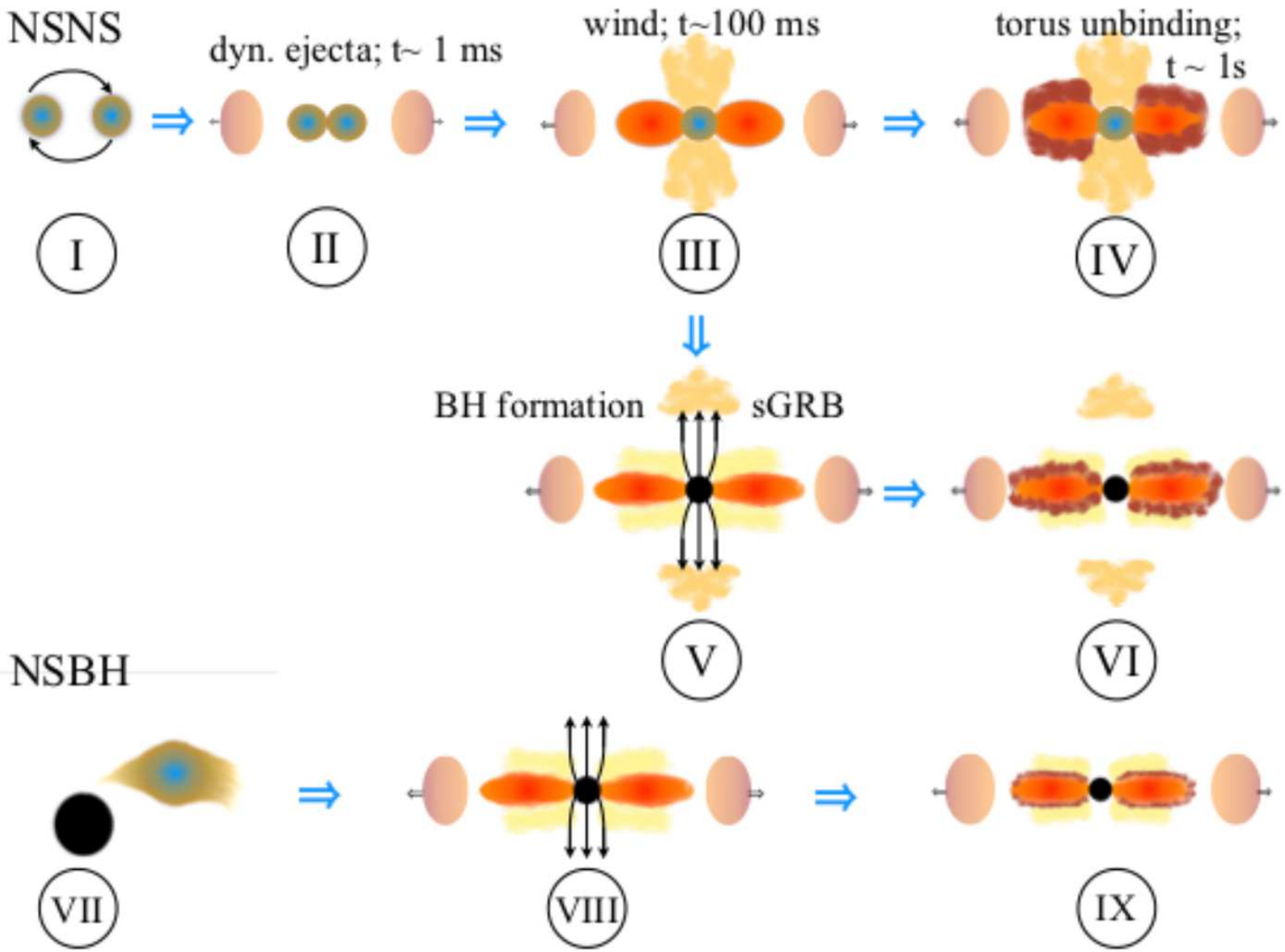
AT2017gfo - the first kilonova

Anders Jerkstrand

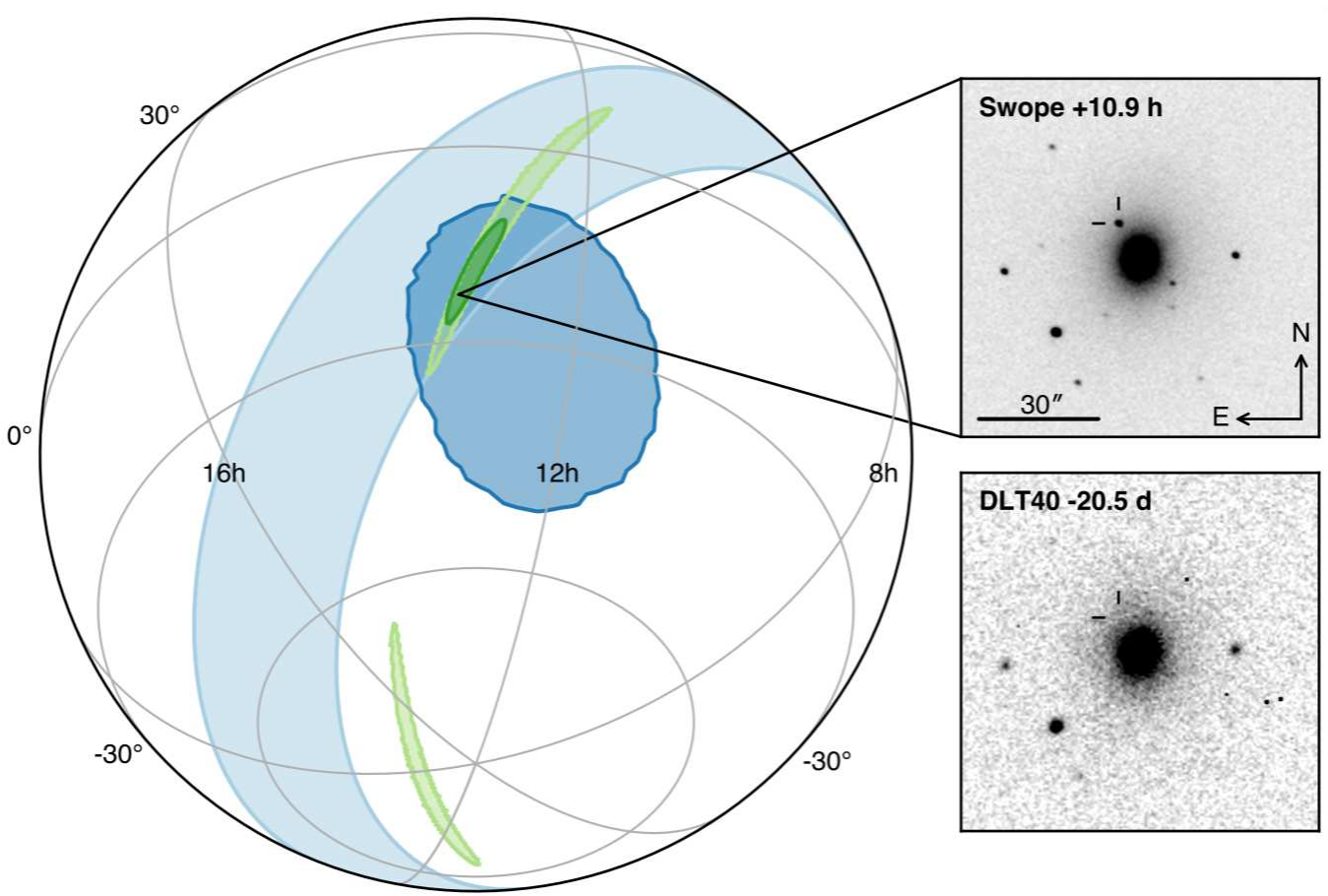
Max-Planck-Institut für Astrophysik, Garching

Neutron star mergers and kilonova creation



Rosswog 2017

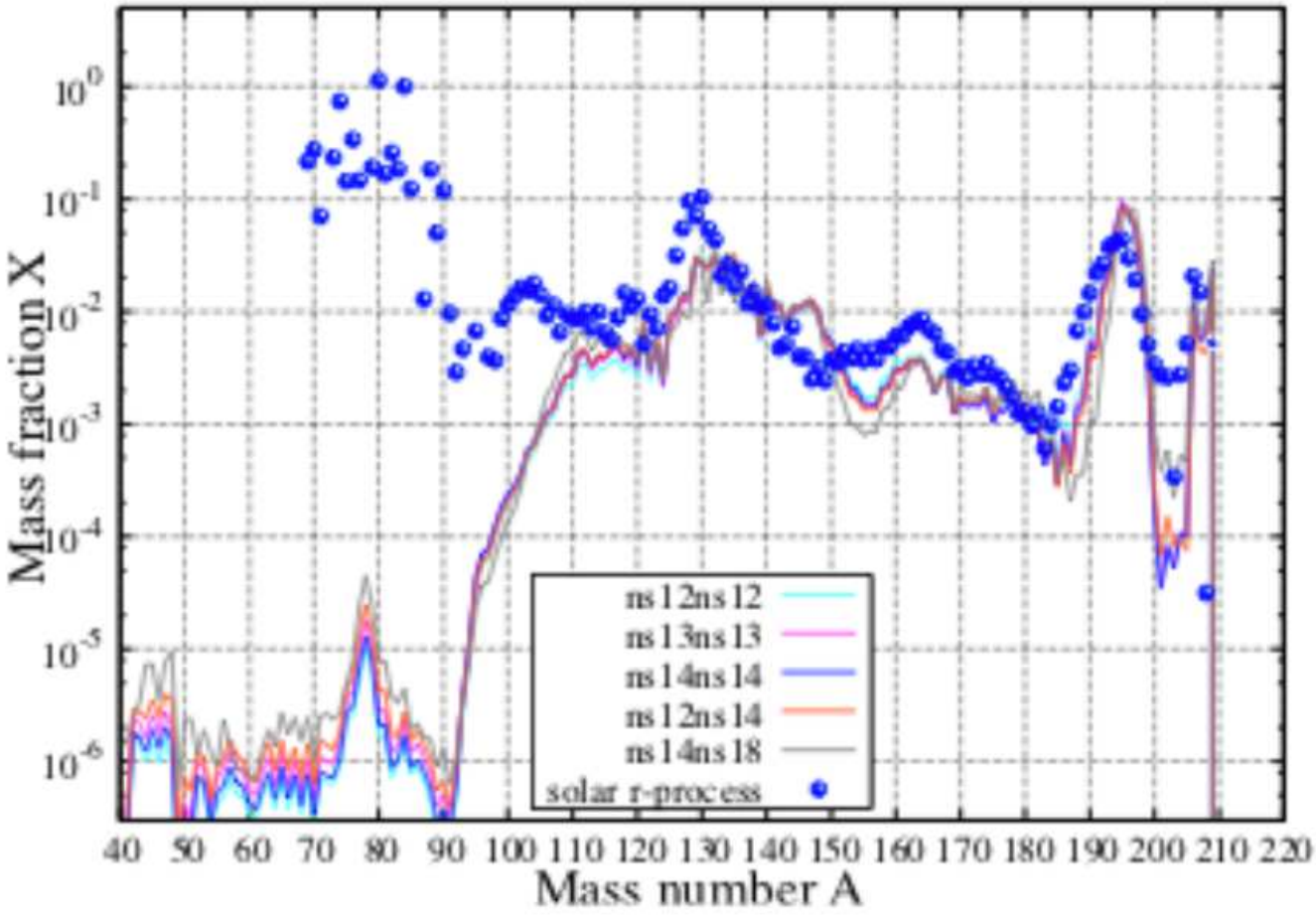
AT2017gfo



LIGO multi-messenger paper

Nucleosynthesis

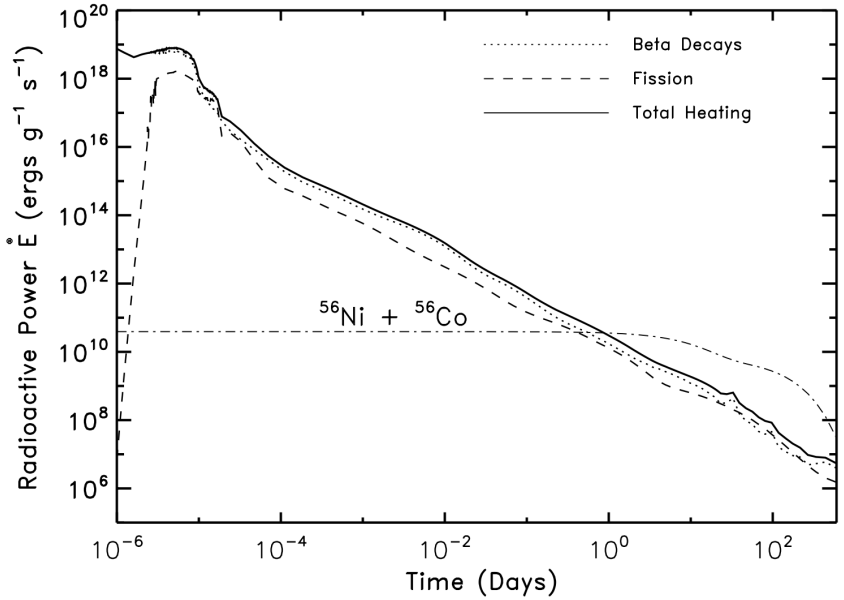
- NS-NS and NS-BH mergers suggested to be important source of r-process elements long ago (Lattimer & Schramm 1974, Eichler 1989)

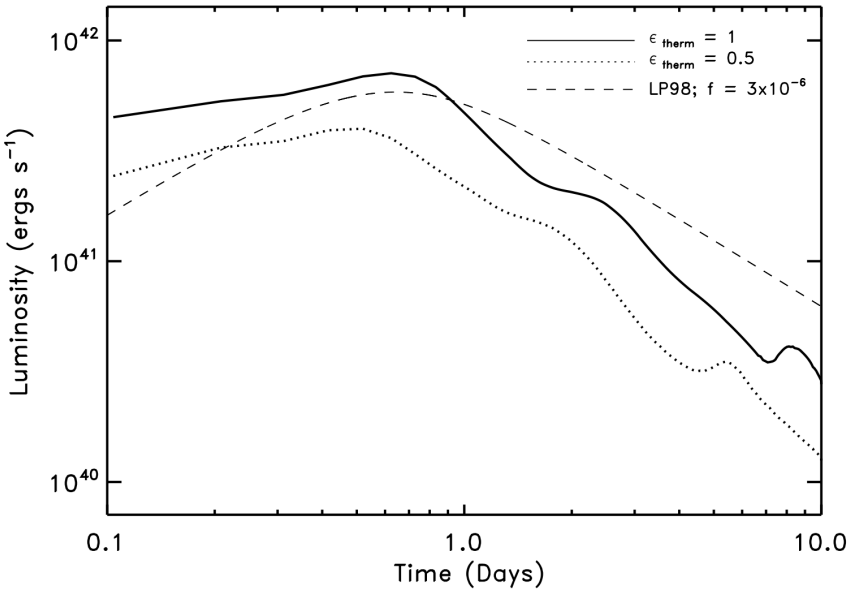


Rosswog 2017

Metzger+2010 : first predictions of KN appearance

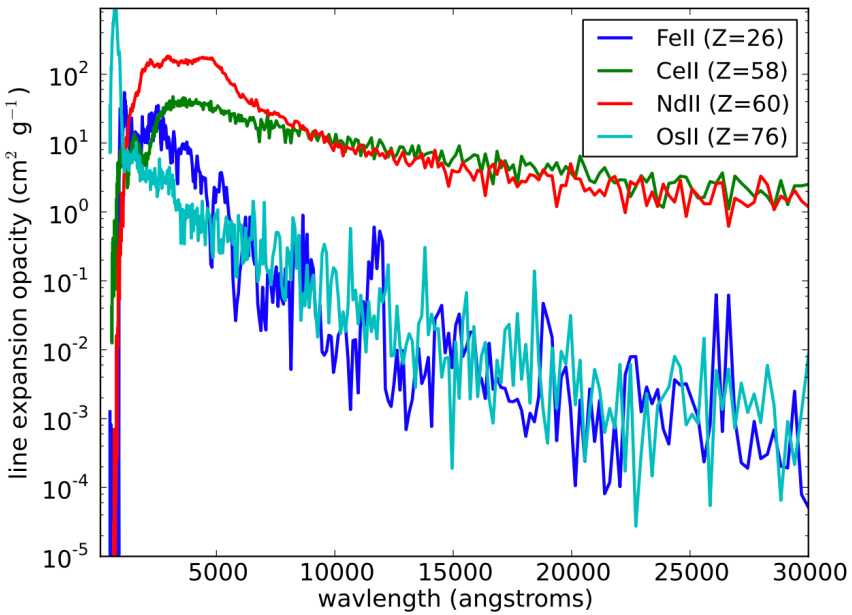
- Radioactivity closely follows a $t^{-1.3}$ power law
- Assuming an iron-like opacity, the transient peaks at $\sim$1d and $\sim 10^{42}$ erg/s.

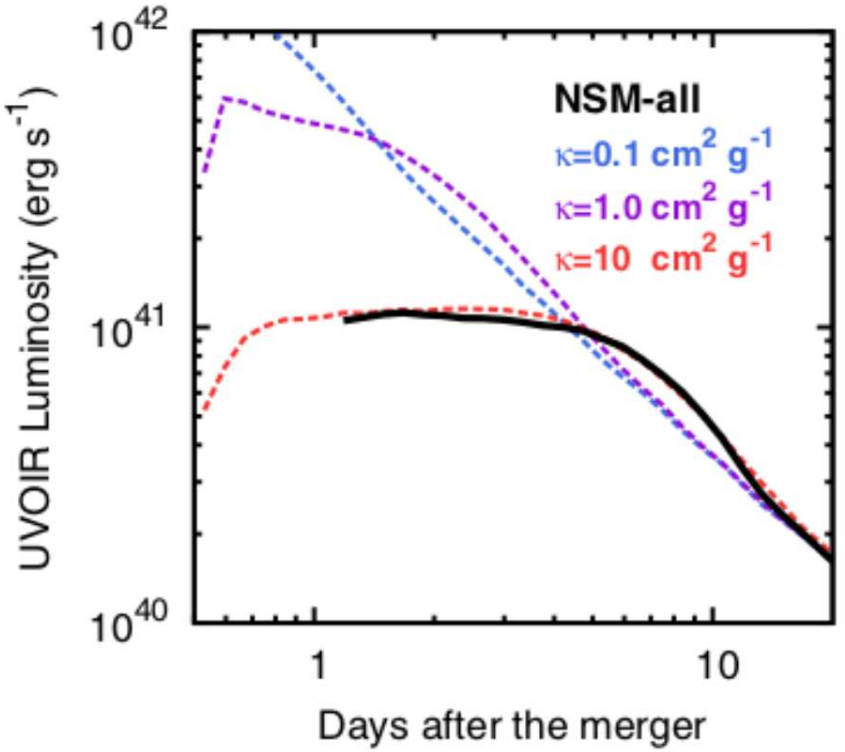




Kasen 2013 : What is opacity?

- Completely depends on composition. E.g. lanthanides $\rightarrow$ 100 times higher than Fe.
- If so, the transient peaks at $\sim$10d and in the IR rather than optical

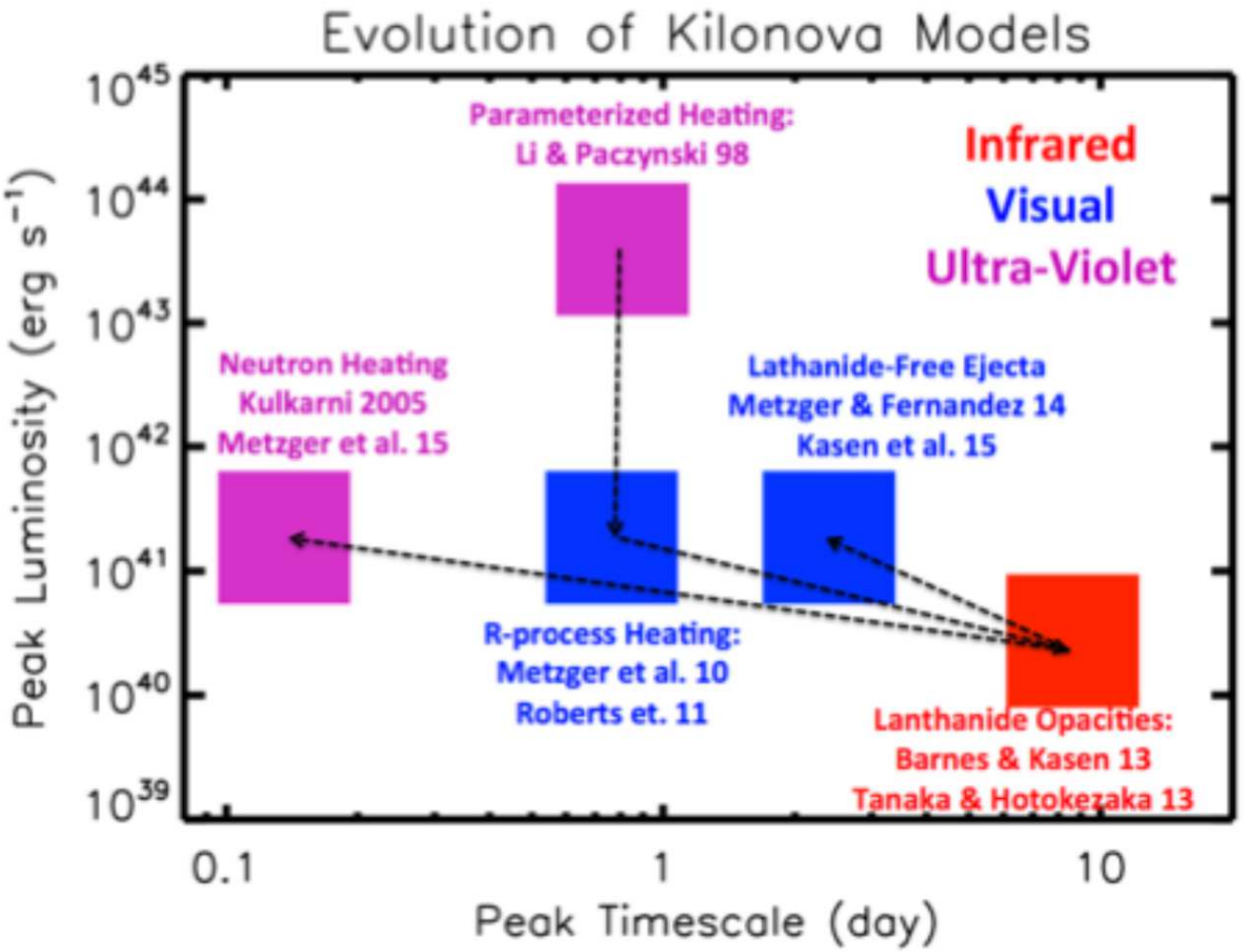




Tanaka+2013

Model predictions

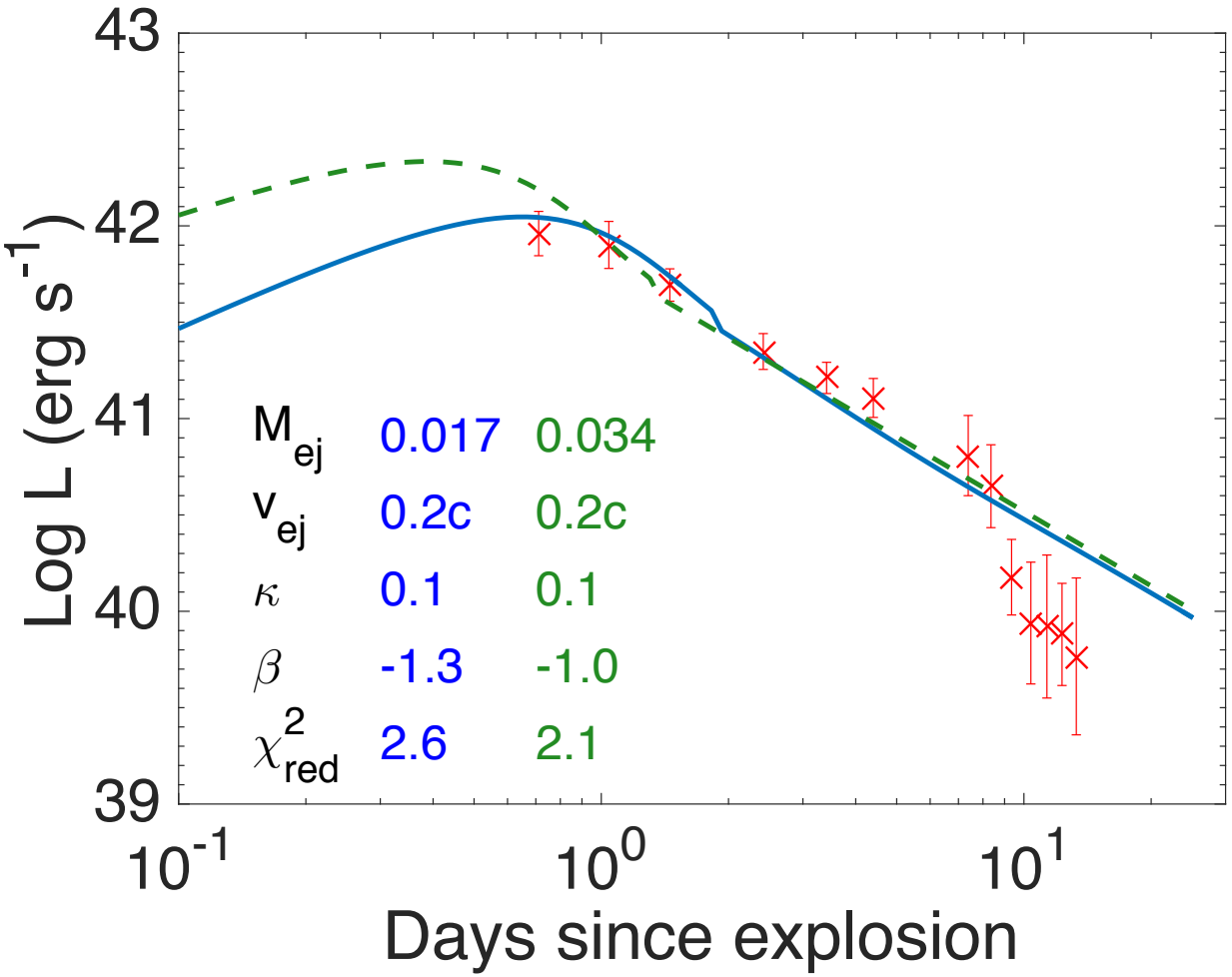
- As most r-process elements lack atomic data, opacity is highly uncertain



Metzger+2017

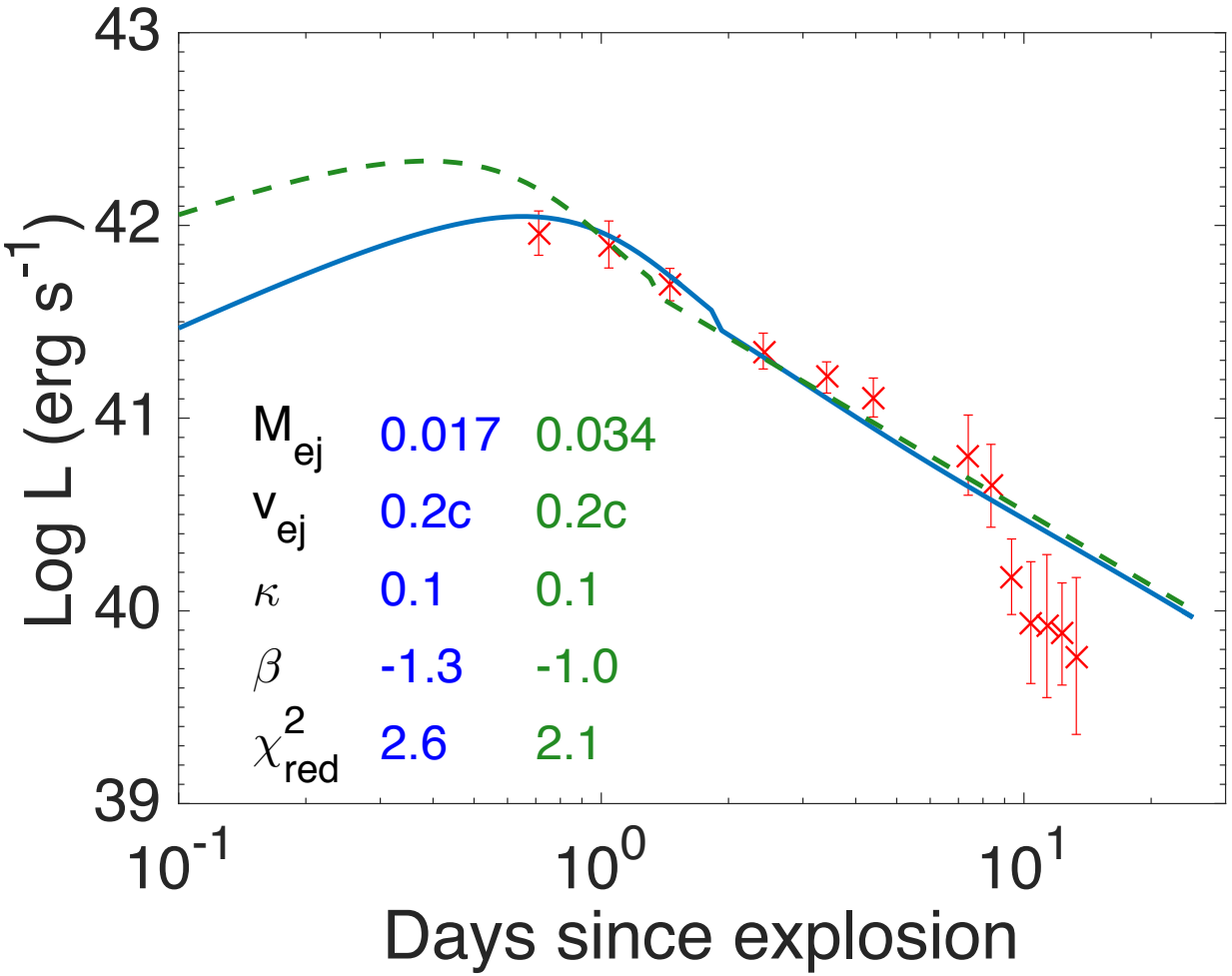
AT2017gfo - bolometric light curves

- **Opacity** A single-component fit requires a low opacity $\rightarrow$ not consistent with predictions



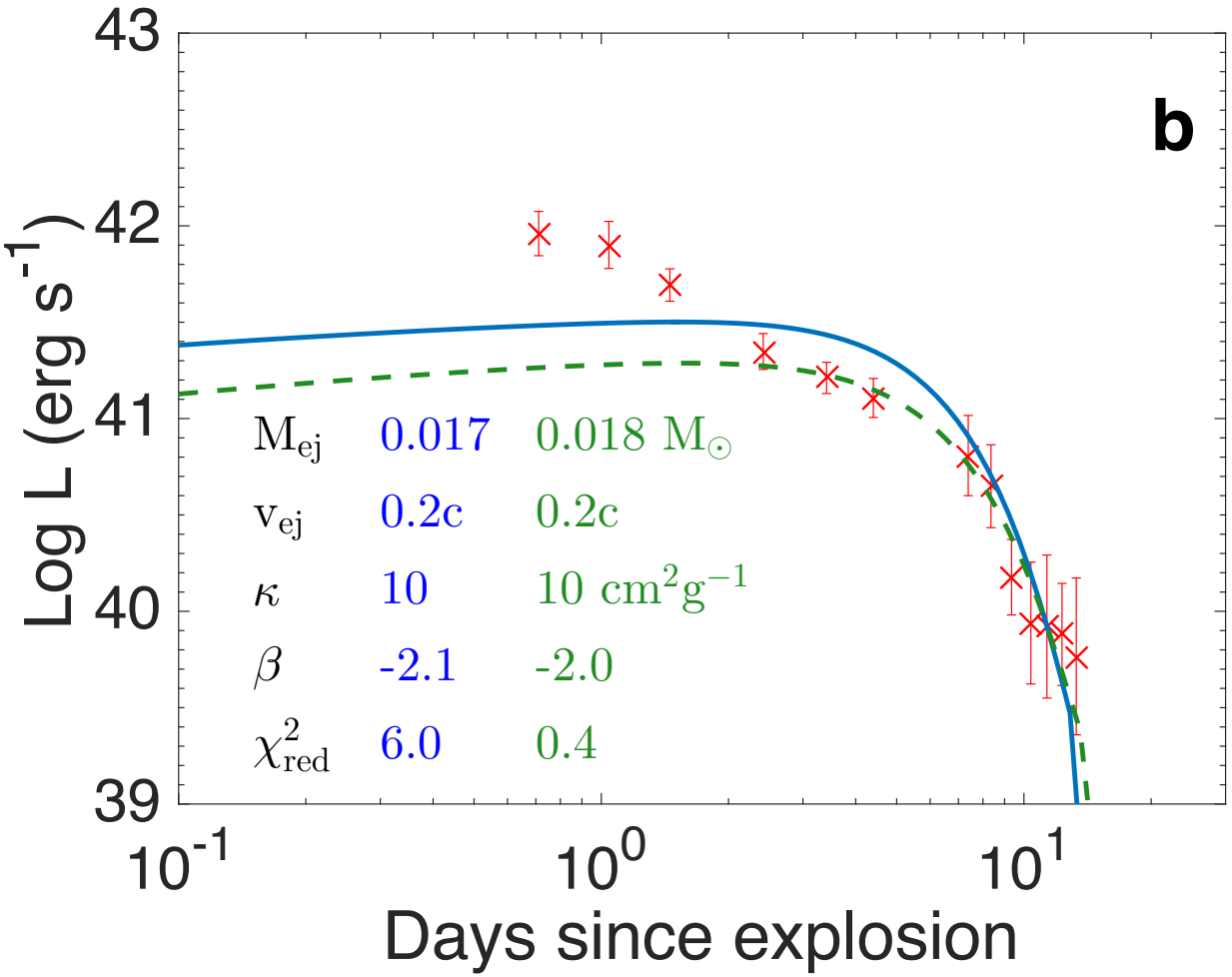
AT2017gfo - bolometric light curves

- **Mass** The best estimate is 0.04 $M_\odot$, higher than most predictions. *Almost certainly wind following delayed BH formation*. This delay also explains low opacity.

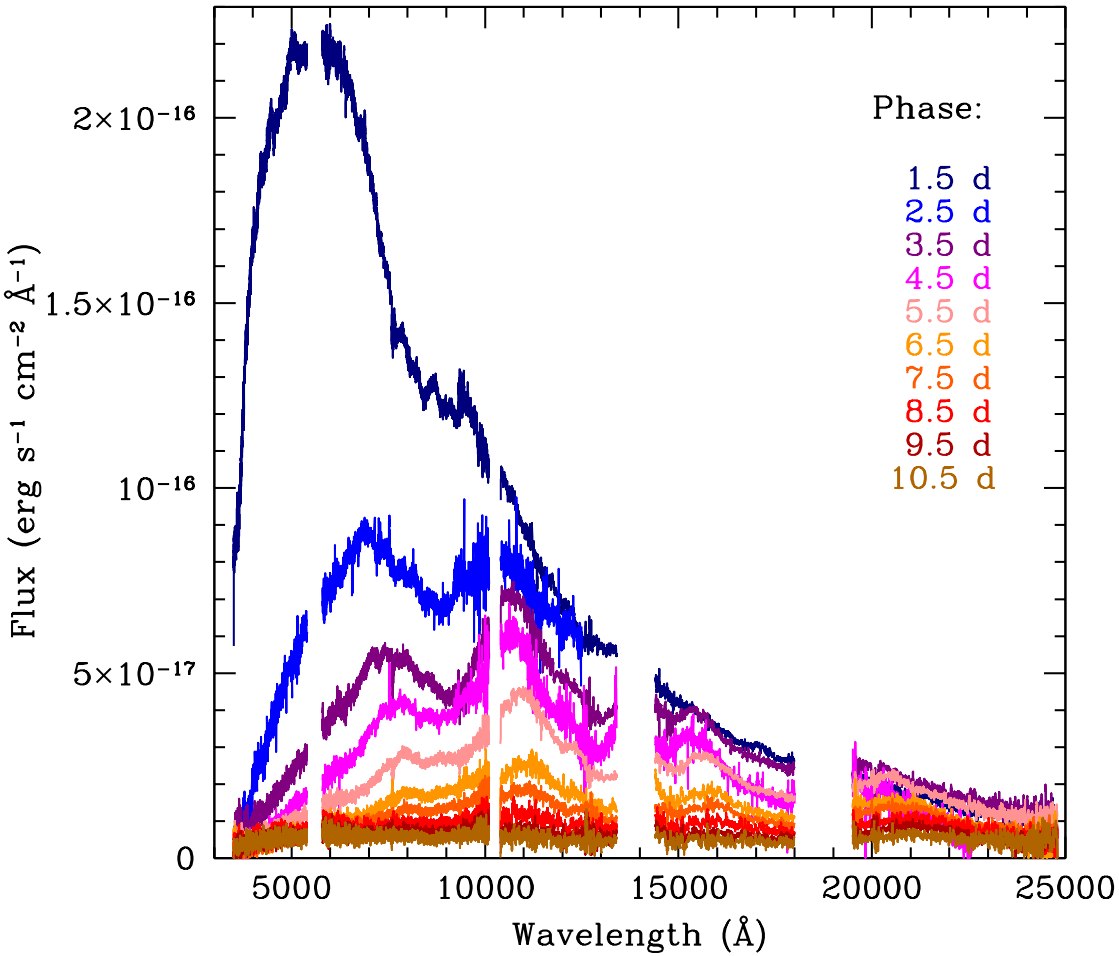


AT2017gfo - bolometric light curves

- A forced high opacity $\rightarrow$ can fit later points but not early ones. Also, the power law is less consistent with $t^{-1.3}$.

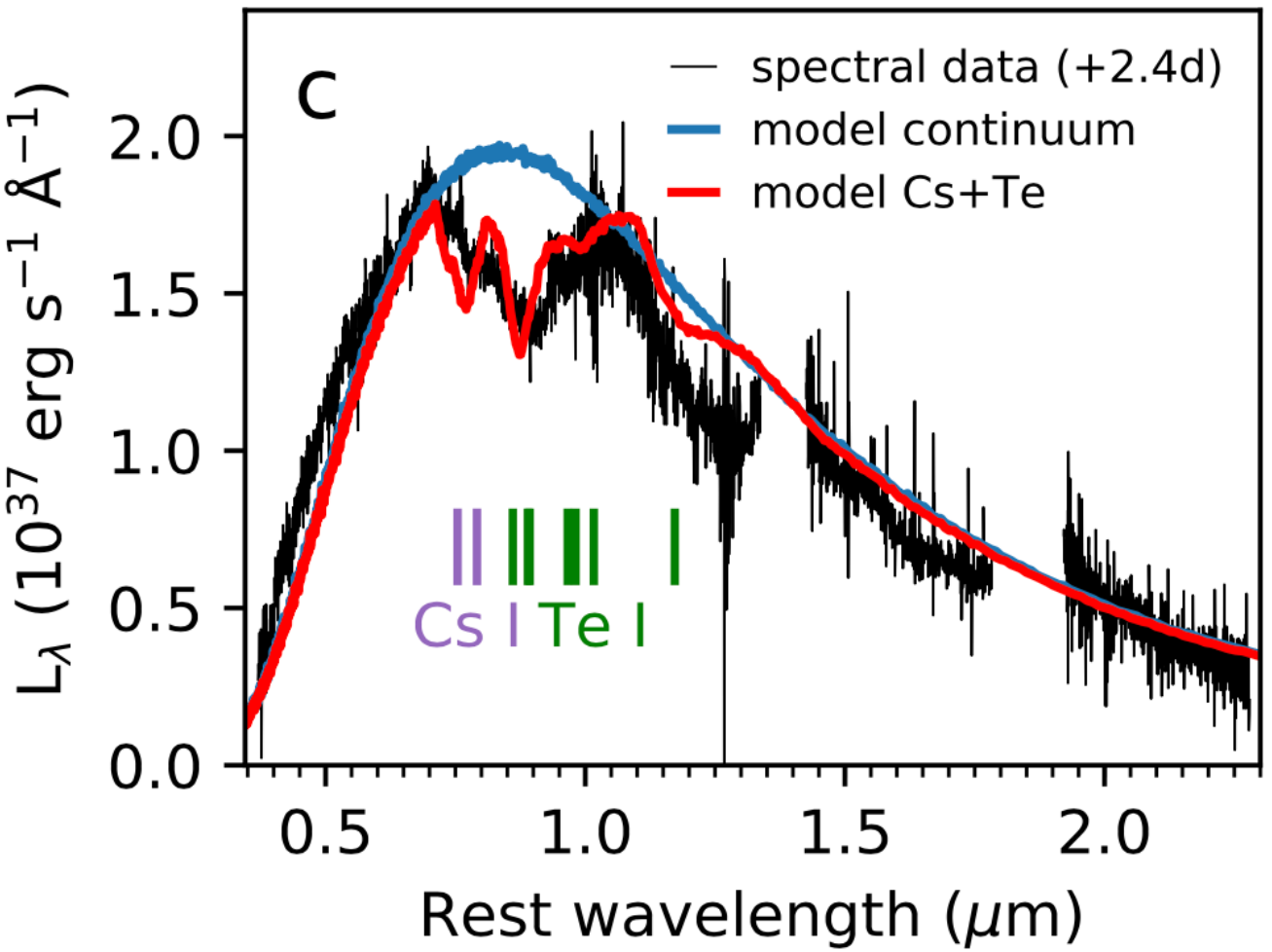


AT2017gfo - spectra

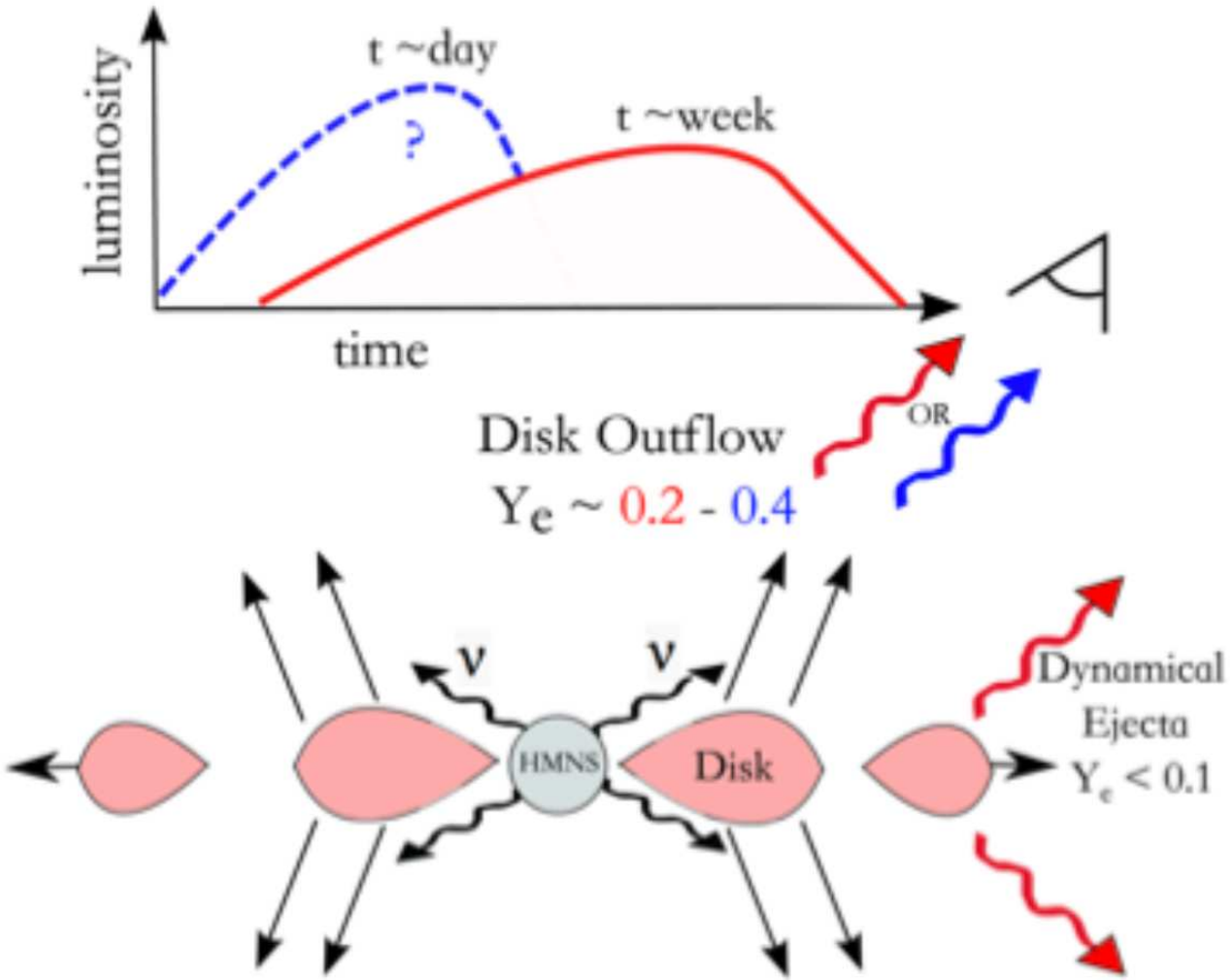


LIGO multimessenger paper

AT2017gfo - Spectral analysis: possible first detection of r-process production (Cs and Te)



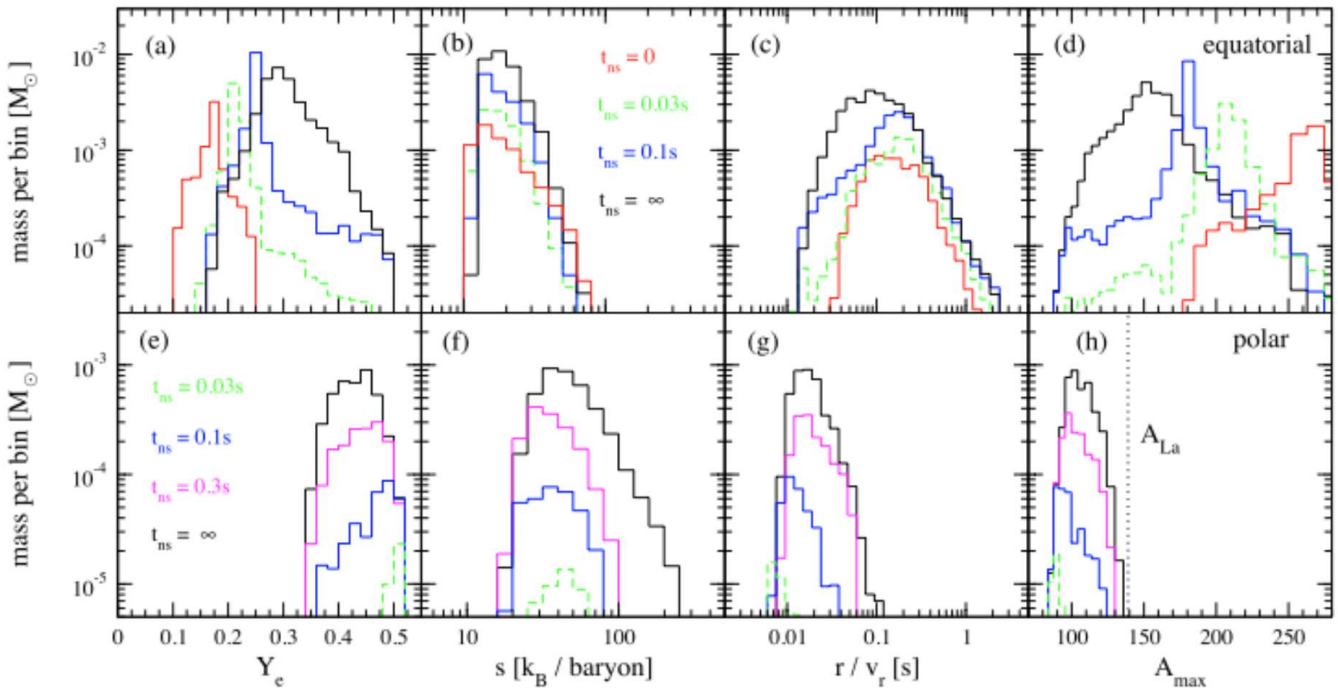
Determining the wind opacity constrains Y_e, and in turn the survival time of the HM neutron star



Metzger+2014

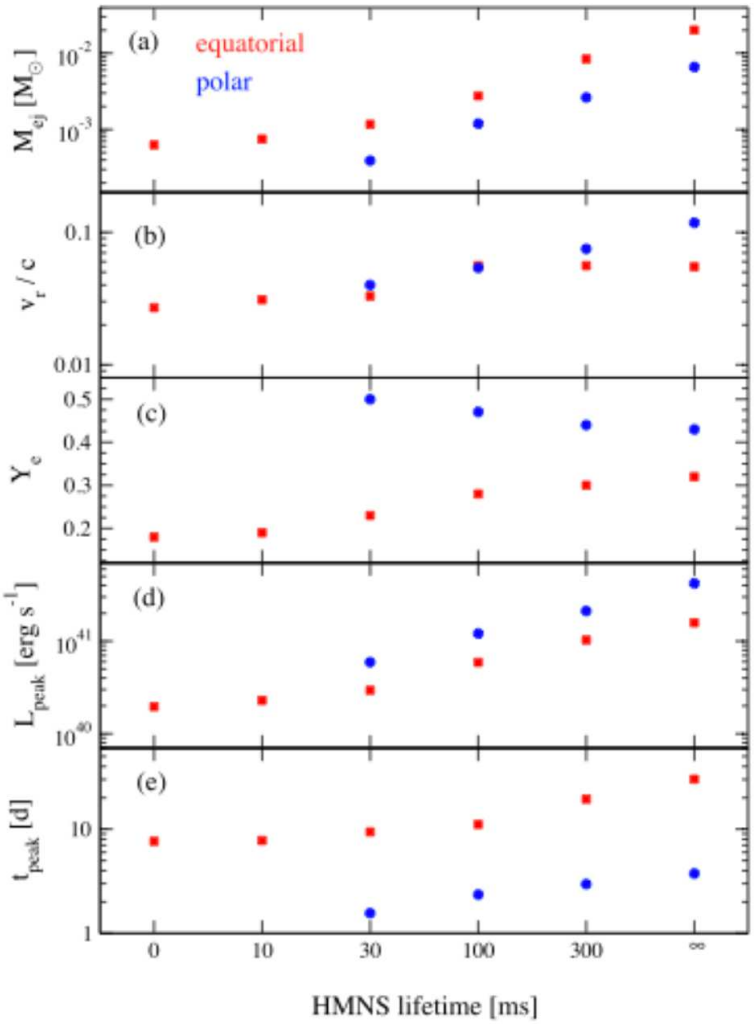
Impact of survival time

- Higher Y_e
- Ligher r-process elements



Metzger+2014

Impact of survival time



Metzger+2014

Outlook

- Observations:
  - KNe have been searched for following sGRBs before but never clearly identified. It seems they typically do not contrast against the afterglows.
  - Why was AT2017gfo different? Because the GRB afterglow was unusually weak. Implications for next few years?
- Modelling:
  - Biggest hurdle right now is the radiative transfer treatment.
  - Also, low opacity ejecta finish diffusion phase at $\sim$1d $\rightarrow$ NLTE effects
  - Most simulations predict $M_{dynamic} \sim M_{wind} \rightarrow \rightarrow$ need to consider 2-component models