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Short update on nova detection prospects

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What are novae?

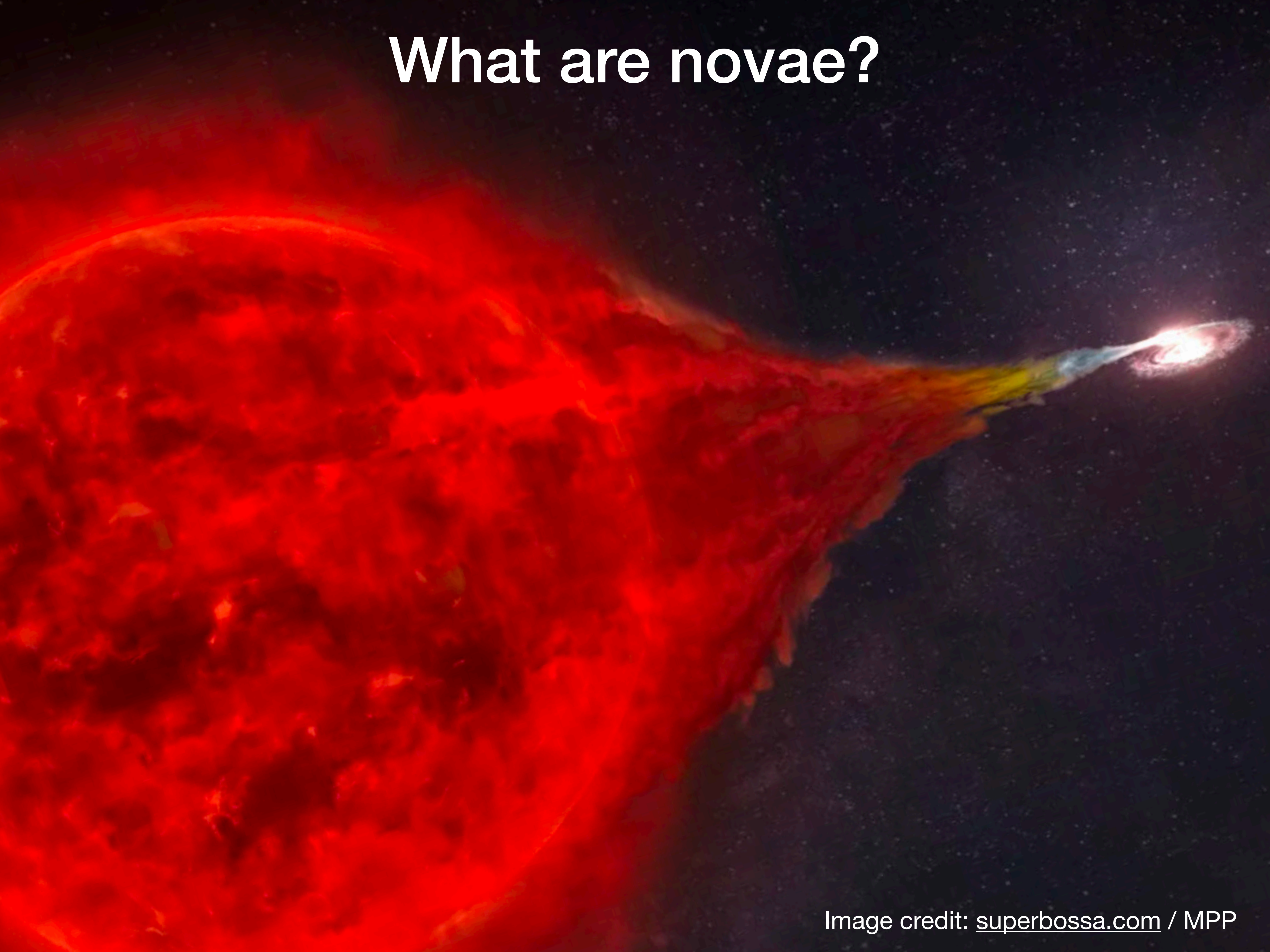


Image credit: superbossa.com / MPP

What are novae?

- Novae are thermonuclear eruptions in binaries that take place on a WD surface (**classical** novae), or arise due to an instability in the accretion disc around the WD (**dwarf** novae). *Recurrent novae* are novae that ‘go off’ with a high cadence (i.e. once every <30 yrs). *RS Oph* is a recurrent nova (has a red giant companion, unlike most classical novae which have main sequence companions).

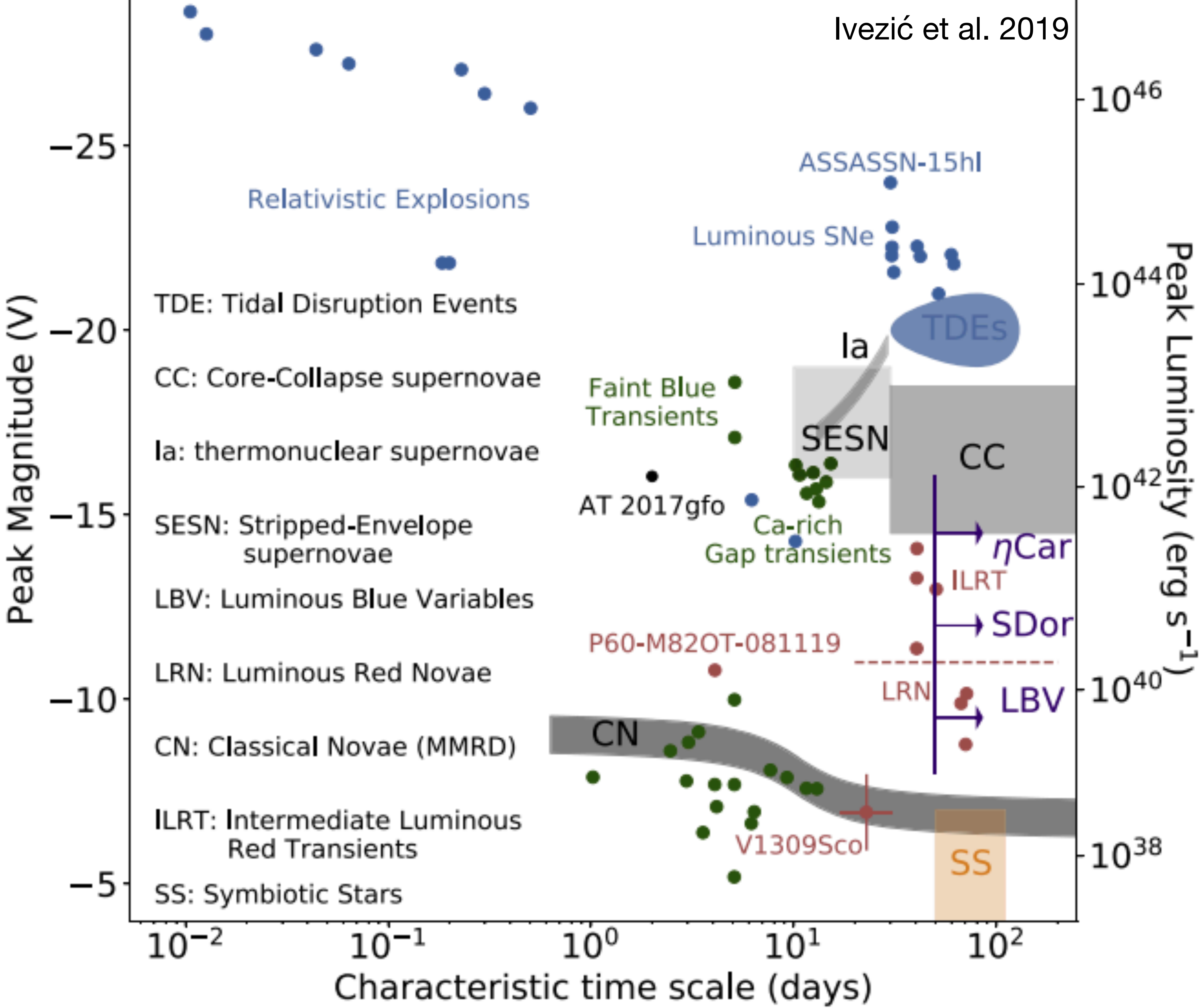
- Novae are useful for studying binary star evolution (my main interest) but now also particle acceleration and shock physics! Current understanding of their formation and evolution however has a lot of holes (theory vs. observation).

- Nice review on classical novae by Chomiuk et al.: https://ui.adsabs.harvard.edu/abs/2021ARA%26A..59..391C/abstract

- In the last decade, some novae have been observed at high energies (MeV, GeV, and at least one with >TeV photons).

- For recent theoretical work on nova rates see papers by A. Kemp (2021, 2022; Monash U). **Galactic nova rate ~20-60 events per year.**

- *It is thought most Galactic novae are being missed in optical bands due to dust extinction* (De et al. 2021), somewhat mitigated by infrared detectors! (see later slides).


Ivezić et al. 2019
Relativistic Explosions
ASSASSN-15hl
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TDE: Tidal Disruption Events
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Ia: thermonuclear supernovae
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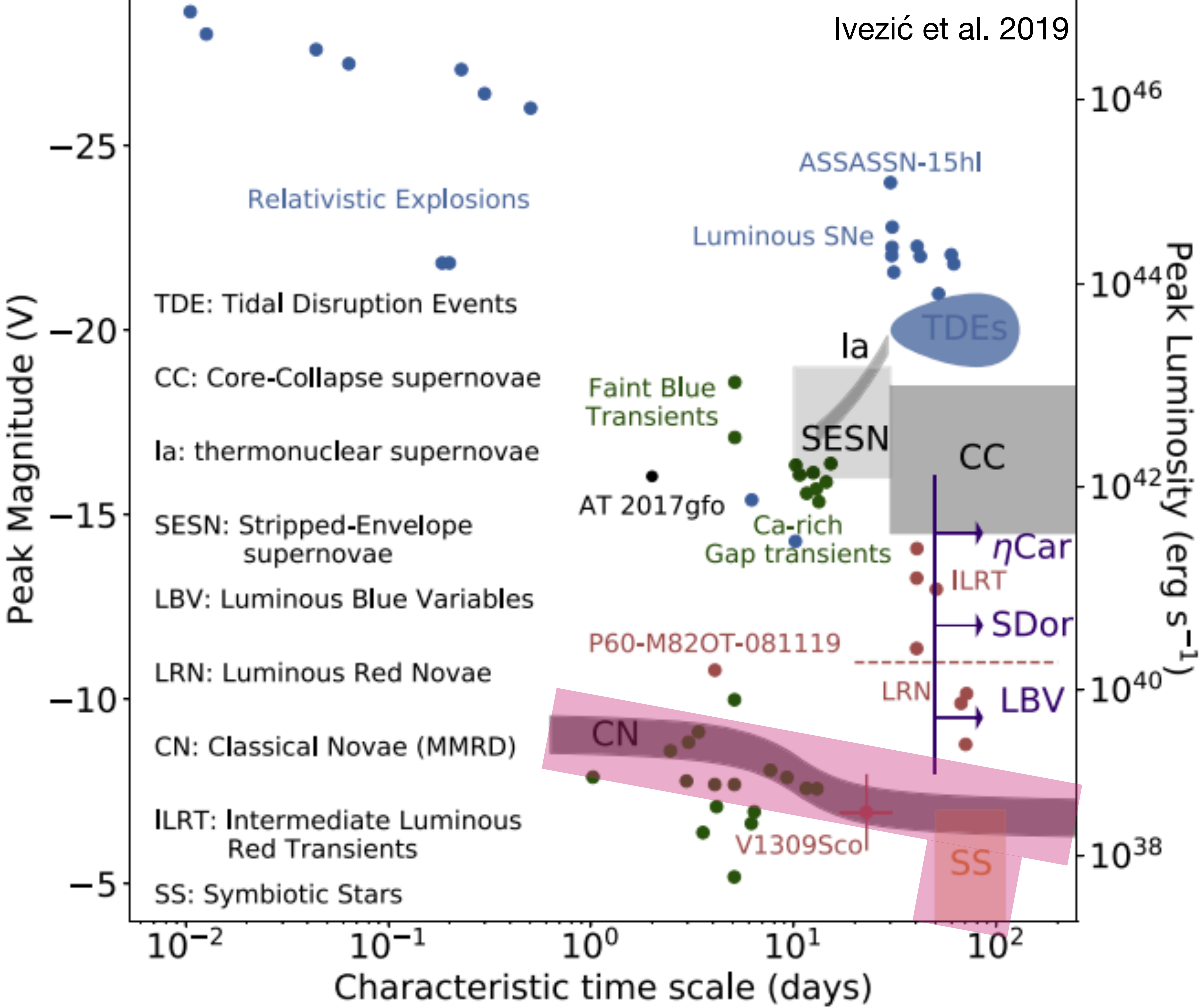
Peak Magnitude (V)
Peak Luminosity (erg s−1)
Characteristic time scale (days)
−25
−20
−15
−10
−5
10^46
10^44
10^42
10^40
10^38
10^−2
10^−1
10^0
10^1
10^2



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Some of what we think we know, and what we know we don't know, about novae

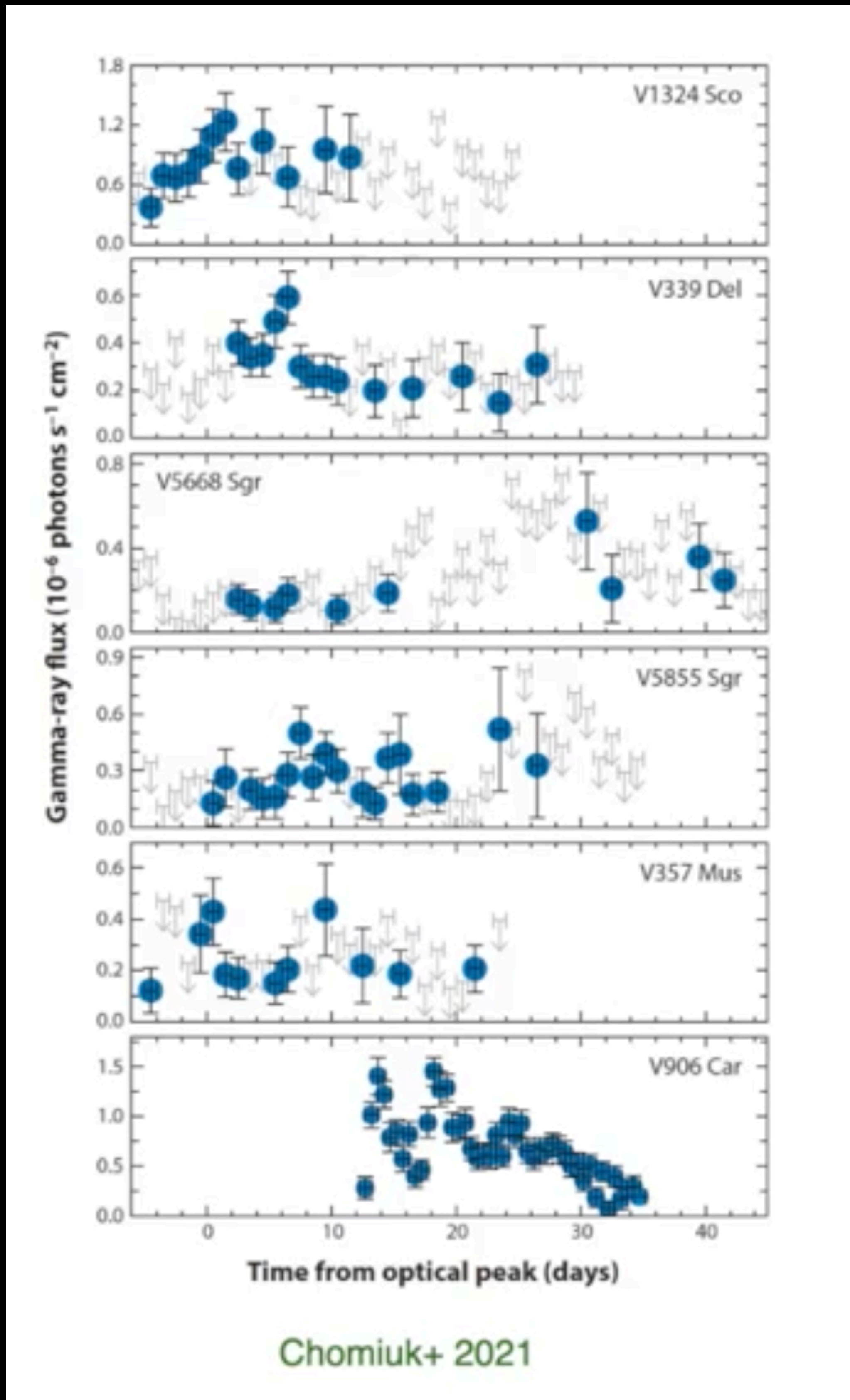
'know' 🥲

- We are biased to observing the 'recurrent' novae, and these systems tend to have very high-mass WDs (i.e. **RS Oph** WD mass > 1.3 Msun).
- Accretion: through RLOF or through a red giant wind (i.e. RS Oph; symbiotic).
- Shocks that give rise to high energy gamma rays (~GeV) in classical novae appear to be internal to the nova ejecta and are deeply embedded (internal shocks; between WD and ejecta).
- There are also 'helium' novae, i.e. V445 Pup. But these are rare compared to the 'canonical' type(s).

'don't know' 🤔

- Are they type Ia supernova progenitors? Maybe some of them. Maybe none of them!
- In general, *the formation and evolution of novae is poorly known,* though every cataclysmic variable is technically a "nova in waiting".
- *Which novae will be able to produce TeV photons?* And does this depend on the nature of the system/progenitor, or mass transfer mechanism, or …?
- *Is nova γ-ray emission hadronic or leptonic?* (Hadronic is favoured via decay of neutral pions).
- How long will the (TeV) signal last - probably depends on nature of shock speed, ejecta mass, previous (ejected or circumbinary) material density/morphology. All difficult to model.
- How do classical novae eject their material? (Shen & Quataert 2022).

Some nova lightcurves (from Chomiuk et al. 2021 review)



Jeno Sokoloski talk,
KITP Physics of WDs Nov 2022

- Most classical novae that are nearby have been detected by Fermi, with varying luminosity of ~10^{35} erg/s; this requires a powerful shock!
- Ejecta contain shocks -> diffusive acceleration can lead to GeV continuum emission (cf. Mukai & Ishida 2001).
- See H.E.S.S. collaboration, 2022; Acciari et al. 2022.

Some takeaways

- CTA Galactic transients paper to be submitted soon (Alicia Lopez Oramas et al.)
- A consistent picture of what to expect in terms of which types of novae will be readily seen with CTA is a work in progress; *this is a new area of research in an old topic*.
- Ongoing work re: expected nova detection rates with CTA, though they are definitely observable! + a number of current/upcoming synergies.
- Preliminary modelling (A. Aguasca-Cabot) suggests that **novae within ~2 kpc have a good chance of being detected with CTA-N within hours, but those >8 kpc not so much.** Bias toward novae harbouring massive WDs (*from CTAO/CTAC General Meeting Nov 2022*).
- Paper re: Imaging Air Cherenkov Telescopes to provide trigger for CTA and continuous follow-up — *ideal for transients* like the nova RS Oph and others: https://ui.adsabs.harvard.edu/abs/2022PASA...39...41L/abstract by Simon, Einecke, Rowell, et al. 2022.
- Interesting fact: it seems that the optical flares seen in nova lightcurves are actually powered by the gamma rays (nova V906 Car; Aydi et al. 2020).

Some synergies: novae with CTA and other instruments

- CTA will likely be able to detect accelerated particles in the shocks of novae that harbour high-velocity (>1500 km/s) winds if ejecta mass is sufficiently large. *Such a case should produce >100 GeV signals.*

- *What are the expected rates?* Note we are basically restricted to the Milky Way; M31 probably too faint.

What might help increase CTA detection of Galactic novae?

- Rubin LSST (transient survey of Southern sky) and other transient surveys. *(Gavin mentioned DREAMS, SSO)*.

- *IceDrake* - proposed wide field (50 sq deg) K-band imager in Antarctica:

Groups in the US, Europe, Australia are gaining momentum to *build a ~50 sq degree infrared detector (K band) at Dome C in Antarctica*. This detector (IceDrake) would hopefully be built by end of 2020s. Perfect for finding obscured novae in the Galactic plane/behind the bulge?