Supernova 2022acko and Supernova progenitor Star properties: Detection and Light Curves

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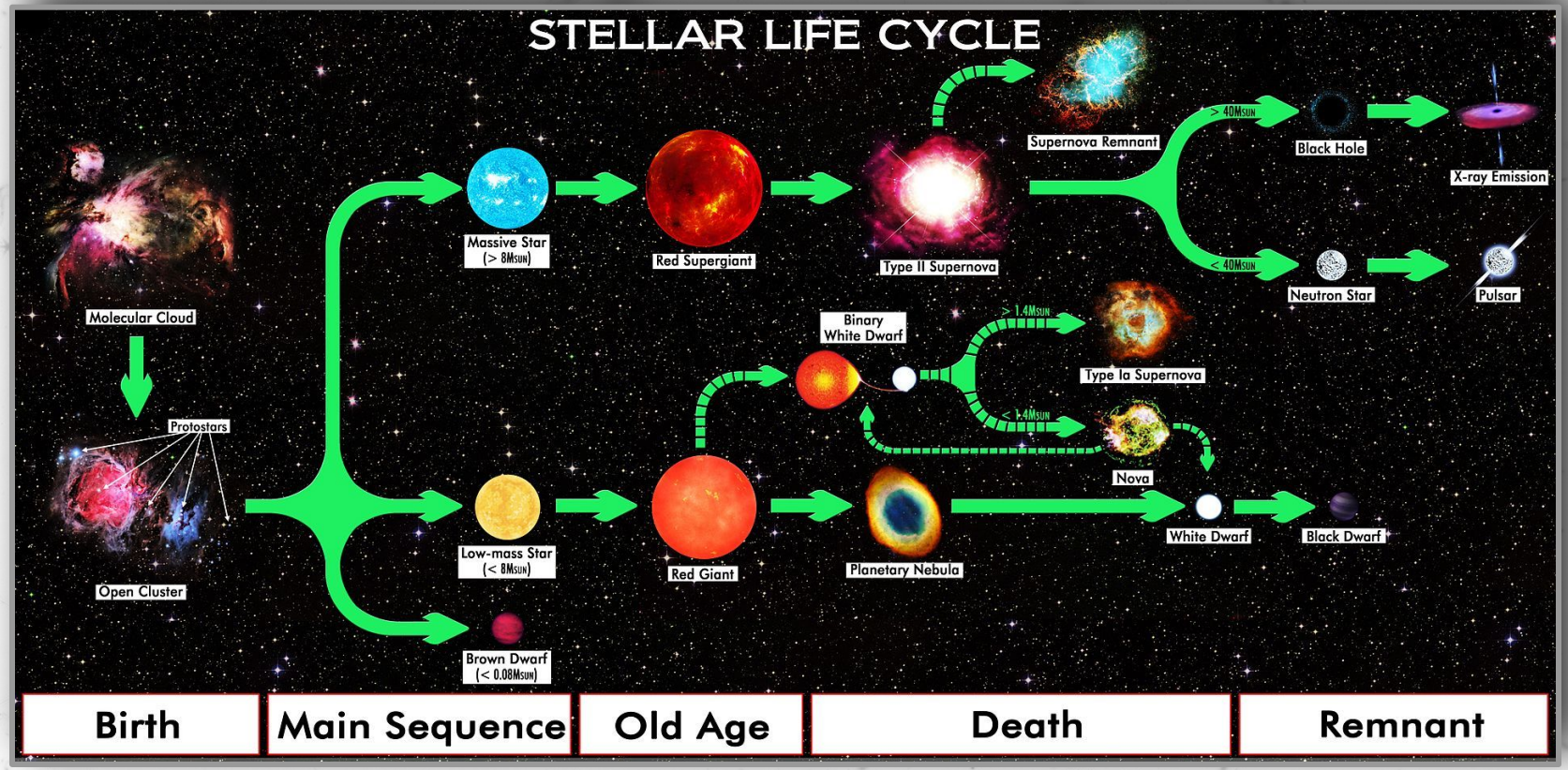
S-PLUS Southern Photometric Local Universe Survey

Summary

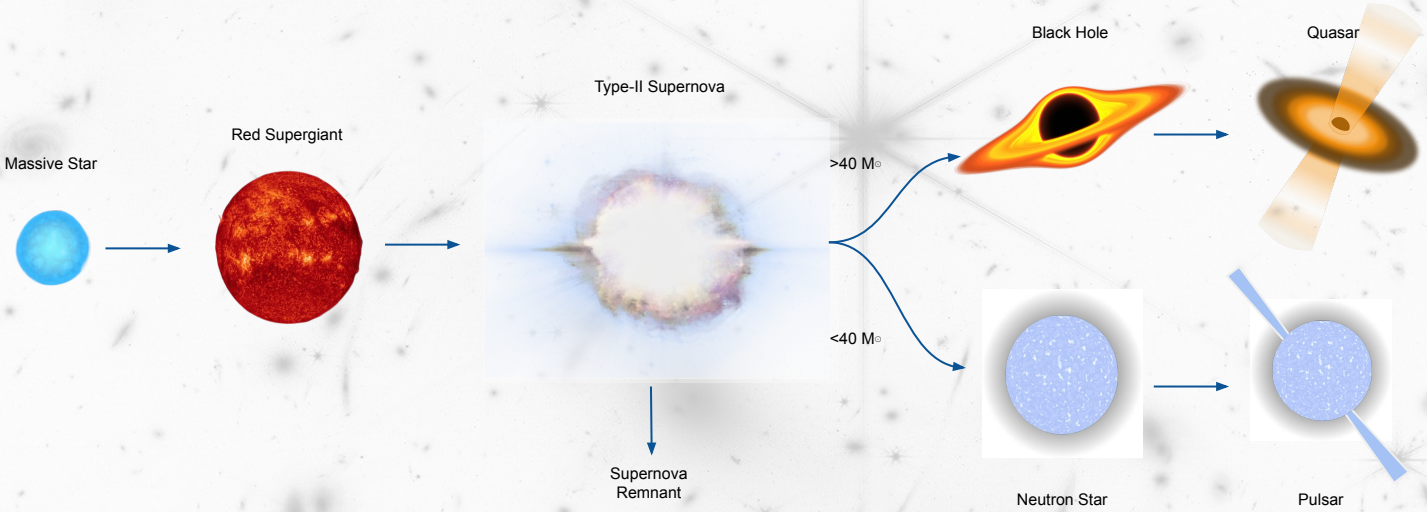
- Introduction
- SN 2022acko observations
- Light curves analysis

Supernovae



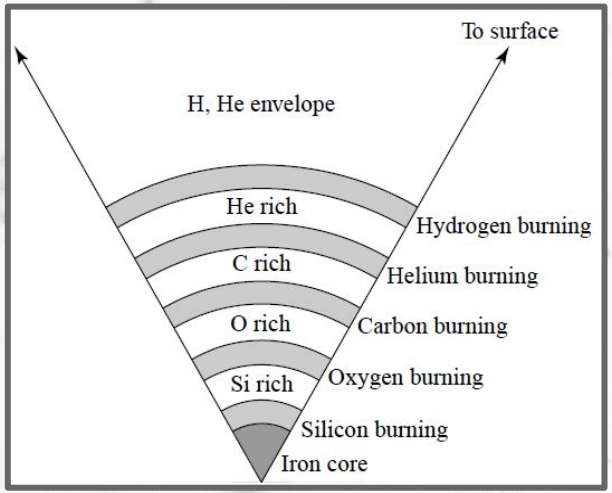
https://en.wikipedia.org/wiki/Stellar_evolution

Supernovae


Massive Star
Red Supergiant
Type-II Supernova
Supernova Remnant
>40 M☉
<40 M☉
Black Hole
Quasar
Neutron Star
Pulsar

Final stage of a massive star

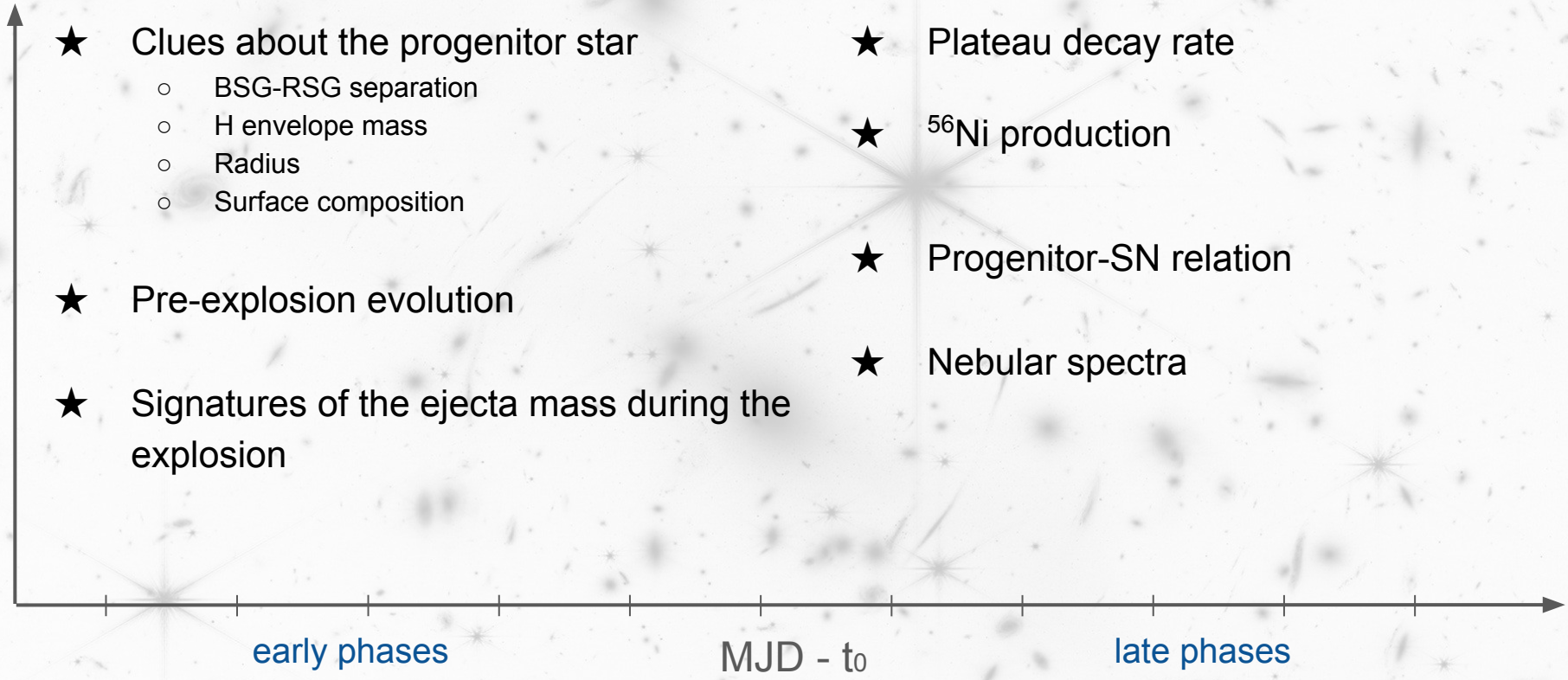
- ★ Silicon nuclear reactions forming iron/nickel core
- ★ Pressure-Gravity Equilibrium breaks
- ★ Gravitational collapse
- ★ Shock propagation



B. Carrol, An Introduction to Modern Astrophysics (2017)

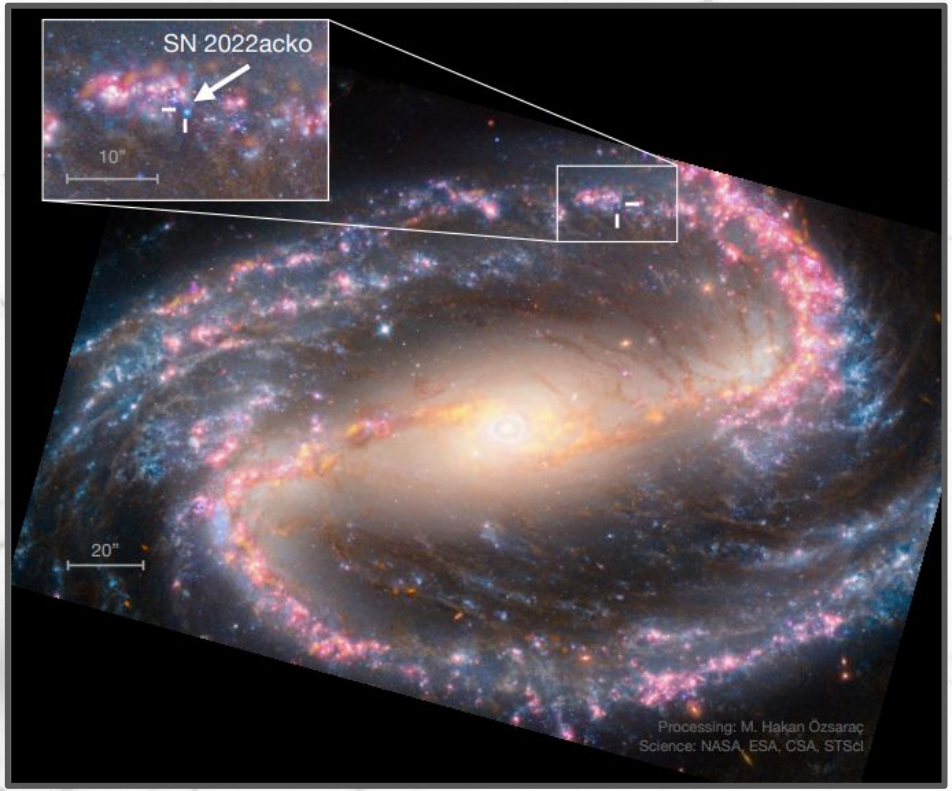
Motivations

- ★ Clues about the progenitor star
  - BSG-RSG separation
  - H envelope mass
  - Radius
  - Surface composition
- ★ Pre-explosion evolution
- ★ Signatures of the ejecta mass during the explosion
- ★ Plateau decay rate
- ★ ^{56}Ni production
- ★ Progenitor-SN relation
- ★ Nebular spectra



Bostroem et. al. (2023) - https://doi.org/10.48550/arXiv.2305.01654

Observations



★ First observation
- 12/06/2022, 03:53
- DLT40 Survey team

★ Location
- Spiral arm of NGC 1300
- Distance of 19 ± 2.9 Mpc

★ Data we have
- Exposures made by the Swift, LasCumbres, T80, Atlas and DLT40 instruments
- Coverage in *UVW1, UVW2, U, B, V, g, r, i, z, c, o* bands, and *Open Filter* exposures by DLT40

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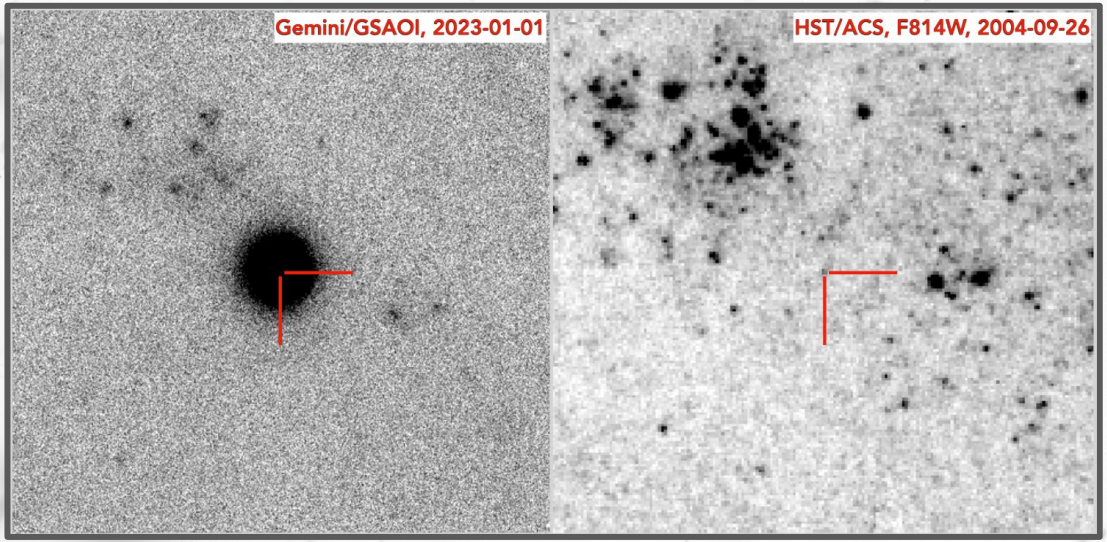

Teixeira et. al. (in prep)

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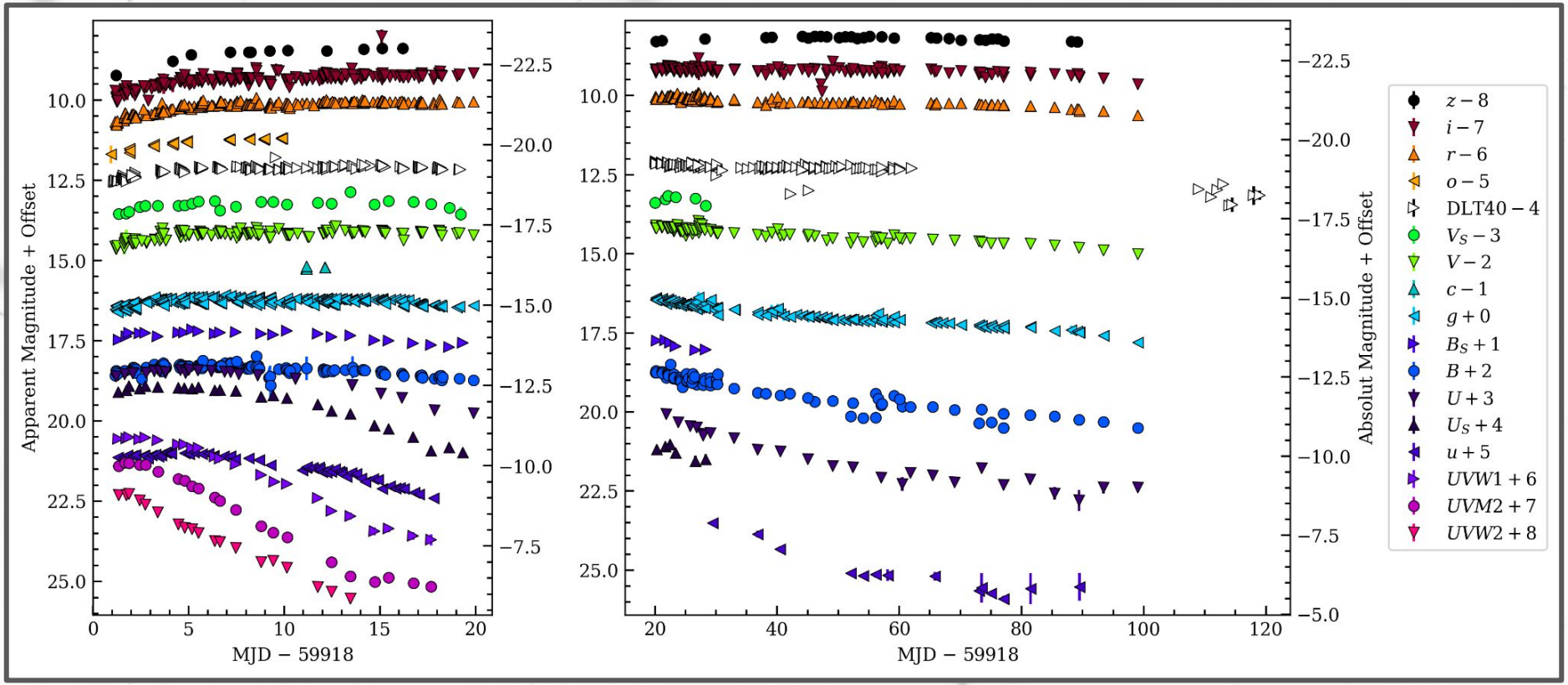


Teixeira et. al. (in prep)

Shock Cooling Models

Waxman & Katz (2017) - https://doi.org/10.1007/978-3-319-21846-5_33

★ Describe the time dependence of the supernovae luminosity and color temperature

- The parametrization allows us to infer properties of the progenitor stars

Shock Cooling 2

$L_1 \quad T_1 \quad t_{\rm tr} \quad t_0$

Sapir & Waxman (2017) - https://doi.org/10.3847/1538-4357/aa64df

$$L(t) = L_1 t^{\varepsilon_L} \exp\left[-\left(\frac{at}{t_{\rm tr}}\right)^{\alpha}\right]$$

Shock Cooling 4

$v_{\rm s*} \quad M_{\rm env} \quad f_\rho M \quad R \quad t_0$

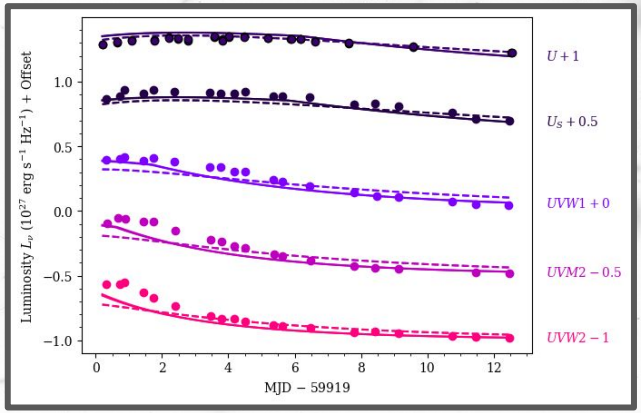
Morag et. al. (2023) - https://doi.org/10.1093/mnras/stad899

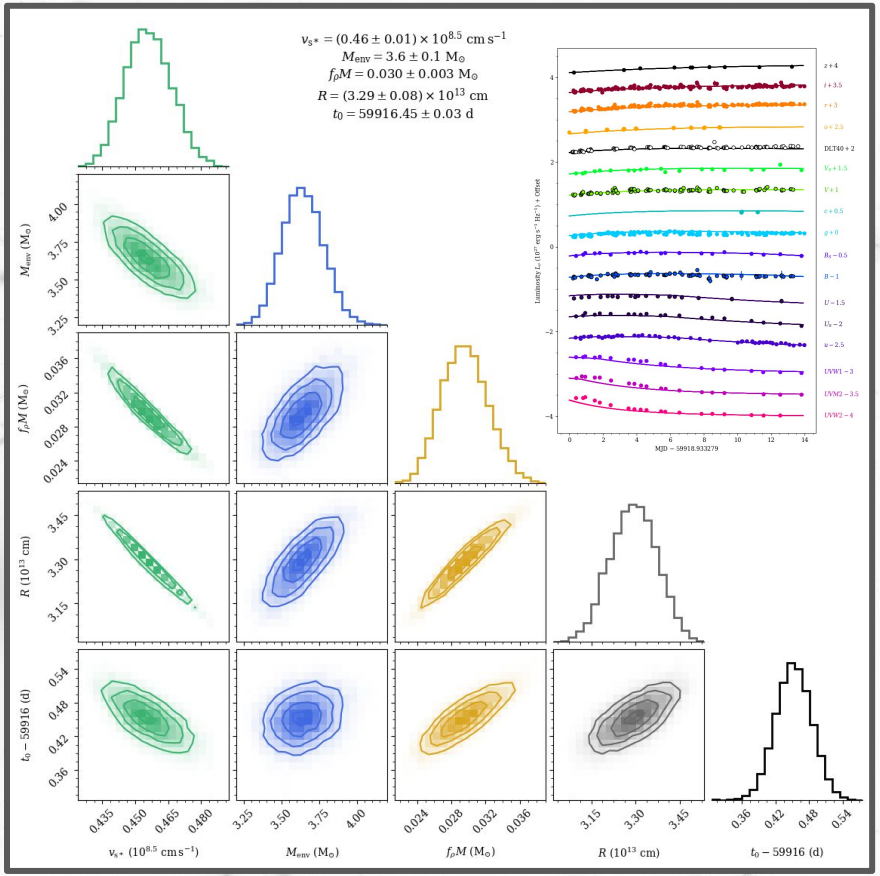
$$L(\tilde{t}) = L_{\rm br}\left\{\tilde{t}^{-4/3} + 0.9\exp\left[-\left(\frac{2.0t}{t_{\rm tr}}\right)^{0.5}\right]\tilde{t}^{-0.17}\right\}$$

$$L_{\rm br} = (3.69\times10^{42}\,{\rm erg\,s^{-1}})R^{0.78}v_{\rm s*}^{2.11}(f_\rho M)^{0.11}\kappa^{-0.89}$$

Lightcurve Fitting

- ★ Light curve fitting package
  - https://zenodo.org/record/8049154
- ★ Monte Carlo Markov Chain
  - 50 walkers
  - 800 burn-in steps
  - 2400 steps





Teixeira et. al. (in prep)

Modeling results

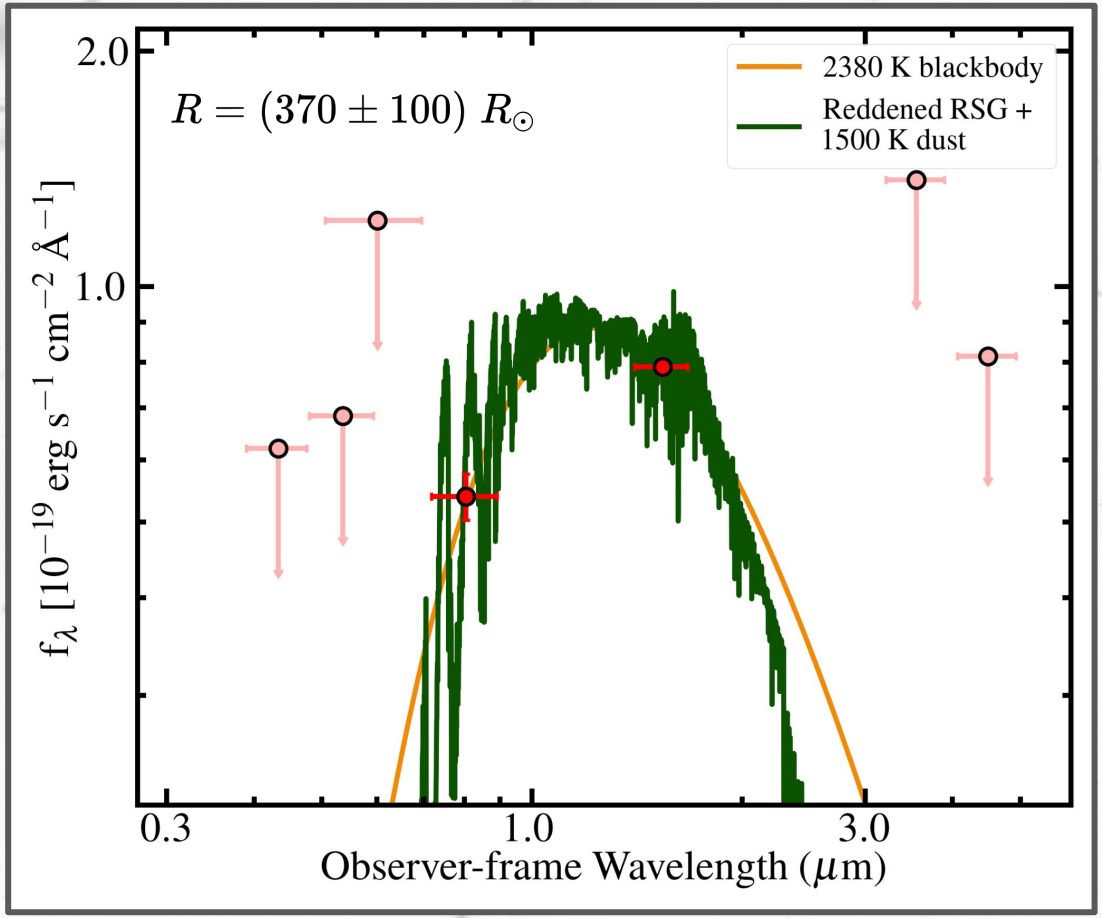
$$v_{s*} = (0.46 \pm 0.01) \times 10^{8.5}\ \mathrm{cm\,s^{-1}}$$

$$M_{\mathrm{env}} = 3.6 \pm 0.1\ \mathrm{M_\odot}$$

$$f_\rho M = 0.030 \pm 0.003\ \mathrm{M_\odot}$$

$$R = (4.7 \pm 0.1) \times 10^2\ \mathrm{R_\odot}$$

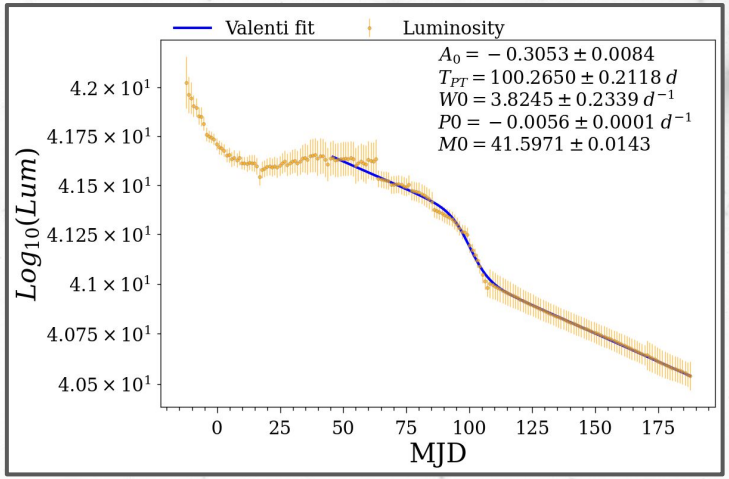
$$t_0 = 59916.45 \pm 0.03\ \mathrm{d}$$



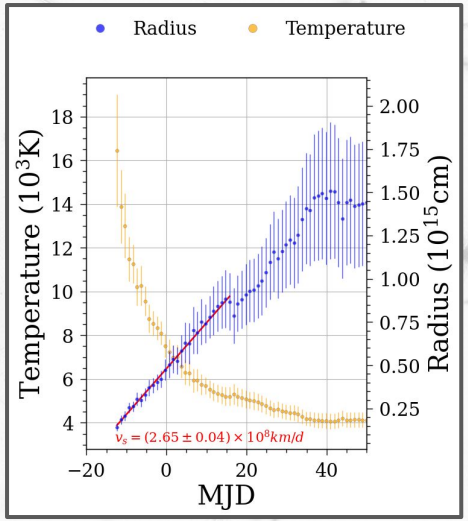
Bolometric light curve

Fitting blackbody (nebular) emission light curve using extrabol

$$Log_{10}[Lum(t)] = \frac{-A_0}{1 + e^{(t-T_{PT})/W_0}} + (P_0 \times t) + M_0$$



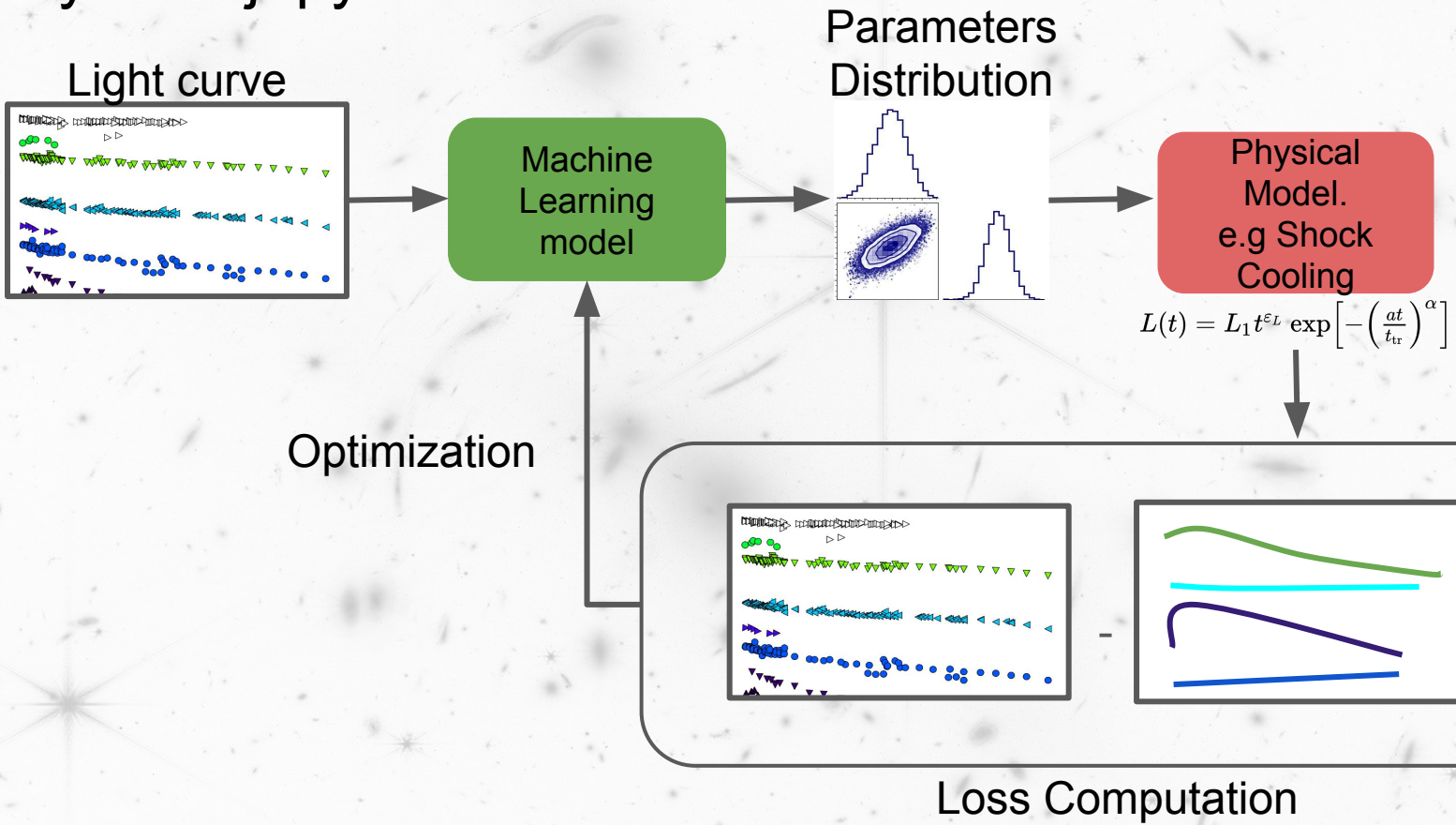
$$v_s = (2.65 \pm 0.04) \times 10^8 km/d$$



Conclusion and Perspectives

- We have a lightcurve modeling consistent with the observed data
- Shock Cooling 4 shows more efficiency in modelling the UV suppression
- Proceed with nickel mass estimation
- Automatize the analysis for late phases properties
- Implement fast physics informed DL models to derive model parameters in real time

Not yet on jupyter…



Thank You

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References

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Hosseinzadeh et. al. (2023) - https://doi.org/10.48550/arXiv.2306.06097

Light curve fitting package - https://zenodo.org/record/8049154

RSG fitting package - https://zenodo.org/record/8060641

B. Carroll & D. Ostile - An Introduction to Modern Astrophysics (2nd edition, 2017)