Robert Eugene Marshak

An obituary by *J. Pasupathy*

Robert Eugene Marshak, son of poor Jewish immigrants, was born on 11 October--1916 in New York. After graduating from Columbia University in 1936, he went on to Cornell to work with the renowned nuclear physicist Hans Bethe, obtaining his doctoral degree in 1939. He moved on to Rochester where he stayed for three decades, transforming the place in the process into an internationally famous centre for high energy physics. He was President of the City College of New York from 1970 to 1979. Relinquishing the administrative work in 1979, he became Distinguished Professor at Virginia Polytechnic Institute and State University at Blacksburg and devoted all his energies to full-time research in physics until sudden death took him away last Christmas eve.

Marshak's interest in physics and astrophysics ranged over a wide spectrum. I shall just comment on three of his most important contributions. (i) *The two meson hypothesis*—with the advent of Yukawa's theory that a new particle or meson (mass intermediate between an electron and a proton) was responsible for nuclear forces, the experimental search was earnestly on. The cosmic-ray meson discovered in the late thirties, although more massive than an electron, did not behave the way Yukawa had predicted. The puzzle was resolved in the post war period by Marshak and Bethe in the USA (independently by Sakata in Japan) who asserted that there are actually two mesons—one of them a parent particle called the pion which is to be identified with the Yukawa particle. The pion lives for a very short time and decays into a second meson (now called a muon), which is to be identified with the puzzling particle seen in the cosmic-ray experiments. This prediction was beautifully confirmed experimentally in the late forties by Cecil Powell and his colleagues at Bristol.

(ii) *Indirect test of time reversal invariance*: Time reversal invariance is an exact symmetry at the microscopic level in both classical and quantum physics. However in quantum theory dynamical evolution is described by a complex state vector which has important phase information. For this reason, comparing the amplitude for $A \rightarrow B$ with the time reversed process $B \rightarrow A$ involves apart from reversing the signs of momenta and angular momenta the phase as well and is therefore virtually impossible to accomplish in practice. However when one looks at cross sections which involves only the absolute value of the amplitude and not the phase, comparison of the two reactions $A \rightarrow B$ and the time reversed process $B \rightarrow A$ becomes possible. This gave the first practical method for measuring the spin of the pion as pointed out by Marshak in 1950.

Again, characteristically, Marshak not only made the important theoretical proposal, he helped in the experimental effort as well. During his Chairmanship, a cyclotron was built at Rochester. Richard Wilson one of his younger colleagues at that time was able to do the experiment and establish successfully that the pion spin is zero.

(iii) *Universal V–A theory of weak interaction*: The year 1956 witnessed the overthrow of parity as a symmetry in weak interactions (which is responsible for beta decay of nuclei, the decay of a pion into a muon, etc.)—but the nature of the space–time structure of the interactions was very confusing because of mutually conflicting evidence from different experiments. In the early Spring of 1957, Sudarshan and Marshak, brought order in a chaotic situation by introducing the universal vector–axial vector V–A theory of weak interactions. It asserts that only chiral, i.e. left handed elementary fermions participate in weak interaction. [The universal V–A theory was also advanced by Feynman and Gell-Mann from a different perspective. The story of this major scientific discovery is recounted by Marshak in *Current Science*, 1992, **63**, 60–64.] This has been brilliantly confirmed by several experiments over the last few decades. The chiral fields introduced by Sudarshan and Marshak form fundamental building blocks of what is now called the standard model. In the words of Shelley Glashow (Nobel lecture 1979), "The synthesis of Feynman and Gell–Mann and Marshak and Sudarshan was a necessary precursor to the notion of a gauge theory of weak interactions."

Teacher: Over fifty physicists obtained their Ph D under his supervision. They came from all over the world—North America, Europe, Middle East, South Asia, Far East—among them such famous physicists like Regge and Sudarshan. Although he had at any given point of time his own list of interesting and important problems, Marshak let everyone of his students do what he or she liked researchwise. This of course was mutually beneficial—it encouraged the student to pursue his own ideas with good advice and constructive criticism from the teacher, who maintained excellent contacts with various labs and institutions round the world. It also helped the teacher in turn to keep pace with the rapidly expanding field. Although in later years due to his many administrative and other responsibilities, Marshak did not participate in some of the knitty-gritty details of research, he had a rather unique way of making sure that the student had done his work properly. While never feeling hesitant or awkward to accept his student's superior technical ability, he

would ask enough probing and difficult questions and sometimes even seemingly absurd ones, which only the student who had carefully done his work would be able to answer. All drafts submitted by students were immediately gone through, with neat comments in pencil.

At Rochester he used to run a weekly discussion meeting in particle physics which sometimes lasted all morning. Everyone — professors and first-year graduate students — participated in them. Much fruitful research work emerged from collaborative work between persons who probably would have never worked together but for Marshak's ability to create a very congenial atmosphere and get people together. He had the most charming manner in dealing with the speakers. In one of these meetings, a well-known visiting professor from abroad went on and on for quite some time — then momentarily paused and declared that whatever he had said earlier was just an introduction to what was to come. Gloom had descended on the audience. Somehow in the next few minutes Marshak was able to bring the visitor's talk to an end, homing in on the essential points, without in the least offending him.

Administrator and organizer: Marshak became the Chairman of the Department of Physics and Astronomy in 1950 which soon became one of the top schools for physics in the United States. That so many distinguished physicists have served on the faculty at Rochester, is a reflection on his ability to attract talent. He became the University Distinguished Professor in 1964 and a few years later in 1970 returned to administrative work as the President of the City College of the City University (CCNY) of New York (whose alumni include Schwinger and Feynman). In a period of political and social turmoil, he steered CCNY to a path of steady growth. In 1979 he once again returned to full time research in physics despite enormous pressures on him to stay on as President. A grateful college, acknowledged its debt by naming the science centre after him.

Inspired by the success of the famous Shelter Island Conference organized by Oppenheimer in 1947, which heralded the rapid advance of quantum electrodynamics in the post war era, Marshak began organizing a conference every year from 1951 onwards. That, these now famous Rochester conferences were initially supported by Rochester Gas and Electric Company not only speaks for the good sense of the managers of this utility company, but the enormous talents of Marshak the fund raiser. From 1958 onwards the venue of the conference was shifted periodically between Western and Eastern Europe, the USA and later to Asia as well. Nowadays it is held once in two years with over a thousand participants from all over the world.

Patriot and public servant: Marshak was a deputy group leader in the Manhattan project at Los Alamos. He served also as a member of the US delegation in international parleys. Despite the increase in cold war tensions in the late fifties and early sixties, thanks to the "Rochester Conferences", many distinguished physicists from the Iron Curtain countries were able to meet with their colleagues abroad.

As President of the American Physical Society in the early eighties, he fostered international cooperation in science and helped mobilize physicists for reduction of nuclear arsenal.

The ideal Grihasta or the family man: The Marshak family exemplified the ancient Tamil poem Kural, "The only reason for maintaining a household is to provide hospitality for others". Ruth, whom he married in 1943 and remained his companion ever since, and Bob Marshak, made everyone welcome in their house. People got together not just on formal occasions, many went to their vacation home, joined them in picnics. The Marshaks were also ideal guests — everyone felt completely at ease in their presence. Bob Marshak travelled extensively to many parts of the world, with Ruth as his constant companion, especially during the last three decades. He visited India thrice — in 1953 as a visiting professor at the Tata Institute of Fundamental Research, in 1963 as the Niels Bohr Visiting Professor at the Institute of Mathematical Sciences and in 1977 as the UGC Guest Professor.

Some aspects of his personality: He was always most excited about new results coming out of ongoing experiments and looked for newer and deeper theoretical insights that these will bring in their wake. While success did not make him smug, failure did not depress him either. He attached great importance to performing one's duty or Dharma in life. He was aware, that he missed out participating in the exciting developments of the Gauge Theories in the 1970s because his Presidency of CCNY left him little time for anything else, but never complained about it. As a colleague, he was a very good critic, but never spoke discouragingly let alone disparagingly of anyone's ideas.

Another outstanding trait of his was his eagerness to foster cooperation among not just high energy physicists but different people in all walks of life. He was always willing to use every available, even the smallest opening or opportunity that came his way to help some one.

During the past summer when I met him, he was giving finishing touches to his book on *Concepts in Particle Physics* and was full of ideas for research in the years ahead. He was also greatly disturbed by the worsening of ethnic conflicts in various parts of the world.

In his death, the world lost not only an outstanding physicist, a great human being as well.

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