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PROFILE OF A KEY PROGRAMME

A Photometric and Spectroscopic Study of Supernovae of All Types

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Supernovae are unpredictable events. For this reason, despite the fact that their interest spreads over numerous different fields, from stellar evolution to the interstellar medium and to cosmology, they have been observed, generally, with medium/small telescopes, whose schedules are flexible enough to ensure prompt observation of new objects. Therefore, the observations have been limited to the first months after outburst, and even in this period hardly on a regular basis.

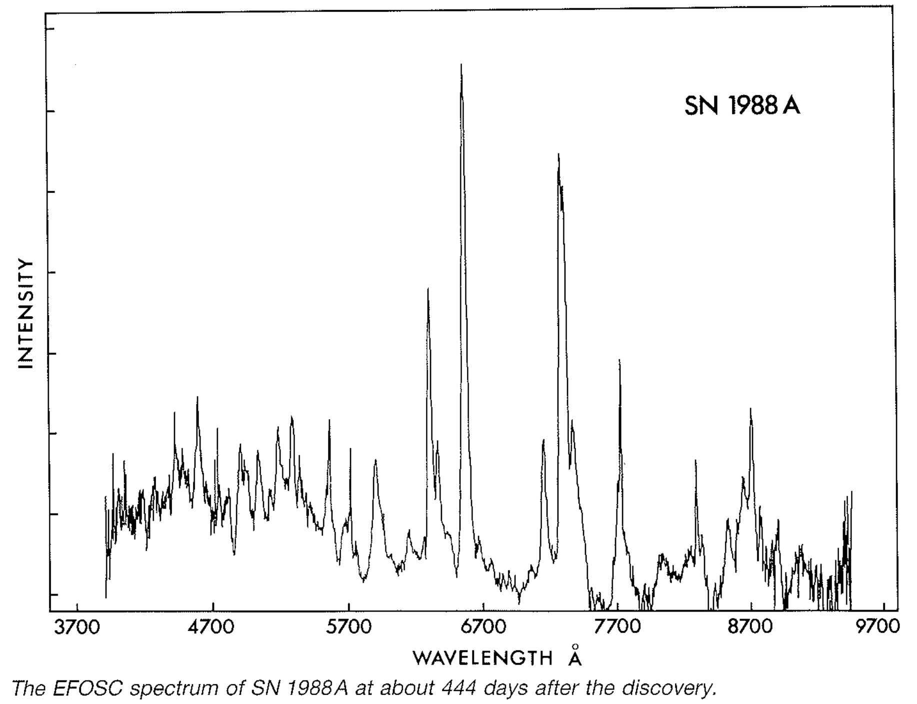
The recent experience with SN 1987A has demonstrated the large interest in this field of research including the ESO community, and also that it is possible to carry out successfully, even within a large structure like ESO, a programme needing regular observing for periods of years. Thanks to the use of appropriate equipment and to a dense temporal coverage approved by the OPC, astronomers at ESO have been able to announce a number of firsts, such as the discovery of molecules and dust formation, the temporal mapping of the ^{56}Co (+^{57}Co) decay (both from the bolometric light curve and the measurement of the CoII 10.52 μ line), the first order computation of elemental abundances in the envelope and the spectral characteristics of the just resolved shell around SN 1987A. There has also been much success in theoretical modelling of the expanding envelope.

Successful observations of a sample of SNe with modern detectors at large telescopes during a pilot programme started at ESO have also demonstrated that it is possible to follow photometrically and spectroscopically the evolution of SNe, other than the exceptionally close SN 1987A, for years (Fig. 1) and, at least in some fortunate cases, even for decades (Turatto et al. 1989).

In this framework, our Key Programme, dedicated to the study of the photometric and spectroscopic evolution of SNe of different types, has been proposed and approved at ESO. The general aim of the programme is to accumulate regularly spaced photometry, particularly for constructing bolometric light curves, and spectroscopy of SNe from their earliest announcement. At the same time, late-time spectra of already known SNe will be secured. It will be possible to store in a large unique database a great deal of material for a selected sample of supernovae. Emphasis will be put on observing a few objects in detail rather than many sparsely.

The regular allotment of telescope time over a span of years, awarded to the Key Programme, will allow us to address different questions.

From a quick inspection of the Asiago Supernova Catalogue (Barbon et al. 1989), it appears that the average rate of discovery in the last years is of about 20 SNe per year. Of these, about 6 are closer than 40 Mpc (H = 50 km/s Mpc) and reachable from La Silla. Whatever their type, all these SNe stay above the detection limit of EFOSC (or EMMI) for longer than 1 year in spectroscopy and 2 years in photometry. We will be able, therefore, to cover all phases of the optical evolution for several SNe of various types.



The EFOSC spectrum of SN 1988A at about 444 days after the discovery.

Although spectroscopy is available for several SNe Ia around maximum light, we still entirely lack bolometric luminosities and regular spectral observations beyond 150 days. It is not clear, in fact, how wide among various objects are the differences suggested both by spectra (Branch et al. 1988) and by light curves (Barbon 1980) and how they correlate with other parameters. This could be a problem for the frequent use of such objects as standard candles unless such differences can be accounted for and calibrated in a systematic way. For the less luminous and rarer Type Ib SNe, the observational status is at present even worse. Few objects have optical light curves, and bolometric information is completely lacking. Even the early spectral evolution is poorly known (because of sparse observations). Because the conditions in the envelope have not been clarified, since neither a spectroscopic temperature nor a thermal equilibrium calculation have been derived, the actual mass of oxygen has not been determined to within a factor of 10, preventing an accurate determination of the mass range of possible progenitors and their contribution to the chemical evolution of galaxies.

The heterogeneous class of Type II SNe represent another interesting field of investigation. In particular, we will try to understand if different shapes exist also in the bolometric light curves and to determine their total energy budget, which will lead to the determination of the total mass of radioactive ^{56}Co produced. Regularly spaced spectra of a number of objects will clarify whether all the documented differences are real or due only to the uneven spacing of the available information. If this variety represents differences in the envelopes of these SNe, it is not clear how this relates to the characteristics of the progenitor stars.

Beside the regularly spaced observations of newly discovered SNe, a special effort will be devoted to the identification and eventual observation of "very old" supernovae. There exists, in fact, an observational gap between the latest stages of SNe, which can be placed at about 2 years after the light maximum, and the youngest SNRs, whose ages are of the order of a few centuries. The optical detection of SN 1957D in M83 (Turatto et al., 1989; Long et al., 1989) and of SN 1885A in M31 (Fesen et al., 1989) indicates that it is possible to get precious information on the intermediate ages even with the presently available instrumentation. In particular, the spectrum of the 30-year-old SN 1957D in M83 shows broad [OIII] 4959, 5007 lines with asymmetric profiles and a velocity of the maximum emission of approximately −650 km/s relative to the rest velocity. This could be due to the presence of dust filling the line-forming region analogous to the situation found in SN 1987A. For this SN, unfortunately, early-stage observations are missing and an unambiguous classification is then impossible. However, there are about 70 SNe older than 10 years accessible from La Silla, which are candidates for detection. Although many difficulties arise when one tries to locate the very faint candidates inside the parent galaxy, even a small number of successes would constitute milestones in the understanding of the evolution of young SNR.

The collaboration with CTIO, with whom important coordinated observations have been obtained on SN 1987A, and with the Asiago Observatory, for the early stages of the SNe visible also from the northern hemisphere, should also ensure both a better temporal and spectral coverage.

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PROFILE OF A KEY PROGRAMME

Optical Follow-up Identifications of Hard X-Ray/ Soft γ-Ray Sources Discovered by the "SIGMA" Telescope

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The aim of this programme is to search for the optical counterparts of hard X-ray/soft γ-ray sources (including γ-ray bursts and transient events) discovered by the SIGMA telescope (successfully launched on December 1, 1989), also exploiting the soft X-ray data of the all sky survey to be performed by the ROSAT satellite (launched on May 31, 1990).

It will be the first time that coordination between on-going high-energy space missions, such as SIGMA and ROSAT, and ground-based telescopes is implemented on a programmed long-term basis.

The SIGMA telescope (constructed by two French groups at CEA/Saclay and CESR Toulouse) aboard the Soviet GRANAT satellite represents the first breakthrough in one of the last unexplored wavelength regions in astronomy. Launched on December 1, 1989, it consists of a gamma camera/coded mask telescope system (see Fig. 1) separated by 2.5 m, with imaging capability yielding a source localization accuracy of 2′ within a field of view of $4^{\circ}.3 \times 4^{\circ}.7$ and a sensitivity in the milliCrab region. The energy range goes from 35 keV to 1.3 MeV, and operations, planned for two years, will be based on 10^5–10^6 sec. pointed observations of the 3-axis stabilized telescope.

After the mandatory outgassing period of the various SIGMA subsystems, more than two months of in-flight operations were required both to complete the telescope adjustment (a quite difficult task, taking into account the 131 photomultiplier tubes of the gamma camera, the on-board calibration sources and the active shielding device), and to evaluate the background along the orbit. This is now stabilized on a rather constant value of 440 counts/sec, which compares favourably with the one computed on the ground of 320 counts/sec,