CALCULATED ENERGY DISTRIBUTIONS FOR SN II

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ABSTRACT

We have calculated a large grid of hydrogen-rich supernova photospheres,
in which radii, effective temperatures, density profiles, and expansion
velocities have been varied. Spherical geometry, radiative equilibrium
and LTE level populations are assumed. In the quasi-exact radiative
transfer, the dilution of the radiation field, and scattering as well
as absorption (by all relevant continuous processes and up to 150 000
lines in some models) are accurately considered. Good agreement can be
obtained with the UV and IR spectra of supernovae 1979C, 1980K, and
1987A as observed during the coasting phase. Potential methods of para-
meter determinations for SN II are briefly discussed.

Since supernovae of type II are believed to be explosions of massive
stars with large hydrogen-rich shells (see e.g. Woosley and Weaver,
1986), the spectra of these objects contain important information on
the abundances of the elements of the parent stars (and therefore im-
plicitly on the abundances of the parent galaxy) during the first days
up to a few weeks after the outburst and at later times information
on the amount and the composition of the processed matter returned to
the interstellar medium. In addition, the atmospheric parameters can be
used to determine the distance to the object with a minimum of assump-
tions by means of the Baade-Wesselink method. Since - due to the very
high brightness of SNe II - the data can be obtained for a very large
volume of space, it is highly desirable to model in detail the photo-
spheres of these objects. However, until recently realistic models were
inhibited by the required complexity of the radiative transfer (spherical
geometry, differential expansion, dominance of scattering, line blanke-
ting etc.).

In order to obtain an overview on the significance of these effects and
on the influence of the parameters on the emergent fluxes we have cal-
culated a large grid of spherical hydrogen-rich supernova photospheres
with the following assumptions: (i) the radial density distribution is
given by a power law (exponents n = 5...14), (ii) the expansion veloci-
ties are proportional to the radial distance (the values at absorption

optical depths of unity are varied between 5.10^3 and 15.10^3 km s^{-1}),
(iii) the level populations follow Boltzmann distributions of the
local temperature, (iv) the temperature stratifications are derived
from the condition of radiative equilibrium. In the non-grey quasi-
exact radiative transfer all relevant opacity sources for the continuum
(cf. Hauschildt et al., 1987) and in some models up to 150 000 indivi-
dual lines are taken into account. We consider ranges of effective
temperature 6000 $\leq T_{eff} \leq$ 15000 K and radius $10^{13} \leq R \leq 10^{15}$ cm. The
composition is solar, except for two sets in which the metal content
is reduced to 1/3 and 1/10 solar.

The resulting energy distributions show that for $T_{eff} > 10^4$ K line
blanketing is of minor importance (even in the UV), but for lower
temperatures it is highly significant both for the spectrum and for
the temperature stratification. In most wavelength ranges the fluxes
are strongly influenced simultaneously by n, R, and T_{eff}, i.e. a
change in one parameter can be compensated by changes in the other ones.
However, rather accurate determinations of T_{eff} seem to be possible
from the slope in the red and infrared range. The radii and density
parameters should be derived from a simultaneous fit of the Blamer
discontinuity and the flux gradient in the ultraviolet. It seems
difficult to obtain accurate estimates for the abundances of individual
metals from UV and optical spectra because usually many lines are
blended and most lines have absorption and emission components. But
from such features the expansion velocities can be determined rather
reliably.

Comparison of our calculated fluxes with the observed spectra of the
SNe 1979C and 1980K shows that good agreement can be obtained for the
UV and the IR during the coasting phase (see e.g. Hauschildt et al.,
1987). In the visible a good fit is possible as long as the Balmer
lines are weak indicating NLTE effects for hydrogen in the outer line
forming layers as expected (Höflich et al., 1986). For the heavily
blanketed SN 1987A the main features in the UV can be reproduced for
metallicities 1/3 to 1/1 solar; however, details indicate that the
relative abundances in the irongroup differ from the solar values.

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