Obituary

David N. Schramm (1945-97)

Astrophysicist who linked outer space to the inner space of particle physics

AP/UNIV. CHICAGO, M. GILSON

David N. Schramm thought big. Twenty-five years ago, few shared his optimism about cosmology, whereas today most cosmologists speak of a golden age. The standard hot Big-Bang model already accurately describes the Universe from the time it was 0.01 seconds old; and the future is also promising, with bold ideas prompted by fundamental physics now being tested by an avalanche of data. No one appreciated this confluence of theory and observation more, and very few, if any, did more to bring it about than David Schramm, who died on 19 December when his aeroplane crashed near Denver.

As a graduate student at Caltech, Schramm worked with William A. Fowler and Gerald Wasserburg. Having two advisors, each of great stature, was an early indication of the energy Schramm would show throughout his career. Both advisors were part theorist and part experimentalist, and pioneers in applying nuclear physics to astrophysics in order to understand the origin of the chemical elements in stars and elsewhere. David would take it one step further, applying elementary-particle physics to evolution of the Universe. He began his career studying the origin of the heaviest elements in the explosions of stars (supernovae), but his most important work involved the production of the lightest elements — deuterium, ^{3}He, ^{4}He and ^{7}Li — in the Big Bang.

Big-Bang nucleosynthesis was first studied in the 1940s, but it was David Schramm who realized its potential as an extraordinary probe of cosmology and fundamental physics. In the process, he helped to create the field of 'particle physics and cosmology'.

Schramm took a special interest in deuterium, using it as a 'baryometer', to deduce the mass density of baryons (neutrons and protons) present in the Universe today. In 1972, Schramm and his colleagues reasoned that the present deuterium abundance could be used to set an upper limit on the density of baryons: 10% of the critical density necessary to halt the expansion of the Universe. Any denser than that, and too little deuterium would have been created in the early Universe.

The implications are profound. Measurements of the dynamics of galaxies and clusters of galaxies tell us that the total amount of matter is at least 20% of the critical density, and perhaps much more — so deuterium clinches the argument for the existence of some form of exotic dark matter, not made of familiar baryons. The leading candidate is slow-moving elementary particles left over from the earliest moments, called cold dark matter.

Another light isotope, ^{4}He, allowed Schramm to make an extraordinary contribution to fundamental physics. The amount of ^{4}He made in the Big Bang depends upon the number of types of neutrino, increasing with additional neutrino species. As there is one neutrino species for each type of electron and pair of quarks, the species number determines how many fundamental particles there are altogether.

In 1977 Schramm, Gary Steigman and James Gunn used observations of the present helium abundance to limit the possible number of neutrino species to fewer than seven. At the time, only two neutrino species were known, but it was believed that there might be many more, and laboratory experiments could only limit the number to be less than around 5,000. Over the next ten years, refinements in theory and in the observations led to a cosmological limit of three species. Finally, in 1989 experiments at high-energy accelerators confirmed that there are indeed three species.

Schramm also encouraged his colleagues to explore the flip side of this 'inner-space/outer-space' connection: the implications that particle physics has for astrophysics. Today, the leading explanation for the decades-old solar-neutrino problem is neutrino oscillation — an hypothesized fundamental property of neutrinos. And in cosmology, the leading ideas to extend the hot Big-Bang model, namely inflation and the cold-dark-matter model, are motivated by elementary-particle physics.

Schramm helped establish particle astrophysics and cosmology as a vital area of research. In 1982, he and Leon Lederman, the director of Fermilab, convinced the US space agency NASA to fund a theoretical astrophysics group at a particle-accelerator laboratory. His own contributions were multiplied by those of the 24 thesis students he supervised and the even greater number of postdocs he mentored at the University of Chicago, as well as the countless young scientists whose careers he influenced around the world.

Schramm was a most effective spokesman for cosmology, astrophysics and basic research, reaching the general public as well as world and national leaders. He was also a physicist of the highest energy. In the month after his death, for example, he was scheduled to attend a scientific conference in Aspen; the World Economic Forum in Davos, Switzerland; a Council meeting of the American Astronomical Society in Washington; a PhD defence in Paris; and a Physics Division Advisory Committee meeting at Los Alamos.

Schramm's zest for life was as big as his enthusiasm for science. Affectionately known as Big Dave, in his collegiate days he was a champion Greco-Roman wrestler, and he continued his involvement in wrestling as a coach at Caltech and Chicago. He was an avid mountaineer, climbing in Colorado, South America, the Caucasus, the Alps and the Tatras. Although he turned down an opportunity to climb Everest, Dave proudly proclaimed that by climbing Chimborazo in Ecuador he had reached the farthest point from the centre of the Earth (owing to the equatorial bulge). And as both of us can testify, he was a game competitor on the racquetball court, basketball court and ski slope.

Dave had a passion for flying, and over the years owned four aeroplanes. But of his primary passion there was never a doubt: his red Porsche bore the licence plate "BIG BANG", and he was the President and Chief Pilot of "Big-Bang Aviation".

Because of his energy and enthusiasm, many of his colleagues described Big Dave as a primaeval force of nature. We can only add that he was a most positive force, and a force that will be dearly missed.

Edward W. Kolb and Michael S. Turner

Edward W. Kolb is in the Department of Theoretical Astrophysics, Fermi National Accelerator Laboratory, PO Box 500, Batavia, Illinois 60510, USA. Michael S. Turner is at the Enrico Fermi Institute, 5640 South Ellis Avenue, Chicago, Illinois 60637-1433, USA.