Measuring Ω and Λ with Type Ia Supernovae

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The explosive carbon incineration of white dwarfs produces very luminous events with no hydrogen in their spectra - Type Ia supernovae (SNe Ia). These objects display a fairly uniform behavior which led to their use as cosmological distance probes. The simple adoption of a unique peak luminosity (standard candle), however, has recently been challenged by SN Ia samples with accurate relative distances. A dispersion of 0.6 magnitudes in maximum luminosity and a correlation of luminosity with the light curve shape have been described (Phillips 1993, Hamuy et al. 1996). Local samples can be corrected by the proposed light curve shape fitting which leaves only a small residual scatter (<0.2 mag; Hamuy et al. 1996, Riess et al. 1996).

The determination of the Ω and Λ through standard candles is based on very general cosmological considerations (Carroll et al. 1992). With many supernovae observed accurateluy at large, but different, redshifts the two parameters can be constrained simultaneously (Goobar & Perlmutter 1995). It has been argued that this approach is preferable to the traditional decelaration parameter q_0 in the classical Hubble diagram for standard candles (Perlmutter et al. 1997). The complication of the luminosity variations has to be treated carefully for a trustable result. Only the combination of spectroscopy, to assure correct classification and discriminate peculiar objects, and multi-filter light curves, for estimates of absorption, can produce reliable determinations (Leibundgut & Spyromilio 1997, Schmidt 1997).

There are currently two groups searching and recording distant supernovae (Schmidt 1997, Leibundgut et al. 1996, Perlmutter et al. 1997). Both find substantial numbers of SNe Ia (>15 per year) at z>0.3. The classification is based on spectroscopy acquired with Keck and 4m-class telescopes around the world. Light curves are measured for as many objects as possible.

Determination of the cosmic deceleration is observationally simpler than determining the Hubble constant, since it is done through relative measurements. It is based on the comparison of the apparent brightness of objects with known relative luminosity at largely different redshifts. The ability to find the luminosity of a distant SN Ia relative to a nearby twin rests purely on observables (Schmidt 1997, Perlmutter et al. 1997). Measuring the luminosity distance $\mathcal{L}$ as a function of redshift z, one can directly estimate the cosmological density parameter Ω and the cosmological constant Λ by virtue of their different dependence on z in $\mathcal{L}$ (Goobar & Perlmutter 1995).

A first measurement using SNe Ia has been presented by Perlmutter et al. (1997). Their determination of Ω and Λ is based on the analysis of 7 supernovae at redshifts $z > 0.35$. The redshift range is not yet sufficient for significant independent limits on Ω and Λ. With the additional assumption of a spatially flat universe the cosmological constant can, however, be constraint to <0.7 (2σ).

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