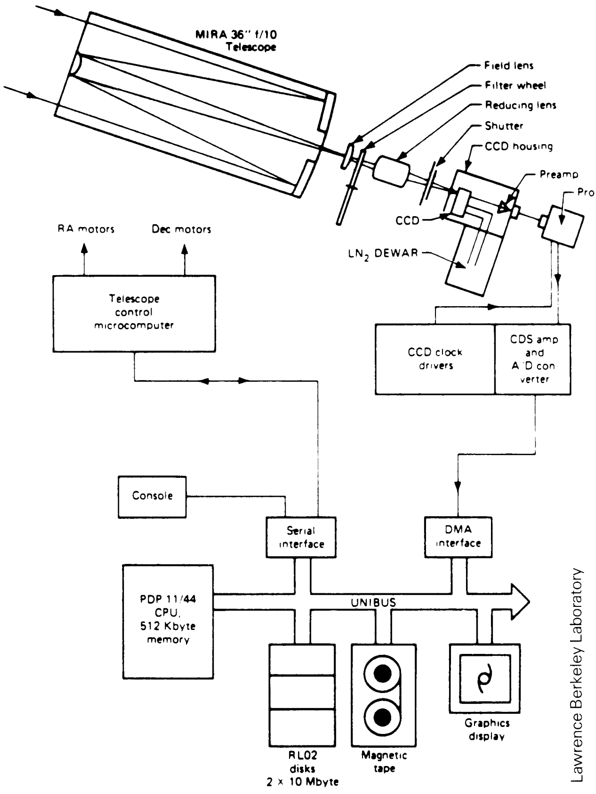


Lawrence Berkeley Laboratory

MIRA telescope will patrol 7,500 galaxies.

1054 and All That

Supernovas have fascinated astronomers for at least a thousand years. In a short while automation and the latest in electronic light sensing will be applied to a search for them.

By DIETRICK E. THOMSEN

Supernovas are transient phenomena. Chinese astronomers used to call them "guest stars" because of the way they come and go. Supernovas are the cataclysmic explosions that end the lives of certain stars. Not all stars go out with this kind of a bang, but many do, so the dynamics of the explosion are naturally of interest to astrophysicists concerned with theories of the life histories of stars.

The most famous Chinese supernova report refers to the one in the year 1054. In retrospect we know there must also have been a nearby one in 1006; it left us the radio source Cassiopeia A. Modern statistics indicate that there is about one supernova per galaxy per century. Most of those that happen in our galaxy are apparently screened from our view by the dust in the disk of the galaxy, but the vagaries of chance provided both Tycho Brahe (1546-1601) and his pupil Johannes Kepler (1571-1630) with one bright nearby one each in their lifetimes.

There has not been a bright nearby supernova since Kepler's. Modern astronomers rely on supernovas that happen in other galaxies for a systematic study of the phenomenon. A major drawback to this study is that supernovas in other galaxies are usually not noticed until they are at or beyond maximum brightness, but a good deal of the interesting astrophysics happens before the brightness reaches its maximum.

Over the years and especially in recent years there have been a number of projects for systematic searches and watches for supernovas. These vary in speed, comprehensiveness and astrophysical goals. One of the most ambitious is being prepared by a group at the Lawrence Berkeley Laboratory in Berkeley, Calif.: Jordin T. Kare, Carlton E. Pennypacker, Richard A. Muller, Terry S. Mast, Frank S. Crawford and M. Shane Burns. This search will use a fully automated telescope to patrol a sample of 7,500 galaxies for supernovas and so expects to average 75 sightings a year. It intends to be quick enough to find them while their brightness is rising, and to alert a network of astronomers who can bring all sorts of advanced observing techniques to bear on the ones that are found.

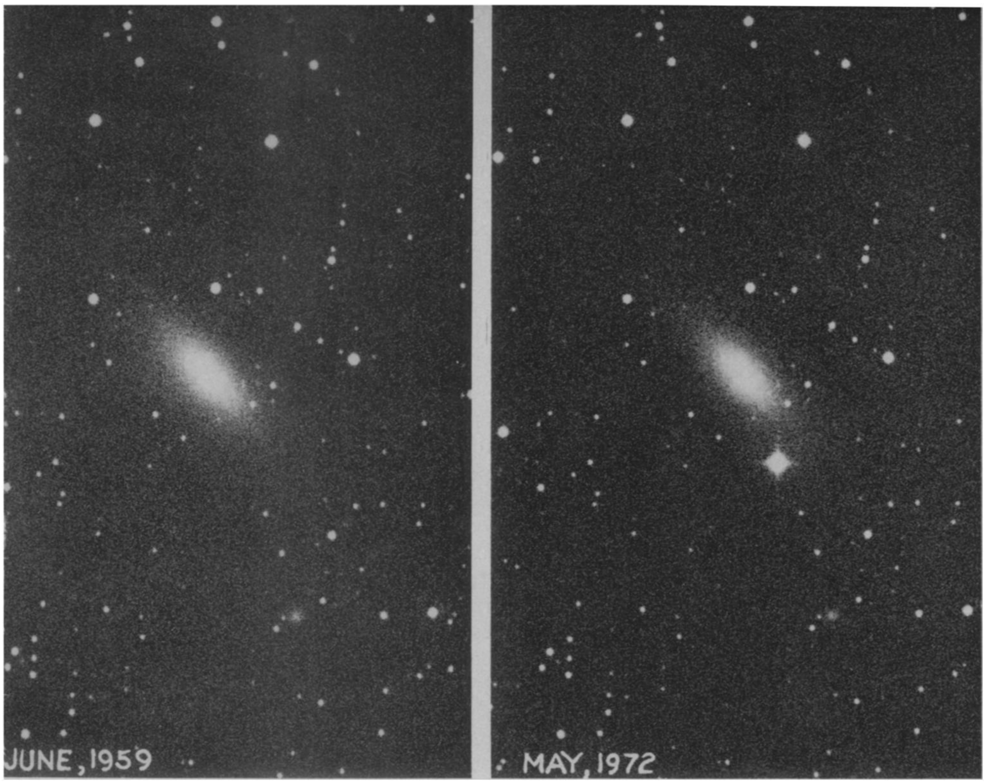
Supernovas are a beginning as well as an end. They feed material from dead stars into the interstellar medium, where it may be used for the formation of a new generation of stars and their attendant planets. Supernovas send shockwaves into the interstellar medium. These waves are suggested by some theorists as a means for accelerating cosmic rays. The waves may also trigger the formation of stars and planets out of the interstellar matter. Lately there have been suggestions that a supernova had something to do in this way with the formation of our own solar system out of the pre-solar nebula, and that matter expelled from the supernova explosion is embedded in meteorites as evidence of it.

In an interview in his laboratory, Pennypacker pointed out all these things, and stressed a process that happens in the explosion itself: the synthesis of heavy elements, including some necessary to life (carbon, nitrogen, oxygen) and particularly iron. There is a theoretical scheme that starts with a large amount of nickel (perhaps the equivalent of the mass of the sun). During the explosion this nickel fuses with silicon. The fusion product decays to cobalt, which then decays to iron. Most of the iron in the universe could be made this way, Pennypacker says.

There are indications from supernova spectra that this process does occur. Most of it, however, occurs while the explosion is on the way up. Spectra taken during that period are necessary to confirm and study the details of this mechanism. The Berkeley automated survey is designed to provide them. Pennypacker estimates that the system could pick up a supernova in a galaxy of the Virgo cluster (the nearest cluster to us) at one percent of maximum brightness. Farther out Pennypacker expects the system will notice them at 10 percent of maximum light. It takes about 10 days on the average for a supernova to go from nothing to maximum light and then weeks or months to decay back down again. Most supernovas nowadays are discovered at or after maximum light.

The idea of an automated search of this kind was first brought up in 1971 by Stirling Colgate of the Los Alamos National Laboratory, and the Berkeley group consider their project to be the descendant of his. Colgate continues to work on the preparation of his system. Ten years ago Colgate's idea strained the available technology. "He didn't even have integrated circuits," Pennypacker says. The Berkeley project has been able to take advantage of the latest developments in circuitry, computer operation and the photoelectronic sensors known as charge-coupled devices (CCDs).

The program is designed to examine 2,500 galaxies per six-hour night, getting



A bright supernova appeared in May 1972 in the galaxy NGC 5253. Berkeley survey will take before-and-after shots with lapses of one week rather than 13 years.

the whole 7,500 in three nights of patrol. Light from the telescope aperture, which covers an area of about one-third of a degree by one-third of a degree, will be focused on the CCD. The CCD is divided into 160,000 pixels (picture elements) in an oblong 500 pixels by 312. Each pixel represents a "bucket" of electric charge. A photon of light arriving at a pixel generates an electron of charge, which is stored in the bucket. After an integration time of about five seconds, the charge built up in each bucket, which represents the contrast level of that pixel, will be read into the computer. The actual galaxy being surveyed will take up on the average about 10,000 of the pixels (100 × 100); the rest of the image is fiducial stars to give a good fix on the location of this piece of sky.

As the telescope swings to the next galaxy, a move that takes about three seconds, the computer will analyze the image just made and compare it to an older image of the same galaxy to see whether the bright spot that indicates an incipient supernova has appeared. If there should be such a spot, the computer will do some cross checks, and if it is satisfied that there is a supernova, it will ring an alarm.

Then the telephoning begins. A large number of astronomers have asked to be on the wire. When they have been informed, they will employ everything from ultraviolet and X-ray satellites to perhaps some of the world's largest telescopes to observe the supernova. The relevant satellites and most telescopes have provisions for what is known as "target of opportunity" time. That is, the observer originally scheduled will be bumped, and the instrument turned over to the supernova observers. The bumped parties will be compensated later. This is not a system that makes everybody deliriously happy, but in a science like astronomy, it's a necessary one.

To mount their supernova patrol the Berkeley group had to find a telescope that could be automated in the required manner and one whose owners and managers would permit it to be so automated and then be willing to devote a major portion of its observing time to the project. That ruled out most observatories. Fortunately there is a small observatory in the Carmel Valley about 100 miles south of Berkeley on the California coast, the Monterey Institute for Research in Astronomy, which proved willing and able. MIRA is a cooperative established by a group of young astronomers who decided to build their own observatory when they could not find suitable positions at existing institutions (SN: 11/12/77, p. 323). It has a 36-inch telescope that is suitable. While the supernova project is being tested, the MIRA telescope will devote one night a week to it. When it is actually running (for the first six months at least) the commitment will be three nights a week.

Hardware for the system is ready to go, but as Colgate found out and the Berkeley group confirms, the major part of the effort is computer software to control the operation. At the time of the interview they had written 80,000 lines of software, and they have done more since. The writing goes slower than they originally anticipated, and though they had hoped to begin observing by the beginning of 1983, it seems it will be sometime later than that before all the software is ready to go. □