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Spectroscopy of supernovae

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1. Introduction

The discovery of several bright supernovae in the recent years has evoked a great deal of interest in these objects. The study of these objects is of importance not only as probes to the end stages of stellar evolutions, but also as probes for cosmology. Supernovae are broadly classified based on their spectral properties. The ones whose optical spectra exhibit hydrogen are Type II, while the hydrogen deficient ones are Type I. The Type I's are further classified as Ia, Ib and Ic.

Spectroscopy of supernovae is essential for a variety of reasons. It is essential for their classification. The temporal development of the spectrum gives an insight into the physical conditions in the ejecta and its interaction with the local environment. The spectral features due to elements present in the ejecta are excellent probes of stellar nucleosynthesis and also provide information about the progenitor.

2. Type Ia supernovae

A majority of SNe Ia belong to a fairly homogenoeous class, both in their photometric as well as their spectroscopic properties (Branch et al. 1993), while some show spectroscopic as well as photometric pecularities. The peak absolute magnitudes of SNe Ia in the B, V and I bands correlate with the decline rate of the immediate post-maximum light curve giving a photometric sequence from luminous blue events with a relatively slow decline of the light curve to the subluminous red events with a rapid decline of the light curve. When arranged in the photometric sequence, SNe Ia also form a spectroscopic sequence. This has interesting impications on the explosion models of SNe Ia.

The spectra of 'normal' SNe Ia, although fairly homogeneous, do show some inhomogeneities. At a given phase, there is a spread among the absorption blueshifts as well as minor differences in the line strengths (Branch & van den Bergh 1993). The absorption velocities appear to be correlated with the type of the galaxy as well as the location of the supernova in the host galaxy, with the SNe in early-type galaxies having lower velocities than those occurring in the late-type galaxies (Filippenko 1989; Branch & van den Bergh 1993). Similarly, the SNe Ia occuring in the nuclear bulges of spirals have lower expansion velocities (e.g. SN1997Y : Anupama 1997).

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The light curves of high-z SNe Ia are broader than those of nearby SNe Ia by a factor (1+z), as expected if the redshifts are produced by the expansion of space. Similar effects are present in the temporal development of the spectrum also (Filippenko & Riess 1998 and references therein).

3. Supernovae as cosmological probes

Research on supernovae have demonstrated the potential of SNe Ia as excellent cosmological distance indicators. SNe Ia are exceedingly luminous enabling measurement of their distances to an accuracy of 5-10%. A majority of SNe Ia have a small dispersion in their peak absolute magnitudes ($\sigma \lesssim 0.3$ mag). The physics of the explosion and the progenitors of SNe Ia are well understood. In order to use these objects as standard candles for distance measurments, it is important to accurately determine their absolute magnitude distributions. Further, inorder to improve the calibration, the various effects discussed in the previous section need to be understood better by observations of SNe Ia in galaxies with known distance.

Recent research based on both nearby SNe Ia and the high-z ones show that while low-z SNe Ia measure the present rate of expansion of the universe, the high-z SNe measure its variation due to the cosmic matter energy content. It also appears that SNe Ia provide the most accurate values of the Hubble constant, the deceleration parameter, the matter density and the cosmological constant.

4. The role of a large telescope

In order to be able to use supernovae as either cosmological probes or as probes of end stages of stellar evolution, it is essential to have spectroscopic confirmation as well as classify them. While it is possible to confirm SNe in the range 22-22.5 with 4-m class telescopes, the fainter ones (high-z; magnitude range 22.5-24.5) require 8-10 m class telescopes. The use of large telescopes reduces the time required to spectroscopically confirm the brighter ones. Further, the large telescopes help in obtaining data with better signal-to-noise ratios making the redshift estimate more accurate and will also allow the measurement of the age of the supernova by comparison with existing spectral libraries. With the use of large telescopes, not only can a large number of SNe be confirmed, one can also search for pecularities in the spectra. This can help in the understanding and identification of the physical origin of the observed diversity of SNe Ia.

Very little data exists on the late time development of supernovae, especially those of type Ia. With a larger telescope, it is also possible to follow the brighter objects into later epochs (about a year after the explosion). At these epochs most of the flux from the supernova is in the red-infrared regions. Observations in these regions are hence extremely useful.

References

Anupama G. C., 1997, AJ, 114, 2954

Branch D., Fisher A., Nugent P., 1993, AJ, 106, 2383

Branch D., Van den Bergh S., 1993, AJ, 105, 2231

Filippenko A. V., 1989, PASP, 101, 588

Filippenko A. V., Riess A. G., astro-ph/9807008