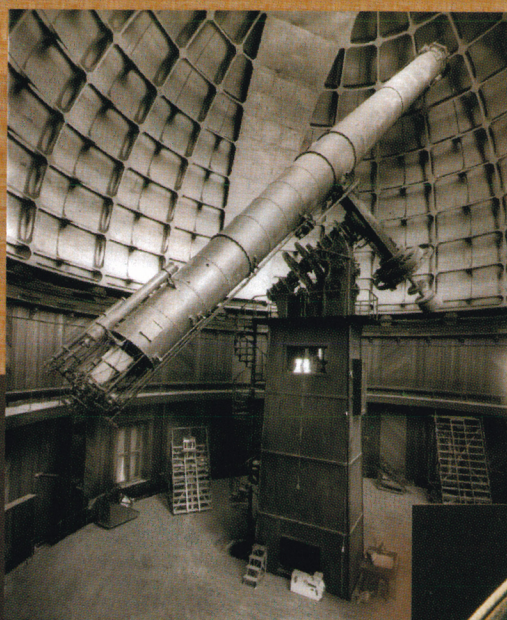


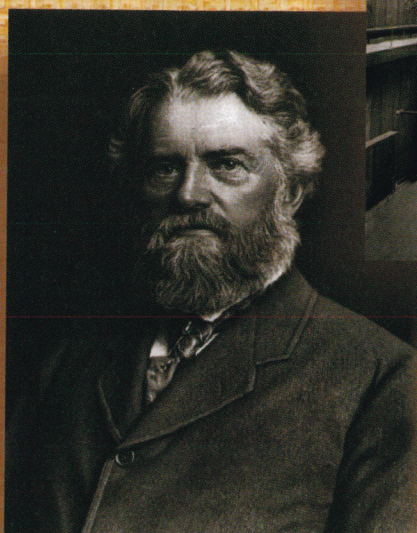
ONE HUNDRED YEARS OF ASTRONOMY IN AMERICA

In honor of the American Astronomical Society's centennial, we celebrate American astronomy's remarkable century of technological innovation and breathtaking, ever-expanding discovery.

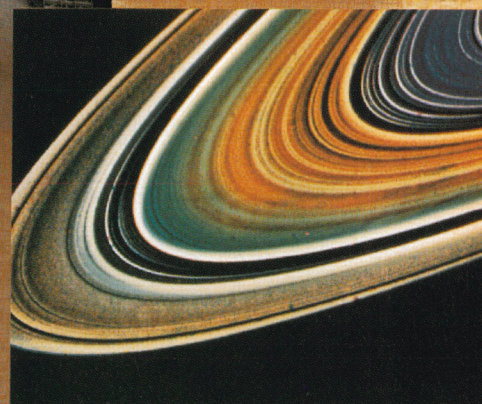
► **LICK 36-INCH REFRACTOR.**
Built by Warner & Swasey of Cleveland in 1887, it was, at the time, not only the largest refracting telescope in the world, but also the first to be adapted for visual, photographic, and spectroscopic studies. (This and other pictures herein courtesy of the Niels Bohr Library's Emilio Segrè Visual Archives, unless otherwise noted.)



▼ **THE ROTATION** of Saturn's rings was proved in 1895 by James E. Keeler and William Wallace Campbell's discovery of the rings' Keplerian velocity profile. (Voyager 2 image courtesy of Caltech/JPL/NASA.)

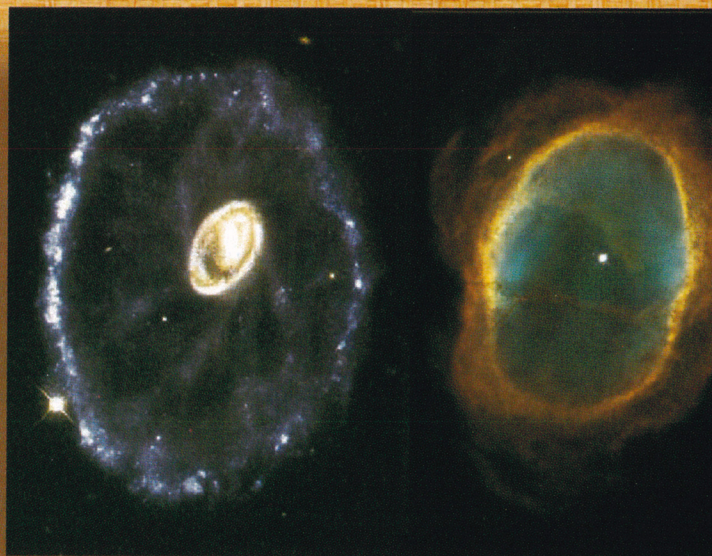


◀ **SIMON NEWCOMB**, the long-time director of the Nautical Almanac Office and later the first president of the AAS, was born in Nova Scotia in 1835. His near-flawless tables of celestial motions remained unsurpassed in accuracy for half a century.



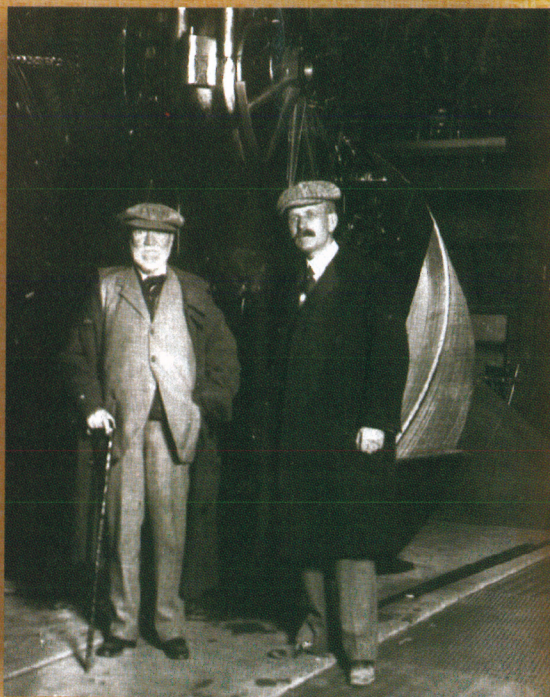


▲ PIONEER ASTRONOMERS Annie Jump Cannon (left) and Henrietta Swan Leavitt. Cannon classified the spectral types of 225 000 stars to produce the *Henry Draper Catalogue* in 1918–26. Leavitt's 1907–12 study of Cepheid variable stars established the first rung of the cosmic-distance ladder.



▲ THE QUESTION of whether so-called spiral nebulae were extragalactic, like the Cartwheel galaxy (left), or Galactic, like the planetary nebula NGC 3132, was conclusively answered in 1925 by Edwin P. Hubble, who discovered Cepheids in the galaxy M33. (Hubble Space Telescope images courtesy of STScI/AURA/NASA.)

▼ ASTRONOMY BENEFACTOR Andrew Carnegie (left) stands before the Mount Wilson 60-inch telescope (then the biggest telescope in the world) and next to George Ellery Hale, the astronomer who persuaded him to help pay for it.



▼ HENRY NORRIS RUSSELL (left), one of the 20th century's most influential astronomers, and Harlow Shapley, his first graduate student. Russell published his now-famous diagram of stellar luminosity against spectral type in 1914. That same year, Shapley deduced the Sun's location in the Galaxy.



THE VELOCITY-DISTANCE RELATION AMONG EXTRA-GALACTIC NEBULAE*

BY EDWIN HUBBLE AND MILTON L. HUMASON

ABSTRACT

Methods of determining distances of extra-galactic nebulae are discussed, and the mean absolute magnitude is revised on the basis of (1) Shapley's revision of the zero-point of the period-luminosity curve for Cepheids, and (2) more extensive observations of stars involved in nebulae. The revised value is $M(\text{vis}) = -14.0$.

The mean color-index of the nearer extra-galactic nebulae appears to be of the order of $+1.1$ mag., hence $M(\text{pg}) = -13.8$. A color-excess is suggested which is independent of distance but shows some relation to galactic latitude.

The velocity-distance relation is re-examined with the aid of 40 new velocities, 26 of which refer to nebulae in 8 clusters or groups. Distances of the clusters, ranging out to about 32 million parsecs, have been derived from the most frequent apparent magnitudes. The velocity displacements reduce the apparent magnitudes by amounts which become appreciable for the more distant clusters.

The new data extend out to about eighteen times the distance available in the first formulation of the velocity-distance relation, but the form of the relation remains unchanged except for the revision of the unit of distance. The relation is

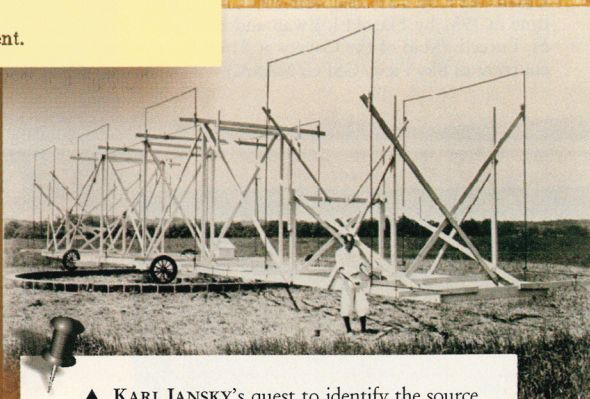
$$\text{Vel.} = \frac{\text{Dist. (parsecs)}}{1790},$$

and the uncertainty is estimated to be of the order of 10 per cent.

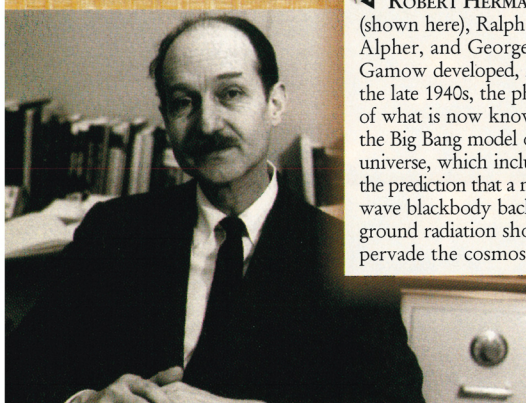
◀ EDWIN HUBBLE and his collaborator Milton L. Humason published their 1929 discovery that the universe is expanding in the *Astrophysical Journal*, which became a AAS journal in 1972.



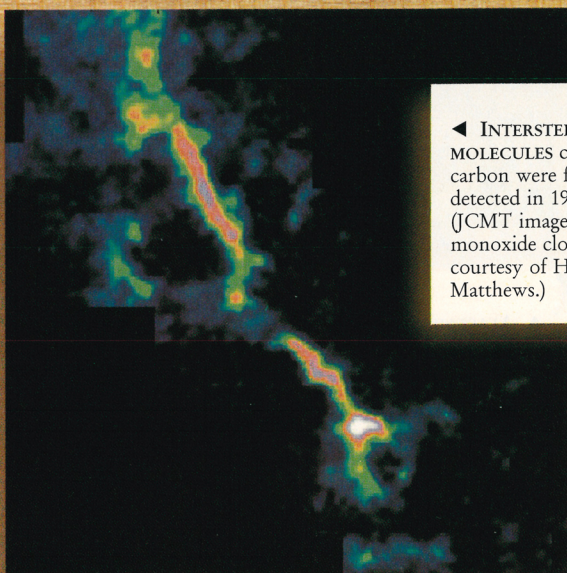
▲ FRITZ ZWICKY (chatting with Otto Stern on the right) showed in 1937 that most of the gravitational mass of the Coma cluster of galaxies is invisible. Earlier, in 1934, he and Walter Baade had identified supernovae with the explosive transformation of normal stars into neutron stars.



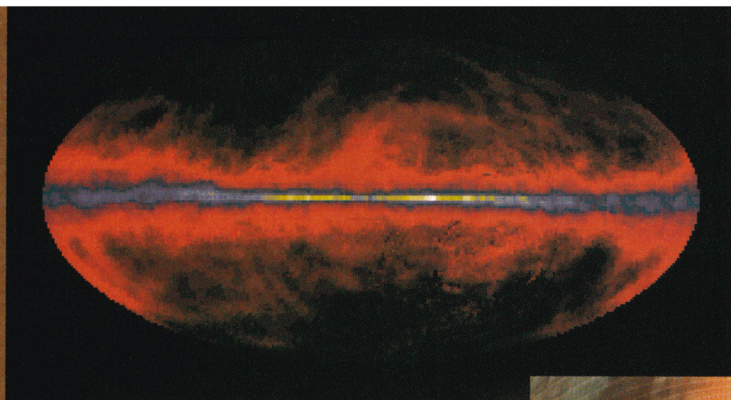
▲ KARL JANSKY's quest to identify the source of radio interference in the early 1930s led to the discovery of celestial radio waves and to the birth of radio astronomy. (Photo of Jansky and his antenna courtesy of Lucent Technologies, Bell Laboratories.)



◀ ROBERT HERMAN (shown here), Ralph Alpher, and George Gamow developed, in the late 1940s, the physics of what is now known as the Big Bang model of the universe, which included the prediction that a microwave blackbody background radiation should pervade the cosmos.

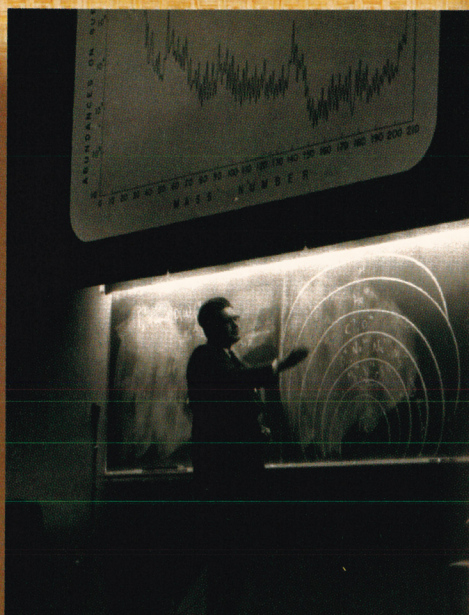


◀ INTERSTELLAR MOLECULES containing carbon were first detected in 1937-41. (JCMT image of carbon monoxide cloud courtesy of Harry Matthews.)

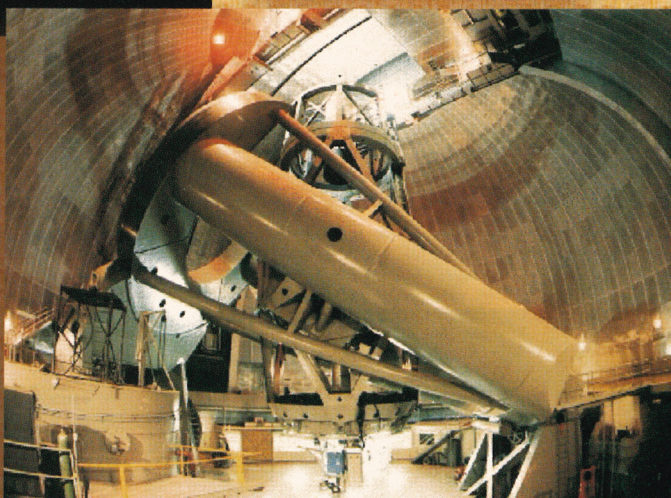


▼ THE 200-INCH HALE TELESCOPE on Mount Palomar began operation in 1947. (Fisheye view of the dome interior courtesy and copyright of Alain Maury.)

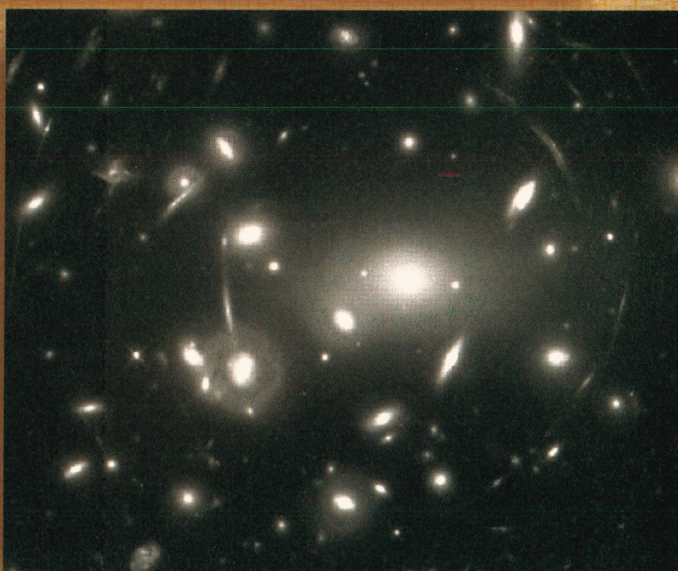
▲ HYPERFINE 21 CM LINE EMISSION from neutral hydrogen was predicted by Hendrik van de Hulst in 1945 and observed for the first time in 1951 by Harold I. Ewan and Edward M. Purcell. (Map of the Galaxy at 21 cm courtesy of SkyView/GSFC/NASA.)

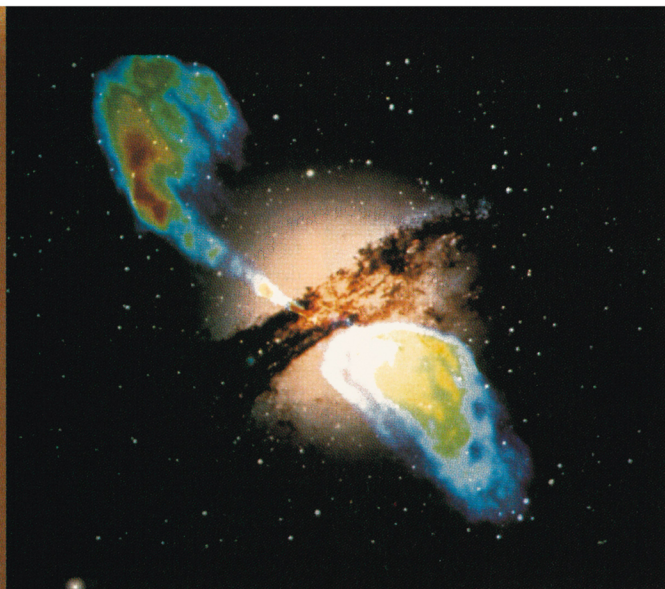


▲ ALASTAIR G. W. CAMERON (shown here) and the team of Geoffrey and Margaret Burbidge, William Fowler, and Fred Hoyle both published papers in 1957 explaining how nuclear reactions synthesize elements in stars.



▼ ABELL 2218 (shown here) is one of the thousands of galaxy clusters identified, measured, and classified by George Ogden Abell, whose eponymous catalog was first published in 1958. (Hubble Space Telescope image courtesy of W. Couch, Richard Ellis, and NASA.)

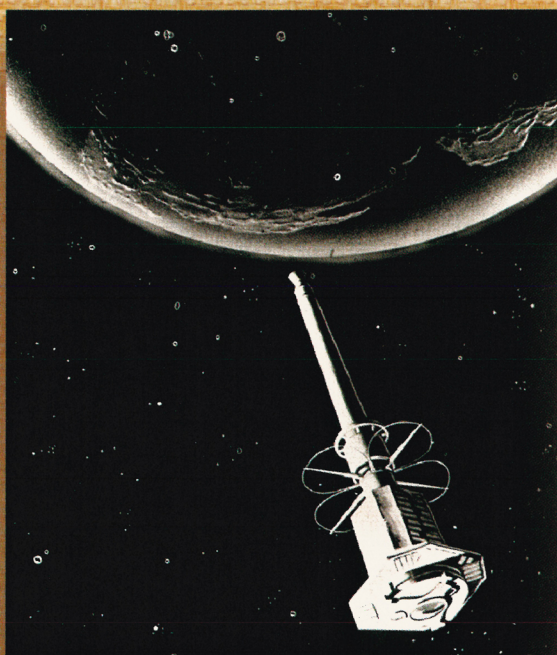




▲ **SYNCHROTRON RADIATION** emerged in the 1950s as the explanation for the nonthermal radio spectra of galaxies. (Radio and optical images of Centaurus A courtesy of Jack O. Burns.)

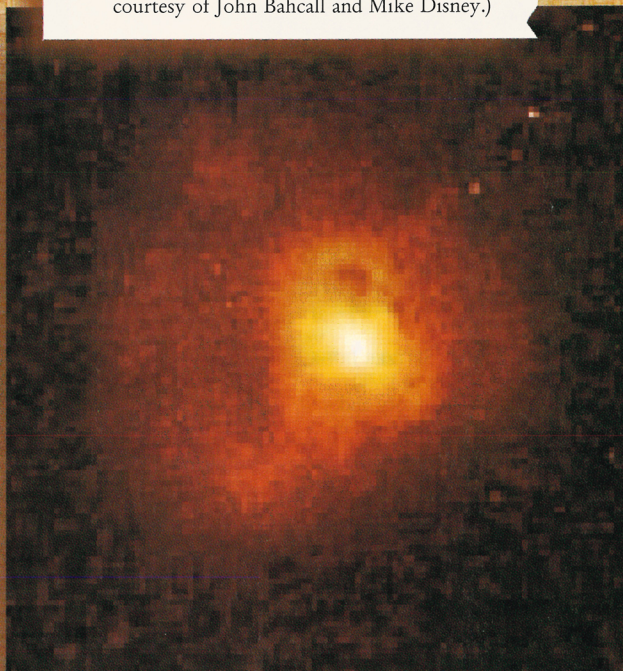


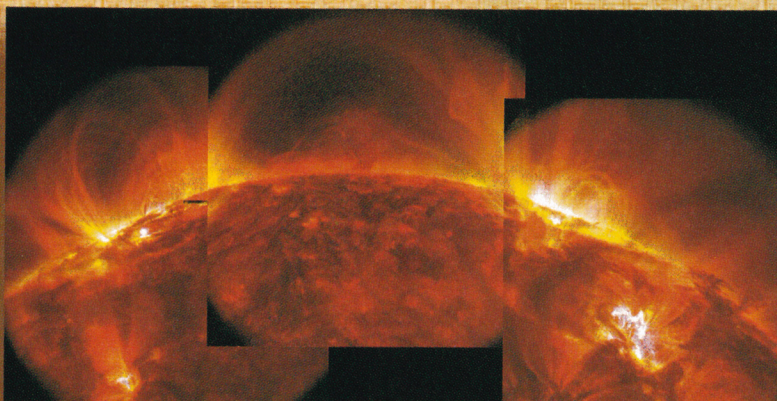
▲ **ROBERT BENJAMIN LEIGHTON** discovered, in the 1950s, that the surface of the Sun oscillates, and, in the 1960s, he built an instrument that surveyed the sky in the infrared for the first time.



▲ **EXPLORER 11**, which was launched in 1961, was the first satellite-based gamma-ray observatory. A year later, cosmic x-ray astronomy was born when a rocket experiment detected x-rays from the constellation Scorpio. (Artist's impression of Explorer 11 courtesy of HEASARC/GSFC/NASA.)

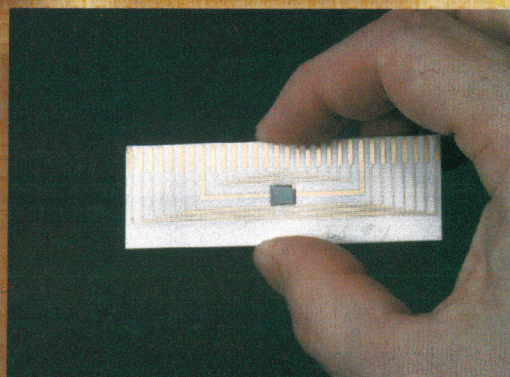
▼ **THE FIRST QUASAR** was discovered by Maarten Schmidt in 1963. (Image of the redshift 0.21 quasar IRAS 13218+0552 courtesy of John Bahcall and Mike Disney.)



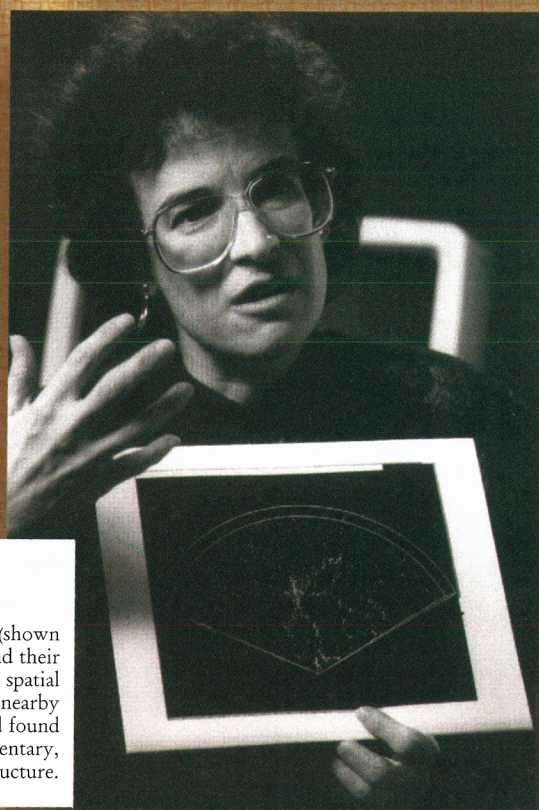


▼ **CHARGE-COUPLED DEVICE** cameras were developed at Bell Laboratories in the 1970s for television—and for astronomy. (Photo of an early 1×128 CCD courtesy of Bell Laboratories, Lucent Technologies.)

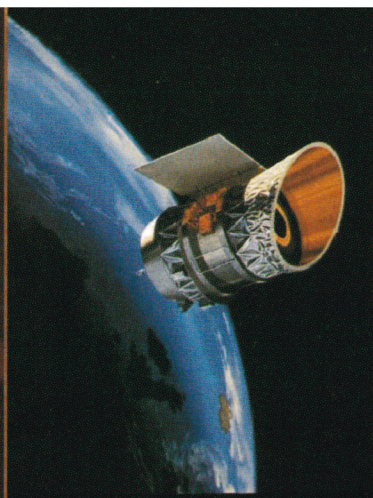
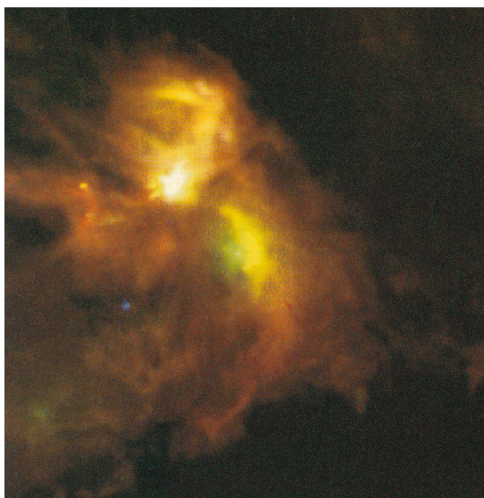
▲ **RECONNECTING LOOPS** of the Sun's magnetic field were discovered in the solar corona by NASA's Skylab mission in 1973. (TRACE image courtesy of Stanford-Lockheed Institute for Space Research.)



▲ **LYMAN SPITZER JR.** (shown here in 1978) studied laboratory and cosmic plasmas, and, in 1946, proposed what would become the Hubble Space Telescope more than 40 years later.

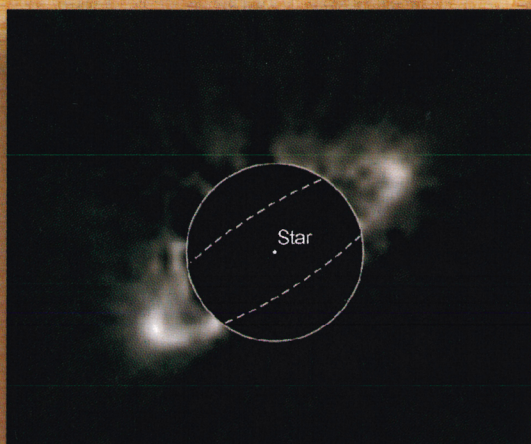


► **MARGARET GELLER** (shown here), John Huchra, and their colleagues measured the spatial distribution of 14 000 nearby galaxies in the 1980s and found it adopts a filamentary, spongelike structure.

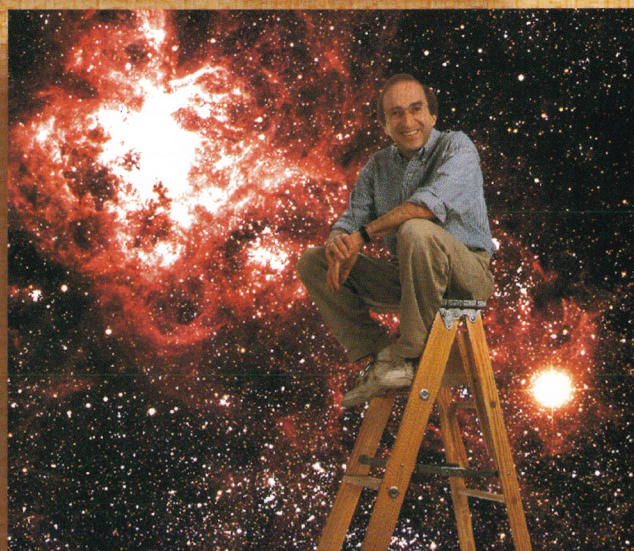


▼ SAUL PERLMUTTER leads the Supernova Cosmology Project, which has been gathering evidence since 1995 that the expansion of the universe is accelerating—possibly due to a nonzero cosmological constant. (Photograph of Perlmutter and supernova 1987A courtesy of Lawrence Berkeley National Laboratory.)

▲ LAUNCHED IN 1983, IRAS surveyed the sky at 12, 25, 60, and 100 μm and detected more than 350 000 cosmic sources of infrared radiation. IRAS also greatly elucidated the physics of star formation, which takes place in dense dusty clouds like Rho Ophiuchi, shown on the left. (Images courtesy of Caltech/JPL/NASA.)



▲ THE DUST RING that surrounds the star HR 4796A (blotted out in this 1998 image) could harbor young planets (Hubble Space Telescope image courtesy of Brad Smith, Glenn Schneider, and NASA.)



► THE TWO W. M. KECK TELESCOPES, each 10 meters across, are the largest in the world. (Photo courtesy and copyright of W. M. Keck Observatory and Richard Wainscoat.)

