Seeking Supernovas Systematically

Automated patrols will alert astronomers to new supernovas so that they can gather the statistics they need

By DIETRICK E. THOMSEN

Since its discovery last February, Supernova 1987A has been much in the news. The unanticipated find is giving astronomers computer memories full of information (SN: 8/22/87, p.117 & 122), but as more and more details of the development of this nearby supernova become known, astronomers need a context in which to put them. Many aspects of the supernova have not been seen before, and astronomers wonder whether these are unique to it or common to a class or classes of supernovas.

To tell the common from the uncommon, the usual from the anomalous about supernovas, astronomers need good statistical information about them. This will not come from nearby supernovas like 1987A. The odds against another blowing off as near to us as the Large Magellanic Cloud are probably too astronomical to calculate. Where the odds are good is in the random, more or less distant galaxies scattered over the sky. To find a lot of supernovas to make up the statistical base, automated observational patrols, which were under development long before SN 1987A appeared, are now beginning to operate.

Supernova action is not infrequent in the distant galaxies, when those galaxies are taken as a whole. As of Aug. 22, according to International Astronomical Union Circular 4441, the count had gone as far as SN 1987L, the twelfth supernova to be discovered this year.

However, in the absence of automated patrols, most supernovas are found by accident during other investigations, as Ian Shelton of the University of Toronto found SN 1987A. And most discoveries are not as lucky as his. Usually a supernova is not noticed until its astrophysically most interesting period — its earliest days — are already past. According to Carl Pennypacker of the University of California at Berkeley, only 10 type II supernovas, which are in many respects the most interesting kind, have been discovered before their light output reached its maximum level. Astronomers would like to find supernovas before maximum light so that they can follow their development from as early an epoch as possible.

At the recent Workshop on Instrumentation for Ground-Based Optical Astronomy, held at the University of California at Santa Cruz, Pennypacker and Sterling Colgate of New Mexico Institute of Technology in Socorro and Los Alamos (N.M.) National Laboratory described the supernova patrol programs that each of them leads.

The first systematic supernova search took place in the mid-1960s under the direction of J. Allen Hynek of Northwestern University in Chicago. Unlike that effort, the two current ones are based on completely automated observation, a point Colgate stresses. "The computer should make the decisions," he says. Developing software for them has been the really difficult and time-consuming part of setting up. Computer capacity is also important, as is the question of whether to do the image processing at the telescope or back on campus. This is particularly true for the New Mexico program, where the telescope is a sizable distance from the campus. Colgate says they consulted AT&T Bell Telephone Laboratories about a data link by cable and were told it would cost $2 million. As their entire budget for five or six years is $250,000, they decided to use a microwave radio link instead. "We're renewing our FCC licenses," he remarks.

The telescopes they use are not large — 30-inch diameter in both cases. Both programs work by dividing the sky into a large number of fields of view, and observing these fields in regular rotation. When his system is fully operational, Colgate hopes to do about 36,000 such observations a month. At that rate, he says, they "might like to find one [supernova] a month." The California group has comparable hopes.

Each time a new image of a given field is taken, the computer compares it with a reference image stored in its memory. The two systems have different ways of identifying supernovas. As described by Eric Pearce, a New Mexico Tech graduate student working with Colgate, the New Mexico system maps the new image into the reference image pixel by pixel, counting the bright spots and determining which, if any, are new. New bright spots are possible supernova candidates. The California system subtracts the reference image from the new one, pixel by pixel, and thus will wind up with a blank screen if no new bright object has appeared in the field between observations.

Ironically, neither program would have found SN 1987A, basically because they don't look for supernovas so rare and close. Says Pearce, "The Large Magellanic Cloud is not in our system." The New Mexico system has been going through a kind of shakedown period that started Feb. 22. "The first totally automated supernova discovery should come soon," says Pearce.

The California system started operations somewhat earlier than the New Mexico one. During its working-in period it has been attached to a telescope at the University of California's Leuschner Observatory, located in the hills just east of Berkeley. Now they are about to move it to a much better (darker) site on Mount Locke, near Marfa, Tex., where the University of Texas McDonald Observatory stands. According to Pennypacker, the system has so far found five supernovas, two of which were previously discovered by other observers, and two asteroids.

One of these finds, SN 1986I in the galaxy M99, is "the best studied type II [supernova] after SN 1987A," Pennypacker says. "As soon as we got the

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supernova, we called the Kitt Peak [Ariz.] 4-meter." That telescope took a spectrum almost immediately and has taken them once a month thereafter. By comparing the different spectra, astrophysicists can learn a great deal about the development of the supernova, the motions of different materials as the explosion progressed, and related issues. In all, the Berkeley group notified about 30 observatories of the discovery of SN 1986I, and many of them did various specialized observations.

That, in fact, is the main point of having these patrols in regular operation. As they find something, they notify many observatories, and so larger telescopes and a variety of specialty equipment can be quickly brought to bear. "In an hour you want to be on it," says Pennypacker.

As they move their telescope to Mount Locke, his group is now negotiating with the managers of the ARC telescope for a general backup arrangement. The ARC, which is under construction in New Mexico, will be a 3.5-meter telescope, fully automated and capable of quick changes of observing program. Once completed, ARC could take up a new supernova very swiftly after receiving a signal from the patrol telescope.

Supernovas are important as the final, cataclysmic stage in the life cycles of stars and the sources of many heavy chemical elements, but they can also be used cosmologically as "standard candles." All supernovas of a given type are expected to have the same intrinsic luminosity at maximum light. If that is so, they can be used to determine cosmic distances by the simple optical law that the apparent brightness of such a standard candle is its intrinsic brightness divided by the square of the distance. From such a calculation comes an estimate of the Hubble constant, the expansion rate of the universe.

Pennypacker says that on the basis of observations made so far, they have calculated a "preliminary" value of the Hubble constant to be 100 kilometers per second per kiloparsec. However, they do not claim great accuracy for this, saying only that they are within 45 percent of the true value. The debate over the value of the Hubble constant is whether it is 50 or 100 or something between, so 45 percent accuracy doesn't help much. However, future refinements may.

SN 1987A seems to have opened more questions about supernovas than it answered. As these patrol systems come into routine, fully automated operation, their managers hope to be ringing bells from time to time in observatories all over. They hope that coordinated observations of the early days of many supernovas will build up a library of information that can answer the questions. □

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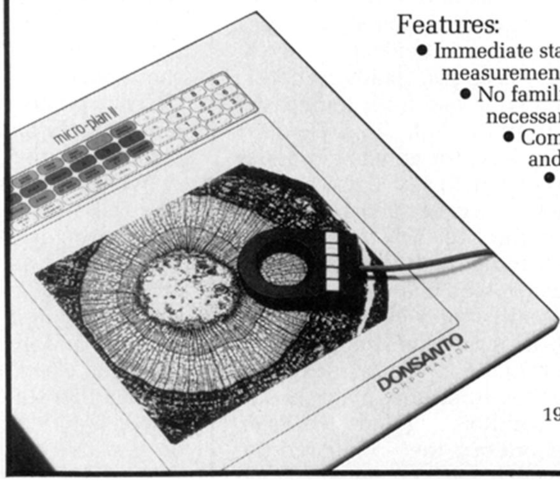

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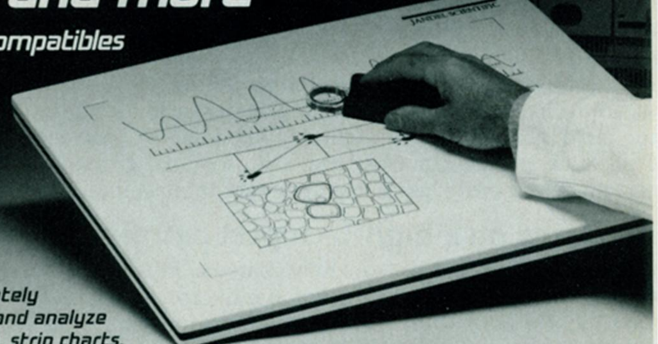

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