

From Binary Interactions to Luminous Red Novae

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Winter Meeting - February, 6-7



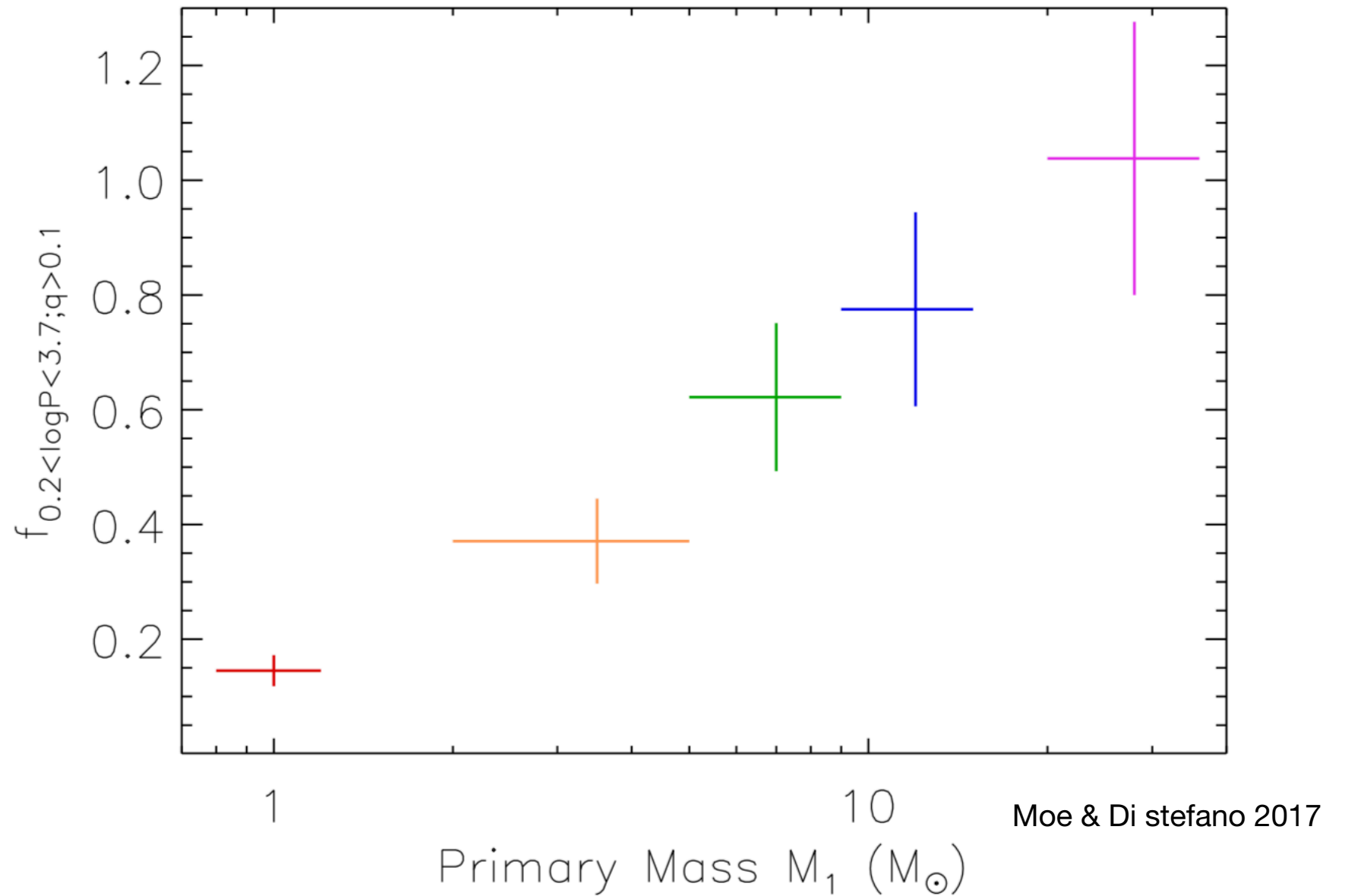
UNIVERSITAT DE
BARCELONA



ICCUB

Multiples are not unique!

High probability
to find massive
stars in multiples



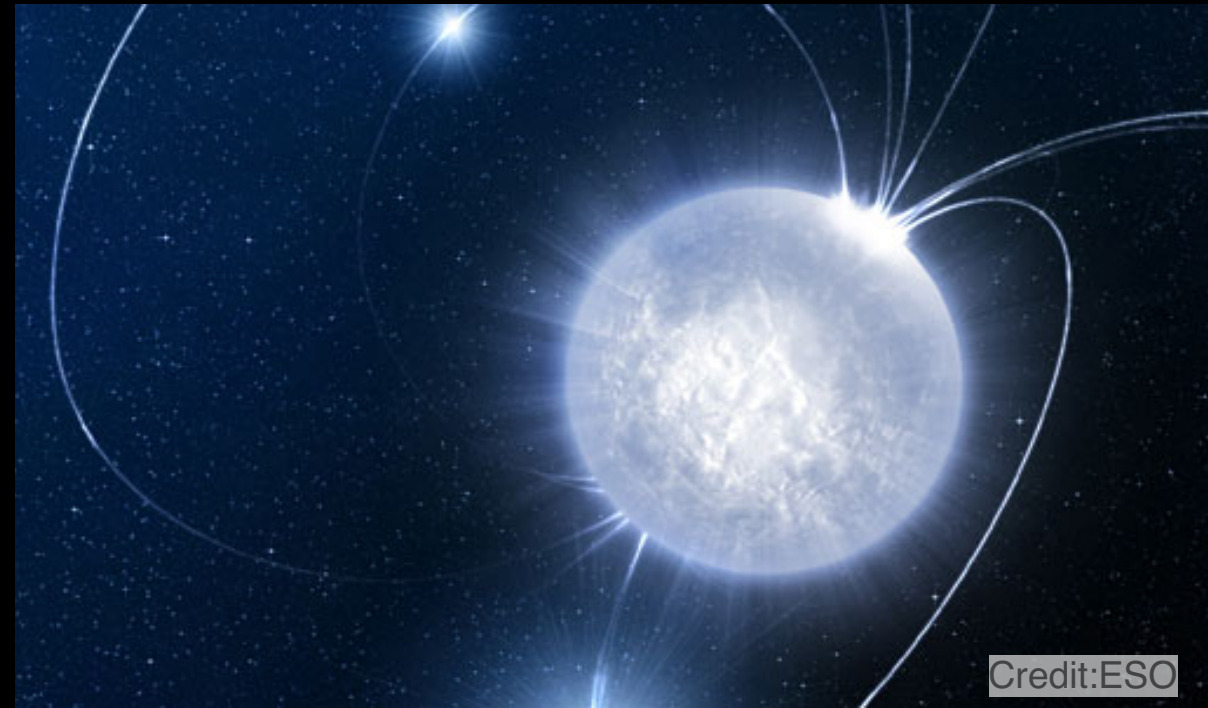
Van Albada & Blaauw (1966)
Paczynski (1967)
Paschek & Paschek (1967)
Sana et al. (2012)
De Mink et al. 2013

Why is it important ?

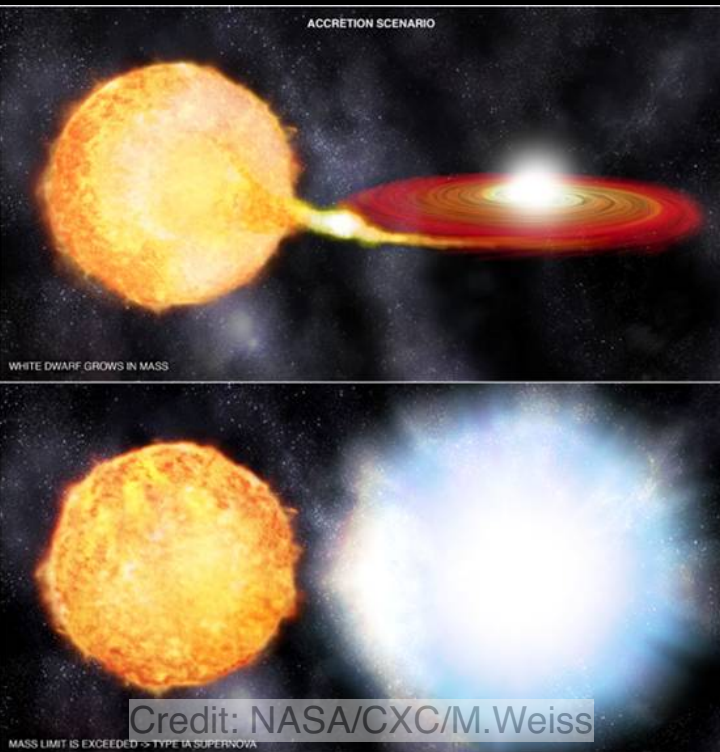
Neutron Star merger



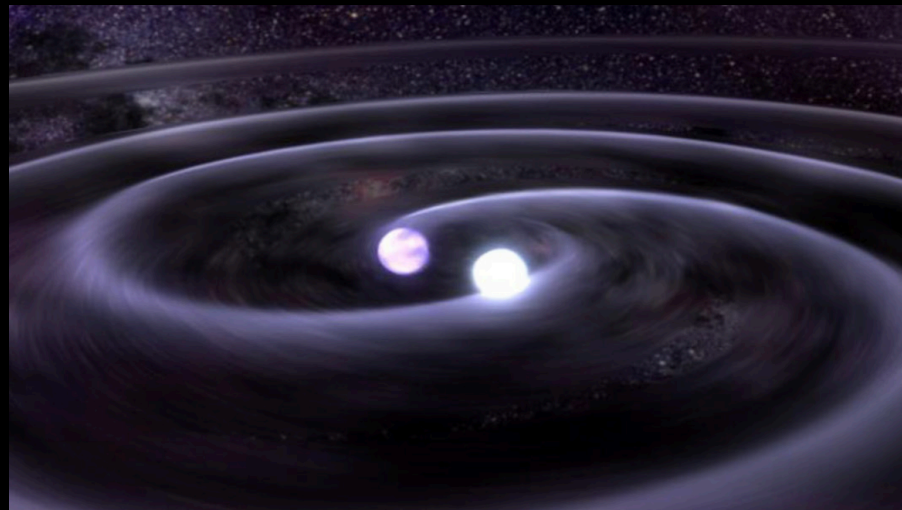
Magnetic A-star



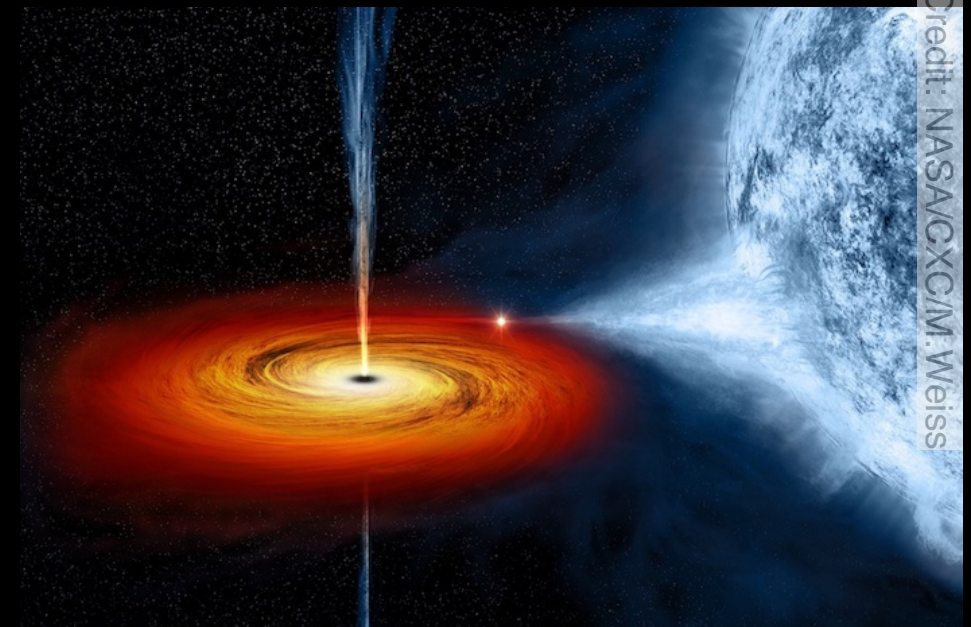
SN Ia



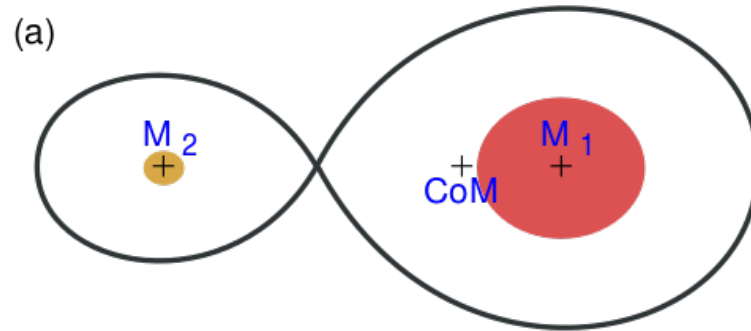
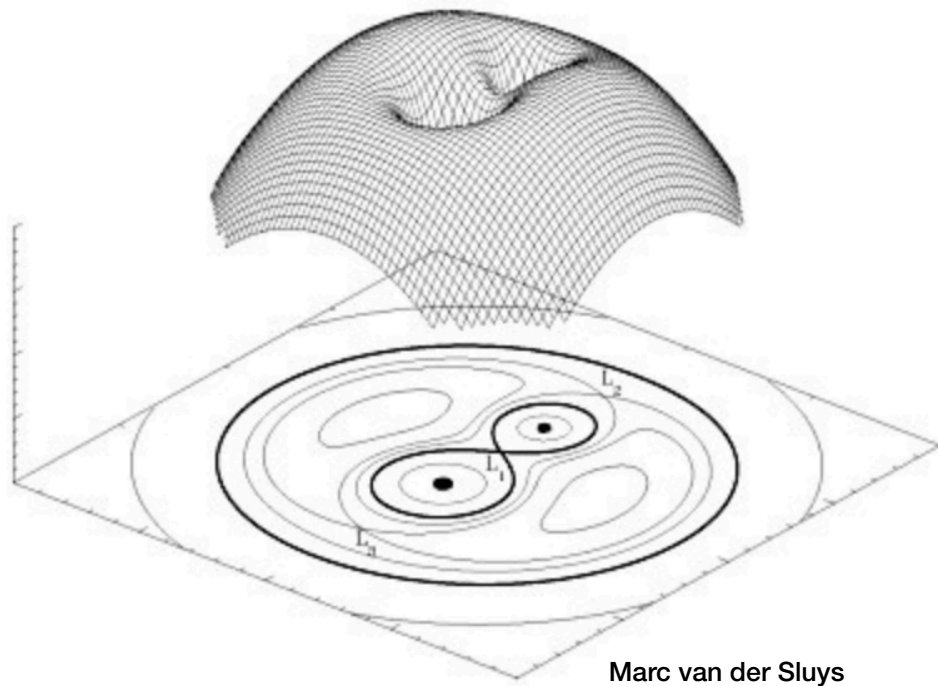
GW sources



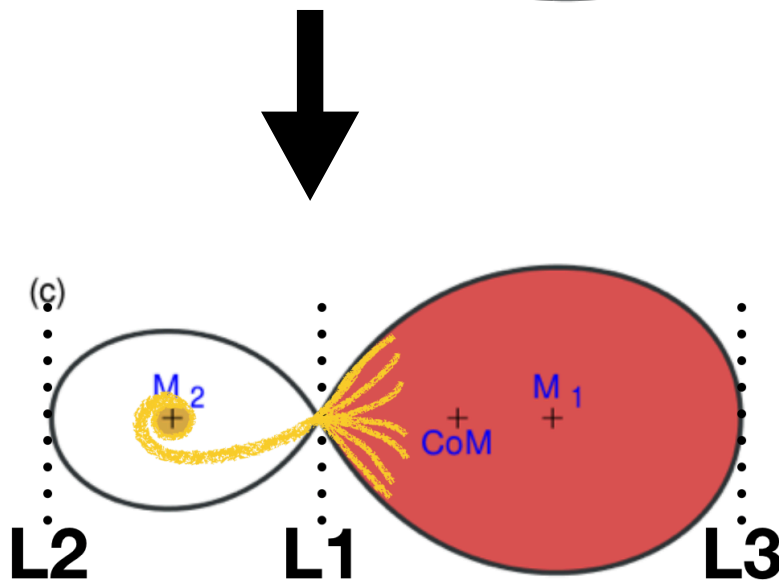
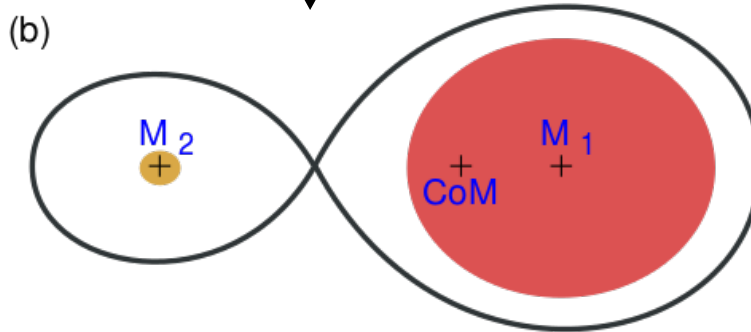
X-ray binaries



Binary interactions

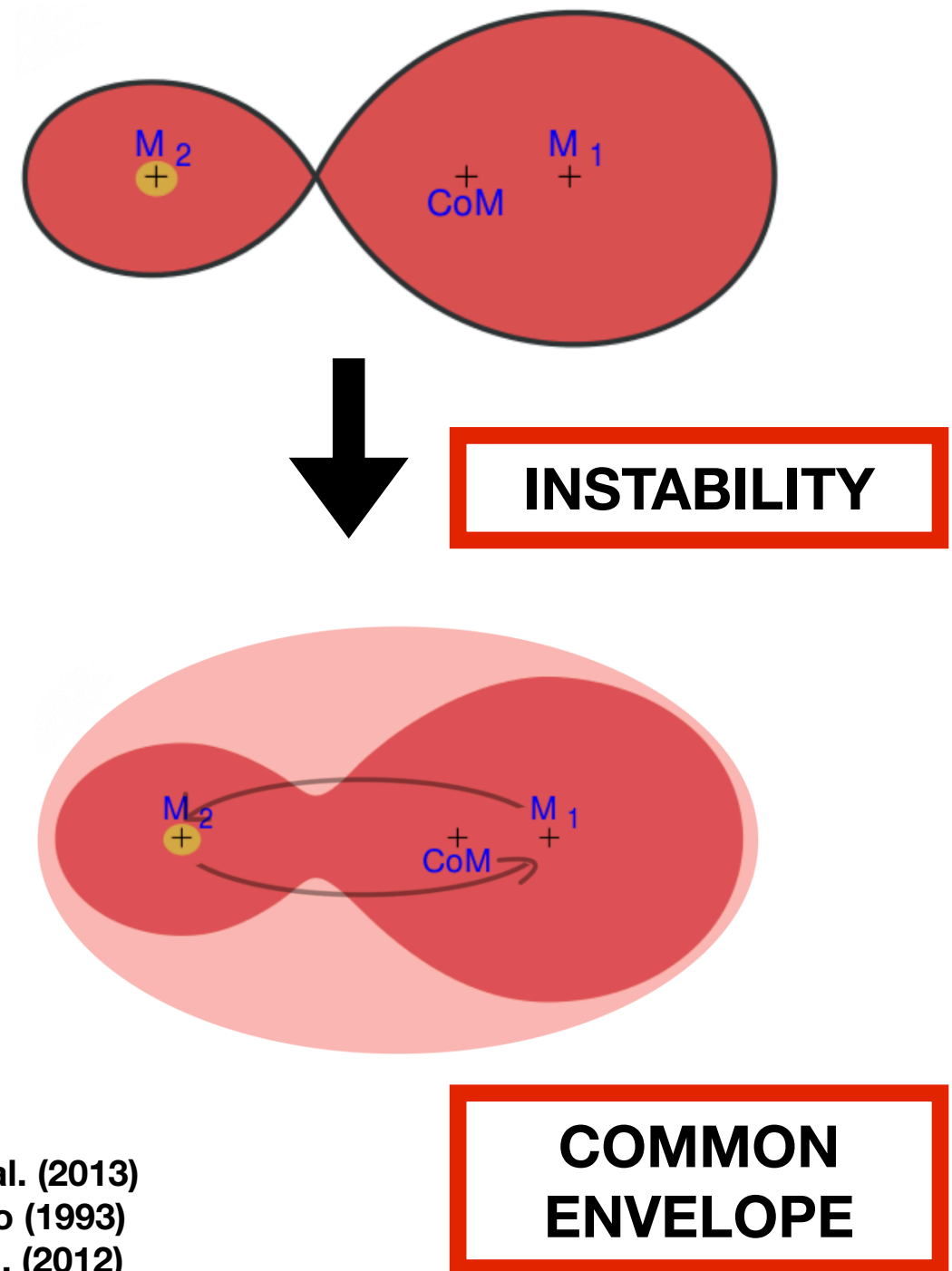
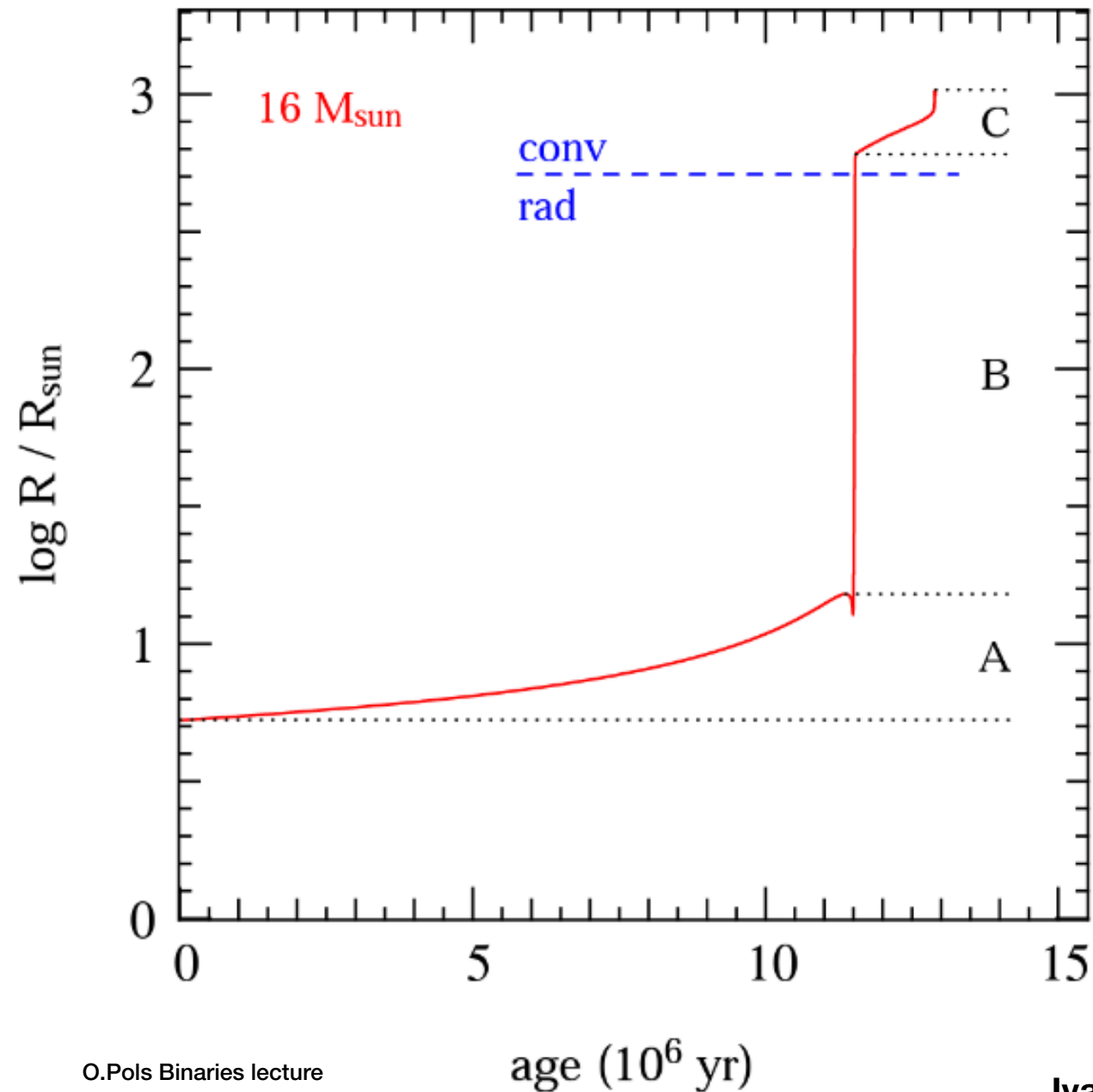


Primary star is filling its Roche Lobe (RL)

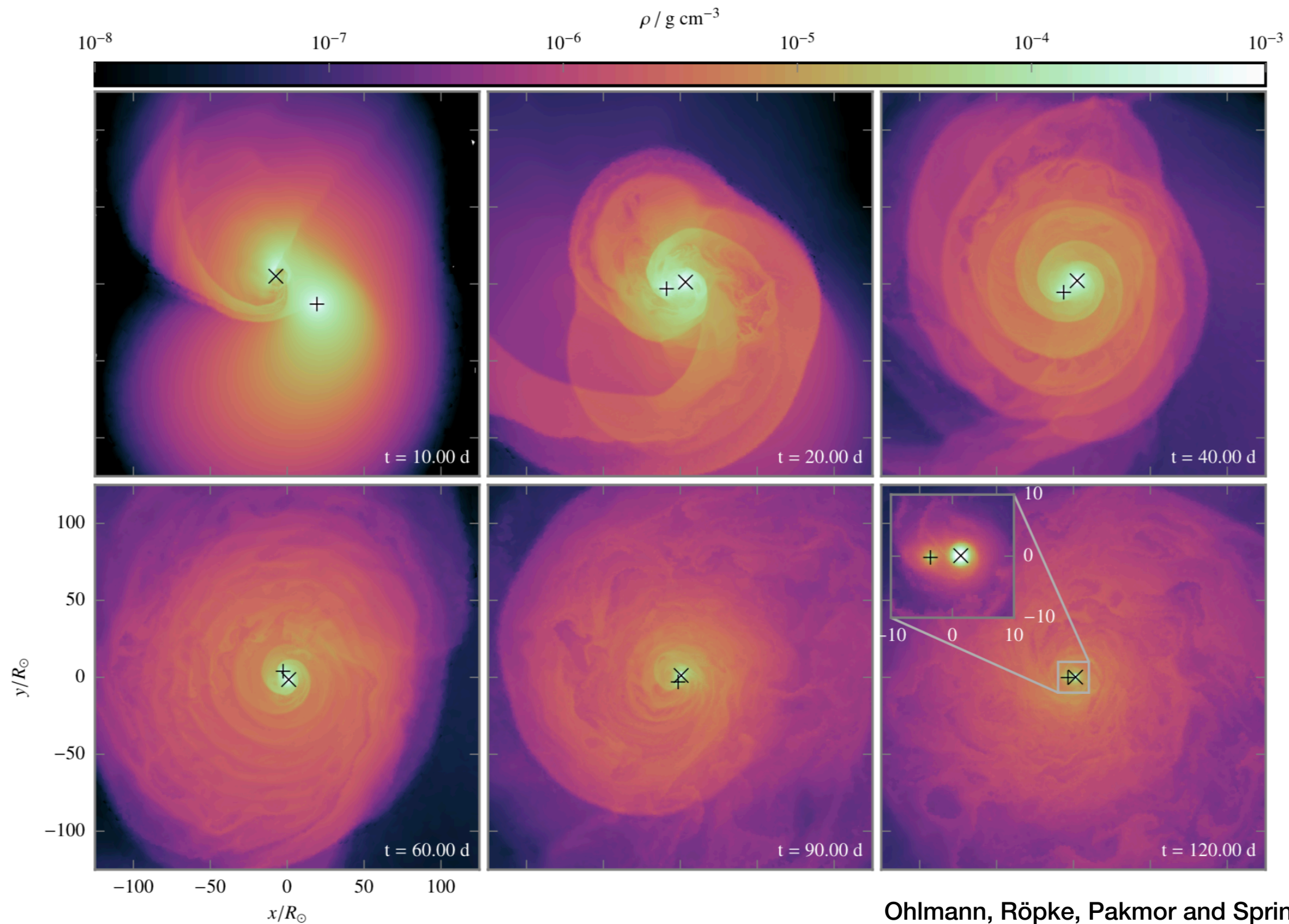


Mass Transfer

Type of envelope and unstable MT



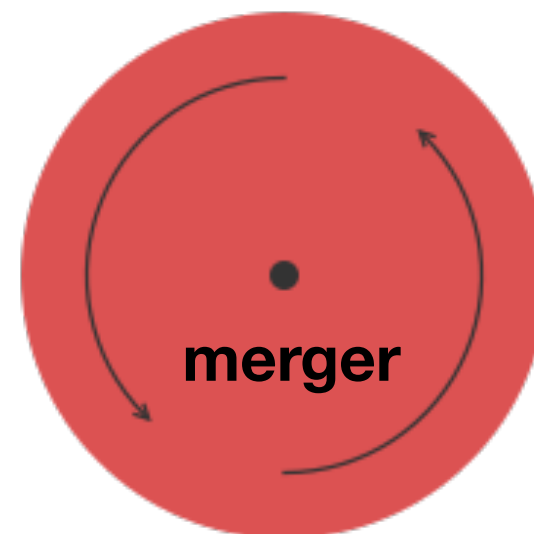
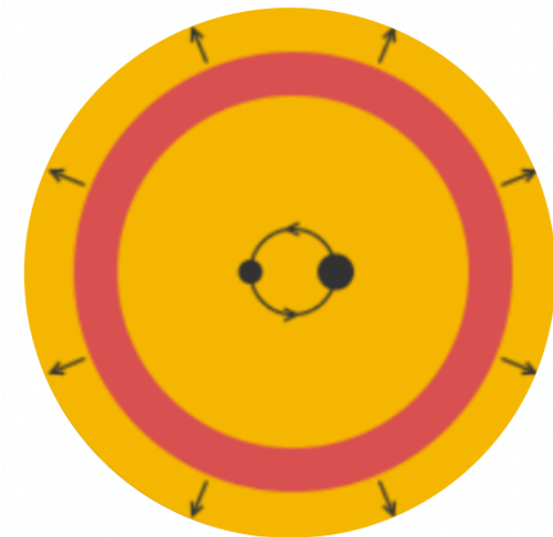
Modeling challenges: 3D hydro simulations



ONLY 8% of the envelope mass ejected! -> Recombination?

Energy budget and envelope ejection?

- **Orbital energy**
- **Tidal heating**
- **Accretion**
- **Internal energy:**
 - ▶ **Kinetic energy**
 - ▶ **Radiation**
 - ▶ **Recombination**
 - ▶ **Nuclear energy**





**From CE ejection to transients:
*Luminous Red Novae (LRNe)***

LRNE as observables

- LRNe \leftrightarrow CE ejection
- Detection in the visible with a red color
- Intermediary energetic event:



$< 10^{40} \text{ ergs} \cdot \text{s}^{-1}$

**LUMINOUS RED
NOVAe**

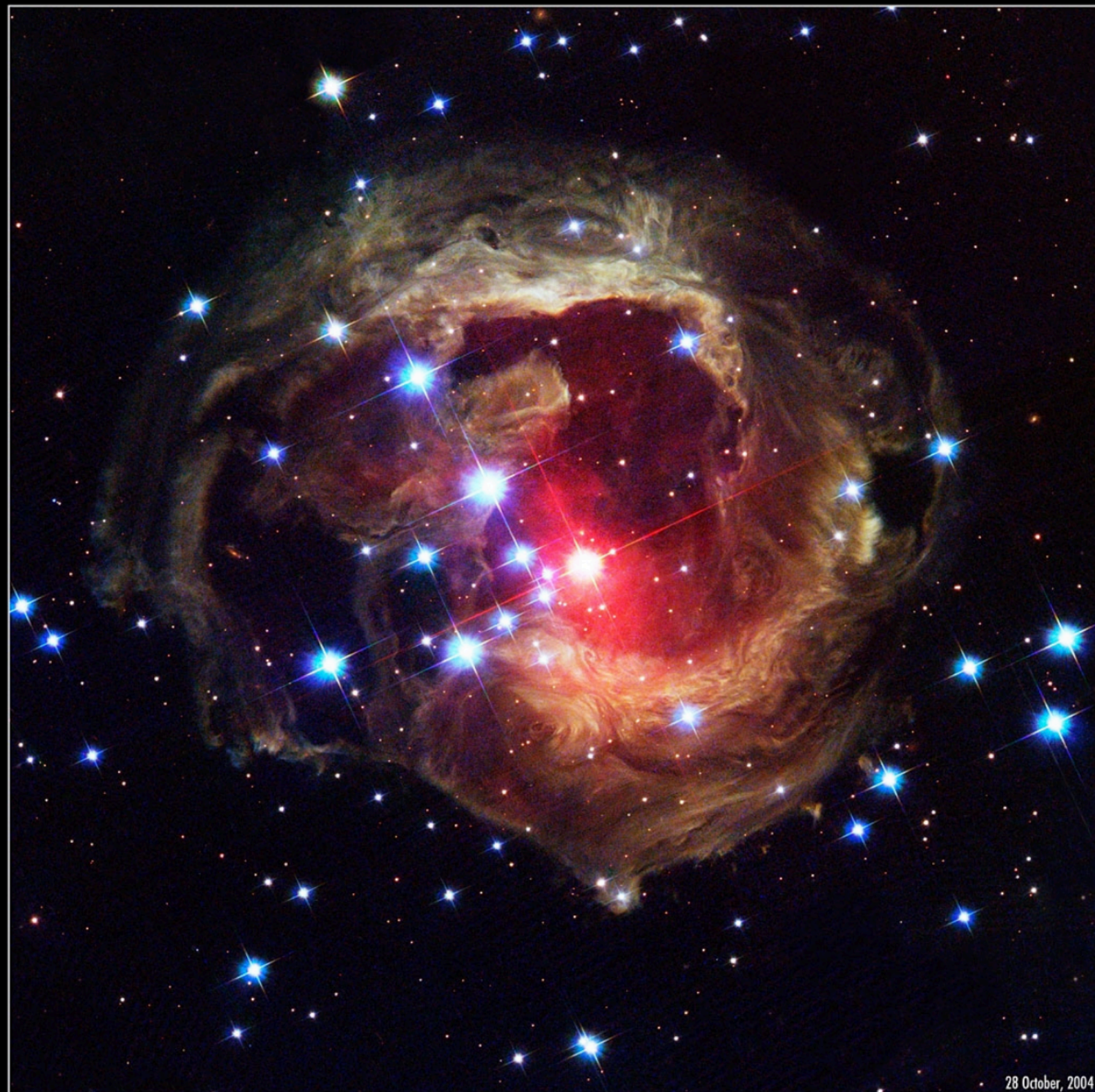
$10^{39} - 10^{42} \text{ ergs} \cdot \text{s}^{-1}$



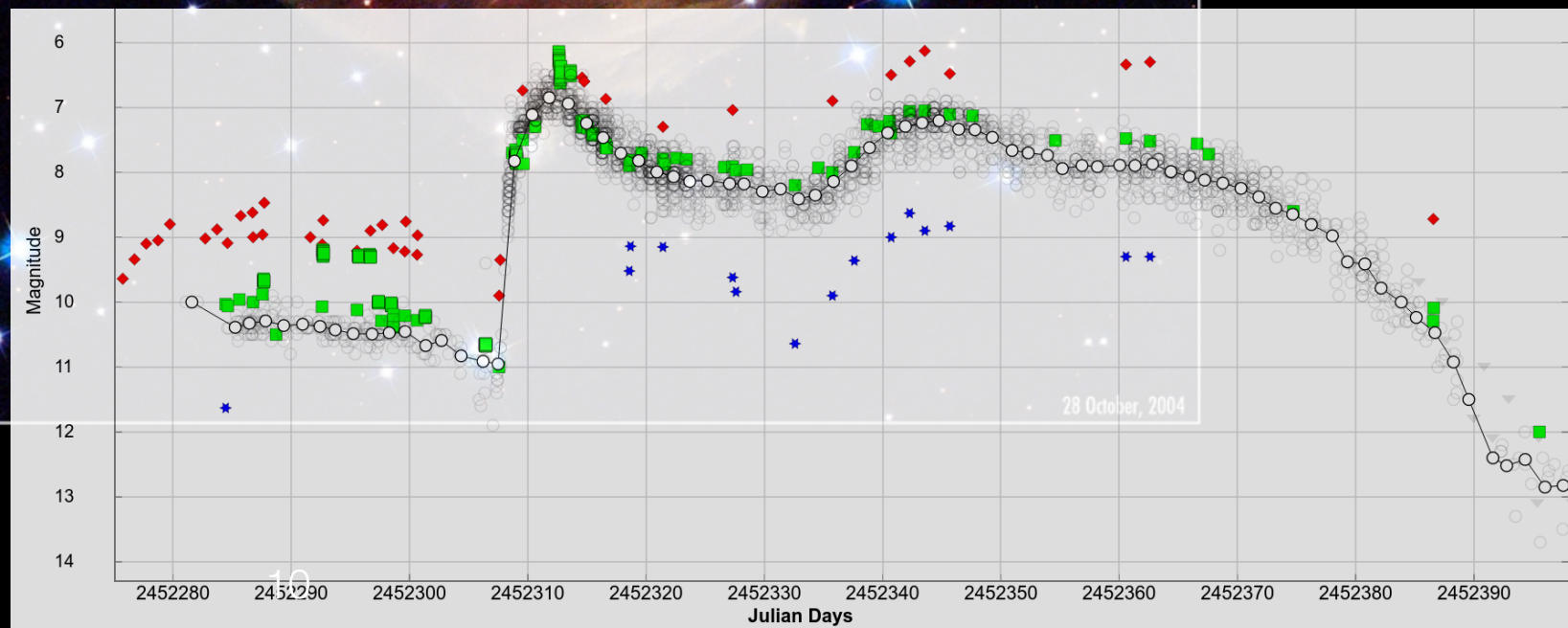
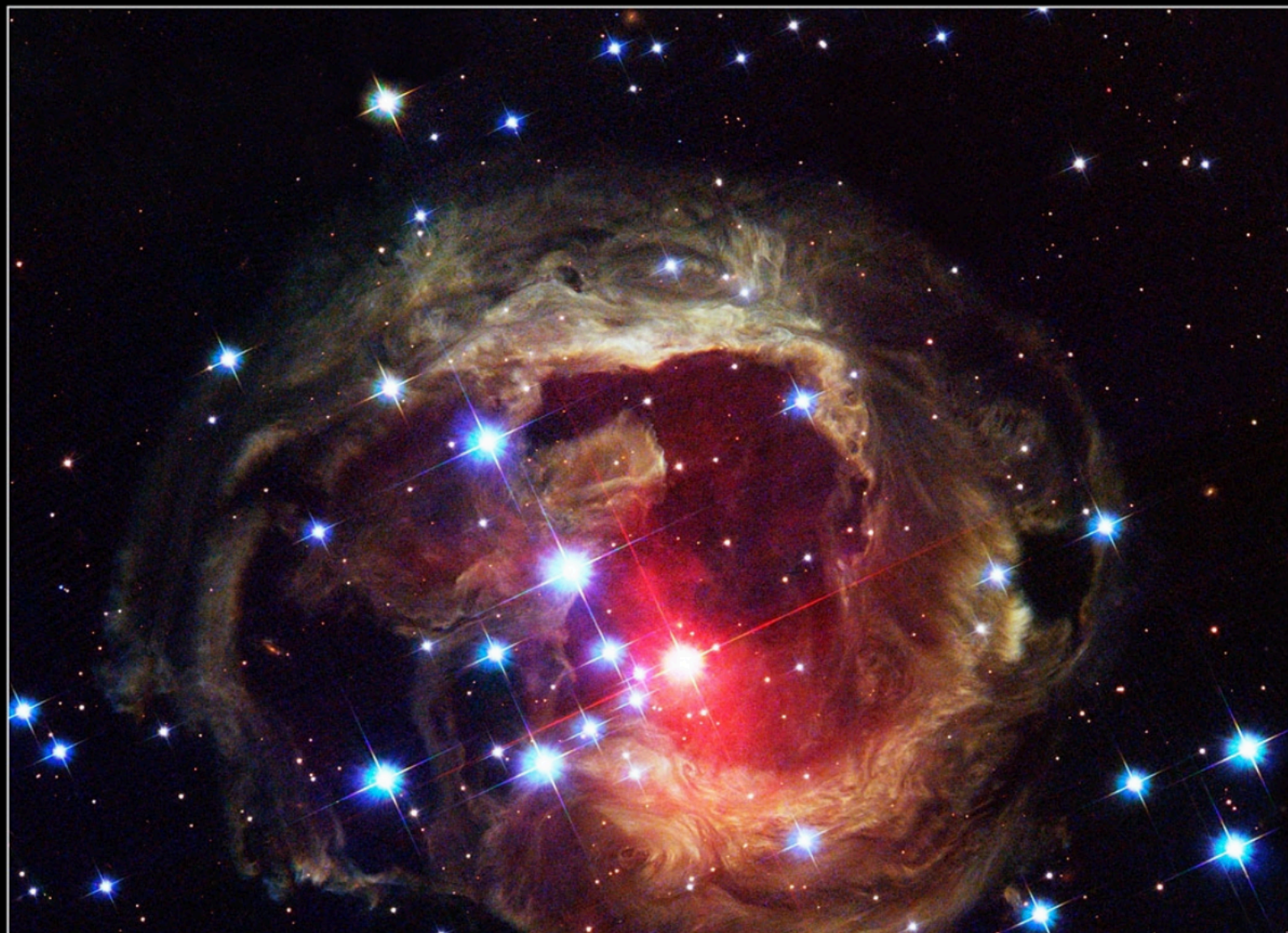
$> 10^{41} \text{ ergs} \cdot \text{s}^{-1}$

- LRNe observation to constrain the CE models

V838 monocerotis

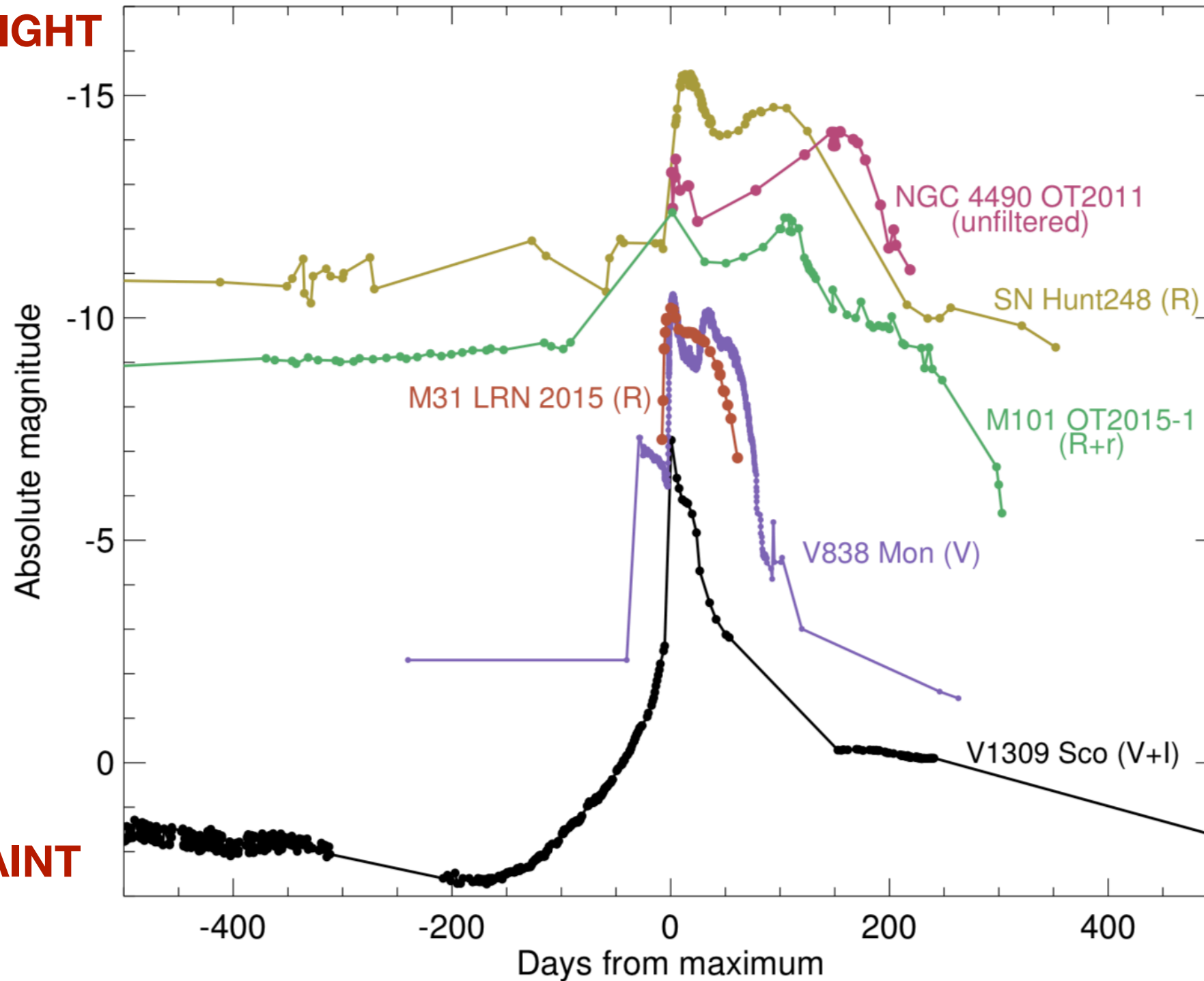


V838 monocerotis



LRNe Light Curves (LC)

BRIGHT



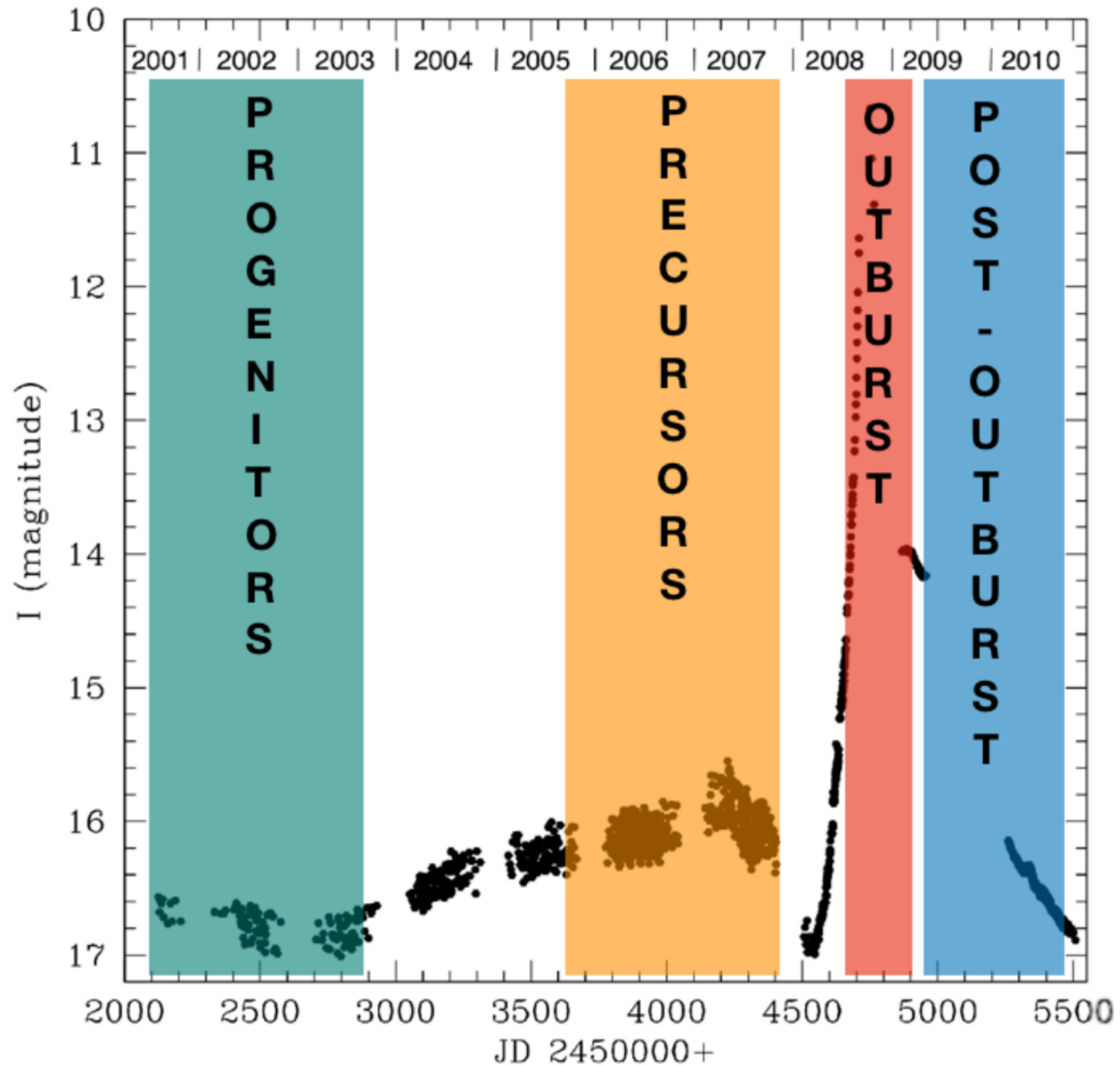
FAINT

- Powered by:**
- **RECOMBINATION**
 - **SHOCKS**
 - **NUCLEAR ENERGY**
 - ...

Ivanova et al. 2013

Ivanova & Nandez (2016)
Mastumoto & Metzger (2022)
Metzger & Pejcha (2017)
Podsiadlowski et al. (2018)

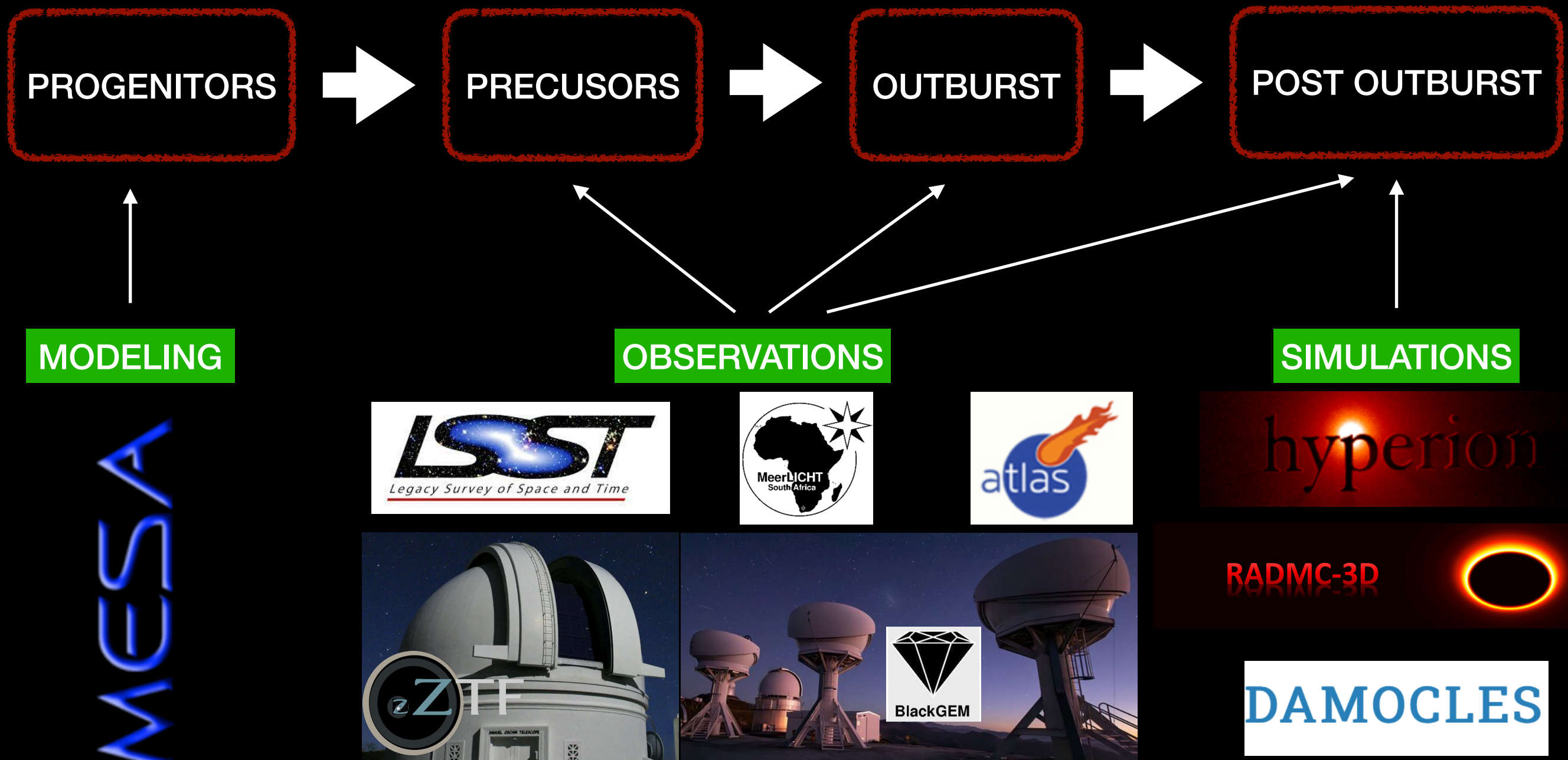
Light Curves Phases



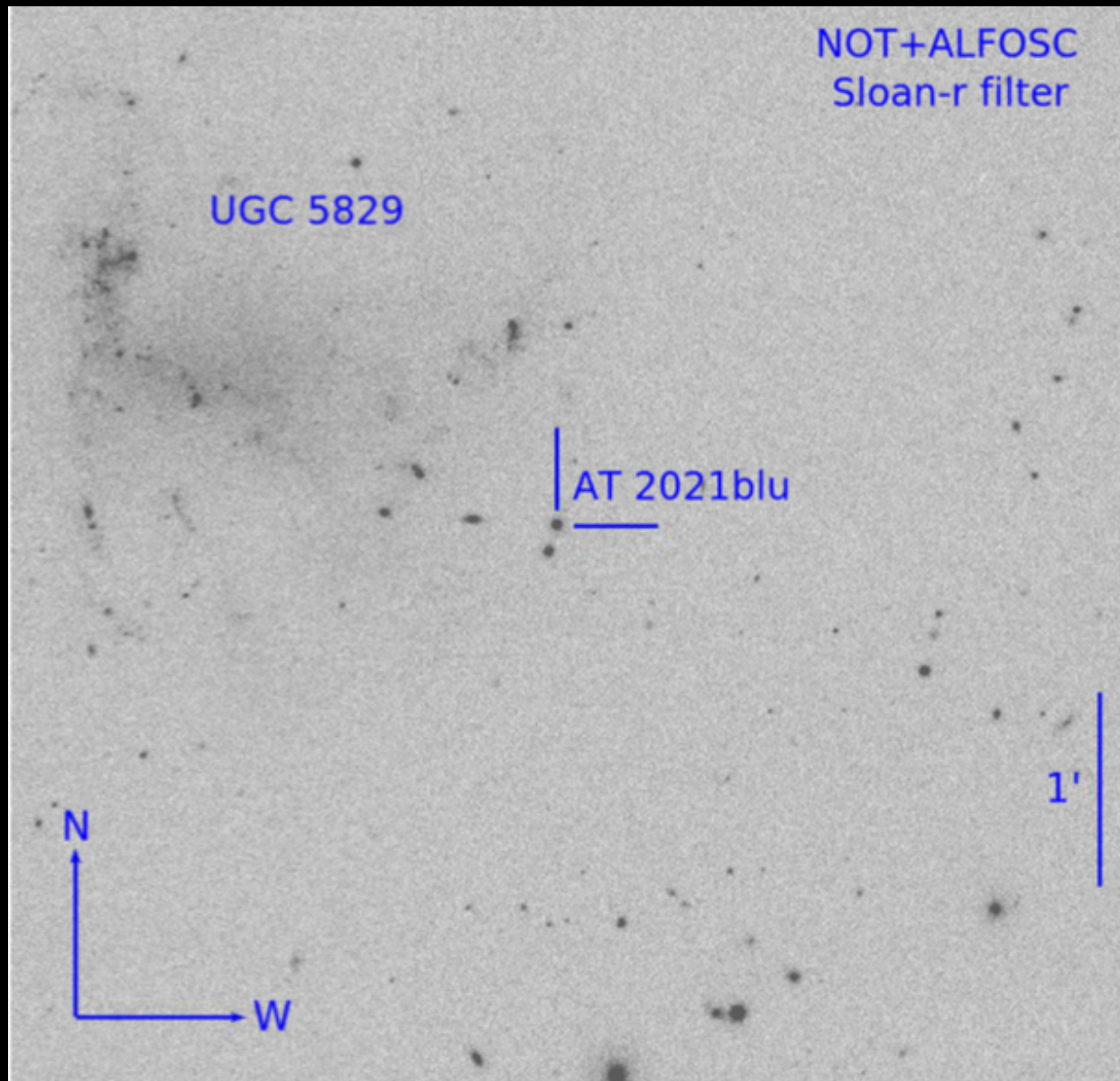
V1309
Scorpii

What is the goal of the thesis?

⇒ Provide a big picture of LRNe

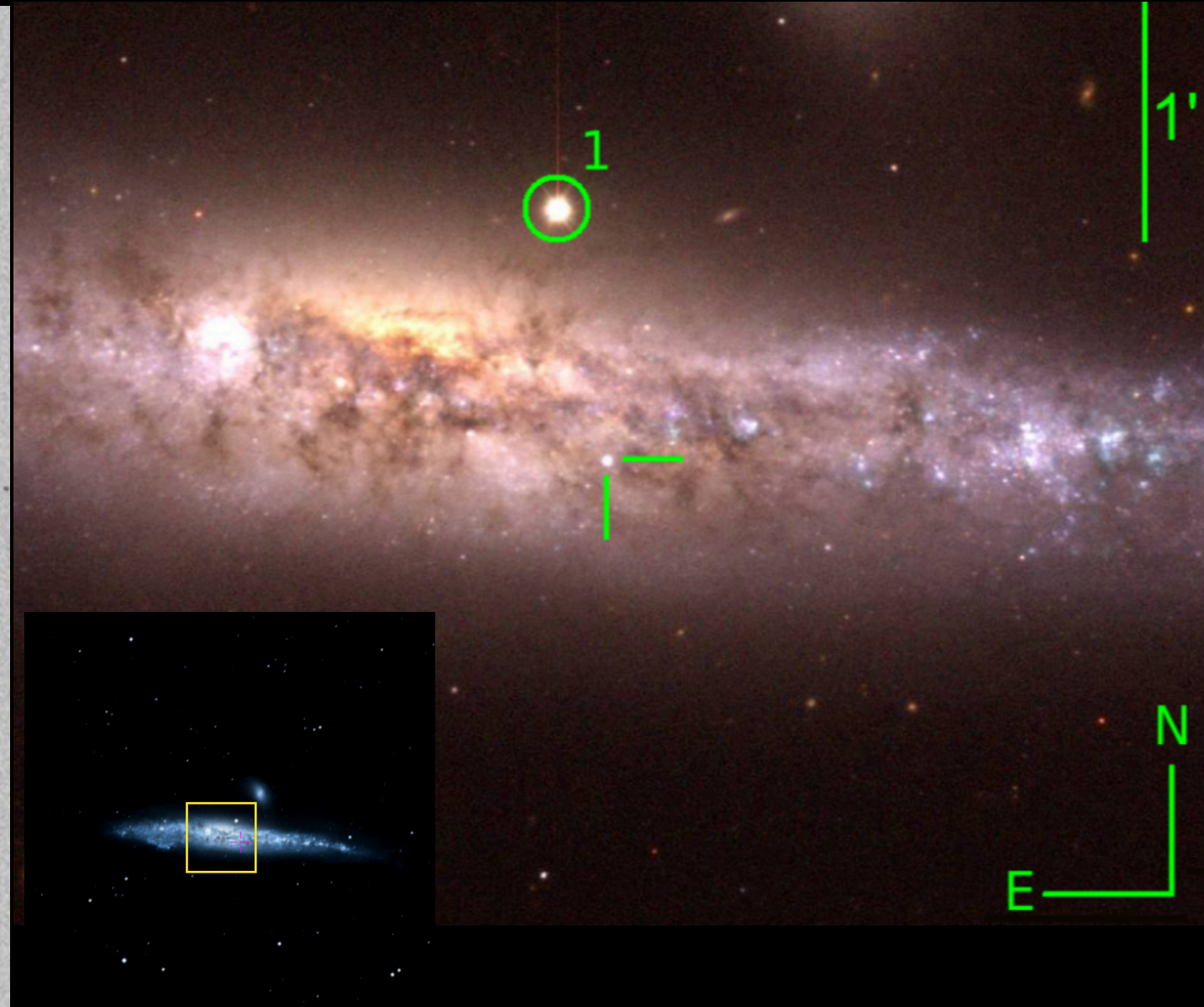


AT2021blu



- Discovered on 2021 January
- Extragalactic
- Mag = 18.486
- Distance = 8Mpc

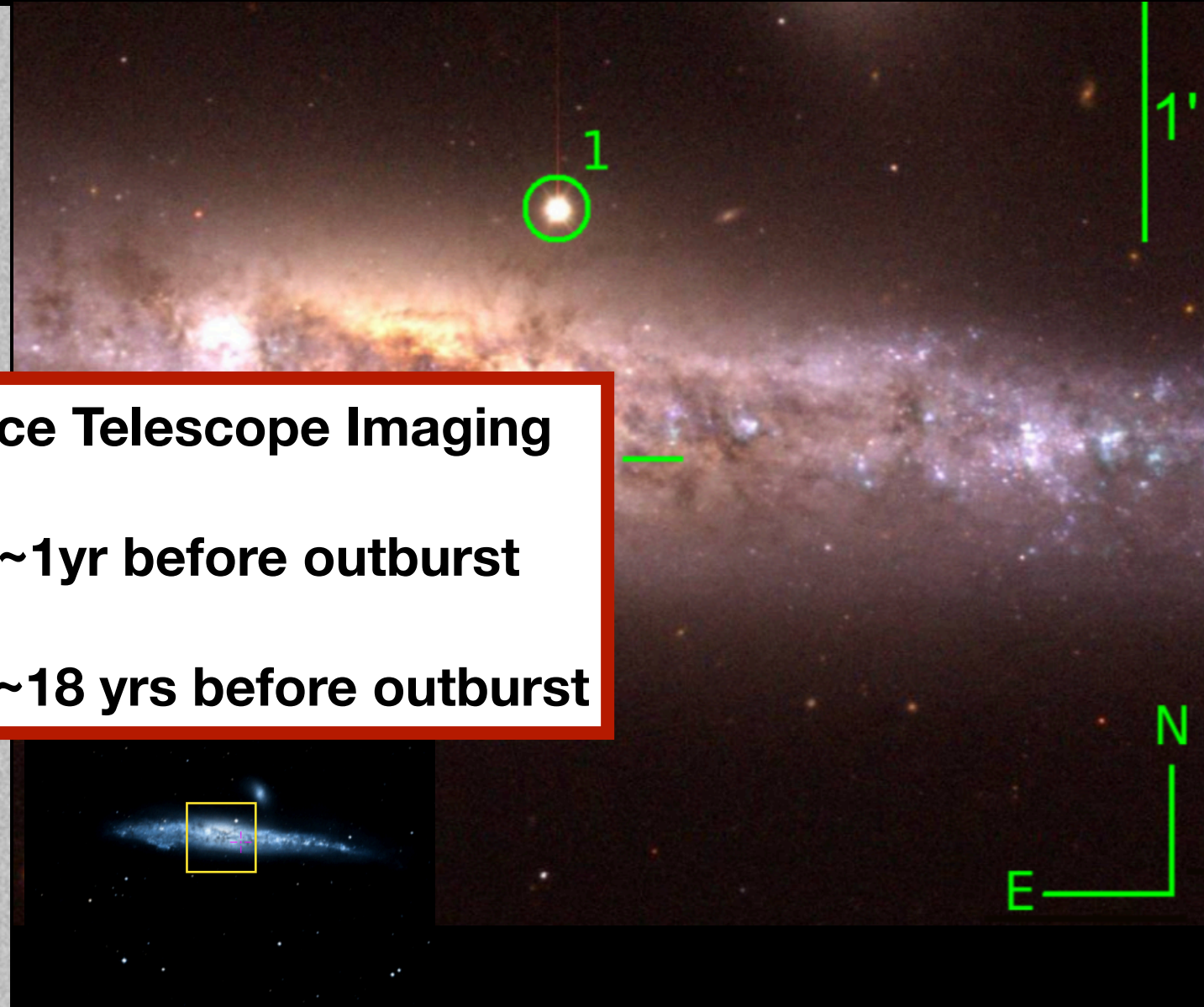
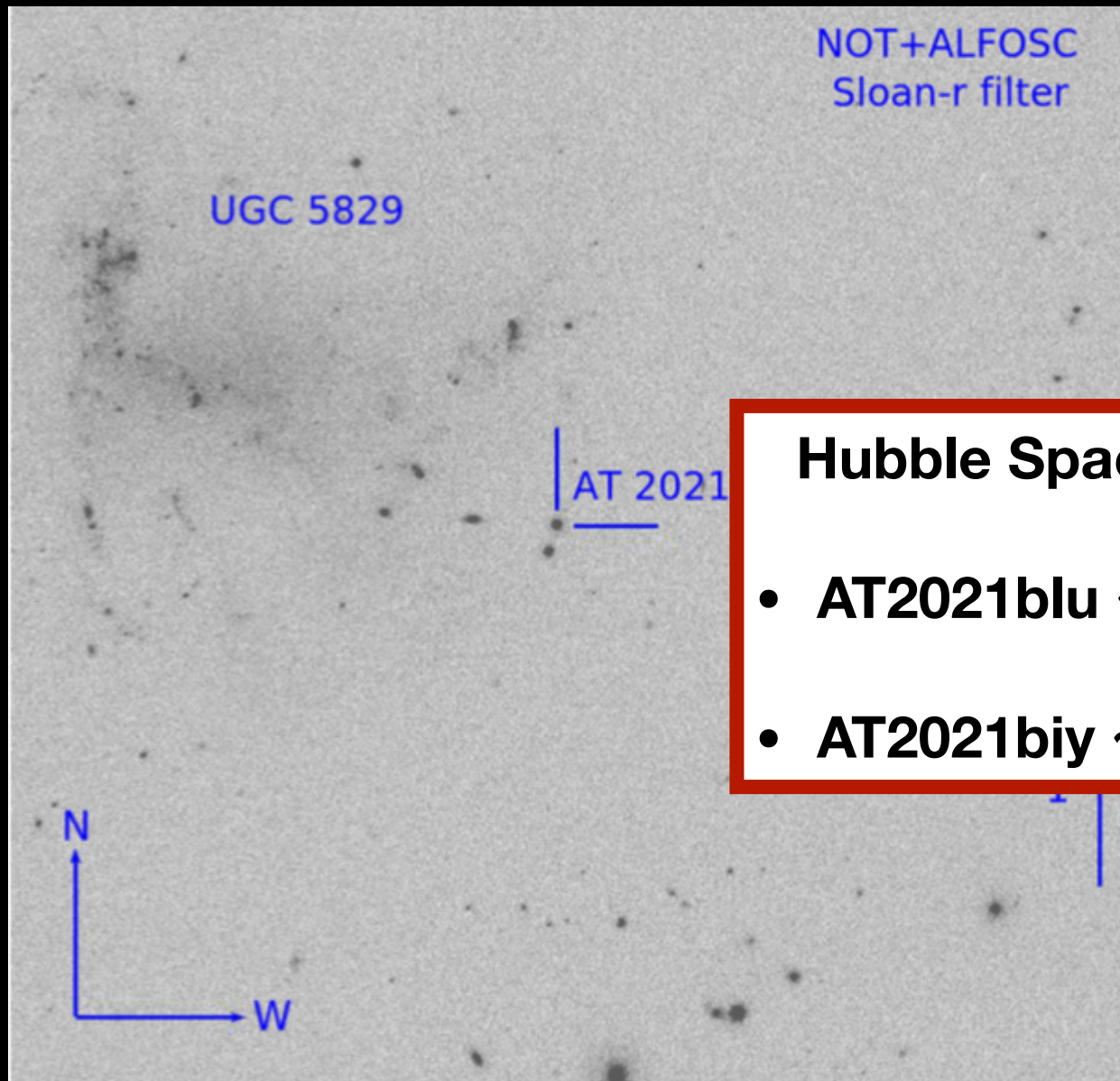
AT2021biy



- Discovered on 2021 February
- Extragalactic
- Mag = 18.12
- Distance = 7.46Mpc

AT2021blu

AT2021biy



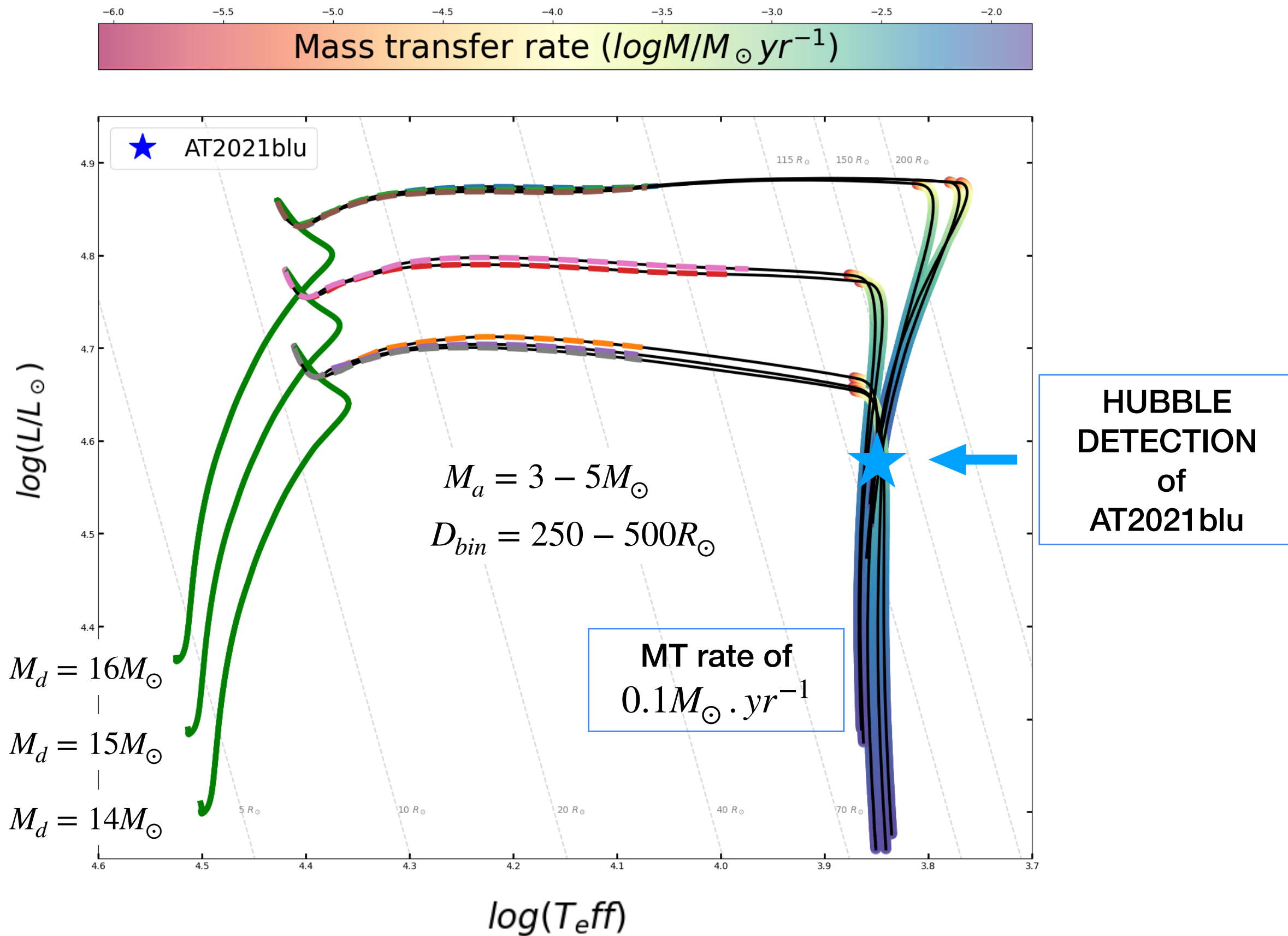
Hubble Space Telescope Imaging

- AT2021blu ~1yr before outburst
- AT2021biy ~18 yrs before outburst

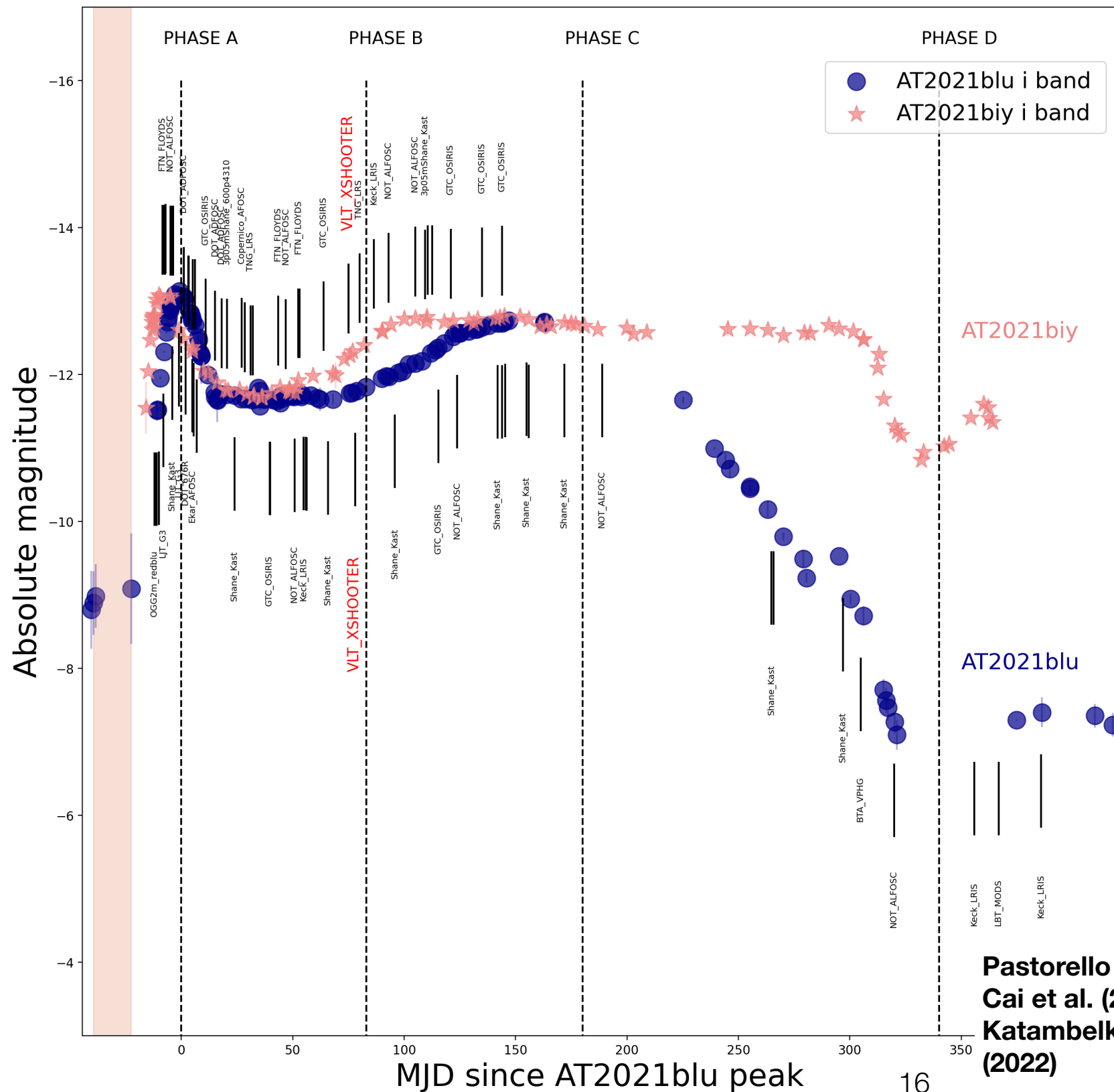
- Discovered on 2021 January
- Extragalactic
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- Discovered on 2021 February
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- Distance = 7.46Mpc

MESA Modeling



AT2021blu and AT021biy LC

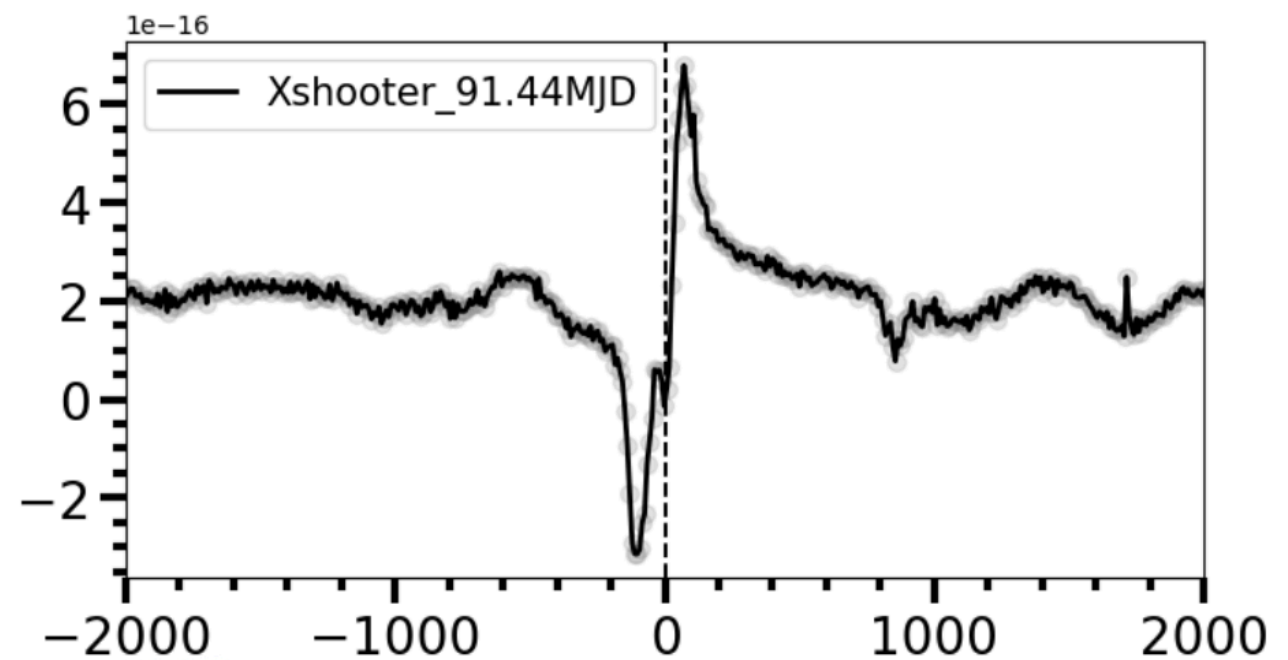
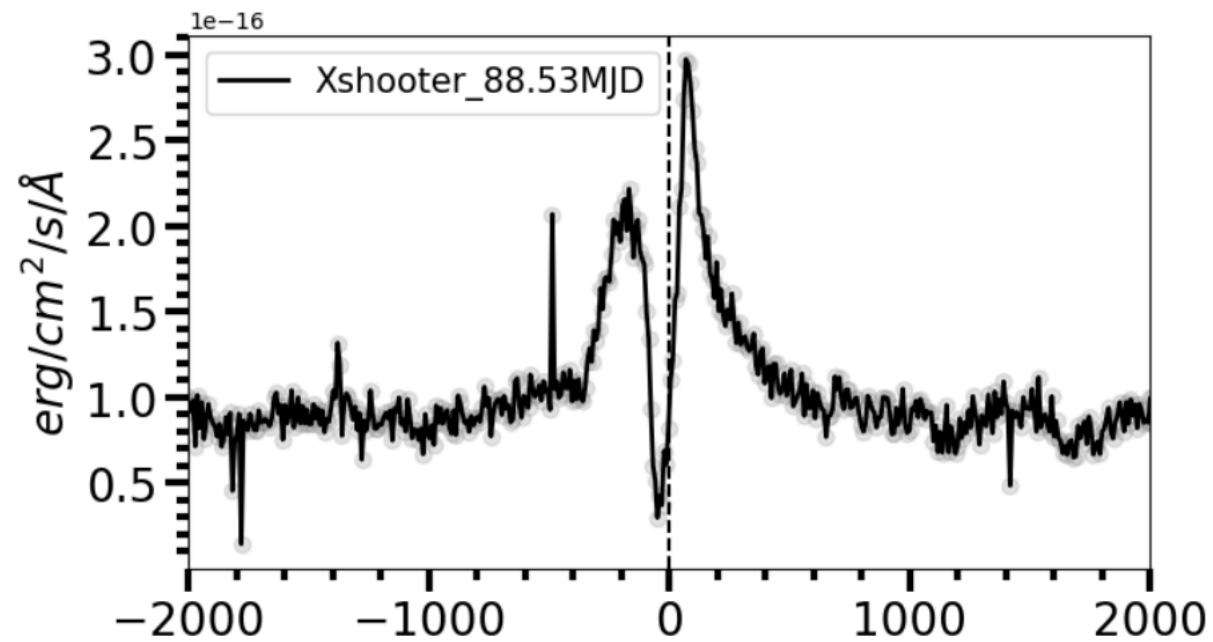


Spectroscopic Data

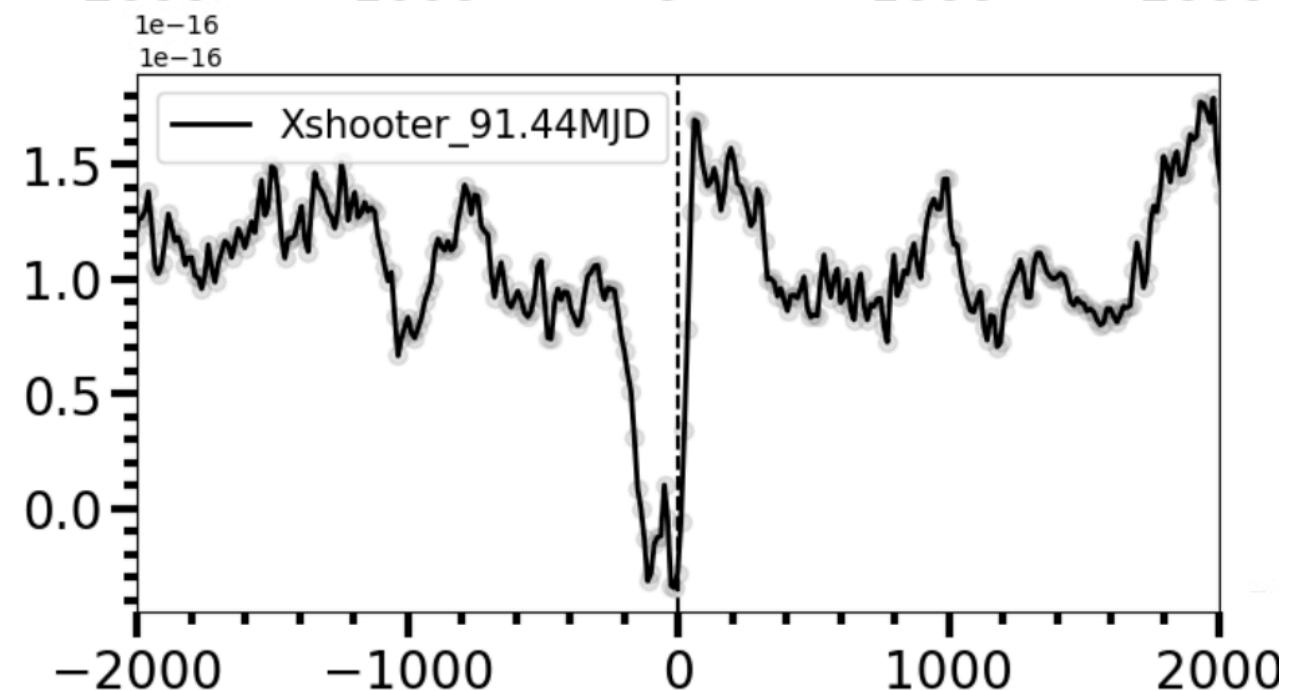
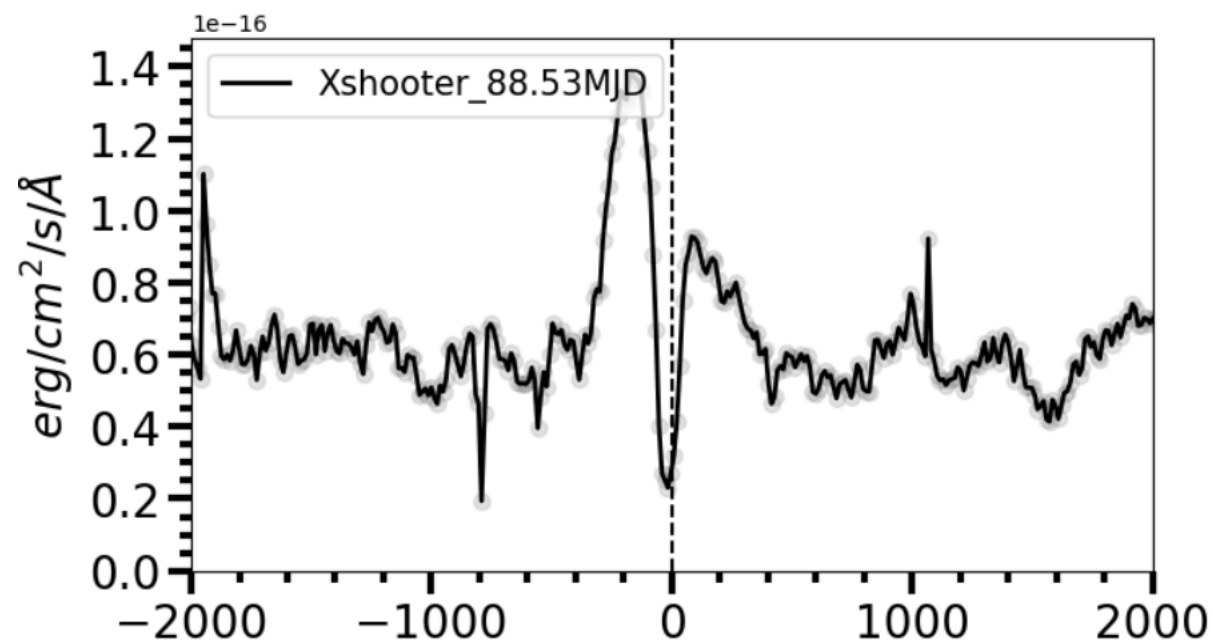
AT2021blu

AT2021biy

H α



H β

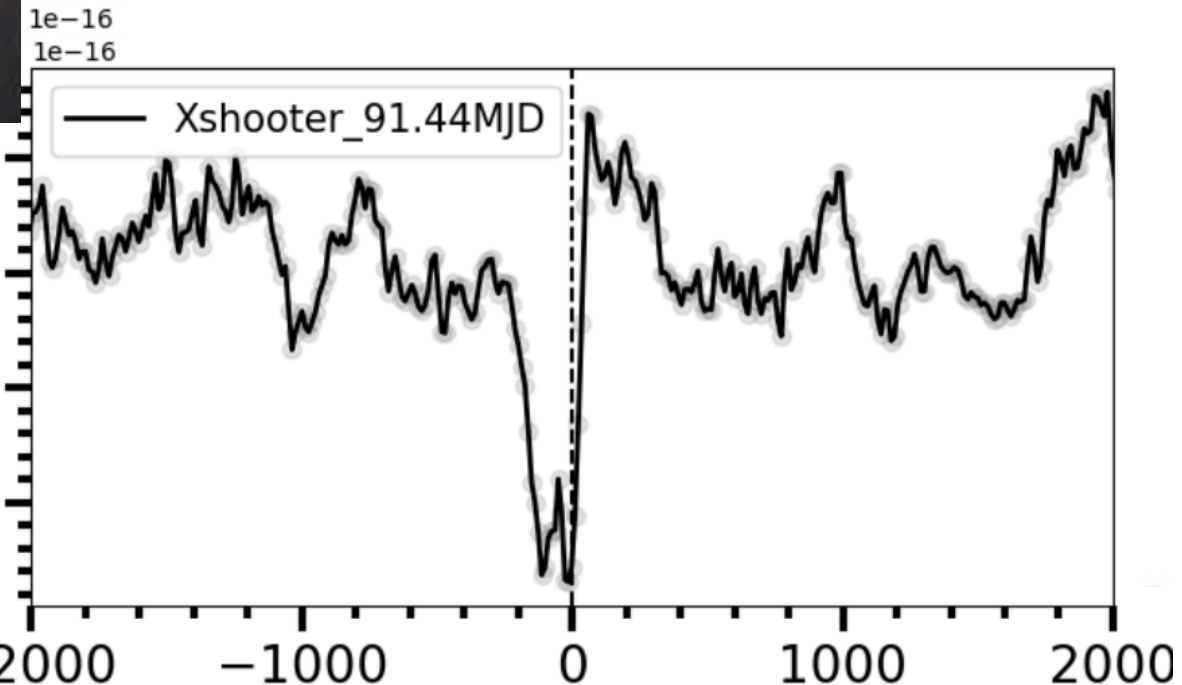
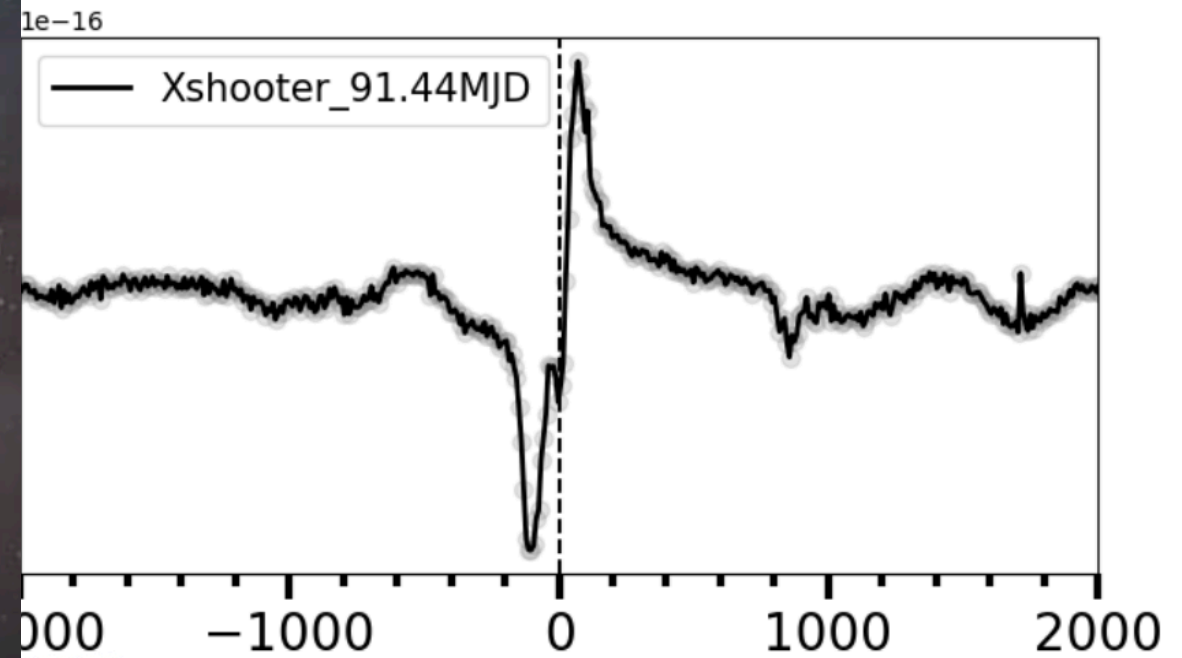


Spectroscopic Data

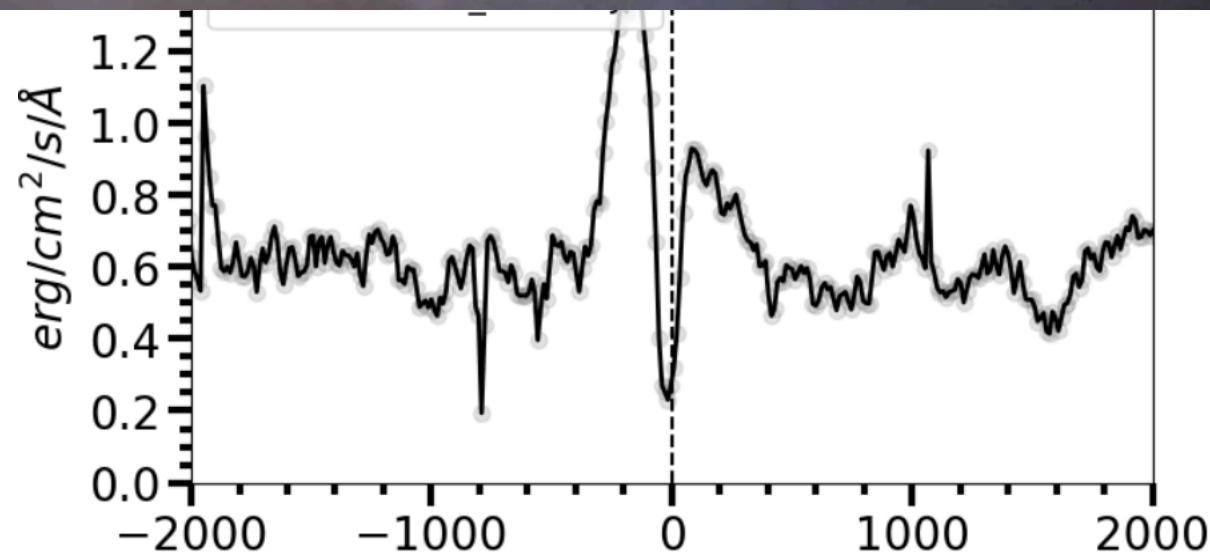
AT2021blu



AT2021biy



$H\beta$

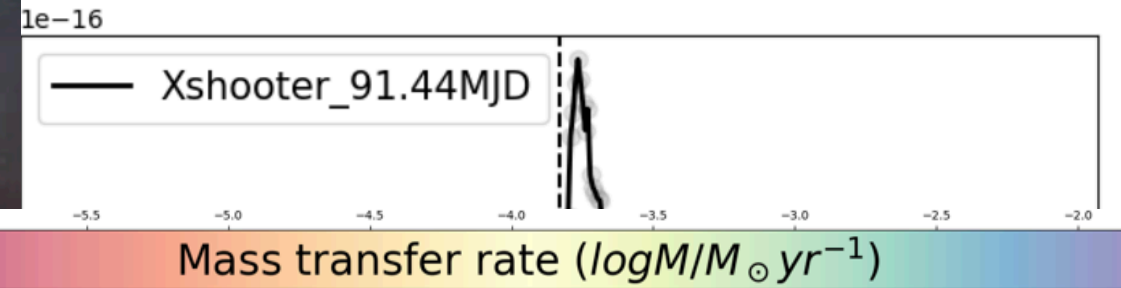


Spectroscopic Data

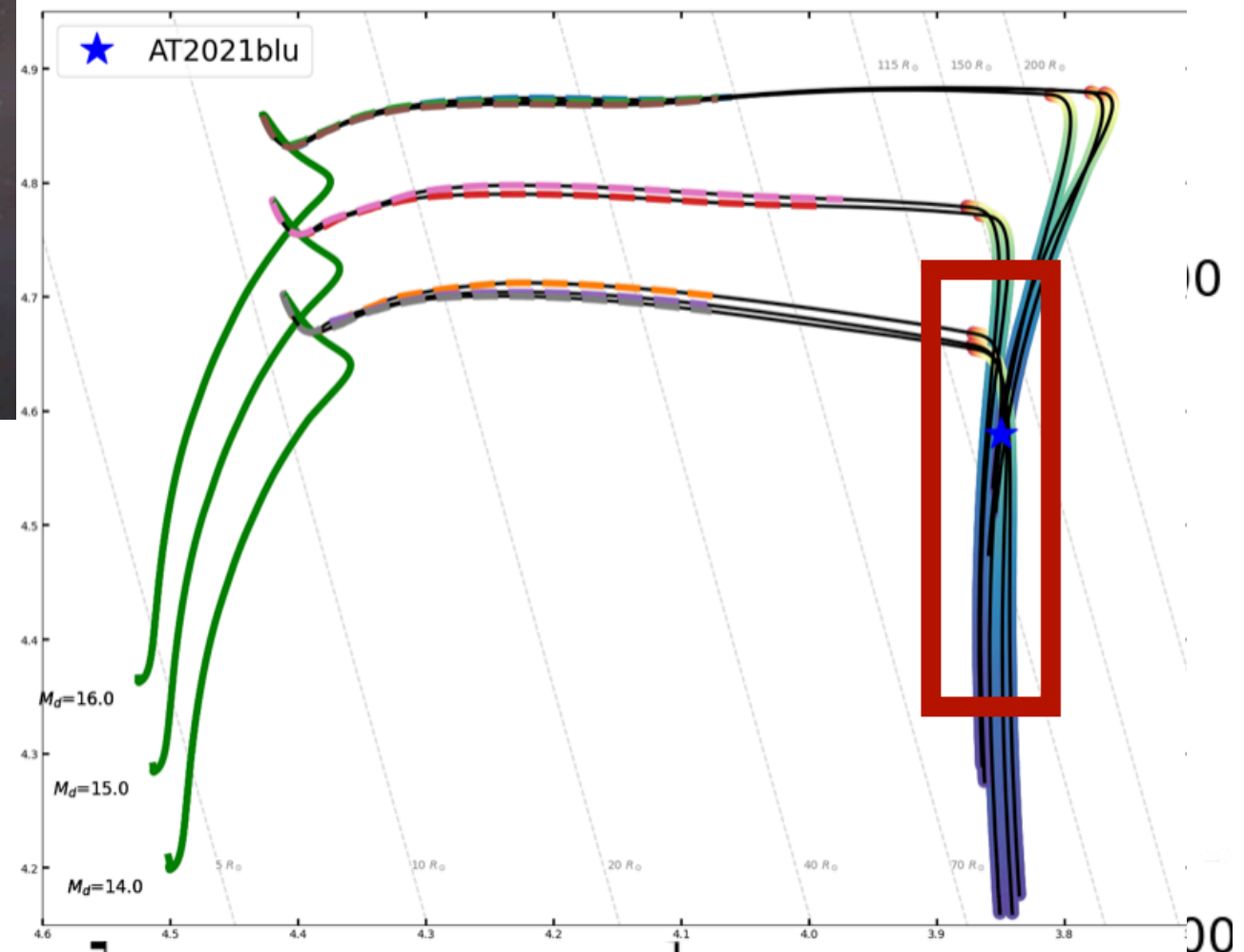
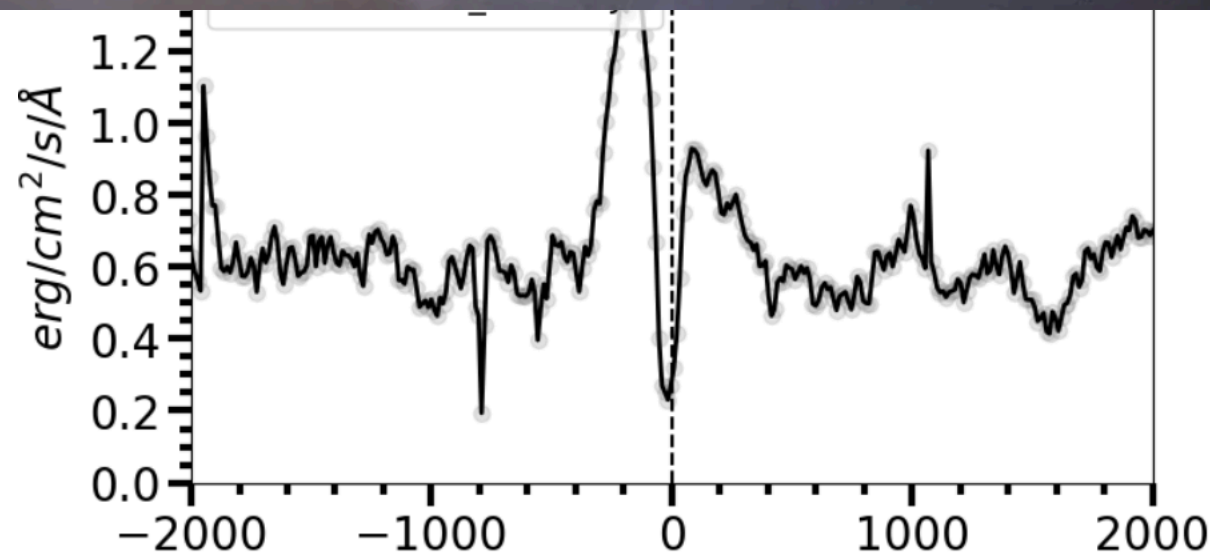
AT2021blu



AT2021biy



H β



CONCLUSIONS

- CE phase crucial in binary evolution
- Modeling is challenging (scales, 3D)
- LRNe are the observables
- Getting a big picture: progenitors → outburst
 - ▶ Binary modeling for progenitors
 - ▶ Spectroscopic analysis for internal dynamics
- Future works: galactic detection of LRNe, dust modeling and spectropolarimetry



THANK YOU !