

# Late Time Spectral Models of SN 2011fe

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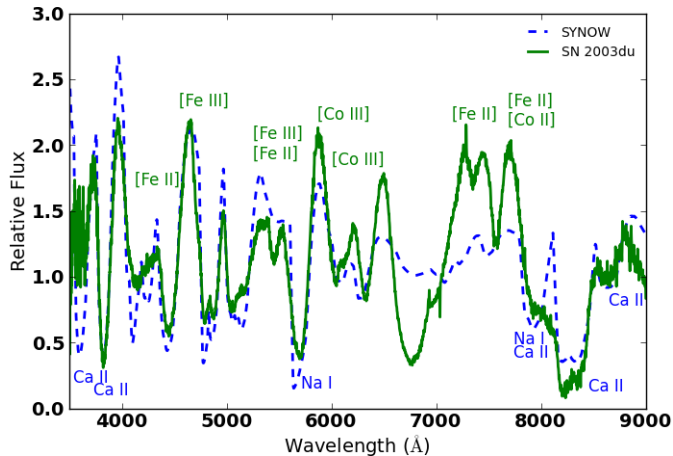
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# SN 2003du (day +84)

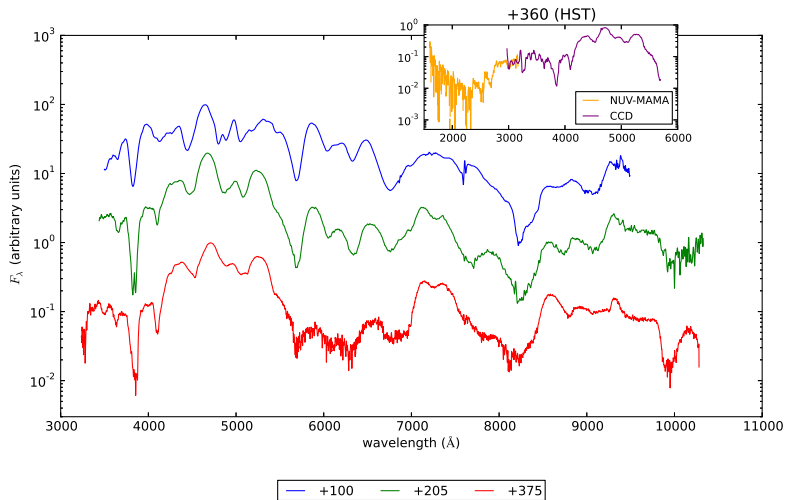
Branch+ 2008



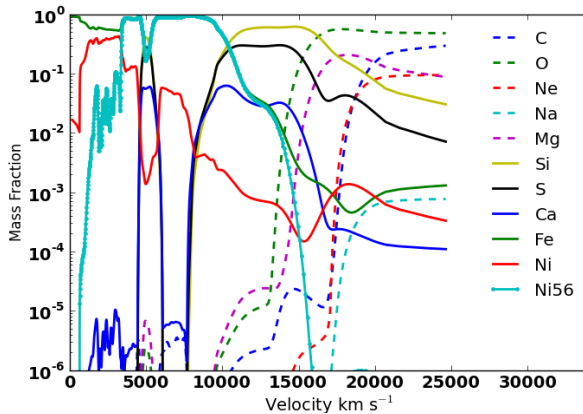
Unmarked SYNOW features are permitted Fe II

- Add forbidden lines to the model atoms Ca II, C I, C III, O I, O III, Na I-II, Mg I-III, Si I-III, S I-III, Ti II, Cr II, Mn I, Fe I-III, Co II-III, Ni I-III.
- Modify current Unsöld-Lucy temperature correction to approximately handle heating = cooling. (Needs some work).

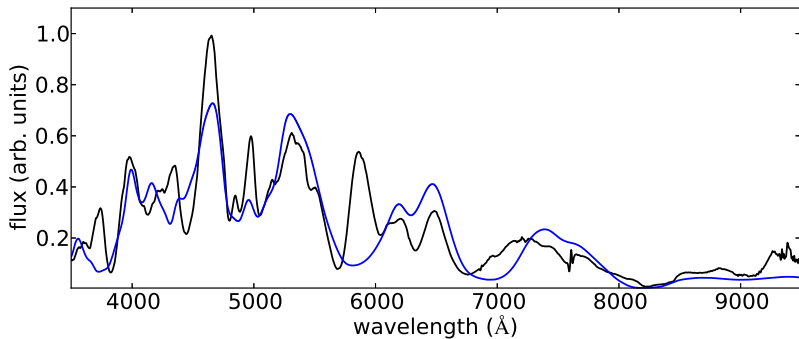
# SN 2011fe: Late time observed spectra



# Hydro Abundances



Day +100

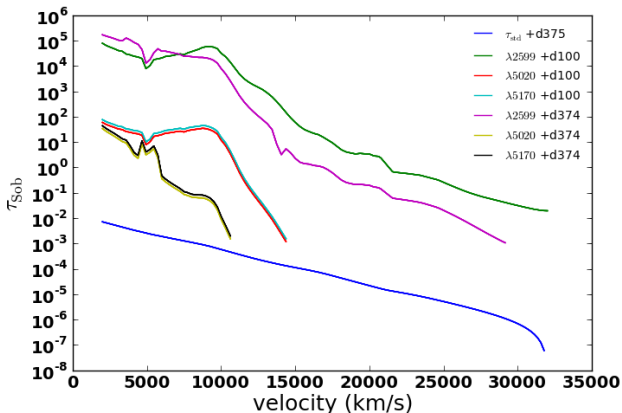


— SN 2011fe +100

— PHOENIX model spectrum

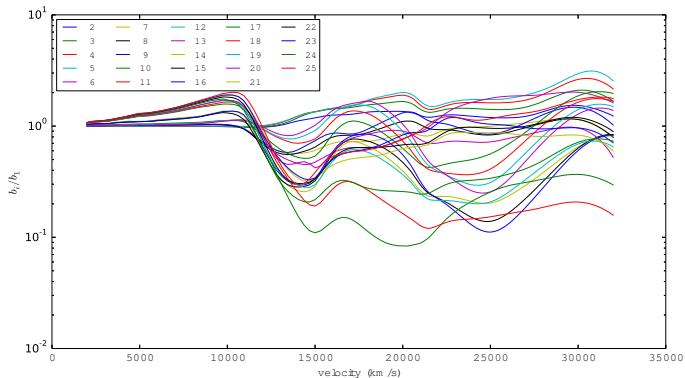
No Forbidden lines included

# Sobolev Optical Depth



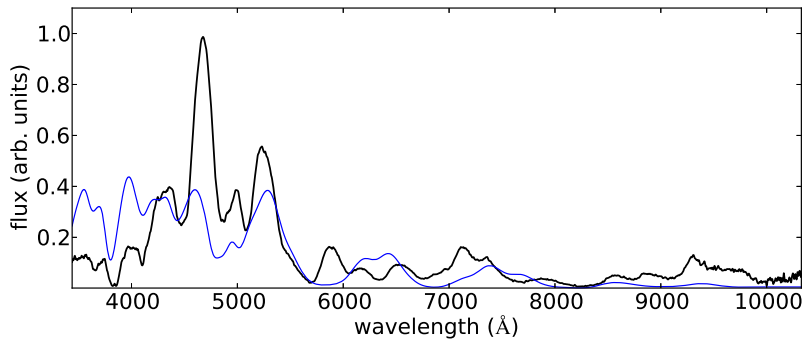
Sobolev optical depth for the Fe II permitted lines  $\lambda 2599$ ,  $5018$ ,  $5169$ , as well as the *total* optical depth at  $\lambda = 5000 \text{ \AA}$ , as a function of velocity, at various epochs.

# Departure Coefficients



NLTE departure coefficients of the first several energy levels of Fe II at day +100, normalized to that of the ground state.






— SN 2011fe +205      — PHOENIX model spectrum

Forbidden lines included.

# Summary



- No clear nebular transition
  - Both permitted and forbidden lines are likely needed
  - Some ambiguities in late time spectra likely
- Improved models needed to analyze late-time SNe Ia spectra.