Models of Type-II Supernovae
F. Douglas Swesty (Laboratory for Computational Astrophysics, NCSA, and Astronomy Dept., UIUC)

I will present a series of models for the explosion mechanism of Type-II (core collapse) supernovae. These models are based on general relativistic radiation-hydrodynamic numerical simulations of stellar core collapse and the subsequent evolution of the proto-neutron star. The simulations employ various models for the equation of state (EOS) of hot, dense matter and various models for the presupernova progenitor. I will discuss the proposed late-time neutrino reheating mechanism, as well as the role of both the progenitor model and the EOS in this mechanism. Additionally, I will address the problem of the accuracy and consistency of the numerical radiation-hydrodynamic techniques used to model supernovae. Both the shortcomings of the existing generation of models and the improvements that will be provided by the next generation will be discussed.

Hydrogen Molecules in Supernova Envelopes
Michael Culhane and Richard McCray (JILA, U. Colorado, NIST)

The observations of CO and SiO in the infrared spectrum of SN1987A clearly indicate that molecules can form in the debris of a supernova explosion. Since H2 is not easily observable we compute its abundance theoretically. For conditions typical of the inner (\( \rho < 2500 \text{ km/s}^2 \)) envelope of SN1987A, the fraction of H that is in molecular form rises to ~1% by \( \approx 800 \text{ days} \). For \( t > 500 \text{ days} \) the formation is dominated by the gas phase reactions: \( \text{H} + \text{H}^+ \rightarrow \text{H}_2 + \text{e}^+ \); \( \text{H}_2 + \text{H}^+ \rightarrow \text{H}_3^+ + \text{e} \); \( \text{H}_3^+ + \text{H} \rightarrow \text{H}_2 + \text{H}_2^+ \). Thereafter, the formation is dominated by the reactions: \( \text{H} + \text{e} \rightarrow \text{H}^+ + \text{e} \); \( \text{H}^+ + \text{H} \rightarrow \text{H}_2 + \text{e} \). At early times the H\(^+\) may absorb ~10-30% of visible photons, contributing to the apparent paucity of Ha emission. For \( t > 800 \text{ days} \) the abundance of H2 “freezes out” due to the slowing of all reactions. The opacity of the supernova envelope in the range \( 912 < \lambda < 1150 \text{ Å} \) is dominated by resonance scattering in the Lyman and Werner bands of H2. The resulting fluorescence emission bands of H2 in the range \( 1150 < \lambda < 1650 \text{ Å} \) may be observable in the UV spectra of supernovae at late times.

Semi-analytics Continuum Spectra of Type II Supernovae
M.J. Montes, R.V. Wagoner (Stanford Univ.)

We extend the approximate radiative transfer analysis of Hershkovitz, Lindner, and Wagoner (Ap. J. 303, 800 (1986)) to a more general class of supernova model atmospheres, using a simple fit to the effective continuum opacity produced by lines (Wagoner, Perez, and Vasu; Ap. J. 377, 639 (1991)). The populations of the excited states of hydrogen are governed mainly by photoionization and recombination, and scattering dominates opacity absorption. We match the asymptotic expressions for the spectral energy density \( J_\nu \) at the photosphere, whose location at each frequency is determined by a first-order calculation of the deviation of \( J_\nu \) from the Planck function \( B_\nu \). The emergent spectral luminosity then assumes the form \( L_\nu = 4\pi r^2 T_\nu B_\nu(T_\nu) \), where \( T_\nu = r^2 / (\pi^2 r^2) \) is the photospheric temperature, \( z \) is the dilution factor, and \( r \) is a fiducial radius.

The atmosphere is characterized by the effective temperature \( T_e \propto \nu^{1/2} \rho^{-1/2} \) and hydrogen density \( n_H = n_e (\rho/r)^2 \); less strongly by the heavy element abundance \( Z \) and velocity gradient \( \nu/\tau = (1 - \xi/\eta)^{-1} \). We obtain the dependencies of \( T_e \) and \( T_\nu \) on frequency \( \nu \) and the parameters \( T_e \), \( n_e \), \( r \), and \( \rho \).

The resulting understanding of the dependence of the spectral luminosity on the parameters which characterize the relevant physical conditions will be of particular use in assessing the reliability of the expanding photosphere method of distance determination. This is particularly important at cosmological distances, where no information about the progenitor star will be available. This technique can also be applied to other low-density photospheres, such as those in accretion disks.

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The Contradictory Status of the Crab Supernova: Observational Anomalies and the Theoretical Paradigm
L. C. Hill (BCC)

As a well documented historical supernova (SN1987A) which has left an unusually luminous supernova remnant (SNR), the Crab has served as a paradigm for the theoretical modeling of SNe. However, the records of the original SN plus the panchromatic luminosity, asymmetries, low mass, chemical anomalies and large angular momentum of the SNR are indicative of a very peculiar SN. It is suggested that any theoretical modelling of the Crab event within the framework of conventional theoretical models for Type II & Ib SNe [with mass the only significant differentiating parameter] is likely to be misguided. Two obvious parameters of interest for modeling of SNe (angular momentum; binary exchange) are also discussed.

Optical Spectra of SN 1993J During the First Week
R.A. Finn, R.A. Fesen, J.D. Darling, J.R. Thorstensen (Dartmouth), G. Worthey (U of Mich)

Optical spectra of SN 1993J in M81 are presented for each night from March 31.1 1993 UT to April 7.1 1993 UT with wavelength coverage from 4400 Å to 8200 Å at 4 Å resolution. Emission features near 4950, 5860, and 6560 Å begin to appear on March 31.1 and continue to rise throughout the first week. Faint emission near 6370 Å, probably due to [Fe X] 6374 Å, is detected on April 1.1 and fades by April 2.2. This fading suggests a radius of 0.001 pc for the [Fe X] emitting region, assuming a SN expansion velocity of 10,000 km s\(^{-1}\). The [O I] feature at 6560 Å extends from 6350 to 6800 Å corresponding to velocities of \pm 10,000 km s\(^{-1}\). A slight dip centered at 6516 Å is seen on the [O II] emission peak between April 2.2 and grows deeper through the first week. If the feature at 5860 Å is due to [He I] 5876 Å, the corresponding Doppler width is \pm 12,000 km s\(^{-1}\). Possible absorption features blueward of [O II] and [He I] appear on April 3.1, as well as emission near 5100 Å. On April 4.1 the feature at 4950 Å resolves into two peaks at 4797 and 4909 Å, which we attribute to blue-shifted Fe II 4924, 5018 Å lines. On April 5.1, the emission at 5100 Å can be resolved into two peaks centered at 5073 Å and 5226 Å. Discussion of these data will be presented.

Spectral Analysis of SN 1993J
E. Baron, P.H. Hauschildt, and D. Branch (Dept of Physics and Astronomy, Univ. of Oklahoma, Norman, OK 73019; Dept. of Physics and Astronomy, Arizona State Univ., Tempe, AZ 85287)

We present results of model calculations of synthetic spectra for a time series of observations of the Type IIPe supernova SN 1993J in M81. We find that at very early times the composition was likely to be roughly solar and the atmosphere was rather extended. The structure quickly evolved to be extremely