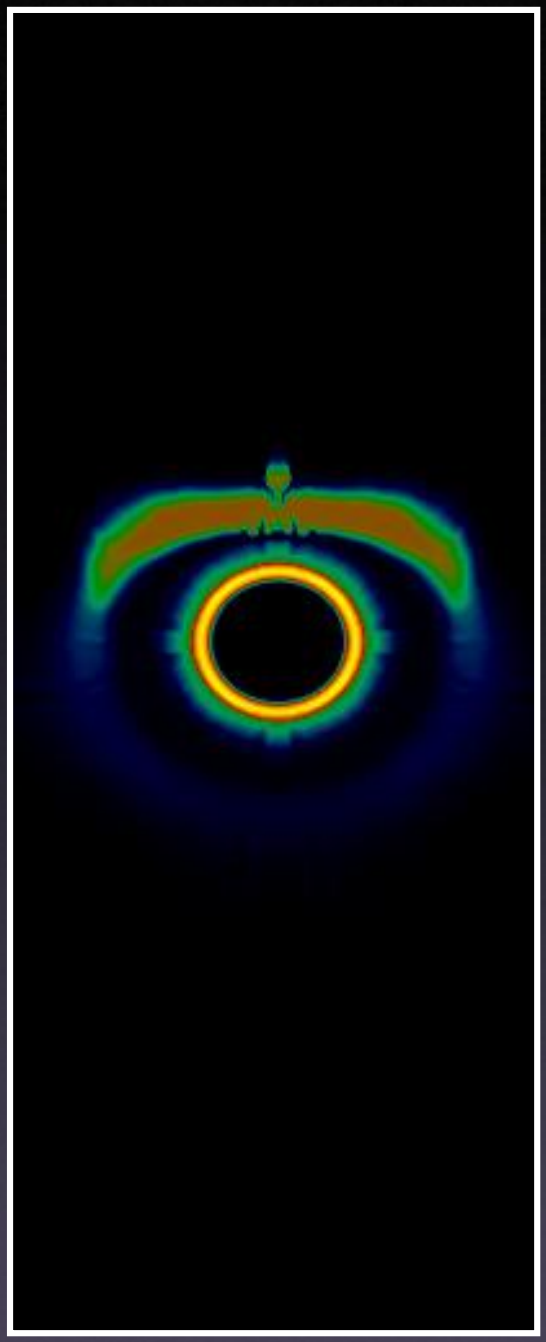
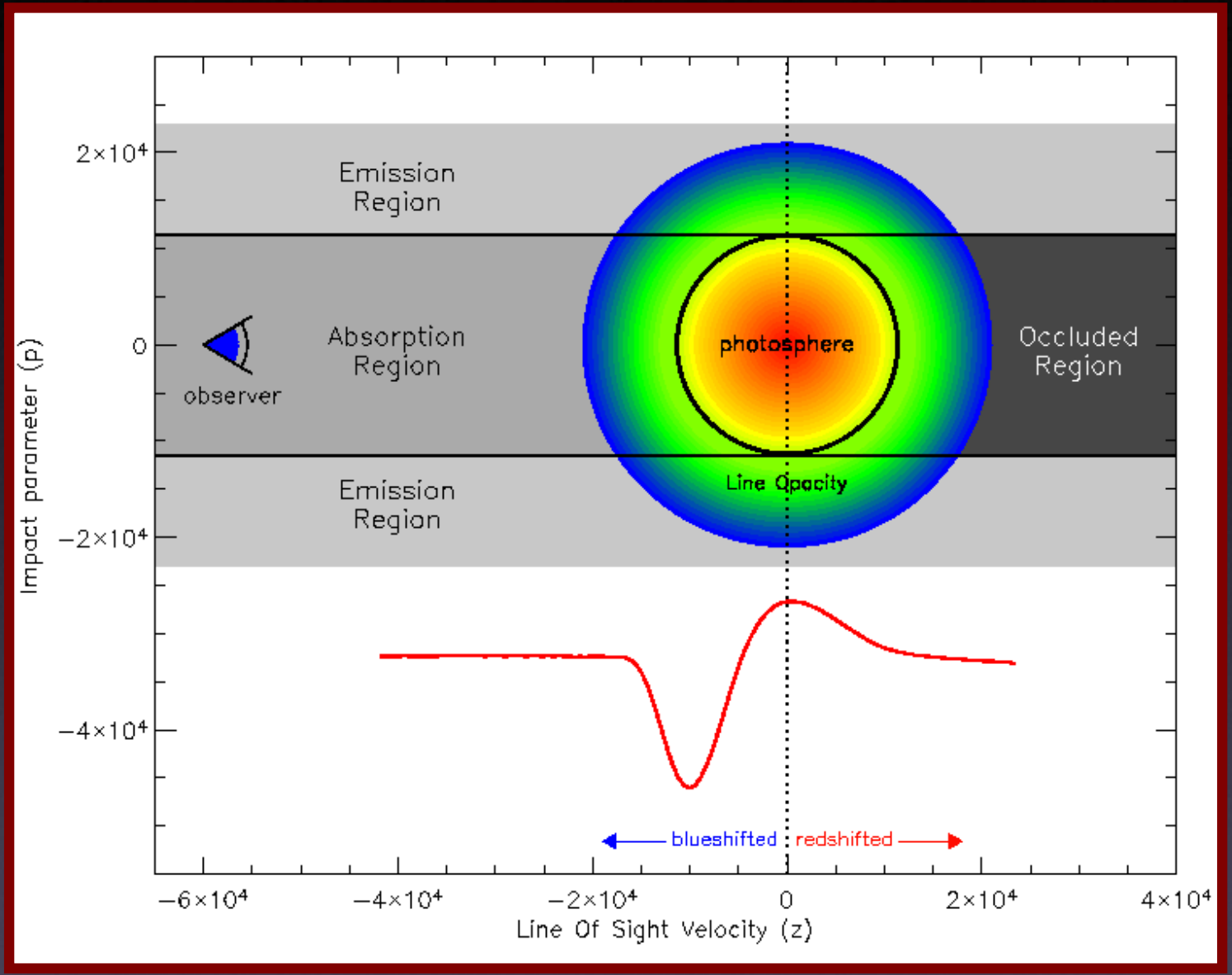
Type Ia Supernovae
Observational Signatures of Asymmetry

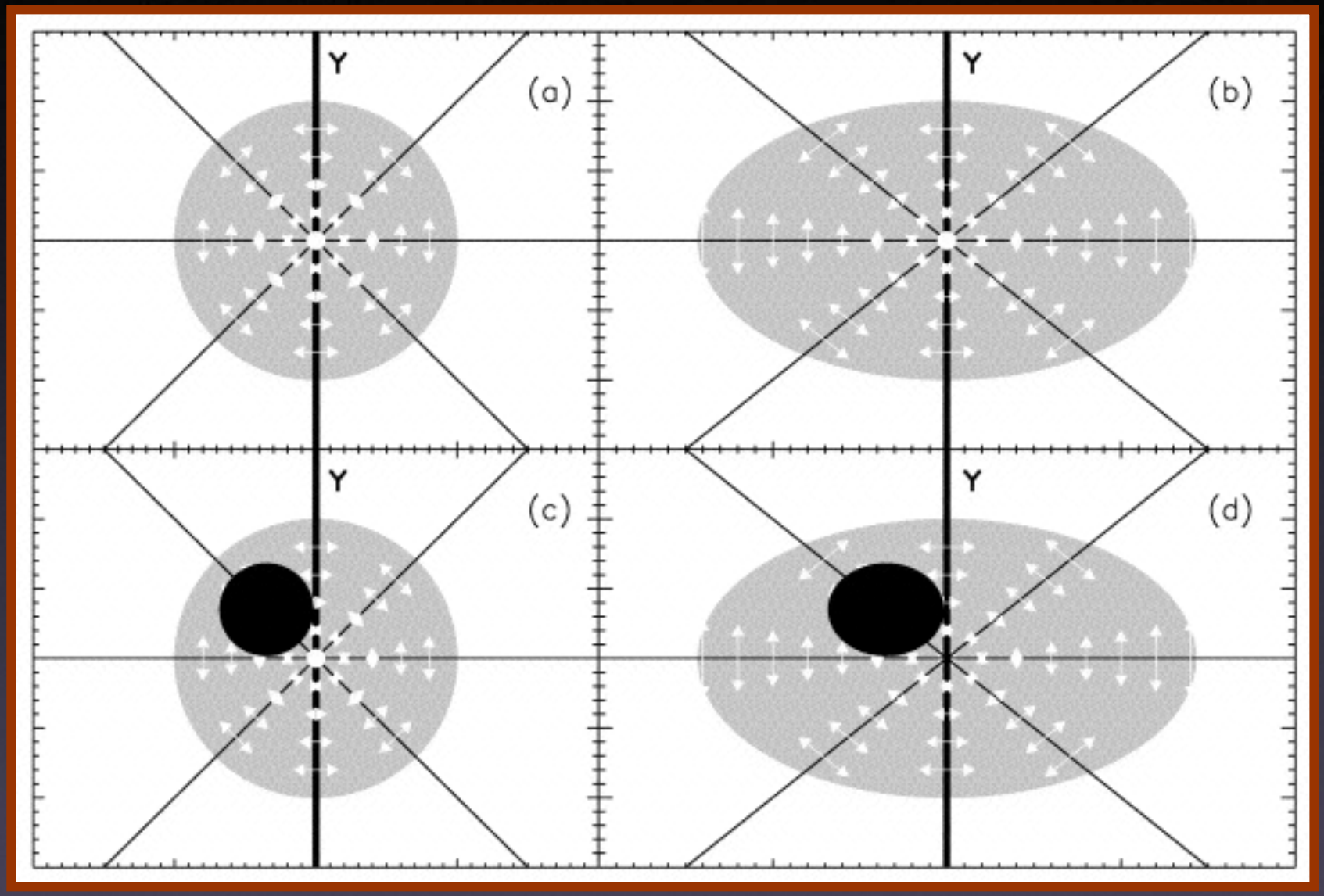


Daniel Kasen
(Johns Hopkins University / STScI)

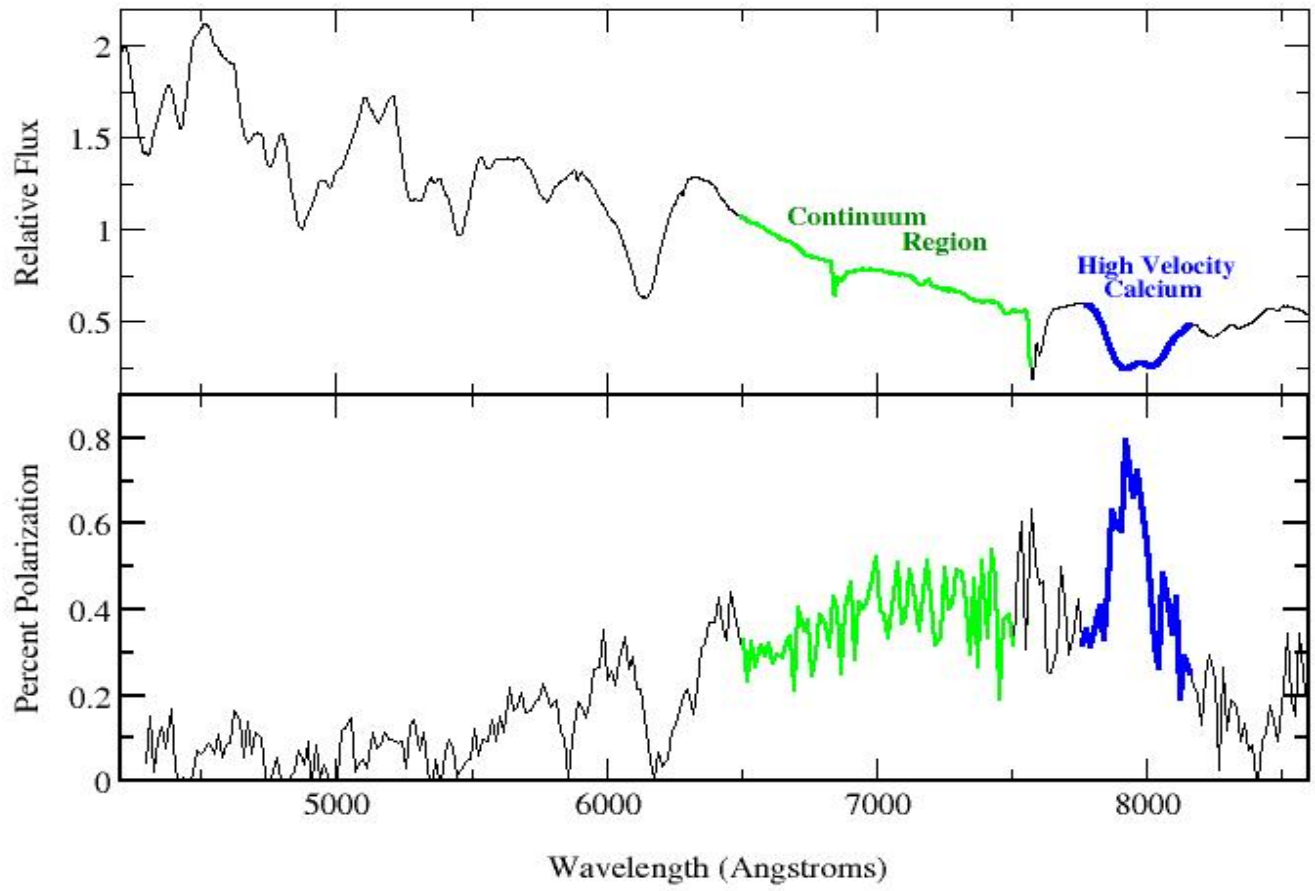
Supernova Spectrum Formation



Asymmetry and Polarization

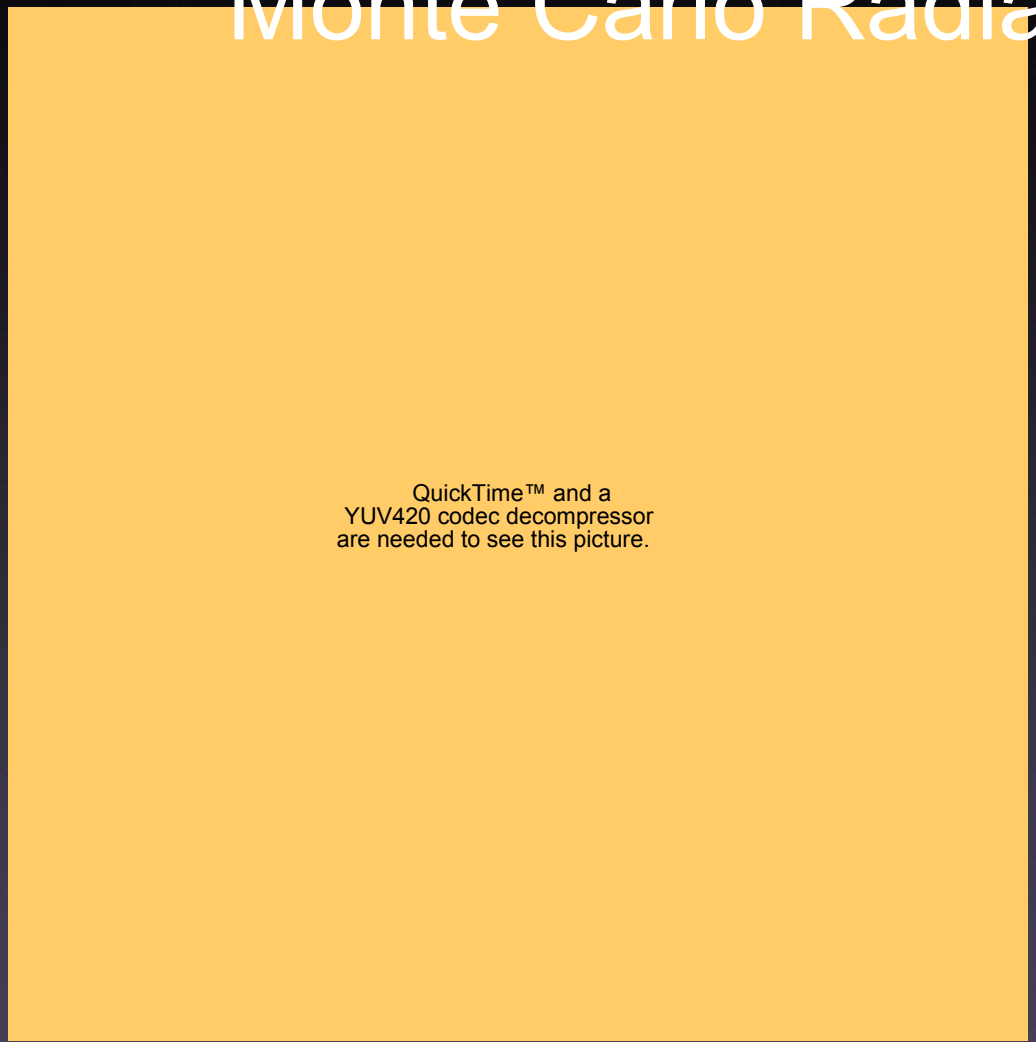


Type Ia Spectropolarimetery

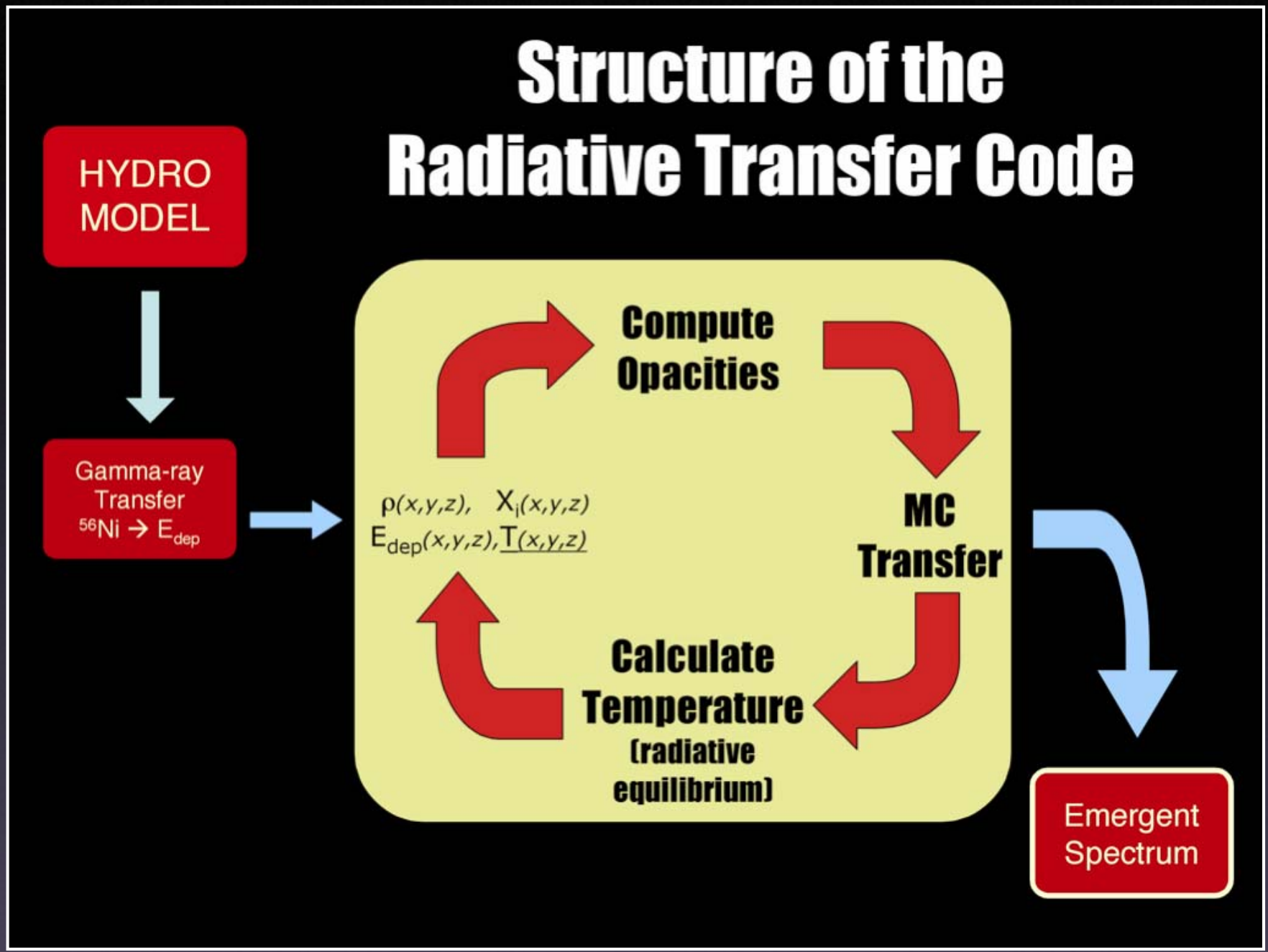


SN2001el --- Wang et al., ApJ 2003

Multi-Dimensional Time-dependent Monte Carlo Radiative Transfer

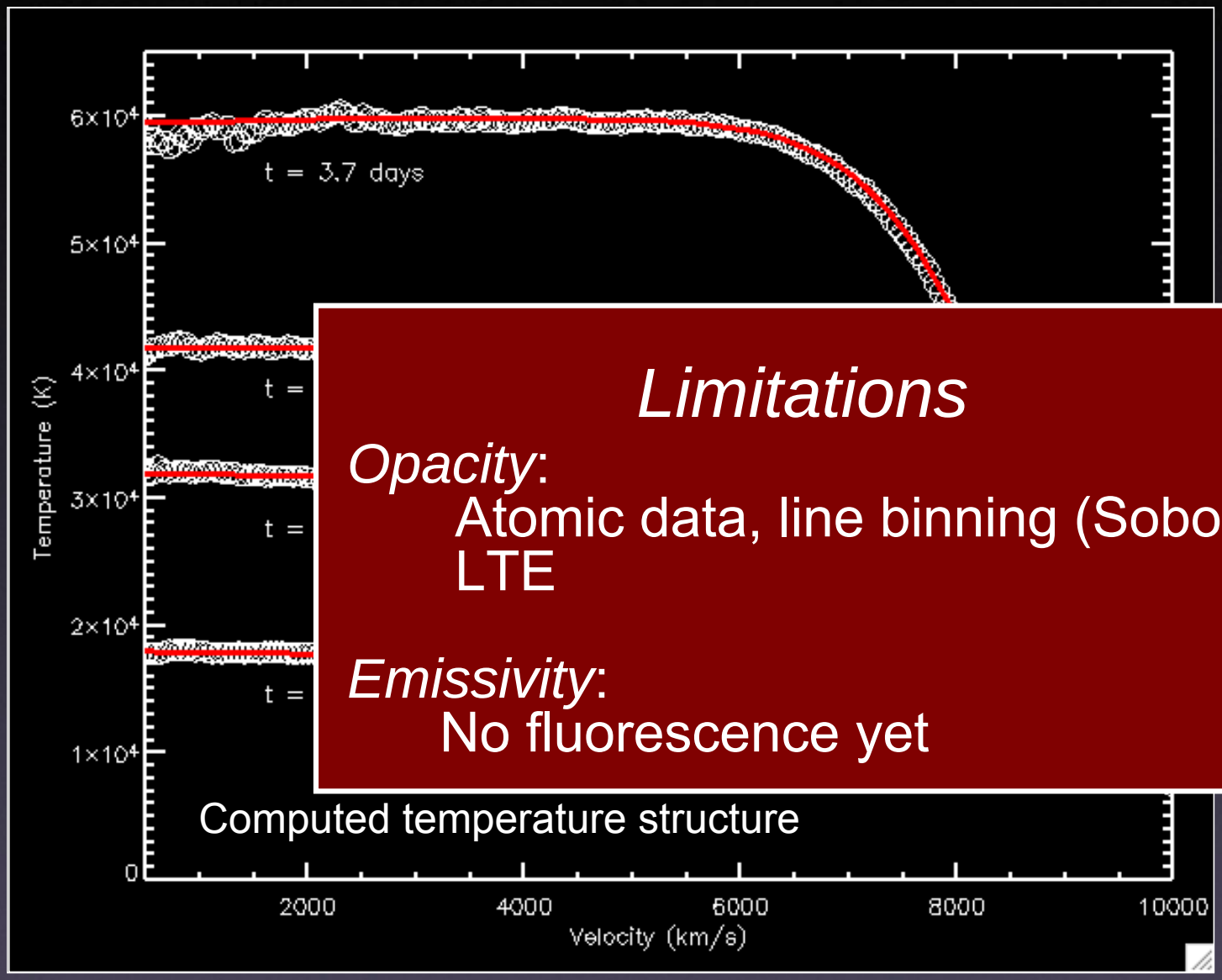


- Fully Time-Dependent
- Calculates gamma-ray transfer for energy deposition and gamma-ray spectra
- Temperature structure computed iteratively from radiative equilibrium
- Includes full optical wavelength dependence and polarization
- Accepts 1D, 2D, or 3D (spherical, cylindrical, cartesian) hydro models


Structure of the Radiative Transfer Code
HYDRO MODEL
Gamma-ray Transfer
$^{56}Ni \rightarrow E_{dep}$
$\rho(x,y,z)$, $X_i(x,y,z)$
$E_{dep}(x,y,z)$, $T(x,y,z)$
Compute Opacities
MC Transfer
Calculate Temperature (radiative equilibrium)
Emergent Spectrum

Test SNe Ia Problem

see Lucy, A&A 2004



Computed temperature structure

Limitations

Opacity:

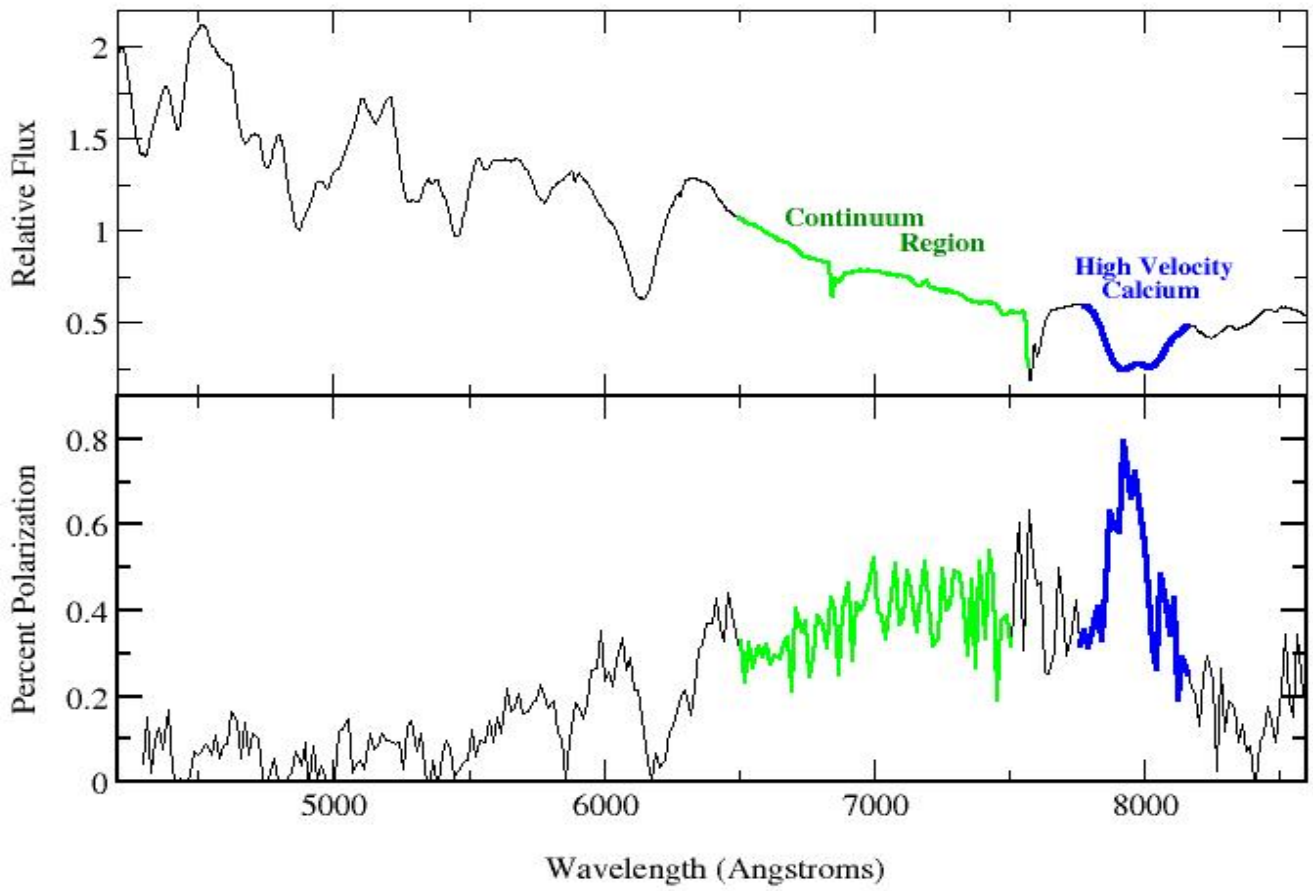
Atomic data, line binning (Sobolev)

LTE

Emissivity:

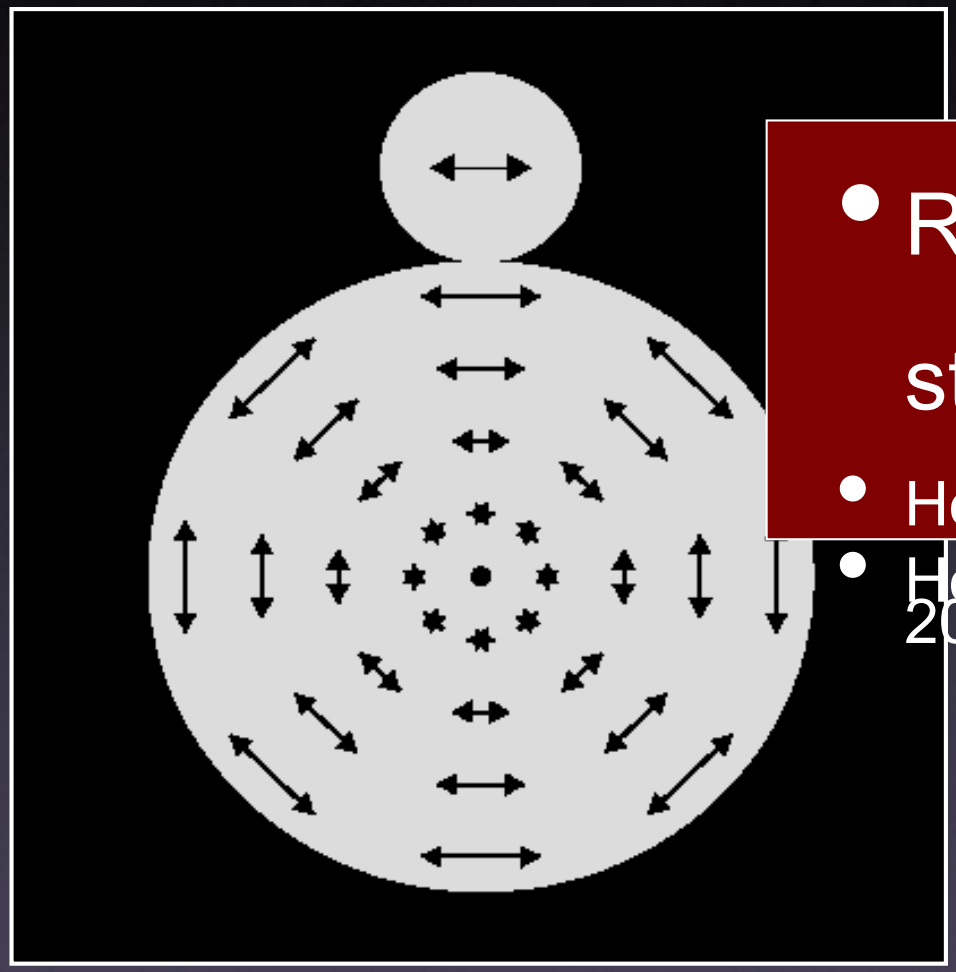
No fluorescence yet

Type Ia Spectropolarimetery



SN2001el --- Wang et al., ApJ 2003

Continuum Polarization Asymmetry Estimate

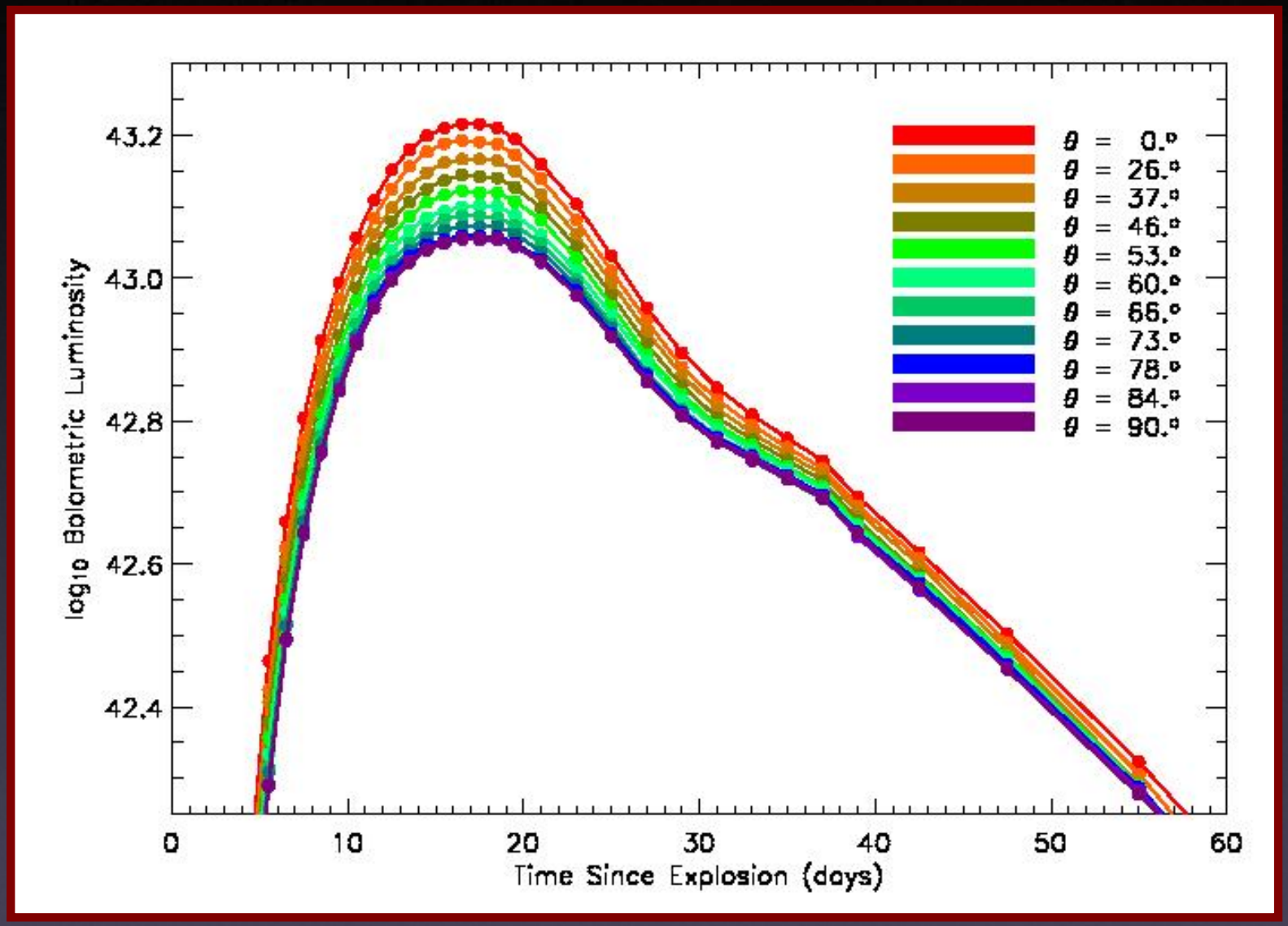


- Radiative transfer studies
- Hoeflich, 1991; Jeffery, 1991
- Howell et al., 2001, Kasen et al. 2004

$P \sim 0.5\%$

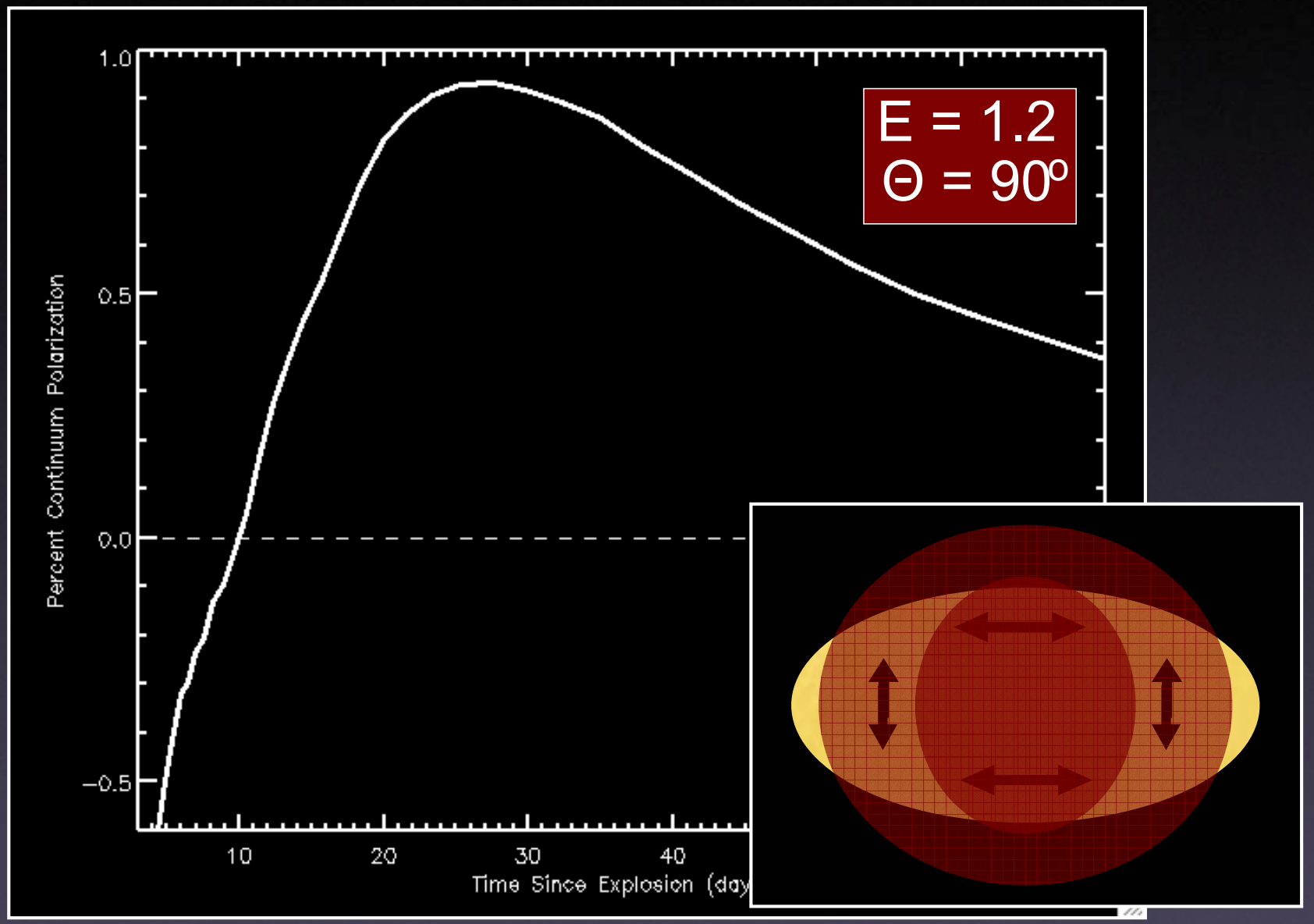
need ~10% asymmetry in emitting area

Asymmetry and SNIa Light Curves

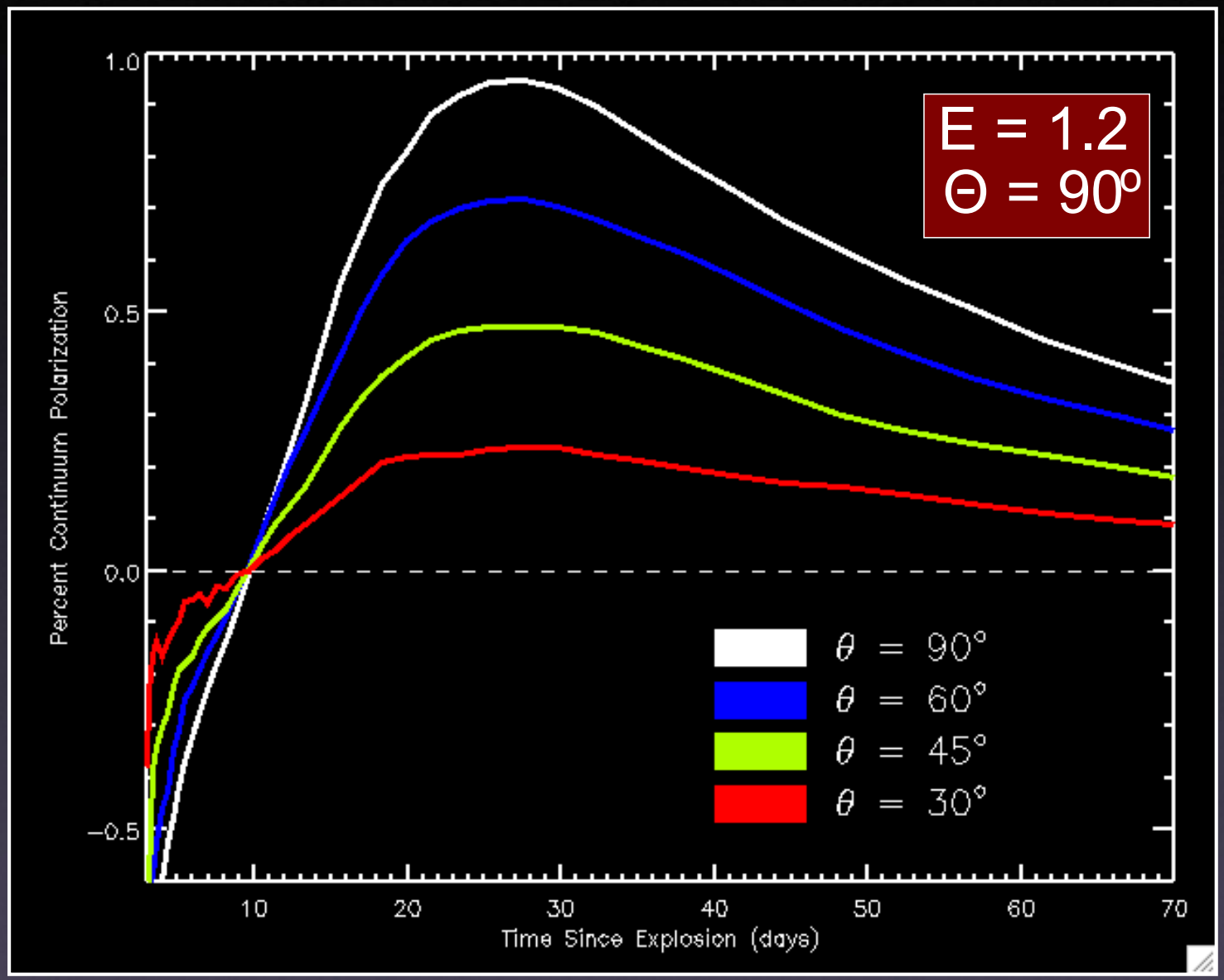


Ellipsoidal w7 model; E=1.2

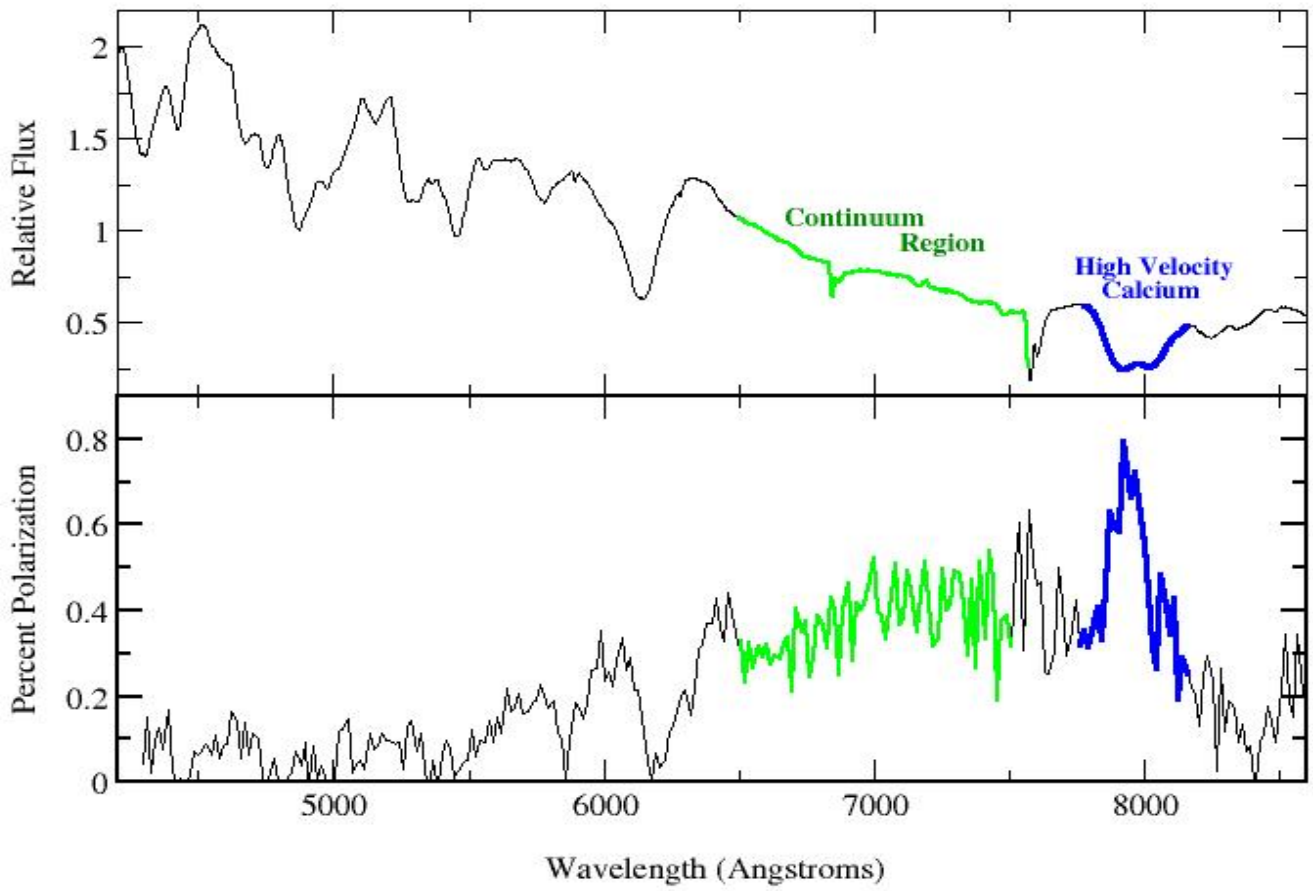
Continuum Polarization Curve



Neither the time, nor the inclination...



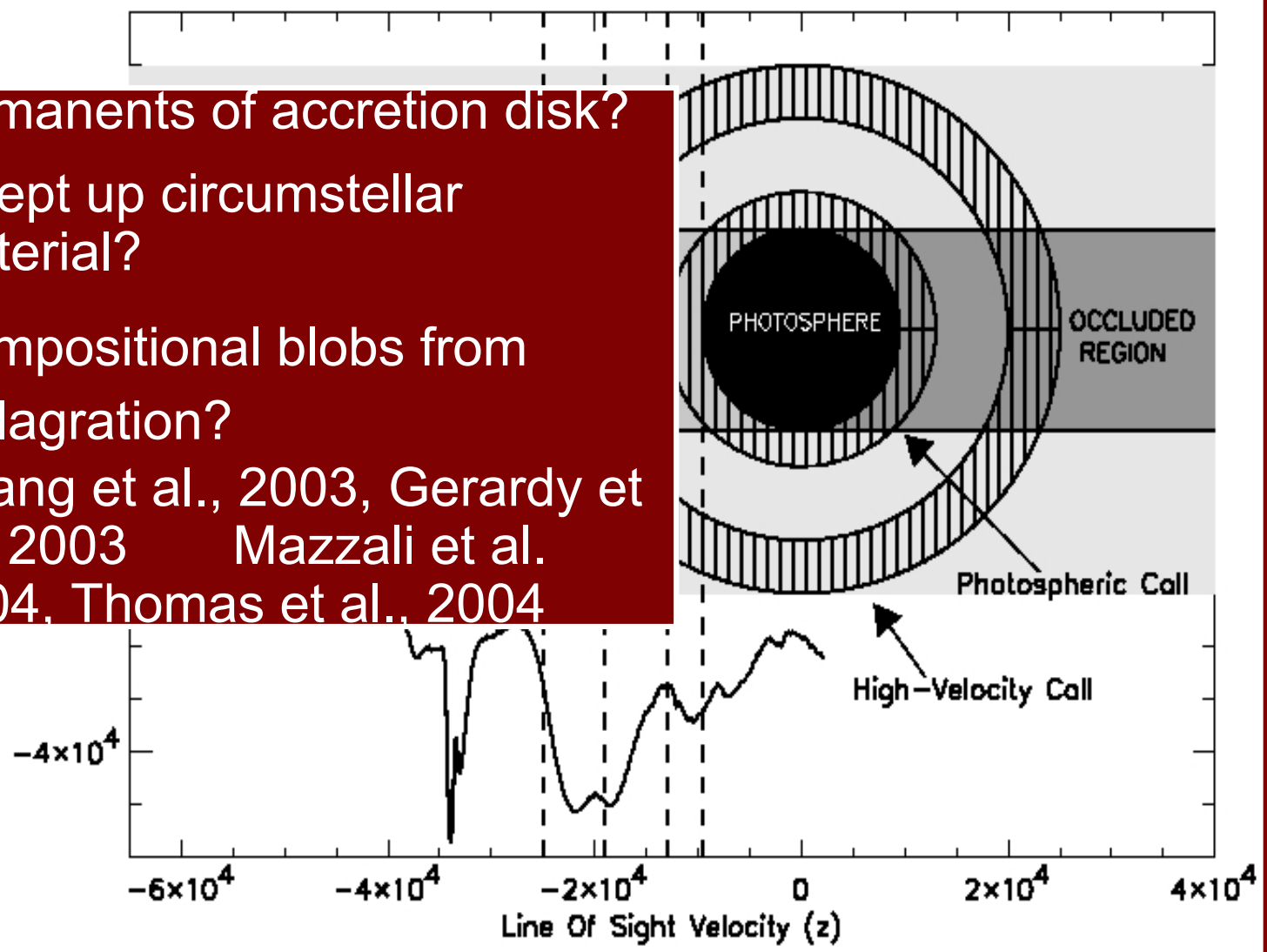
Type Ia Spectropolarimetery



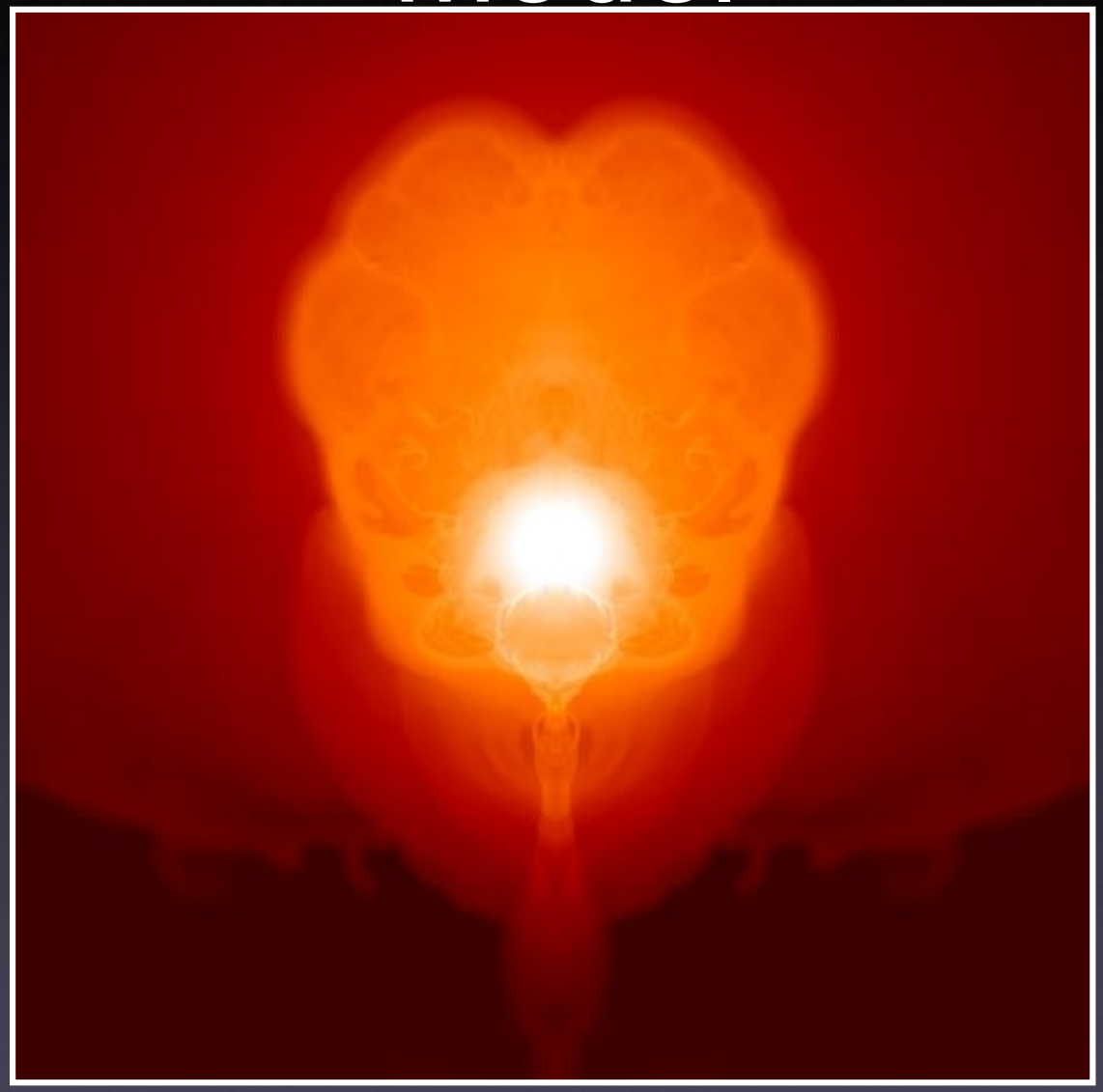
SN2001el --- Wang et al., ApJ 2003

High Velocity Calcium in SNe Ia

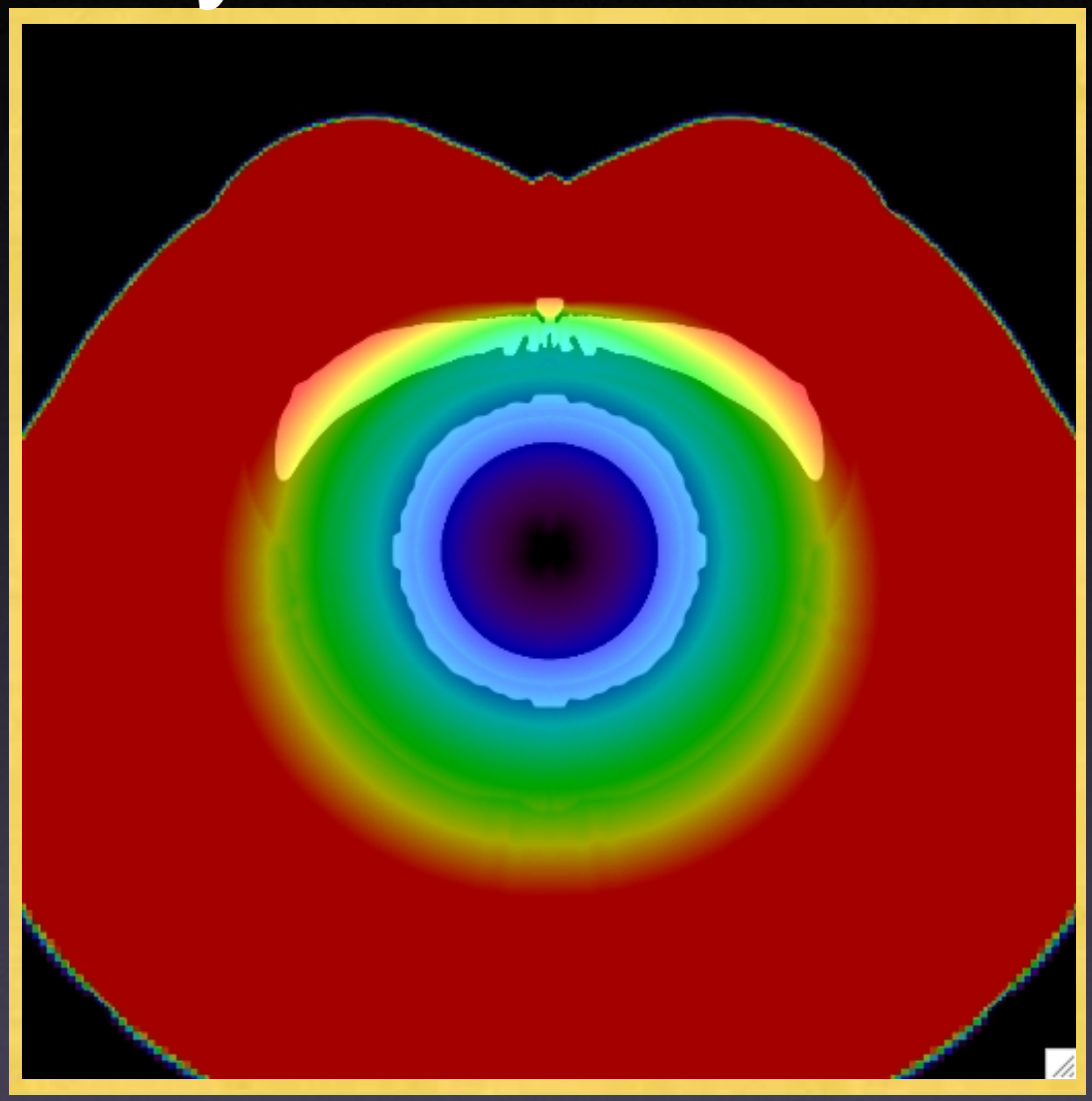
- Remanents of accretion disk?
- Swept up circumstellar material?
- Compositional blobs from deflagration?
- Wang et al., 2003, Gerardy et al., 2003 Mazzali et al. 2004, Thomas et al., 2004



Spectropolarimetric Signatures of the GCD Model

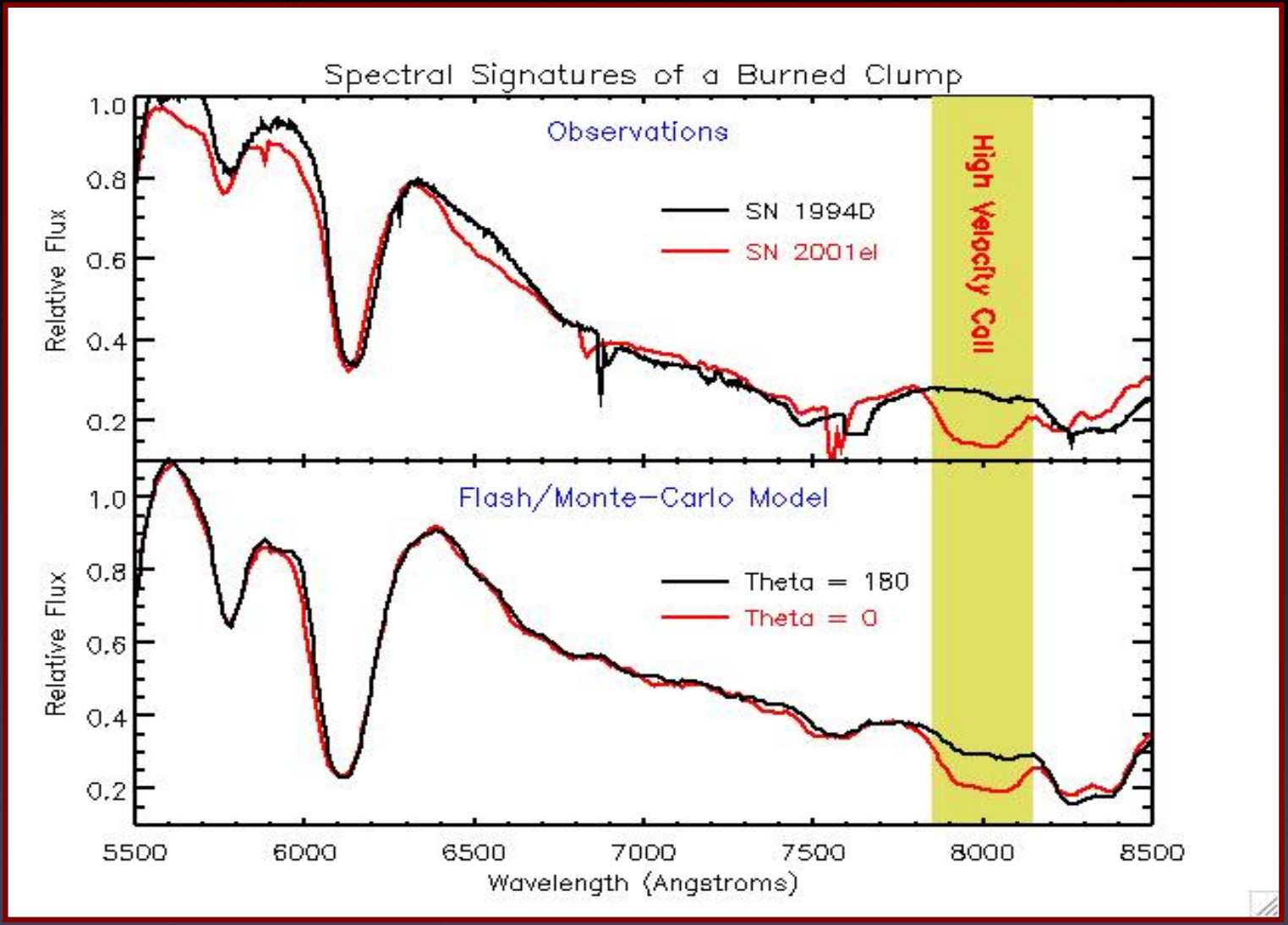


Post-GCD Hydrodynamical Interaction



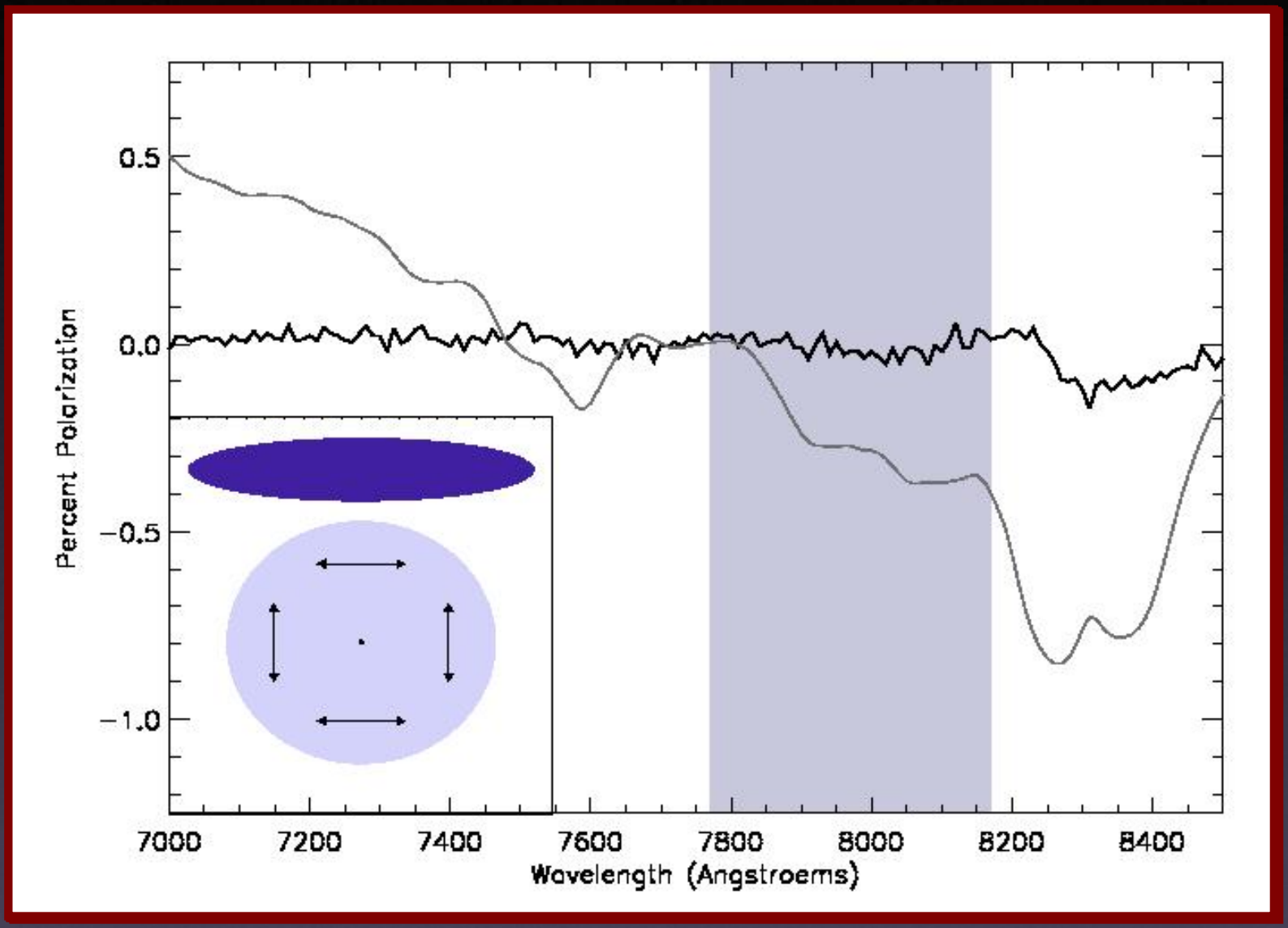
Kasen&Plewa, ApJL 2005

Spectral Signatures of GCD



Kasen&Plewa, ApJL 2005

Polarization Signatures of a High Velocity Clump



Kasen&Plewa, ApJL 2005