Laboratory Measurements for Supernovae Expansion Opacities

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Experiments using 0.5 - 2 MJ pulsed power plasma sources are being used to generate high velocity shear, low density plasmas characteristic of gas in the exploded remnants of Type Ia supernovae (SNe Ia), and which can be used to benchmark SNe Ia radiation transport models and opacity calculations.

Supernovae are one of the most violent events in the modern Universe. They play a central role in the origin and evolution of the elements. Their optical brilliance rivals that of a large galaxy, making them visible at great distances. For this reason supernova, and SNe Ia in particular, have become one of the most important cosmological tools available for determining the geometry of space-time. An improved understanding of these standard candles is therefore of considerable importance.

The use of SNe Ia as cosmological distance indicators hinges upon an empirically derived correlation (the so-called Philip's Relation) between the absolute luminosity at maximum light and the distance- and reddening- independent decline rate. This relationship is calibrated from observations of nearby (i.e. recent supernovae),and then applied to more distant ones which exploded when the Universe was younger. However, there is not now any general consensus on what accounts for the Philip's Relation. Nor is there yet a good understanding of how evolutionary effects such as pre-explosion metallicity might affect the light curve. This is because explosion calculations are very sensitive to the opacity. Useful results are dependent on an accurate knowledge of the complex line spectra of the iron peak elements Fe, Co and Ni.

Experiments are currently being planned that will address the physics of radiative transfer in a scaled analog of the supernovae plasma. Understanding the supernovae light curves depends not only upon accurate atomic models, but also on accurate models for radiative transport in the presence of large velocity gradients. Laboratory analogs of this situation are available in the low density, expanding plasmas created in the pulsed power experiments. In these experiments, high velocity gradient plasmas, in the Sobolev regime, will be created and the absorption properties measured as a function of velocity field. Approximations for the atomic physics used in the OPAL opacity code, as well as others, will be applied with various approximations for the radiative transport, and tested directly by comparing with the experiment. Techniques will then be extended to modeling of supernovae light curves.

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