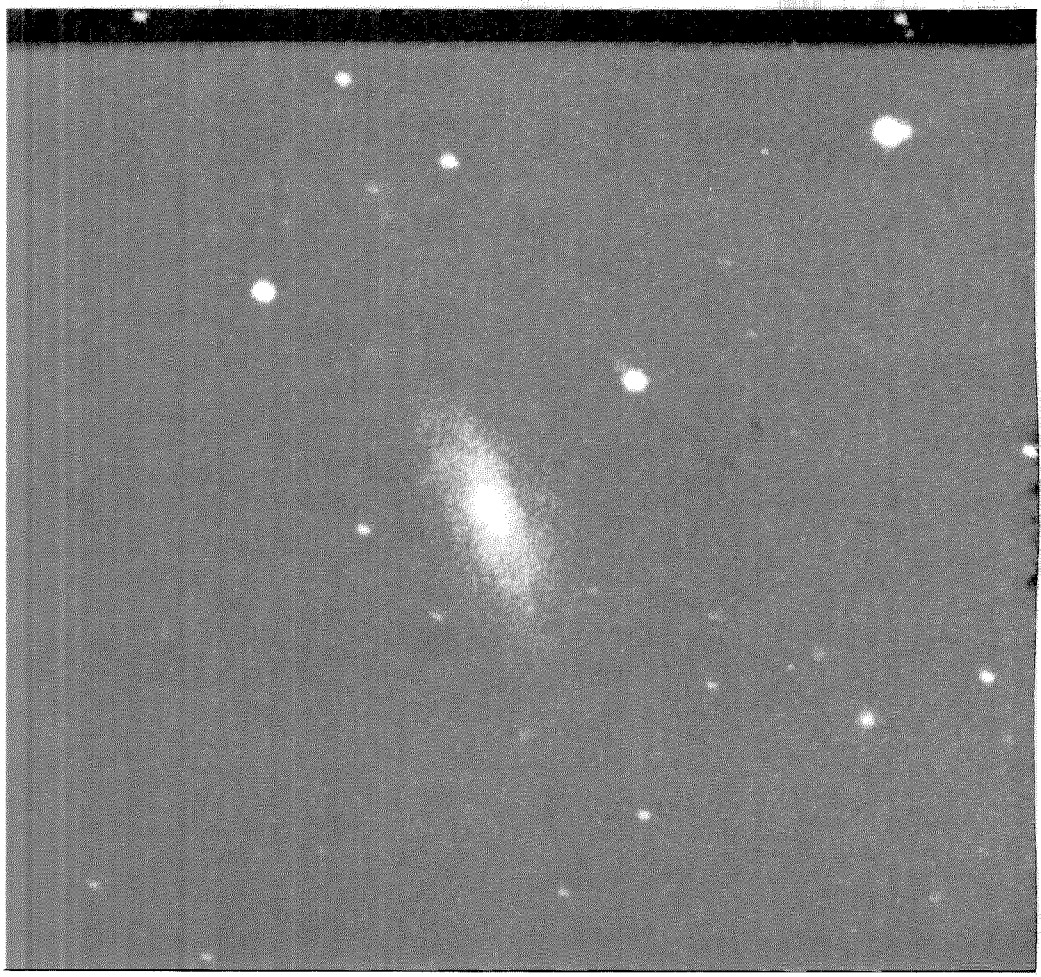


100 Supernovae—The Reward of a 40-Year Search

by Fritz Zwicky

At maximum luminosity, supernovae are thousands of times as bright as common novae—and billions of times as bright as the Sun

In the fall of 1928, thanks to the persistent efforts of George Ellery Hale, then director of the Mount Wilson Observatory, the Rockefeller Foundation awarded the California Institute of Technology a grant of $6,000,000 for the construction of a new astrophysical observatory, to include a 200-inch telescope.

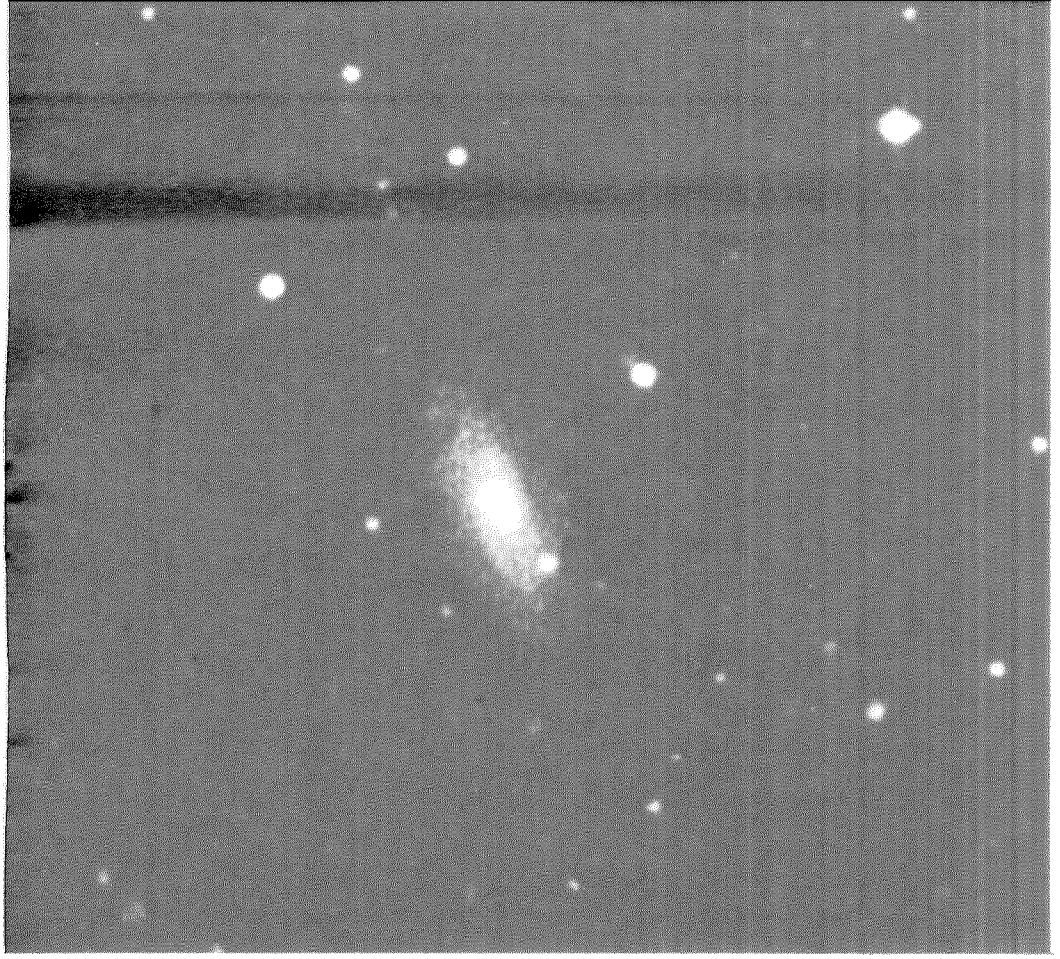
At that time, four members of the physics division of the Institute—Drs. J. J. Johnson, Sinclair Smith, John Strong, and myself—had already been dabbling in some problems of theoretical, instrumental, and observational astronomy. The inviting prospect of a new observatory inspired us to gradually switch our allegiance from physics to astronomy. Dr. Hale's advice, "Do not make any mean plans," encouraged us on our way.

For my part, I felt that developments in astronomy, in spite of the work of thousands of years, had only just been started and that in particular a relentless search for new cosmic bodies and phenomena should prove most rewarding. It seemed to me that the study of cosmic implosions and explosions and their inevitable results of compaction and dispersion of matter had not been given enough attention.

Focusing our attention on one of the best known phenomena in this realm, Dr. Walter Baade and I engaged in a study of novae—stellar implosions and explosions which, within a few hours or days, result in outbursts that increase the luminosity of the stars involved by factors up to the order of one million. A careful perusal, however, revealed that, in addition to what we proposed to call common novae—such as the well known Nova Persei of 1901, Nova Aquilae of 1918, and others—some outbursts had been observed and reported on in the past which indicated the occurrence of a much brighter class of novae. These, in 1933, Baade and I proposed to call supernovae.

There were two types of observations that pointed to the existence of supernovae—which at maximum luminosity were thousands of times as bright as common novae, or billions of times as bright as the Sun.

In the first place, since the discovery in 1885 of a temporary star near the nucleus of the great extragalactic nebula in Andromeda, about a dozen stars had flared up in the line of sight of distant galaxies, nearly equaling the apparent luminosity of these galaxies. Since no similar one-time events had been observed in the enormously greater regions of the sky which are not covered by galaxies, Baade and I concluded that these flare-ups must



A spiral galaxy in the constellation of Leo—photographed in February 1950 (left) and again four years later (right)—shows one significant difference. In the second picture a brilliantly clear supernova has appeared on the southwest edge of the cloud-like galaxy. The outburst probably occurred about 200 million years ago, and the light from it has been speeding toward the earth ever since.

have been caused by exploding stars which were members of the respective galaxies themselves, and therefore supernovae.

Secondly, the so-called Tycho star of 1572 became as bright as Venus. It was easy to calculate that if it had been an ordinary nova, it would have had to be within a few dozen light years of the Earth. Its remnants then would have been easy to locate with large telescopes, since Tycho had given a very good position of the nova. But no remnant of any kind could be found to the limit of the 100-inch telescope on Mount Wilson. From this we could conclude that Tycho's star must have been so distant that its brightness at maximum equaled that of billions of suns.

In 1934 Baade and I published our conclusions in the *Proceedings of the National Academy of Sciences.* To prove that we were right I bought a Wollensack 3¼-inch lens camera and between 1934 and 1936 started photographing the rich Virgo cluster of galaxies. Luck was not with me, for no supernovae appeared on my plates, although I expected two or three—having calculated from the meager historical data available that supernovae, in the galaxies within reach of my camera, make their appearance about every thousand years.

During my fruitless search from the roof of Robinson Hall at Caltech, I heard that Bernhard Schmidt in Hamburg had invented a very powerful type of wide-angle telescope, which is now famous and bears his name. I visited him in Bergedorf in 1935 and upon my return managed to persuade our Chief, R. A. Millikan, that with a fair-size Schmidt telescope it would be a cinch to find supernovae. He agreed, stating laughingly that my project had scientific sex appeal, and he helped me persuade Dr. Hale to allocate $25,000 of the Rockefeller grant to build an 18-inch Schmidt telescope. With the expert help of Drs. J. A. Anderson, Sinclair Smith, Russell Porter, and superb mechanics like Albert R. Brower we built the 18-inch Schmidt within a year. I put it in operation on the night of September 5, 1936, spending thereafter 21 nights on Palomar in a row to show what a determined physicist could do. Beating the "tar" out of the sky, I found my first supernova in March 1937 and the brightest one of this century on August 26, 1937. A third excellent one followed on September 9, 1937. After that, J. J. Johnson and I kept rolling steadily, discovering about four supernovae every year.

By this time we had established the Schmidt telescope as one of the most powerful innovations in astronomy, and we had discovered the previously unknown dwarf galaxies, luminous intergalactic matter, many clusters of galaxies, and other cosmic objects. These successes induced Dr. Hale to ask the Rockefeller Foundation for an additional $450,000 for the construction of the 48-inch Schmidt telescope, which I put in operation on the night of January 31, 1949. Thereafter it was used exclusively for the project of a total-sky survey, and it became available for other projects—including the search for supernovae—only in 1958. This search, with the 18-inch Schmidt, had also been interrupted because of World War II.

While working on our six-volume catalogue of galaxies (which was completed, after 30 years, in 1968), some of my collaborators, particularly P. Wild and H. S. Gates, looked for and found a few supernovae in the 1950's. A new large-scale search with the 48-inch Schmidt was initiated in 1959 when Milton L. Humason joined my group after having retired from the staff of the Mount Wilson Observatory. Things really started to move on an international scale after the International Astronomical Union established a Committee for Research on Supernovae at its general assembly in Berkeley in 1961. I have served as the chairman of this committee since its inception.

Thanks to the joint efforts of about 15 observatories all over the world, the number of bona fide supernovae discovered since 1936 has now risen to about 350, of which 260 have been discovered by the group of a dozen collaborators working with me at Caltech. I myself found my hundredth supernova about a month ago—a milestone (the parsec stone?) which, I think, will entitle me to write a book on the subject. □