THE KECK NORTHEAST ASTRONOMY CONSORTIUM'S CCD SUPERNOVA MONITORING PROJECT

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Abstract

A program of monitoring bright supernovae with CCDs attached to small telescopes at a number of northeastern colleges has been initiated. We describe the program and some preliminary results.

In 1989, the W. M. Keck Foundation approved a grant to a consortium of eight liberal arts colleges and universities in the northeast [Colgate, Haverford, Middlebury, Swarthmore, Vassar, Wellesley, Wesleyan, and Williams] which made it possible to purchase CCD cameras for our campus telescopes and computer workstations to analyze the data. This equipment has vastly improved the quality of the educational experience which we can offer students in the area of observational astronomy. It is now quite possible for them to do front line astronomical research with equipment available on campus. In this paper we describe one outgrowth of the grant - an organized effort to monitor supernovae.

Supernovae are among nature's most violent and awesome events - the explosive destruction of a star. They are bright enough to be seen one-third of the way across the visible universe with current telescopes, and they offer great possibilities for probing the geometry and evolution of the universe. A problem for astronomers is that they occur without warning and, after brightening to an absolute magnitude of -19 or so (i.e. about 25 magnitudes brighter than the Sun!), they fade rapidly over a period of several months. It is very difficult for professional astronomers using shared facilities at large observatories to study these objects. Telescope time is normally scheduled many months in advance and rarely are the right equipment and the right observer on the right telescope at the right time to observe a new supernova. Only exceedingly bright ones, such as 1987A in the Large Magellanic Cloud, attract a lot of attention.

CCDs, however, have changed all of this. It is now quite possible to detect supernovae with small telescopes (0.4 to 0.6-m range) at relatively poor observing sites. Several supernovae per year become as bright as 14th magnitude and they can easily be seen with CCDs on such telescopes. Furthermore, with careful planning and calibration of one's observations, the photometric data can be extremely useful scientifically. It is probably not an exaggeration to say that CCDs on small telescopes will soon revolutionize the field of supernova studies by providing a quantity and quality of photometric data which has never been available before.

The KNAC schools are also interested in supernovae because they are particularly exciting to students. CCD images (see Figure 1) of supernovae are often quite interesting because of the galaxy in which the supernova is embedded. The timescale of weeks on which the supernovae fade is a fortuitous one since students can see, over the course of a semester, the changes taking place. Since many supernovae occur during the course of a year and since there are several different types of supernovae, they provide an essentially endless stream of student projects, each new and with its own challenges, but contributing to a larger goal.

How does the program work? In principle it is very simple. The IAU Telegram service (available in e-mail form) provides notice of recently discovered supernovae. Many are discovered by amateurs! All of the participating institutions attempt to image the new supernova on every clear night after its discovery for as long as possible. To combine data from different telescopes it is essential that a standard photometric system be adopted. We use the Johnson/Cousins BVRI system described by Bessell (1990). It is also essential that a set of standard stars (or a standard field in the case of CCDs) be adopted. We use the "dipper asterism" field in the cluster M67 which has been calibrated by Schild (1983) for this purpose.

Reduction of CCD data to magnitudes is not trivial and, in fact, a good deal more time is generally spent on this step than on actually obtaining the images. The CCD frames must be corrected for dark counts and bias and then flat-fielded. We use twilight flats for this. Clearly one needs image processing software, and IRAF is the most commonly used package within the consortium. A good deal of disk space and an archiving medium is also required. We use Exabyte tapes for archiving and for swapping large numbers of images among consortium members.

Results so far have been promising but have impressed upon us the difficulties of doing accurate photometry on supernovae. There are many pitfalls to be avoided and some which are unavoidable. Supernovae have very peculiar spectra, unlike any star, and evolve in color as well as brightness quite rapidly. If one hopes to combine data from different sites it is quite important to adopt as similar an instrumental set-up as possible. Slight differences in filters or in the quantum efficiency curves of the CCDs can produce offsets in the magnitudes derived. Errors in transformation coefficients can do the same. Finally, the manner in which one corrects for the sky and galaxy background can influence one's results. The advantages of having a well sampled light curve, which is only possible (from eastern sites!) if one combines data from a number of different observatories, make it worthwhile for us, however, to continue to try to combine our data. As an example of what can be done, we show in Figure 2 light curves of SN 1992G obtained by combining data from Wellesley and Wesleyan.

We are in our third year of this program now and some of the results are already in print or in press. The first published paper was done jointly with a group from Berkeley who use an automated telescope with a CCD (Filippenko *et al.* 1992). A light curve for SN 1991bg in M84 was obtained. Three other type Ia supernovae have been well studied by us, SN 1991M, 1991T, and 1992G, and a paper on them is in preparation. Two type II supernovae for which we have a considerable amount of data are SN 1991G and SN 1992H. Additional data are available on about 40 other supernovae, but for faint ones we have only one or two measures. Nearly every supernova discovered north of declination -30 degrees can be detected by us, but only the ones brighter than about 16th magnitude can be studied with any photometric precision.

It is our intention to continue this monitoring program. We expect that the exercise will not only prove educational for the students involved but will also advance the field of supernova studies.

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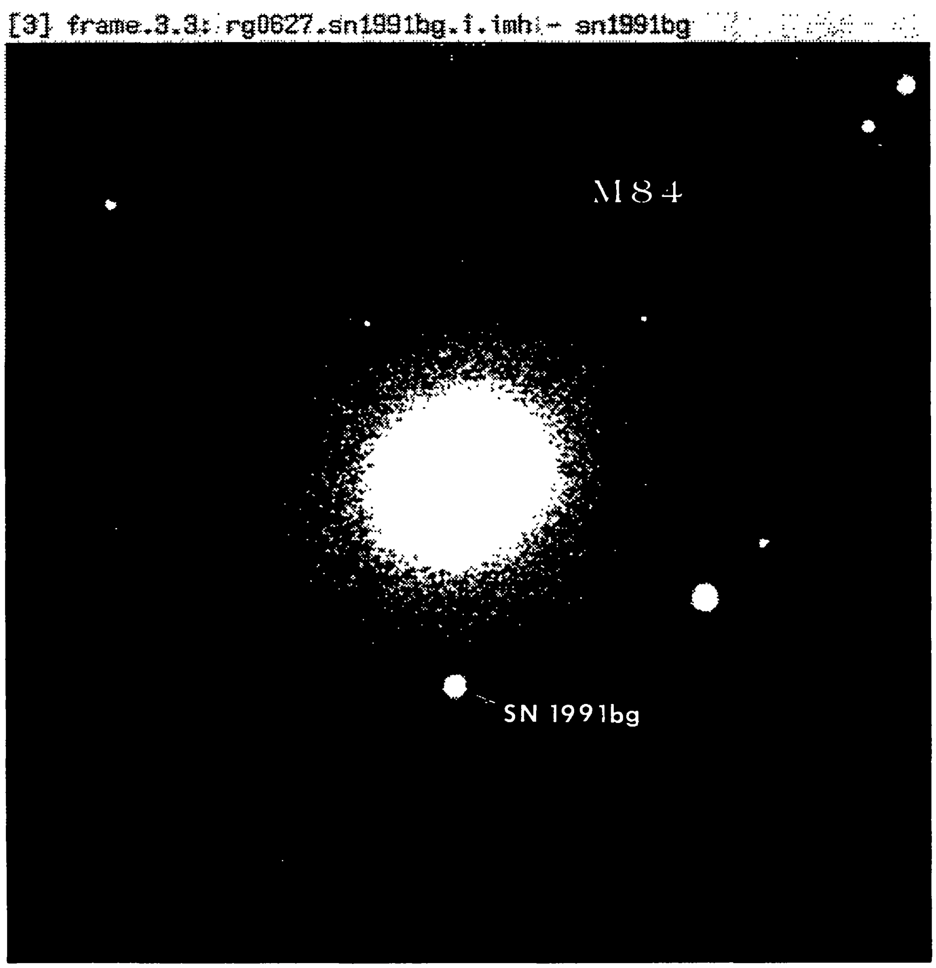

Figure 1. An image of SN 1991bg in M84 taken with a CCD camera attached to the 24-inch Perkin telescope at Wesleyan University.

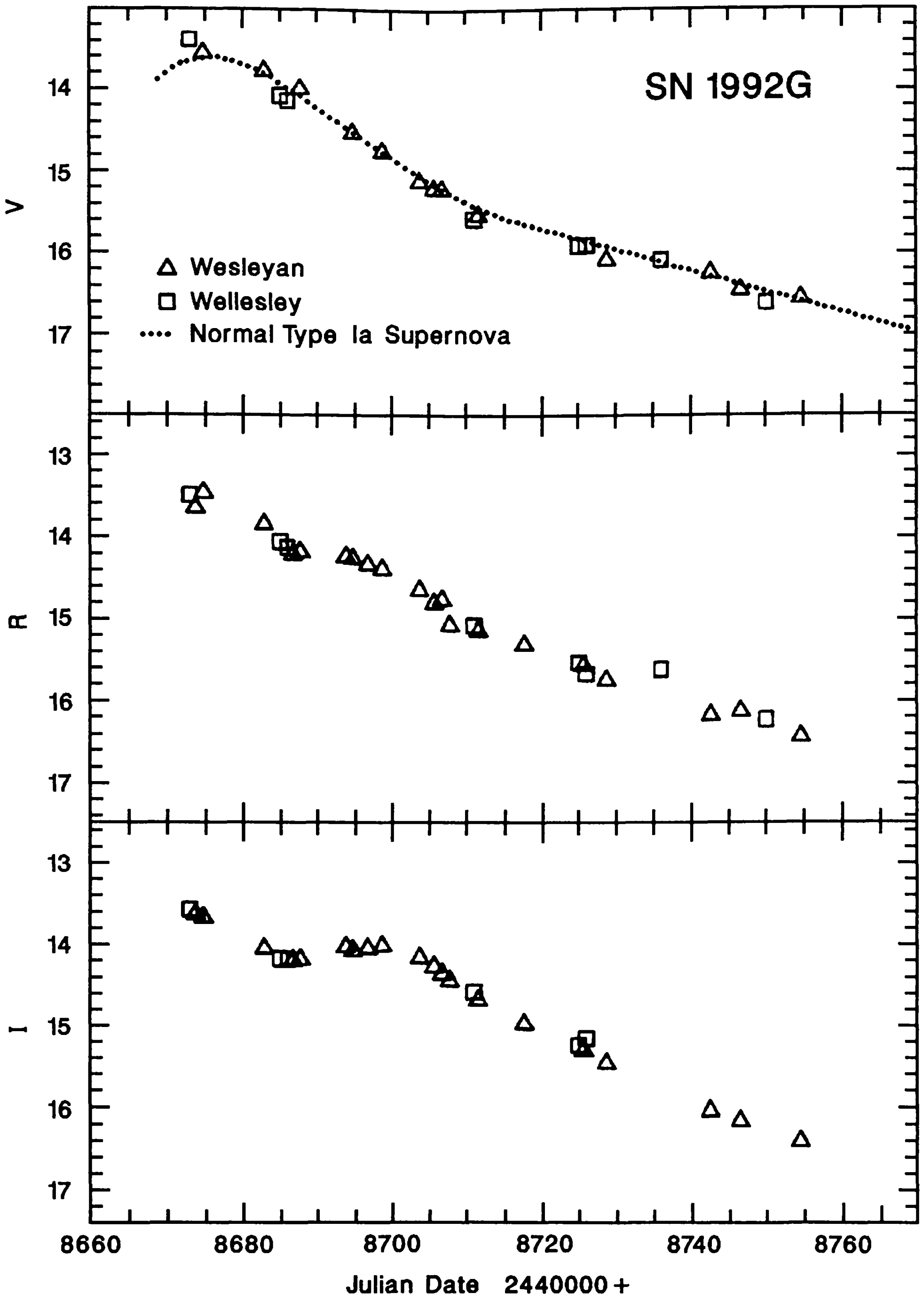

Figure 2. A light curve in I for SN 1992G. Triangle symbols are data obtained at Wesleyan and squares are data obtained at Wellesley.