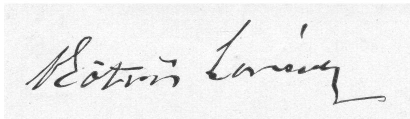
Biography of Loránd Eötvös
(1848–1919)

Loránd Eötvös, 1900. Courtesy the Loránd Eötvös Geophysical Institute of Hungary.

Loránd Eötvös (better known in foreign countries as Roland von Eötvös) is one of the greatest figures of natural sciences in Hungary. He was born in Buda, in Hungary, on July 27th 1848 into an impoverished aristocratic family. His father, Baron József Eötvös, was a novelist, essayist, educator and statesman, whose life and writings were devoted to the creation of modern Hungarian literature and to the establishment of a democratic Hungary. He was a friend of Franz Liszt, the famous pianist and composer. Loránd's mother was Ágnes Rosty, an educated daughter of a well-to-do landowner.

In his younger years, Loránd was educated by private tutors, later he attended the monastic high school of the Piarists where he obtained his final examinations in 1865. In those days it was assumed that boys of aristocratic families who wished to receive higher education had to enter the faculty of law. The law studies, however, failed to satisfy him, therefore he always managed to find time to attend lectures in natural sciences.



Eötvös' signature. Courtesy the Loránd Eötvös Geophys. Institute of Hungary.

Despite the fact that he completed his law studies, his dearest wish was to "study at a university abroad under the guidance of enlightened teachers in order to fully understand the natural forces at work in the scientific field". In 1867 having obtained his father's consent, he took the final decision to follow a career in natural sciences, and to this end entered the University of Heidelberg (Germany). There he became the pupil of famous professors, such as Kirchhoff, Bunsen and Helmholtz. First of all he studied physics, mathematics and chemistry. The following six months he spent at the University of Königsberg, but found the lectures too abstract and returned to Heidelberg. During his university years he kept up a regular correspondence with his father. These letters reveal the depth of understanding and sincerity in the relationship between father and son.

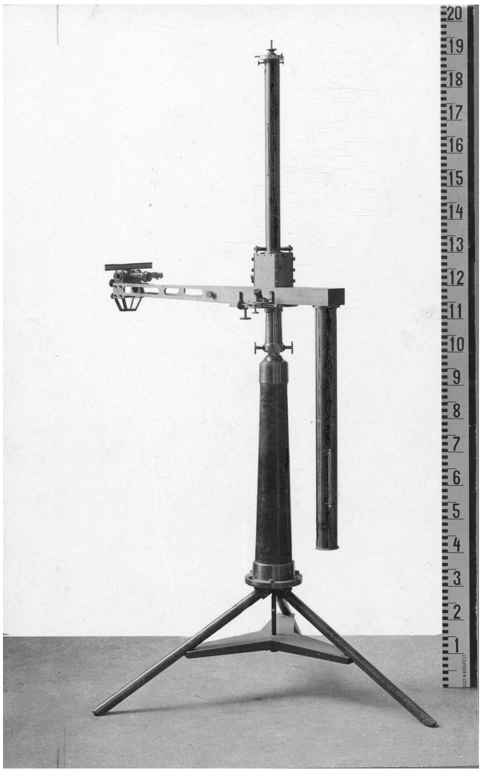
In 1869, the young Eötvös, thirsty for adventure, planned to join Petermann the German geographer on his expedition to the Spitzbergen. At his father's request he gave up the plan to travel and applied all his energy to preparing for his examinations for a doctorate degree, that he absolved "summa cum laude".

Shortly after his return home in February 1871, his father, "the best and truest friend" died. On his death-bed he warned his son once more that his future happiness depended on his devoting himself to science and keeping out of politics.

After his father's death, Eötvös successfully applied for the post of lecturer, advertised by the faculty of theoretical physics at the Pest University, which now bears his name. It was characteristic of the social climate of the time that the majority of the audience attending his inaugural lecture did so because they were curious to see a real baron giving a talk at the university.

After a short period of lecturing, in 1872 he was appointed to the professorship of theoretical physics. In 1874 he was allowed to give lectures in experimental physics and four years later he became professor in this field too. He was then given the task of uniting the departments of experimental and theoretical physics, and was nominated as Director of the newly established Physical Institute.

In 1873 he became Associate Member of the Hungarian Academy of Sciences, then Full Member in 1883, and in 1889 he was elected Presi-

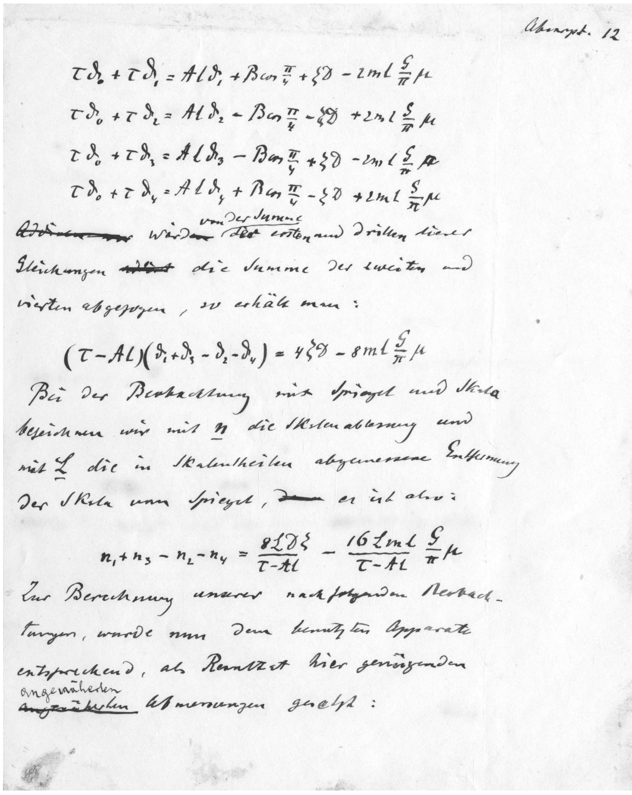


Single torsion balance designed by Eötvös for field work in 1898.
Courtesy the Loránd Eötvös Geophysical Institute of Hungary.

dent. Amongst his offices, he became Minister of religion and education for seven months in 1894. In his inaugural speech as Minister, he addressed the ministerial staff as follows:

> "We must strive, gentlemen, to make the field of public education a true garden of flowers. To achieve this aim we must first create order in the garden, so that every plant has its place. It is also necessary that each one receives the right nourishment, the soil and air that will allow its full development. In short, we have just two things we must do here, to make order and then to help. And gentlemen, I would like us to give more and more assistance and show more tolerance in our regulations."

Eötvös was a modest scientist who shunned the limelight. He disliked noisy ceremonies and did not seek moral or financial reward. In spite of this, he was acclaimed and received awards at home and abroad for



Abschr. 12

$$\tau\vartheta_0 + \tau\vartheta_1 = Al\vartheta_1 + B\cos\frac{\pi}{4} + \xi D - 2ml\frac{G}{\pi}\mu$$
$$\tau\vartheta_0 + \tau\vartheta_2 = Al\vartheta_2 - B\cos\frac{\pi}{4} - \xi D + 2ml\frac{G}{\pi}\mu$$
$$\tau\vartheta_0 + \tau\vartheta_3 = Al\vartheta_3 - B\cos\frac{\pi}{4} + \xi D - 2ml\frac{G}{\pi}\mu$$
$$\tau\vartheta_0 + \tau\vartheta_4 = Al\vartheta_4 + B\cos\frac{\pi}{4} - \xi D + 2ml\frac{G}{\pi}\mu$$

Werden von der Summe der ersten und dritten dieser Gleichungen die Summe der zweiten und vierten abgezogen, so erhält man:

$$(\tau - Al)(\vartheta_1 + \vartheta_3 - \vartheta_2 - \vartheta_4) = 4\xi D - 8ml\frac{G}{\pi}\mu$$

Bei der Beobachtung mit Spiegel und Skala bezeichnen wir mit n die Skalenablesung und mit L die in Skalentheilen abgemessene Entfernung der Skala vom Spiegel, es ist also:

$$n_1 + n_3 - n_2 - n_4 = \frac{8LD\xi}{\tau - Al} - \frac{16Lml}{\tau - Al}\frac{G}{\pi}\mu$$

Zur Berechnung unserer nachfolgenden Beobachtungen, wurde nun dem benutzten Apparate entsprechend, als Resultat hier genügenden angenäherten Abmessungen gezeigt:

Eötvös' handwriting. A fragment of the manuscript dealing with the law of proportionality of inertia and gravity, submitted to the Univertsity of Göttingen, Germany, and rewarded by the Benecke award in 1909. Courtesy the Loránd Eötvös Geophysical Institute of Hungary.

his scientific work and skill as an organiser. The most important ones included the French Legion of Honour, the Franz Josef award from the Hungarian King, the Saint Sava award from the King of Serbia. He was also elected honorary member of the Prussian Royal Academy of Sciences in Berlin and was given honorary doctorates from the Jagello University in Cracow, and the Norwegian Royal Frederick University in Christiania (now Oslo). In addition to the above, he received several major and minor awards during his lifetime and was elected President or a leading member of various social and scientific societies.

Eötvös was a well-balanced individual. Besides his intensive mental work, he always found time for relaxation and sports. He often went riding and regularly made the eleven-kilometre journey from his home to the university on the horseback. In the summer, he often cycled and indulged in his passion for rock climbing. In the classic time of mountaineering, he ranked among the best. As an enthusiastic photographer, he took hundreds of pictures during his mountaineering excursions. In his latter years, his daughters accompanied him on his expeditions, and also became keen Alpinists. Eötvös' climbing achievements in the southern Tirol made his name so well known that in 1902 one peak of 2837 metres high in the Dolomites (Italy) was named after him Cima di Eötvös (Eötvös summit). In the company of friends he often jokingly said that he was prouder of his mountaineering successes than his discovery of the torsion balance. For many years as President of the Hungarian Touring Society, he achieved a great deal in the popularization of tourism in Hungary.

With the advancing years, he strove to avoid prestigious appointments in order to devote himself entirely to his research. This prompted him to give up his position as President of the Academy in 1905. The last years of his life were clouded by a severe illness, but he continued to lecture at the University as long as it was humanly possible. Until the last moments of his life, he followed torsion balance fieldwork with great interest. In the beginning, he asked his colleagues to inform him of the daily results of their survey by telegram because he was very anxious to know how far the results of the survey supported his theories. He had never been able to tear himself away from his research, even during his summer excursions to the mountains. When on holidays, he always kept up a regular correspondence with his co-workers. He continued his scientific work from his sick bed and sent his last paper to be published only a few days before he died on April 8, 1919.

International scientific life and the whole of Hungarian society mourned his death. Hungary had said farewell to one of the last great representatives of classical physics and to the country's greatest natural scientist. Through his work, however, his name will live forever in the history of physics and geophysics.

As a means of expressing their respect for Eötvös posthumously, the international scientific community named the 1×10^{-9} CGS unit after him, and gave his initial, E, as its symbol.

Eötvös' main scientific achievements

In his scientific research Eötvös was not interested in those topics that were fashionable at that time, and would have brought him immediate public acclaim. He was concerned with capillarity, gravitation and magnetism, phenomena so taken for granted that a superficial observer would fail to see the mysterious powers at work within them. He formulated his *ars poetica* as follows:

> "The true natural scientist ... finds pleasure in research itself and in those results which help to increase the prosperity of Mankind."

It was characteristic of Eötvös' scientific activity that he dealt with all aspects of a problem. He first considered the theoretical base and followed this by designing and constructing the instruments and methodology needed for the experiments. Then came the laboratory and field measurements and, finally, he summarized his conclusions derived from the measurements.

Studies in the field of capillarity The beginnings of Eötvös' scientific career are connected with liquids. He worked out a new way to determine surface tension, which subsequently became known as the reflection method. This method made it possible to determine precisely the surface tension of various liquids. During his experiments, Eötvös found a linear relationship between the molar surface energy of liquids and their temperature. The proportionality factor is constant for all compound liquids independently of their composition. The molar surface energy is equal to the work needed to move one molecule from the inside of the liquid to its surface.

Based on this finding, Eötvös was able to state the following relationship: with increasing temperature, the surface tension of a liquid decreases until, at the critical temperature, it becomes zero. Later this rule was named the Eötvös law and the proportionality constant the Eötvös constant. In case of liquids this constant is as fundamental as the universal gas constant in case of gases.

Eötvös torsion balance Around 1885 his attention turned to gravity and magnetism. Studying the behaviour of the Coulomb balance in the gravity field he invented a modified version of this instrument, which is known in geophysics as the Eötvös torsion balance. This unbelievably sensitive instrument can detect a change of 10^{-12} part/cm of gravity. The instrument has been proved to be suitable for geological exploration and paved the way towards world renown for Eötvös and his balance. In the 1920's and 1930's hundreds of oil fields were discovered throughout the world with the help of Eötvös' ingenious instrument.

Inertial and gravitational mass Eötvös became concerned with the question of the proportionality of the inertial and gravitational mass as early as 1890. In 1908 Eötvös and his colleagues, Jenõ Fekete and Dezsõ Pekár, perfected their measurements to such an extent that they were able to establish that the difference between the inertial and gravitational mass was at the most $1/200{,}000{,}000$. Their paper on the subject won them the Benecke award at the Göttingen University in 1909.

Eötvös effect While studying Hecker's results who carried out gravity measurements on moving boats on the oceans in the years 1904–1905, Eötvös noticed that no consideration had been given to the vertical component of the Coriolis acceleration developed by the motion of the boat. In his letter to Hecker, he proposed a correction for compensating this effect. The international scientific world recognizes these phenomena as the Eötvös effect and the Eötvös correction, respectively, both having special importance nowadays in the field of sea and air gravimetry.

Just to list his further scientific achievements:

- He invented a new method to determine the value of the gravity constant.
- He carried out measurements to study the problem of gravity absorption. He concluded that the gravity absorption of a 5 cm thick lead plate (if there is such phenomenon at all) is less than 5×10^{-10} part of its attraction;
- He constructed a bifilar type gravimeter in 1901, more than a decade earlier as Schweydar did;
- He applied the astatic principle to his gravity compensator to make it so sensitive that he could detect 1 cm variation of the water level of the Danube river in a distance of 100 meter;
- He constructed a magnetic version of his balance and carried out archeomagnetic measurements to determine the inclination of the magnetic field in the past;
- Based on his torsion balance measurements carried out in the Arad region (now in Romania), he elaborated a new method to contour a very detailed geoid map for the region.

Zoltán Szabó

All photo images used in this publication were provided by the Loránd Eötvös Geophysical Institute of Hungary (Eötvös Loránd Geofizikai Intézet, ELGI), where the author of the present biographic article, Zoltán Szabó, maintains the Loránd Eötvös Memorial Museum. The author would like to express his sincere gratitude to László Sõrés and Péter Kovács, the close colleagues at the Institute, for their favour and assistance in preparation of the photo images.

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