ALI in Rapidly Expanding Envelopes

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We discuss our current implementation of the ALI method into our radiation-hydro code for rapidly expanding, low density envelopes commonly found in core collapse and thermonuclear supernovae (+ novae and WR stars). Due to the low densities, non-thermal excitation by high energy photons (e.g. from radioactive decays) and the time dependence of the problem, significant departures from LTE are common throughout the envelope even at large optical depths.

ALI is instrumental for both the coupling of the statistical equations and the hydrodynamical equations with the radiation transport (RT). We employ several concepts and approximations to improve the stability, and convergence rate/ control including the concept of leading elements, the use of net rates, level locking, reconstruction of global photon redistribution functions, equivalent-2-level approach, and predictive corrector methods. For appropriate conditions, the solution of the time-dependent rate equations can be reduced to the time-independent problem plus the (analytic) solution of an ODE For the 3-D problem, we solve the radiation transport via the moment equations. To construct the Eddington tensor elements, we use a Monte Carlo scheme to determine the deviation of the solution for the RT equation from the diffusion approximation (ALI of second kind).

At the example of a subluminous, thermonuclear supernova (SN 1999by), we show an analysis of the light curves, flux and polarization spectra and discuss the limitations of our approach.