OBITUARIES

Freeman J. Dyson

Freeman J. Dyson died on 28 February 2020 of complications after a fall in the dining hall of the Institute for Advanced Study in Princeton, New Jersey. That lunch discussions with young colleagues were his frequent pleasure at age 96 says much about this brilliant, gracious, and sometimes contrarian man.

Dyson was born on 15 December 1923 in Crowthorne, UK, into a family at once artistic and establishment; his father, George Dyson, was a noted composer and educator. A mathematical prodigy, Freeman easily won a scholarship to Cambridge University. His mentor there, celebrated mathematician G. H. Hardy, told him, "Young men should prove theorems; old men should write books." That became the pattern of Dyson's life. His "theorems" illuminated physics. His first book of artful and influential essays, *Disturbing the Universe*, was published when he was 56. The first half of his life established his mathematical brilliance; the second half, his unabashed intellectual boldness and literally cosmic imagination.

Immediately after World War II, the effort to turn nonrelativistic quantum mechanics into a relativistic quantum field theory (QFT) was in disarray. Starting with Dirac's equations for quantum electrodynamics, "old" versions of QFT existed, but they did not lead to finite results for radiative corrections. The calculation of observed physics—the Lamb shift or the anomalous magnetic moment of the electron—stumbled on the effects of particles' self-interactions, with divergent results.

By the spring of 1948, however, the landscape had changed, and three theories seemed viable. Julian Schwinger, then a prodigy of 30, had a so-called Green's function method involving prodigious calculations of which only he seemed capable. Richard Feynman, also 30, had what we now call Feynman diagrams. And Sin-itiro Tomonaga's QFT was just becoming known in the West. Feynman also had the "sum-over-paths" idea, now called path-integral formulation. He asserted that it was the same theory as his diagrams, but no one fully understood how that could be.

Dyson, who never received a PhD, was exactly the right person in temperament, place, and time. In June 1948, in Ann Arbor, Michigan, Schwinger gave a series of lectures that most, including Dyson, found incomprehensible. Contrary to Schwinger's reputation, Dyson found him approachable and willing to tutor the 25-year-old acolyte in the arcane art. In the same month, Dyson and Feynman made their now-legendary road trip from Cleveland, Ohio, to Albuquerque, New Mexico, with Feynman talking nonstop. Later in the summer, sleep-deprived on a Greyhound bus somewhere in Kansas, Dyson understood, virtually in a flash, that all three (or four) formalisms were actually the same theory. Schwinger's Green's functions were the commutators of old QFT but cleverly manipulated to avoid the infinities; Feynman propagators were time-ordered Green's functions and were indeed a recognizable perturbation expansion of his path-integral formulation. Dyson's 1949 paper "The radiation theories of Tomonaga, Schwinger, and Feynman" made a Nobel Prize virtually inevitable; it was awarded in 1965 to Feynman, Schwinger, and Tomonaga—not to Dyson. The prize is allowed to be split at most three ways.

In the 1960s the floodlight of Dyson's curiosity shifted from mathematical physics to nuclear energy: reactors, bombs, disarmament, public affairs, and other areas. A member of the JASON group, he advised the federal government on defense issues. Project Orion was definitely "other," a serious attempt at designing and building a spaceship the size of a small mountain, with a crew of 200, that would be powered by small nuclear bombs and capable of exploring the solar system in a matter of months. Orion was overtaken and doomed by the atmospheric nuclear test ban. More down-to-earth, Dyson led, at General Atomics in San Diego, the design of small, intrinsically safe nuclear reactors; many of those TRIGA reactors still exist.

At the same time, he also began to imagine the grand cosmic schemes for which he is now best known to the public: Dyson spheres, in which the mined metals of a single planet (Earth, say) were sufficient to entirely surround its star (the Sun, say) and capture a billion times more solar energy than the planet

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alone; or comets as a source of carbon, oxygen, and hydrogen for the growth, by photosynthesis, of genetically engineered giant sequoia trees—more for the delight of it than for any practical purpose. Dyson's imagination embodied joy and occasional silliness.

One cannot read Dyson's works without sensing a muted Enlightenment deism beneath the scientifically rigorous inventiveness. He credited to his mother his use of the phrase "world soul" and expressed several variants of the thought that intelligence, human or otherwise, played a special role in giving purpose to the universe. It was a controversial view for a physicist. His late-in-life contrarian stance on climate change—that it might be a good thing—made a kind of sense in the context of his seeming belief that the universe is not just purposeful but good. Always respectful of organized religion, Dyson was a recipient of the 2000 Templeton Prize, which celebrates "scientific and spiritual curiosity."

Dyson, whom we remember for his lifelong technological optimism, ended life soberly, writing that today's world—with persistent poverty, brutal dictators, and small wars "presaging worse horrors to come"—most reminded him of the year 1936, when he was 12. He did not live to see the effects of the coronavirus pandemic.

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