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Atmospheric ionization and cosmic rays: studies and measurements before 1912

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ABSTRACT

The discovery of cosmic rays, a milestone in science, was based on the work by scientists in Europe and the New World and took place during a period characterized by nationalism and lack of communication. Many scientists that took part in this research a century ago were intrigued by the penetrating radiation and tried to understand the origin of it. Several important contributions to the discovery of the origin of cosmic rays have been forgotten; historical, political and personal facts might have contributed to their substantial disappearance from the history of science.

1. The spontaneous discharge of electroscopes

A typical electroscope, in the configuration which was invented at the end of the XVIII century (Fig. 1), consists of a vertical metal rod from the end of which hang two gold leaves. A disk or ball terminal is attached to the top of the rod, where the charge to be tested is applied. To protect the gold leaves from drafts of air they are enclosed in a glass bottle. The gold leaves repel, and thus diverge, when the rod is charged.

One could think at first glance that, if isolation were perfect, an electroscope should always maintain its charge. An unexpected result came from the first experiments related to electricity by Charles-Augustin de Coulomb, officer of the French army and member of the Académie des sciences. Coulomb was surprised in finding, around 1785 [1], that electroscopes can spontaneously discharge by the action of the air and not by defective insulation. He published this result in his famous "Mémoires sur l'électricité et le magnétisme".

Also Michael Faraday addressed the problem around 1835 [2], confirming with greater accuracy the results by Coulomb. In the meantime the electroscope was improved by William Thomson, then Lord Kelvin; Crookes [3] (Fig. 2) could measure in 1879 that the speed of discharge of an electroscope decreased when the air pressure was reduced. It became therefore clear that the direct cause of the discharge of the electroscope should be the ionization of the air contained in the instrument itself. But what was the cause of this ionization?.

The explanation of the phenomenon of spontaneous discharge came in the beginning of the 20th century and paved the way to one of mankind's revolutionary scientific discoveries [4]: cosmic rays. And although many reviews on the history of cosmic rays have been published in the literature (see for example [5–15]), most of them, the recent ones in particular, do not spend much time on the first years, in which the field was closely linked to the study of atmospheric ionization.

2. The puzzle of atmospheric ionization

The study of the rate of discharge of an electroscope required a rather sophisticated experimental technology; fortunately this type of measurement was very popular since the late eighteenth century, as related to issues concerning atmospheric electricity, and ultimately meteorology. The technique was also developed in the United States, Canada, Italy, Germany, and particularly in Austria. In most cases these studies were financed thanks to the possible interest for agriculture and military science, two areas which would have greatly benefited from the possibility that humans were able to influence the weather thanks to electricity.

Franz Exner, whose school in Vienna was rewarded by several Nobel prizes [16], not only further perfected the electroscope improving the tools of Lord Kelvin, but also managed to attract many good students – for example the future Nobel prize-winner Schrödinger, who became interested to physics thanks to the study of ionization of the atmosphere.

In 1896 Becquerel [17] discovered spontaneous radioactivity. A few years later, Marie and Pierre Curie (Fig. 3) discovered [18] that the elements Polonium and Radium suffered transmutations generating radioactivity: such transmutation processes were then called "radioactive decays". In the presence of a radioactive material, a

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Fig. 1. An electroscope of the end of XVIII century.

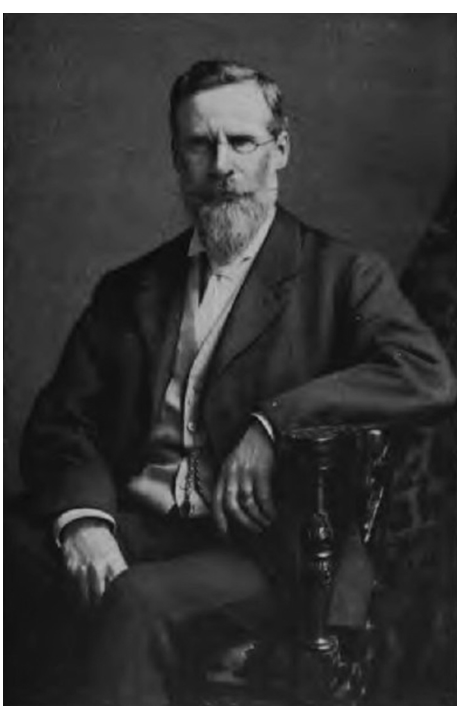

Fig. 2. Sir William Crookes (1832–1919) – source: wikimedia commons.

charged electroscope promptly discharges. It was concluded that some elements were able to emit charged particles, that in turn caused the discharge of electroscopes. The discharge rate of electroscopes was then used to gauge the level of radioactivity.

Fig. 3. Marie and Pierre Curie with their daughter Irène. Marie Curie was awarded with Pierre and Becquerel the Nobel Prize for Physics in 1903, and then in 1911 the Nobel Prize for Chemistry (she is the only scientist awarded the Nobel prize for two different scientific disciplines). Irène will be awarded the Nobel Prize for Chemistry in 1935 for her discovery of artificial radioactivity.

Fig. 4. The two friends Julius Elster and Hans Geiter around 1900.

This observation opened in Europe and the New World (United States and Canada in particular) a new era in research related to studies on natural radioactivity, and somehow unified, thanks to the common experimental technique, studies of ionization in the context of meteorology and research related to natural radioactivity.

Around 1900, Julius Elster and Hans Geitel (Fig. 4) in Germany, and Charles Thomson Rees Wilson in England, improved the technique for a careful insulation of electroscopes in a closed vessel (Fig. 5), thus improving the sensitivity of the electroscope itself. As a result, they could make quantitative measurements of the rate of spontaneous discharge.

Elster (1854–1920) and Geitel (1855–1923) were two high school teachers in Wolfenbüttel, a small town in Lower Saxony; friends since their time in school, they shared the same house with the family of Elster and worked maniacally to study the properties of electricity in the air. In a key experiment in 1899, they isolated the electroscope by putting it in a thick metal box. Also in these conditions they found a decrease in radioactivity, thus concluding [19] that the discharge was largely due to ionizing agents from outside the container. They also found that such ionizing agents were highly penetrating. The obvious question was if the radiation