5. Asymmetries in Type Ia Supernovae

Most Type Ia supernovae are not substantially polarized at the epochs that have been observed. This suggests that, despite occurring in binary systems, the explosions are essentially spherically symmetric. There are some interesting exceptions to this, however. SN 1999by was one of the class of subluminous, rapidly declining Type Ia events. It was substantially polarized and hence asymmetric in some way. We do not yet know whether this was characteristic of subluminous Type Ia, or whether SN 1999by was odd in this regard.

In this context, it is important to obtain spectropolarimetry of "normal" Type Ia supernovae. A step in this direction was taken with our observations of the Type Ia SN 2001el. High-quality spectropolarimetry of the SN 2001el was also obtained with VLT Melipal and FORS1 at 5 epochs. Some of these data are shown in Figure 5. The spectra a week before and around maximum indicate photospheric expansion velocities of about 10,000 km s^{-1}. Prior to optical maximum, the linear polarization of the continuum was $\approx$ 0.2–0.3% with a constant position angle, showing that SN 2001el has a well-defined axis of symmetry. The polarization was nearly undetectable a week after optical maximum.

The spectra of SN 2001el are similar to those of the normally-bright SN 1994D with the exception of a strong double-troughed absorption feature seen around 800 nm (FWHM about 22 nm). The 800 nm feature is probably due to the Ca II IR triplet at very high velocities (20,000–26,000 kms^{-1}). The 800 nm feature is distinct in velocity space from the photospheric Ca II IR triplet and has a significantly higher degree of polarization (= 0.7%), and different polarization angle than the continuum. Taken together, these aspects suggest that this high velocity calcium is a kinematically distinct feature with the matter distributed in a filament, torus, or array of "blobs" almost edge-on to the line of sight. This feature could thus be an important clue to the binary nature of SN Ia, perhaps associated with an accretion disk, or to the nature of the thermonuclear burning, perhaps representing a stream of material ballistically ejected from the site of the deflagration to detonation transition.

If modelled in terms of an oblate spheroid, the continuum polarization implies a minor to major axis ratio of around 0.9 if seen equator-on; this level of asymmetry would produce an absolute luminosity dispersion of about 0.1 mag when viewed at different viewing angles. If typical for SNe Ia, this would create an RMS scatter of several hundredths of a magnitude around the mean brightness-decline relation. This scatter might have implications for the high precision measurements required to determine the cosmological equation of state of the "dark energy."

6. Conclusions

The acquisition of systematic supernova polarization data has led to remarkable new insights. It seems likely that all core-collapse supernovae are substantially asymmetric. They explode by means of bi-polar flow associated with the newborn neutron stars. This discovery may, in turn, give new insights into more exotic jet-induced events like gamma-ray bursts. While most Type Ia supernovae have been found to be little polarized, the number of exceptions is growing. The asymmetries observed in Type Ia may finally yield direct observational evidence that they occur in binary systems, as long assumed, and clues to the combustion mechanism. Understanding these asymmetries may be necessary to properly interpret future data on cosmologically distant Type Ia's.

The authors are grateful to the European Southern Observatory for the generous allocation of observing time. We are also anxious to acknowledge that, contrary to the impression perhaps given in the Introduction, requests for service-mode observations with the VLT are much different than orders to a pizza home-delivery service: The Paranal Science Operations staff and the User Support Group in Garching have gone to considerable effort to augment our proposal with their full range of expertise. We recognize that accommodating our target-of-opportunity observations in an already busy observing and work schedule often poses a special extra challenge. Only this symbiosis enables the ongoing success of this project. We are especially grateful for that. This work was supported in part by NASA Grant NAG5-7937 to PAH and NSF Grant AST 0098644 to JCW.

OTHER ASTRONOMICAL NEWS

An Exciting Working Session on Cataclysmic Variables at ESO/Santiago

E. MASON (ESO/Chile, fellow) and S. HOWELL (ESO/Chile, visiting scientist)

An intensive working session on Cataclysmic Variables (CVs) was held at ESO/Santiago on August 14, 2002. The workshop was organized on the occasion of the presence in Santiago of Dr. S. Howell, from the Planetary Science Institute in Tucson, thanks to the ESO/Chile visiting scientist programme.

The goal of the workshop was to gather all astronomers in Chile working on CVs, for exchanges and fruitful discussions. The participants were from the University of Concepción and from ESO/Chile, and we could also welcome Dr. N. Vogt, from Heidelberg, who had organized the first workshop on CVs ever held in Chile (Viña del Mar, 1992). We hope that the wealth of ideas and projects discussed during the working session, will trigger regular CV workshops here in Chile, possibly involving a larger number of participants and invited speakers. The workshop was organized in a morning review session on CVs, both on observations and on theory, and an afternoon discussion session.

Reviews were about: (i) the photometric behaviour of dwarf novae (DNs) during cycles and super-cycles, (ii) the spectroscopic characteristics of CVs in the wavelength range UV-IR, (iii) the evolution of CVs – theory vs. observations, (iv) radial velocity measurements as a diagnostic for the binary system geometry and (v) the CVs accretion disks and current analysis of their emission lines.

The afternoon talks were more specifically focused on the observation of particular objects or on some aspects of theoretical modelling.

The participants really benefited from being in a fairly small but highly motivated group and could present, discuss, and confront various problems and results of their current research programmes. In particular, the discussion of unsolved problems turned out to be important and fruitful as it triggered the submission of new proposals (on ESO telescopes!), as well as the development of new research projects and collaborations.