100 Years of Cosmic Rays: The Anniversary of Their Discovery by V.F. Hess.

August 7, 2012 marked the centenary of a daring balloon flight of Victor Hess, which decisively proved the extraterrestrial origin of the mysterious, penetrating radiation, that puzzled experimentalists at the time. The phenomenon was later named "Cosmic Rays". This discovery opened the first cosmic window beyond optical astronomy, long before radio, infrared, ultraviolet, X-ray and gamma-ray astronomy extended the accessible range of electromagnetic radiation.

In commemoration of Hess' flight, DESY together with the University of Potsdam and the Max-Planck Institute for the History of Science in Berlin organised a symposium in Bad Saarow (Brandenburg), close to the place where Hess landed his balloon. From August 6 to 8, 2012, almost one hundred scientists from all over the world came together to recall the many facets of the fascinating story of cosmic ray research. This volume contains the written version of most of the presentations. The interested reader is referred to the website of the symposium for access to the slides of the presentations (http://www.desy.de/2012vhess).

Hess' centennial discovery was neither something which immediately stunned the physics community or produced news headlines, nor came it totally unexpected. Jim Cronin, Alessandro de Angelis and Jan Lacki described how evidence on the existence of cosmic rays accumulated over a full decade - marked by the names of F. Linke, A. Gockel, J. Elster, H. Geitel, K. Bergwitz, and notably Th. Wulf and D. Pacini. The latter two came particularly close to what we would call today an uncontroversial discovery of cosmic rays. Eventually the merit for discovering cosmic rays was given to Hess who was the first to measure - with three different detectors - a significant increase of radiation at altitudes between 2000 and 5300 m above ground level and to conclude explicitly, that this increase must be caused by an extraterrestrial radiation.

Peter Schuster summarised Hess' scientific achievements. A modern remake of Hess' flight is described by Guaita Cesare. What we call uncontroversial today was not uncontroversial at that time. Even after W. Kolhörster had pushed the measurements to maximum altitude of 9 km (see the contribution of Dieter Fick and Dieter Hoffmann), his and Hess' results and explanation where questioned by A. Millikan. Soon, however, Millikan announced the discovery of cosmic rays on the base of his own new measurements. Actually several textbooks of that time, including European ones, cited Millikan as the discoverer of cosmic rays.
The scientific battle, probably the first one supported by national newspapers, was finished only in 1936, when Hess was awarded the Nobel Prize for the discovery of cosmic rays. The successes of cosmic ray science in the 1920s and 1930s became possible through new techniques - Wilson's cloud chamber (the main focus of Malcolm Longair's presentation), the Geiger counter, Rossi's coincidence method and nuclear emulsions. Galina Bazilevskya describes early cosmic ray research in Russia and the first cloud-chamber visualisation of a cosmic-ray track by D. Skobeltzyn. Louisa Bonolis' talk acknowledges

the numerous contributions of B. Rossi to cosmic ray physics.
In the 1930s and 1940s, cosmic rays became a bonanza for the discovery of new particles. The positron (C.D. Anderson, 1932), the muon (S.H. Neddermeyer and C.D. Anderson, 1936) and the pion (D. Perkins, G. Occhialiani, C. Powell, 1947) mark only the beginning of a long series of discoveries. Claus Grupen described this glorious period which ended only in the early 1950s when man-made accelerators took over as the working horse of particle physics.

Most of the following talks bridge a seven-decade time interval - from the late 1930s to the present. The main focus of this period was and is the understanding of sources and acceleration mechanisms at highest energies and on the propagation of particles through space. One branch of these efforts is based on the detection of extensive air showers, another branch focuses to the exact measurement of the primary particles with detectors on balloons and in space. The talks of Alan Watson, Arnold Wolfendale, Venyamin Berezinsky Ralph Engel and Dietrich Müller covered the current state of charged cosmic ray research, those of Razmik Mirzoyan, Marco Tavani and Felix Aharonian described gamma rays. Piergiorgio Picozza reviewed the measurement of cosmic electrons and positrons from space.

Whereas cosmic rays provided the first hints of non-thermal processes in the Universe, the astronomical exploration of the non-thermal universe was pioneered by radio and X-ray astronomers in the 1940s and 1960s, respectively. These exciting developments have been described in the presentations of Ronald Ekers and Andrea Santangelo.

The observational window of neutrino astronomy has been opened by the measurement of neutrinos from the Sun and from the supernova SN-1987A, reflected by Yoichiro Suzuki from the perspective of the Kamiokande experiments in Japan. What concerns the high-energy frontier, at the time of the symposium Francis Halzen could not clearly claim the detection of extraterrestrial neutrinos. While this editorial is written, nearly one year later, he could. This is a long-awaited breakthrough, 40 years after first concrete plans to build an underwater neutrino telescope had been discussed (and 101 years after Hess' discovery of cosmic particles).

Whereas the best times of the physics of energetic cosmic particles may still lay ahead, astronomy with electromagnetic waves is already in its golden ages. The talk of Catherine Cesarsky reviewed the development from the largest optical telescopes of the 19th century to the huge facilities for optical, infrared, sub-millimeter and radio observations of the present.

The concluding presentations bring us back from the far distance to our immediate cosmic neighbourhood and eventually to our own existence. Randy Jokipii and Harm Moraal addressed cosmic rays, the Sun and the heliosphere, Erwin Flückinger cosmic rays and space weather. Jasper Kirkby reported on the attempts to determine the correlation between cosmic rays and climate. Last but not least, Dimitra Atri describes the influence of cosmic rays on terrestrial life and reminds us that we do not only celebrate the discovery of just some cosmic phenomenon but also that of possible cosmic drivers of biological evolution and godparents to our own existence.

The scientific talks of the symposium have been complemented with moving reminiscences

of William Breisky about the life and personality of his grandfather, Victor Hess.

The variety of research that sprung up in the last 100 years from the initial discovery of Hess is mind boggling. Today we record a variety of cosmic particles from 10^6 to 10^20 eV, with balloon and satellite borne instruments, with a variety of telescopes and with large arrays of detectors on ground level and deep below the surface. We find that energetic cosmic particles are (almost) everywhere in the cosmos and that they play a major role in the evolution of our local environment, the entire Galaxy and the wider universe. Recent results have revolutionised our understanding of the most energetic regions in the Universe, near exploding stars or mass-devouring black holes. This wider research field is now called "Astroparticle Physics", which has become one of the most dynamic and productive fields of contemporary physics.

The story of cosmic rays is yet another brilliant example of how an unassuming finding in curiosity-driven, basic research develops over decades, by dedicated researchers, in an unpredictable way into a vast, new discipline of science and knowledge. Certainly, neither Hess nor anybody else at the time had any idea of how far-reaching his discovery eventually would be.
So let's continue to be curious, for the fun of learning about nature and for the benefit of future generations.

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