Non-LTE models for synthetic spectra of type Ia supernovae. IV. A modified Feautrier scheme for opacity-sampled pseudo-continua at high expansion velocities and application to synthetic SN Ia spectra

T. L. Hoffmann, D. N. Sauer, A. W. A. Pauldrach, P. J. N. Hultzsch

Universitaets-Sternwarte Muenchen, Scheinerstr. 1, 81679 Muenchen, Germany

Context. Type Ia supernovae (SN Ia) have become an invaluable cosmological tool as their exceptional brightness makes them observable even at very large distances (up to redshifts around z~1). To investigate possible systematic differences between local and distant SN Ia requires detailed models whose synthetic spectra can be compared to observations, and in which the solution of the radiative transfer is a key ingredient. One commonly employed method is the Feautrier scheme, which is generally very robust, but which can yield wrong results under certain conditions that frequently occur in the modelling of supernova ejecta or even in the radiatively driven expanding atmospheres of hot stars.
Methods. We use a sophisticated model atmosphere code which takes into account the non-LTE effects and high velocity gradients that strongly affect the physics of SN Ia atmospheres at all wavelengths to simulate the formation of SN Ia spectra by the thousands of strong spectral lines which intricately interact with the "pseudo-continuum" formed entirely by these Doppler-shifted lines themselves. We focus to an investigation of the behavior of the Feautrier scheme under these conditions.
Results. Synthetic spectra of SN Ia, a complex product of computer models replicating numerous physical processes that determine the conditions of matter and radiation in the ejecta, are affected by large spatial jumps of the line-dominated opacities and source functions for which the application of even well-established methods may harbor certain pitfalls. We analyze the conditions that can lead to a breakdown of conventional procedures and we derive for the Feautrier radiative transfer solver a modified description which yields more accurate results in the given circumstances.

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Email: hoffmann@usm.lmu.de