President Reagan chose him as chairman of the White House Science Council, a position that he held with distinction for eight years; and in 1990 President Bush named him to the newly created President's Council of Advisers on Science and Technology. It was typical of Sol that he participated fully and effectively, via a phone link, in PCAST's last meeting with President Bush, in December 1992, despite the fact that he was in a hospital bed in Boston undergoing a very high-risk medical procedure.

In parallel with these Presidential appointments, Sol found time to serve on the Defense Science Board, the Energy Research Advisory Board and a wide range of other more specialized governmental panels, boards and committees.

A loyal MIT alumnus, Sol served on several committees of the MIT Corporation and was a director of the Draper Laboratory Corporation. He was a trustee of the Rand Corporation and a member of the National Academies of Sciences and of Engineering and of the latter's council.

Truly a self-made man, Sol was urbane and well read. He was tough-minded and warmhearted by turns: He could dismiss with a barbed retort a statement he considered wrong-headed but could also remember a colleague's work in detail and any infirmities with sympathy.

Those of us who had the pleasure of working with Sol remember him particularly for the precision and clarity with which he analyzed very complex issues, both technical and managerial. He was characterized by crisp logic, solid principles and unquestioned integrity. And quite apart from all that, he was fun to work with. He was a role model for generations of young scientists both at Bell Labs and in Washington, and the physics community and the nation are the poorer because of his early and untimely death.

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Jan H. Oort

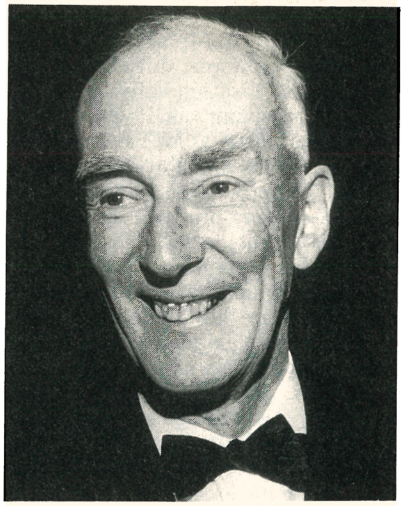
After a research career spanning 70 years, the Dutch astronomer Jan Hendrik Oort passed away on 5 November 1992 at the age of 92. At the time of his death he was still fully active in studying the large-scale distribution of matter in the universe. With an infallible intuition as to the most promising lines of research and the ability to make others follow where he led, he exercised a profound influence on the development of 20th-century astronomy.

Oort studied at the University of Groningen in the Netherlands and obtained his PhD in 1926. He then joined the University of Leiden, where he was professor of astronomy and director of the observatory from 1945–70.

Oort's first research dealt with the rotation of our Galaxy. He concluded that the rotation was unlikely to be at constant angular velocity, and from the available observations of stellar velocities he determined the rotational velocity near the Sun and its gradient, still characterized today by the "Oort constants." From these, Oort later obtained the mass of the Galaxy.

The main problem in determining the overall structure of our Galaxy was the absorption of starlight by interstellar dust. When Grote Reber in 1942 made the first map of radio noise, which demonstrated its Galactic origin, Oort immediately understood the importance of radio waves that could penetrate the dust clouds unhindered. But Oort wanted more, namely radial velocities, and this led Hendrik van de Hulst to search for spectral lines that would allow their determination. A result of this research was van de Hulst's prediction of the 21-cm spin-flip line of atomic hydrogen. As soon as possible after World War II, Oort organized a campaign to develop the instrumentation needed for the observation of this hydrogen line. Though the first detection of the line was made elsewhere, Oort was the first to use it to map out the distribution of the gas in our Galaxy and to delineate its spiral structure. Soon it became clear that the 7.5-m radiotelescope at Kootwijk in the Netherlands (left over from the war) had insufficient resolution and sensitivity for detailed studies of our Galaxy, and Oort took the initiative to build in the Netherlands first the 25-m telescope at Dwingeloo (1956) and subsequently the Westerbork Radio Synthesis Telescope (1970)—an array of fourteen 25-m telescopes—both of which are still very much in use today.

The study of the interstellar gas naturally led Oort to consider its dynamics, and he brought together hydrodynamicists and astronomers for this task. He studied the effects of supernova explosions and their input of energy into the interstellar gas. Of particular interest were his studies of the Crab Nebula, the remnant of



Jan H. Oort

the supernova of 1054, in which he determined (with Fjeda Walraven) the polarization of the optical synchrotron radiation and thereby the distribution of relativistic electrons and magnetic fields, now known to be produced by the rotating neutron star (pulsar) at its center.

In 1932 Oort made a comparison between the local mass density in our part of the Galaxy inferred from its gravitational effects and that determined by adding up all the visible mass in the form of stars, gas and so forth. On the basis of the available data he concluded that not much "dark matter" was present; 30 years later, with improved data, he concluded that as much as one-third of the local mass was dark. Today the question is still open, but the prevalence of dark matter in galaxies and in the universe is generally uncontested, partly on the basis of the rotational velocities of galaxies determined at Westerbork.

Oort was one of the few astronomers to have seen Halley's Comet twice. His studies of the orbits of "new" comets—those that come near the Sun for the first time—led him to the conclusion that there must be a reservoir of comets, now called the "Oort cloud," far outside the orbit of Pluto. Oort showed that passing stars might occasionally perturb the orbits of these comets and direct them toward the inner solar system.

Oort had a strong belief in the benefits of international cooperation. He was general secretary (1938–50) and president (1958–61) of the International Astronomical Union. His wish to complete the data on our Galaxy obtained mainly in the Northern Hemisphere with corresponding data from the south led him to envisage the creation of a European observatory with large telescopes. It took a decade of careful maneuvering through the complexities of European politics before his efforts were crowned with success in 1962 with the founding of the European Southern Observatory. ESO has central facilities near Munich and a large observing facility in Chile.

Through his own research and that of his numerous students, Oort's influence has been far reaching. He received many honors, but perhaps the highest was the epitaph written by Subramanyan Chandrasekhar in a telegram to the Dutch Academy: "The great oak of astronomy has been felled, we are lost without its shadow."

LODEWIJK WOLTJER
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Robert E. Marshak

Robert Eugene Marshak died by drowning on 23 December 1992 at Cancun, Mexico. He was 76 years old.

The child of an immigrant fruit peddler and a garment worker, Bob Marshak was throughout his life driven not only by intellectual curiosity and brilliance but also by an unquenchable quest for social justice and personal recognition. His career was informed by immense achievement but also punctuated by occasional controversy and disappointment.

At Columbia University Marshak majored in philosophy and mathematics, graduating in 1936. As a graduate student at Cornell University, from 1936 to 1939, he did pioneering work in astronomy, especially in the field of white dwarfs, with Hans Bethe. After receiving his doctorate, he joined the faculty at the University of Rochester, but like so many outstanding physicists he left to join the Manhattan Project. During World War II he served at Los Alamos, where he invented a variational method for the crucial neutron diffusion problem in nuclear matter. His work also included a theory of radiative diffusion heat waves; they are now generally known as Marshak waves.

Marshak's major research in particle physics, and undoubtedly his most important contribution to physics, came after his return to Rochester in 1946. In 1947, together with Bethe, he published the now canonical two-meson hypothesis with the correct assignment of the spins to explain the then-puzzling phenomena seen in cosmic-ray events. This hypothesis, which in 1946 was independently advocated by Shoichi Sakata and Takeshi Inoue in Japan, clarified the prevailing confusion by distinguishing the weakly interacting muon from the strongly interacting pion, which Hideki Yukawa had postulated to account for the strong nuclear force.

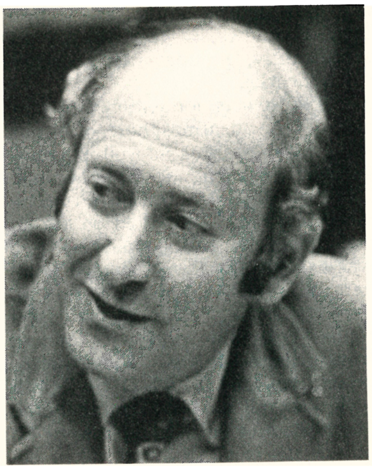
The Rochester cyclotron produced pions on nuclear targets in December 1948, allowing researchers to determine the pion's spin and parity. In 1951 Marshak suggested that one could determine the spin of the positive pion π^+ experimentally by comparing the cross sections for the reactions $pp \rightarrow \pi^+ d$ and $\pi^+ d \rightarrow pp$ and invoking the detailed balancing principle, which in its turn is a result of the time-reversal invariance of strong interactions. Immediately after this proposal, experiments done by R. Durbin, H. Loar and Jack Steinberger at Columbia University, as well as by Donald L. Clark, Arthur Roberts and Richard Wilson at Rochester, confirmed the spin to be zero.

The current state of knowledge of pion physics formed the subject of Marshak's book *Meson Physics*, published in 1952. He also edited a series of books dedicated to developments in contemporary physics, among which *Introduction to Elementary Particle Physics* (1961), by Marshak and a former student, E. C. George Sudarshan, was one.

In possibly the first application of broken symmetry to particle physics in terms of reduced matrix elements, in 1957 Marshak, Susumu Okubo and Sudarshan obtained a magnetic moment sum rule involving Σ-hyperons. During the same period Marshak and his students Peter Signell and Ronald Bryon showed how the inclusion of a spin–orbit contribution to the nuclear force (the Signell–Marshak potential) gave a dramatically improved explanation of the nucleon–nucleon scattering data.

Marshak's major achievement at Rochester was to establish, with Sudarshan, the universal V–A weak interaction theory in 1957. The theory, which emphasized the importance of chiral invariance, was also formulated by Richard Feynman and Murray Gell-Mann. It was the starting point of the present standard unified electroweak theory of Sheldon Glashow, Abdus Salam and Steven Weinberg.

In 1958 Marshak (together with Okubo, Sudarshan, W. Teutsch and Weinberg) introduced the notion of the isospin-$\frac{1}{2}$ weak current with successful applications to K-meson decays, although the structure was naturally built into the standard theory. Marshak's subsequent research on strong, weak and electromagnetic interactions at Rochester culminated in the book *Theory of Weak Interactions in Particle Physics* (1969), coauthored with Riazzuddin and Ciaran P. Ryan.



Robert Marshak

In his time at Rochester Marshak was one of the great research guides, in the tradition of Arnold Sommerfeld and Bethe. He had many students and was host to numerous visiting physicists from all over the world. He served as physics department chairman for 14 years, and his enthusiasm, insight and guidance made the department a leading research center of high-energy physics.

In 1970 Marshak became the eighth president of the City College of New York, at a time of wrenching transition for the venerable institution. Having for many decades provided the means of intellectual advancement and social mobility for the city's poor but bright and motivated children of immigrants—an astounding number of well-known American physicists went to CCNY—the college was then, as a result of open admissions, called upon to serve a larger, less well-prepared population. At the same time, though less known to the general public, City College was striving to become a graduate research institution in physics and other science and engineering fields.

Marshak succeeded in improving about a dozen departments at CCNY, physics prominent among them. However, Bob's most visible and sometimes most controversial achievements came with the new programs he established: a Center for