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Tribute to Bernard Peters

The beginnings of modern science in India coincided with the birth of modern physics and quantum theory, and was pioneered by stalwarts like J. C. Bose and C. V. Raman. After independence the government adopted an explicit policy of developing the country through support of science and technology. In starting new institutions of scientific research and thereby providing a great stimulus to the growth of science and technology in modern India the roles played by M. N. Saha, S. S. Bhatnagar and H. J. Bhabha were both remarkable and complementary. In their efforts they enjoyed the support and participation of many scientists of great perception and dedication, and among these the name of Bernard Peters is prominent, even though his stay in India was only for a period of about seven years, from 1952 to 1959.

Peters, who was already well known as one of the discoverers of heavy nuclei in cosmic rays, came to India at the invitation of Homi Bhabha in 1950 to conduct several stratospheric balloon flights to study primary cosmic radiation in collaboration with scientists of the Tata Institute of Fundamental Research (TIFR) in Bombay. The balloons carried small packets of photographic emulsions capable of recording tracks of energetic cosmic-ray nuclei and relativistic electrons. The experiments were successful beyond expectations. The photographic nuclear emulsions flown in the balloons were recovered, developed and studied. They showed that cosmic rays were made up of matter rather than of equal amounts of matter and antimatter.

The extraordinary successes of this experiment and the friendly scientific atmosphere in India, more than anything else, swayed Peters to accept a permanent position at TIFR in 1952. Within two years his qualities as a scientist and his contributions to the building up of a fine school of cosmic-ray physics and particle phenomenology became widely known, and he was elected a fellow of the Indian Academy of Sciences.

Many new discoveries were made with the nuclear emulsions exposed during these balloon flights. The very first K^- particle was recorded; the developed emulsion (see **cover picture**) showed that the particle slowed down in the emulsion by loss of energy due to ionization and was ultimately captured by a nucleus which then disintegrated. The emulsions also recorded the interaction of a Si or Mg nucleus with a total energy of 2×10^{14} electron volts; several hundred new particles such as π^+, π^- and π^0 were created in the collision (a photomicrograph of such an event appears on **page 723**). These studies were reported at international conferences and helped achieve for India recognition as one of the leaders in research in cosmic-ray and particle physics.

The seven years of Peters' stay at TIFR must be called the golden era, full of excitement and scientific discovery. Some of these excitements and discoveries are described in articles by his students and friends (see section beginning **page 715**). Some of the articles are by later generations of students who came to TIFR and were inspired by the lasting traditions that he left behind.

Family reasons prevailed upon Peters to emigrate to Denmark, where he rose to the position of director of the Space Physics Institute in Lyngby. He has now retired from active research and lives in Lyngby with his wife Hanna. The collection of articles in the special section is intended as a tribute to Bernard Peters, who turns eighty-one this month.

Devendra Lal of Scripps Institution of Oceanography, La Jolla, USA, and Ramanath Cowsik of TIFR gathered the articles and were guest editors.

M. G. K. Menon recalls the impact of Peters' 1949 paper on the discovery of heavy nuclei in primary cosmic radiation (**page 715**). Peters and Menon, who joined the former's group at TIFR in 1955, soon recognized that many aspects of particle physics, till then almost exclusively in the hands of the early cosmic-ray researchers with their emulsions and balloons, were moving into the domain of accelerator physics with the advent of these maçhines. (But see **page 711** for a report on focus on non-accelerator particle physics.) Peters' group did indeed concern itself with other aspects of cosmic radiation. These are described in Peters' recollections (**page 717**) and in Devendra Lal's account (**page 722**) of the discovery of cosmogenic beryllium-10 in India. At the same time, in the United States, cosmogenic beryllium radionuclides were independently discovered by James R. Arnold and others (**page 727**). B. V. Sreekantan (**page 718**). R. R. Daniel (**page 719**), Gaurang B. Yodh (**page 720**) and S. Biswas (**page 724**), all of whom worked with Peters, also provide recollections.

Bruce Dayton, who worked with Peters in Berkeley and Copenhagen, recalls a 1968 project on the charge composition of cosmic rays (**page 729**). The project involved building a double-Cerenkov detector and associated electronics, and flying them in balloons. Dayton's account also has an element of drama—an accidental balloon launch over the French Pyrenees, and the arrest of one of the group by the Spanish Civil Guard!

Jake Waddington (**page 736**) and Philip Morrison (**page 740**) discuss the significance of Peters' cosmic-ray work. Waddington places Peters' work in the perspective of the still-pursued astrophysical questions of the relative abundances of the elements and of the isotopes of elements. To Morrison, Peters' demonstration that cosmic rays were 'a complicated sampling of the ordinary matter of the sun and stars' was yet another confirmation of the material unity of the cosmos, after Copernicus' 'explicit unification of the celestial with the merely earthy', Newton's demonstration of an 'astonishing unity ... under the simple rules of gravitation', and the spectroscopic evidence that 'atoms comprise the entire material world'. Morrison also concludes with a mention of perhaps 'a new kind of matter'—the dark matter of today's cosmology. Ramanath Cowsik reviews the status of the search for dark-matter particles (**page 759**).

Devendra Lal (**page 744**), a codiscoverer of cosmogenic beryllium-10, while surveying the development of the study of cosmogenic nuclides in geophysical contexts, highlights the impact of accelerator mass spectrometry. Rama (**page 751**) and K. M. V. Apparao (**page 756**), also part of the school established by Peters in TIFR, discuss emanation of radon from rocks (Rama) and beryllium stars (Apparao).