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Werner Kolhörster (1887–1945): The German pioneer of cosmic ray physics ☆

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ABSTRACT

Werner Kolhörster belonged to the outstanding German scholars in cosmic ray and particle astrophysics, prior to World War II. But the wide fame of Victor F. Hess overshadows largely his merits nowadays.

1. Introduction

Doubtless, Werner Kolhörster was among the outstanding German pioneers in cosmic ray research, making essential contributions prior to the beginning of World War I (WWI). Furthermore, together with Walther Bothe at the end of the 1920s he introduced the coincidence technique into cosmic ray physics and they thus started the field of particle astrophysics. He was also among the first to observe extended air showers. However, in comparison to Victor Hess, who first observed penetrating rays coming from above the earth, he is comparatively unknown to the broader physics community. This is related to his early death in 1946, to the missed 1936 Nobel Prize (C.D. Anderson, V.F. Hess), and to the so called Matthew-effect:

> For unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken away even that which he hath. (Mt 25:29).

Hess' 1912 measurements and his hypotheses about the existence of penetrating rays [6] were discussed rather contentious in their day. It was the results of Kolhörster's high balloon flights in 1913 and 1914, carrying considerably improved equipment, that finally confirmed Hess' results [10,11]. At the time these measurements were the only ones strongly supporting Hess' thesis of the existence of cosmic rays (Fig. 1).

Werner Kolhörster was born on December 28, 1887 in Schwiebus (now Swiebodzin, Poland) and took his high-school diploma (*Abitur*) in 1906 in Frankfurt/Oder.[1] That same year he began to study National Economics at Berlin University. In 1908, he changed to studying mathematics and physics, first at the University of Marburg, and then in 1911 at the University of Halle (Saale). On the basis of a Ph.D. thesis entitled *Beiträge zur Kenntnis der radioaktiven Eigenschaften des Karlsbader Sprudels* (On the radioactive properties of the mineral water from Karlsbad) Kolhörster graduated *summa cum laude* from Halle University in the spring of 1911. His supervisor was Ernst Dorn, one of the pioneers of radioactivity research and of precision measurements in this field. Among other achievements, he discovered the radioactive noble gas Radon. At Dorns institute in Halle, Kolhörster also received his first academic position. Between 1911 and 1914, he served as an assistant to Dorn.

2. Penetrating rays

The years 1911–1912 were characterized by a growing interest from Kolhörster in geophysical topics, in connection with the solar eclipse of April 1912. Moreover, he was attracted strongly to the studies of the Jesuit physicist Father Wulf [17] and by Hess' balloon flights. As a consequence, he started to improve Hess' and Wulf's electrometer design with the aim of providing further confirmation for the hypothesis of penetrating extraterrestrial radiation. Wulf's electrometer was mainly designed for use on the ground and not

☆ Devoted to Reimar Lüst on the occasion of his 90th birthday.

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[1] More information on Kolhörster's curriculum vitae can be found in the self biography of his wife [8] and in an article just published by one of the authors (D.H.) [7].

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Fig. 1. Werner Kolhörster (left) starting with his fellow passengers a balloon flight in 1913. By courtesy of the Archives R. Fricke, Wolfenbüttel.

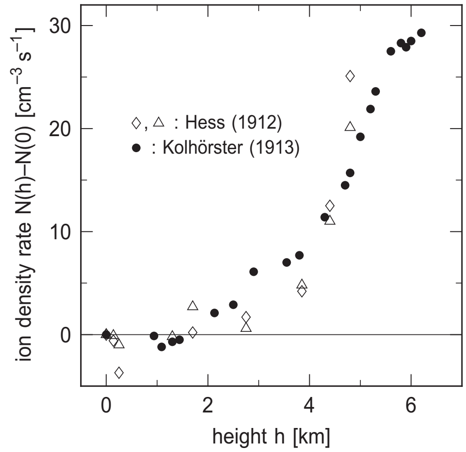

Fig. 2. Ion density rate as function of balloon height as originally measured by Hess in 1912 [6] and Kolhörster in 1913 [10]. Plotted are the data as obtained during the flights. The date plotted with open rhombuses and with triangels refer to results obtained by Hess with his electrometers labelled I and II, respectively.

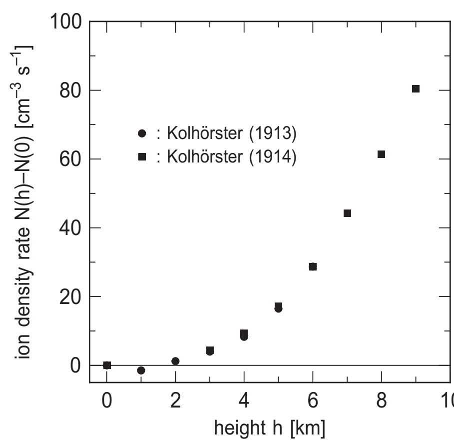

Fig. 3. Ion density rate as function of balloon height as determined by Kolhörster in 1913 [10] and in 1914 [11].

specifically for use during balloon flights at high altitudes, which caused some problems in data recording.

In cooperation with the Brunswick company Günther & Tegetmeier, who already fabricated the electrometers constructed by Wulf and Hess, Kolhörster adapted the Wulf–Hess electrometer, over the course of two years, to the requirements of high-altitude balloon flights [5,9]:

- The electrometer vessel was thickened. The gaskets connecting the electrometer vessel to the flanges, on which the electrometer, the reading microscope, and other tools were mounted, were improved considerably. Finally the new electrometer vessel was able to stand a pressure difference of about 500 Torr, which allowed measurements up to an altitude of around 9000 m.
- In an improved second version, the electrometer wires and the reading microscope were mounted on the same flange. This measure prevented the electrometer wires from shifting with temperature.
- A reduction of the capacitance of the entire instrument enhanced its sensitivity further. It finally allowed Kolhörster to read out the electrometer wire positions each minute and to tabulate values averaged over 10 min. This was important as a balloon can only be kept at constant altitude for a short period of time. In contrast Hess' technique only allowed for readings every 30 min, and so required wide extrapolations to yield the final data.

During the summer of 1913, Kolhörster undertook three balloon flights with the improved electrometer, all starting from Bitterfeld [10]. The first one, went to the south, attaining a height of 4100 m, the second one to the east reaching a height of 4300 m. Finally the most successful flight went to the west and reached the record height of 6300 m (Fig. 2).

The results obtained during the last flight, not only corroborated the trends seen in the high altitude data of Hess, but also improved their precision considerably and added new data for an altitude of over 5000 m. They offered an unambiguous confirmation of Hess' discovery of the existence of a penetrating radiation from outer space. The high precision data obtained with two electrometers for altitudes up to 9300 m on June 28th of the next year, 1914, showed a further, tremendous increase in the ionization and thus further supported his and Hess' claim of the existence of a penetrating radiation from outer space [11] (Fig. 3). In contrast to the data in Fig. 2 these data are not the ones obtained during the flight, but had rather been obtained by interpolating the original data as function of the barometer readings (heights) and the temperatures measured.[2]

The precision of Kolhörster's data may be most easily seen in a plot that Erich Regener, another German cosmic ray researcher, published 1932 in *Nature* [14] (Fig. 4). With unmanned balloon flights and an automatic registration he obtained data up to about 30 km which proved the tremendous increase in ionization observed by Kolhörster up to 9 km as a steady progression. In the overlap region, both data sets agree within 5%.

There was good reason in the 1920s and 1930s to speak not only of *Höhen–strahlung* or ultragamma-radiation, but also of Hess–Kolhörster-radiation. Moreover Kolhörster was honored by some col-

[2] For details see Ref. [10]. The 1914 data had been published in this form only.