Hot subdwarf stars

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and their connection to thermonuclear supernovae

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ESO, Garching

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+ PanSTARRS team

Supernovae type Ia

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(NASA)

SN Ia

- Very bright (V=-19^{m})
- All stellar populations
- No H, no He
- Uniform

→ C/O-WD explosion

→ **Standard Candles**

Double-degenerate progenitors

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(NASA)

Single-degenerate progenitors

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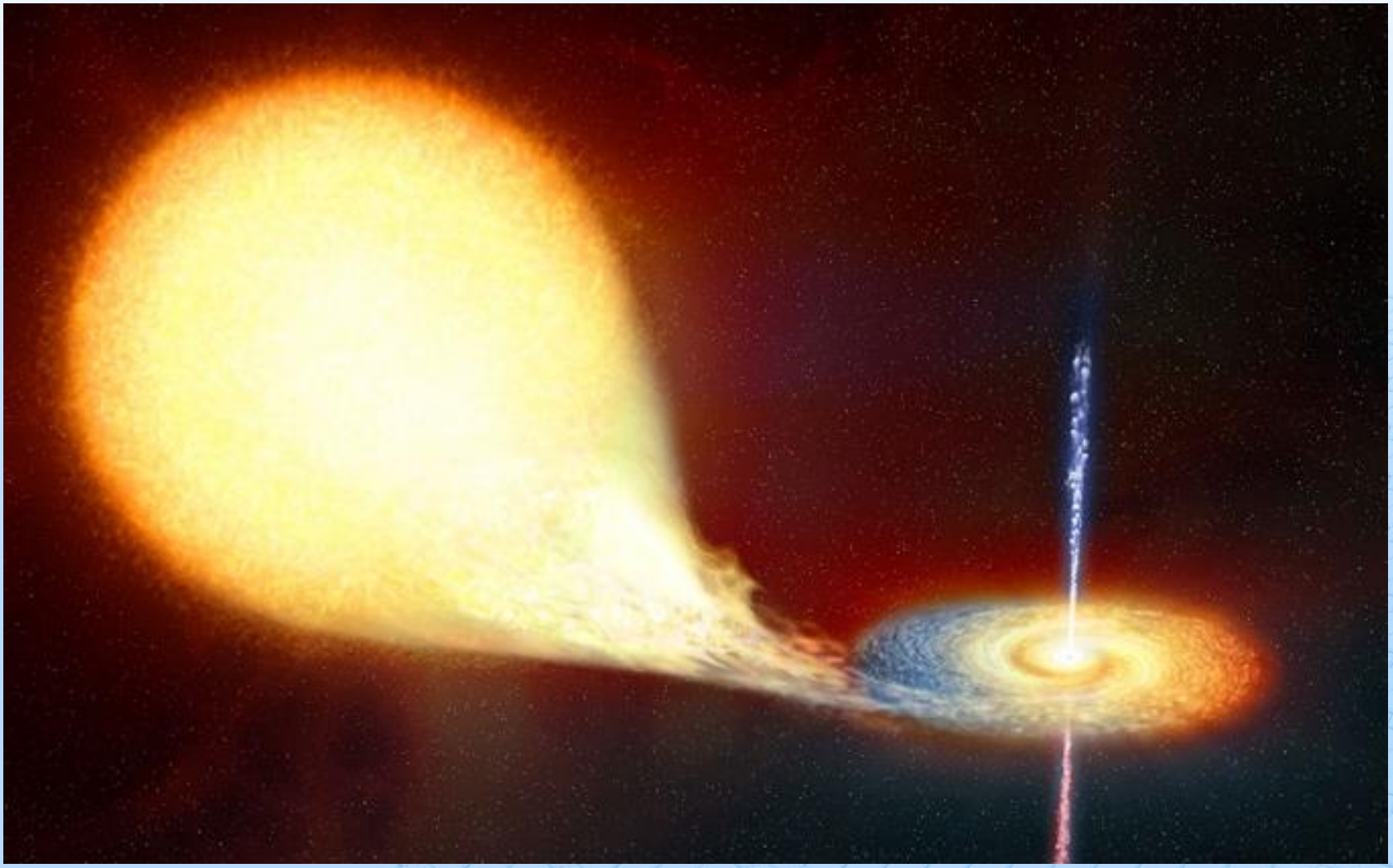
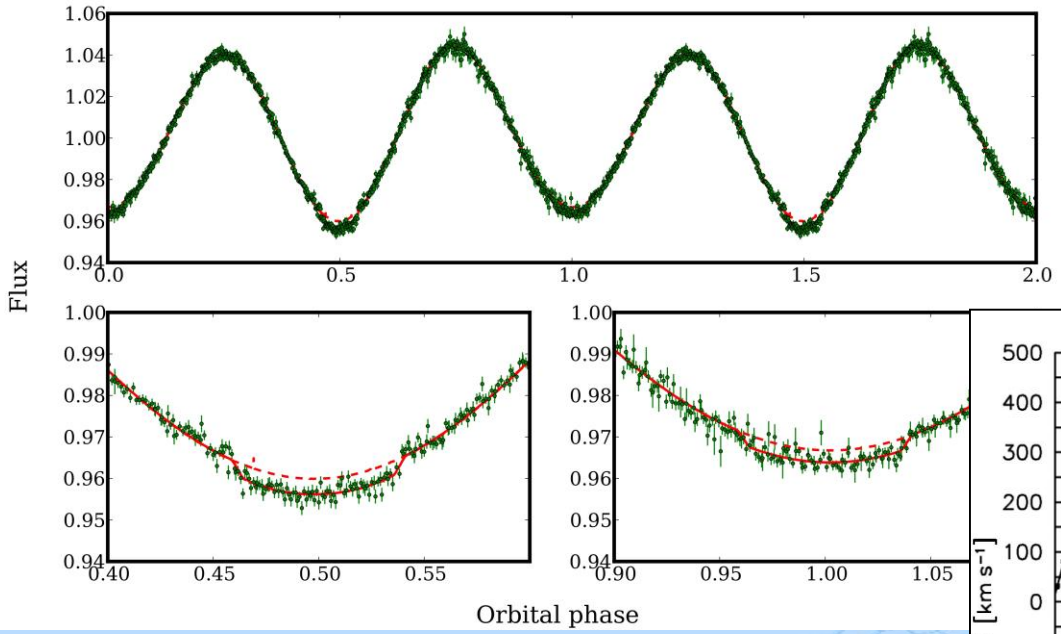
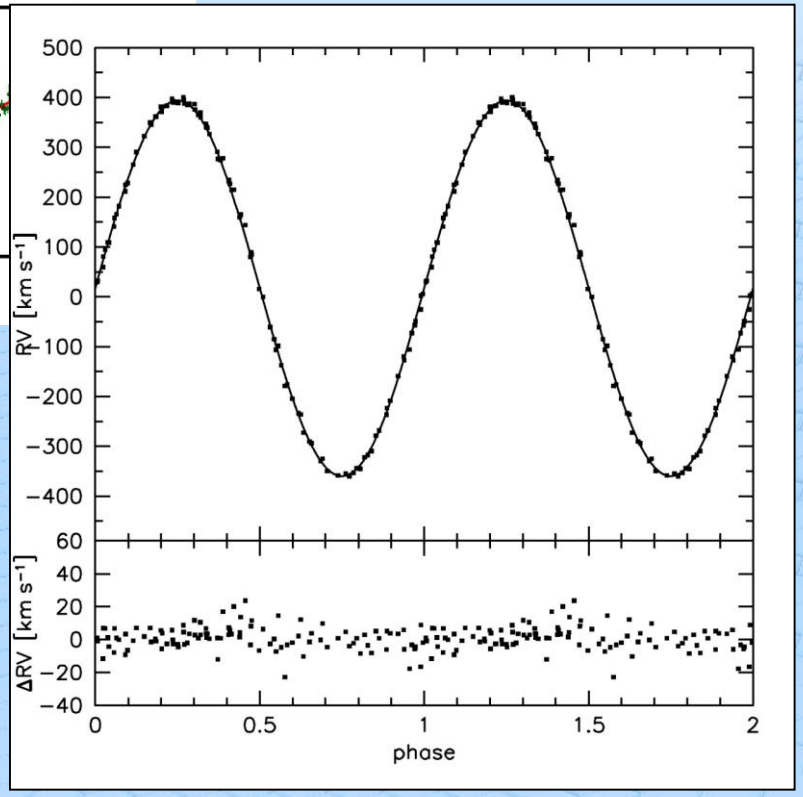


Single-degenerate progenitors



CD -30º11223

(Geier et al. 2013, A&A, 554, 54)



K = 377 km/s

P = 0.0498 d

$M_{sdB} = 0.51\ M_O$

$M_{WD} = 0.76\ M_O$

Stable helium accretion

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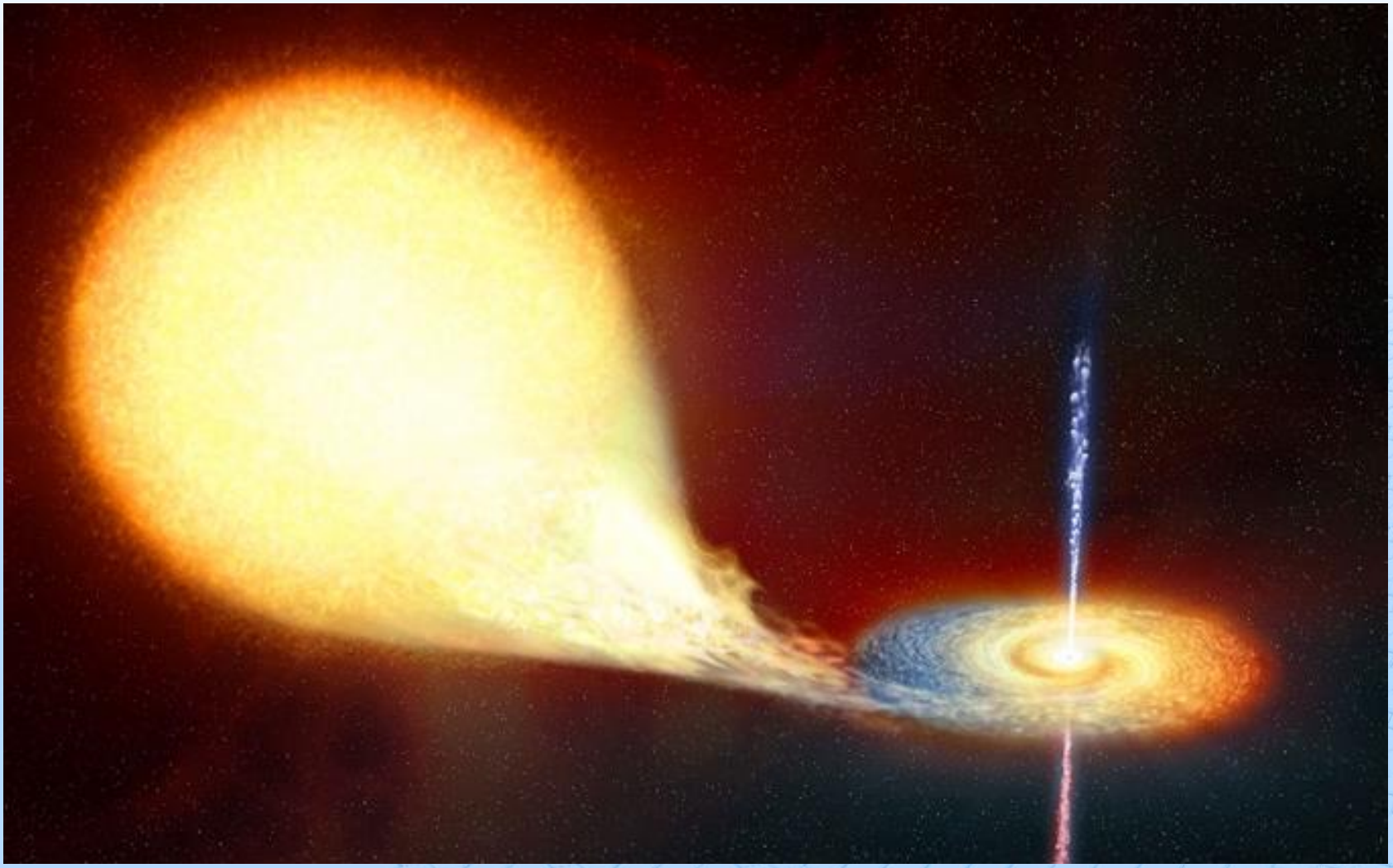
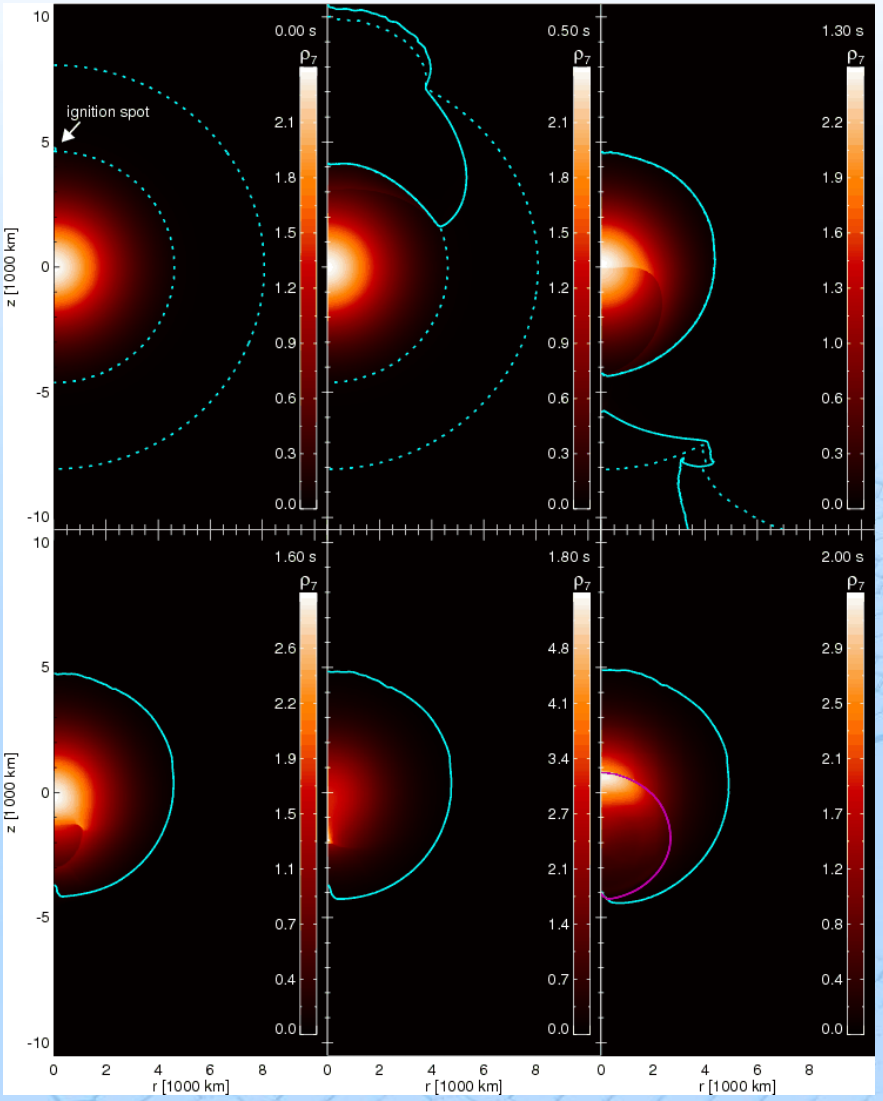
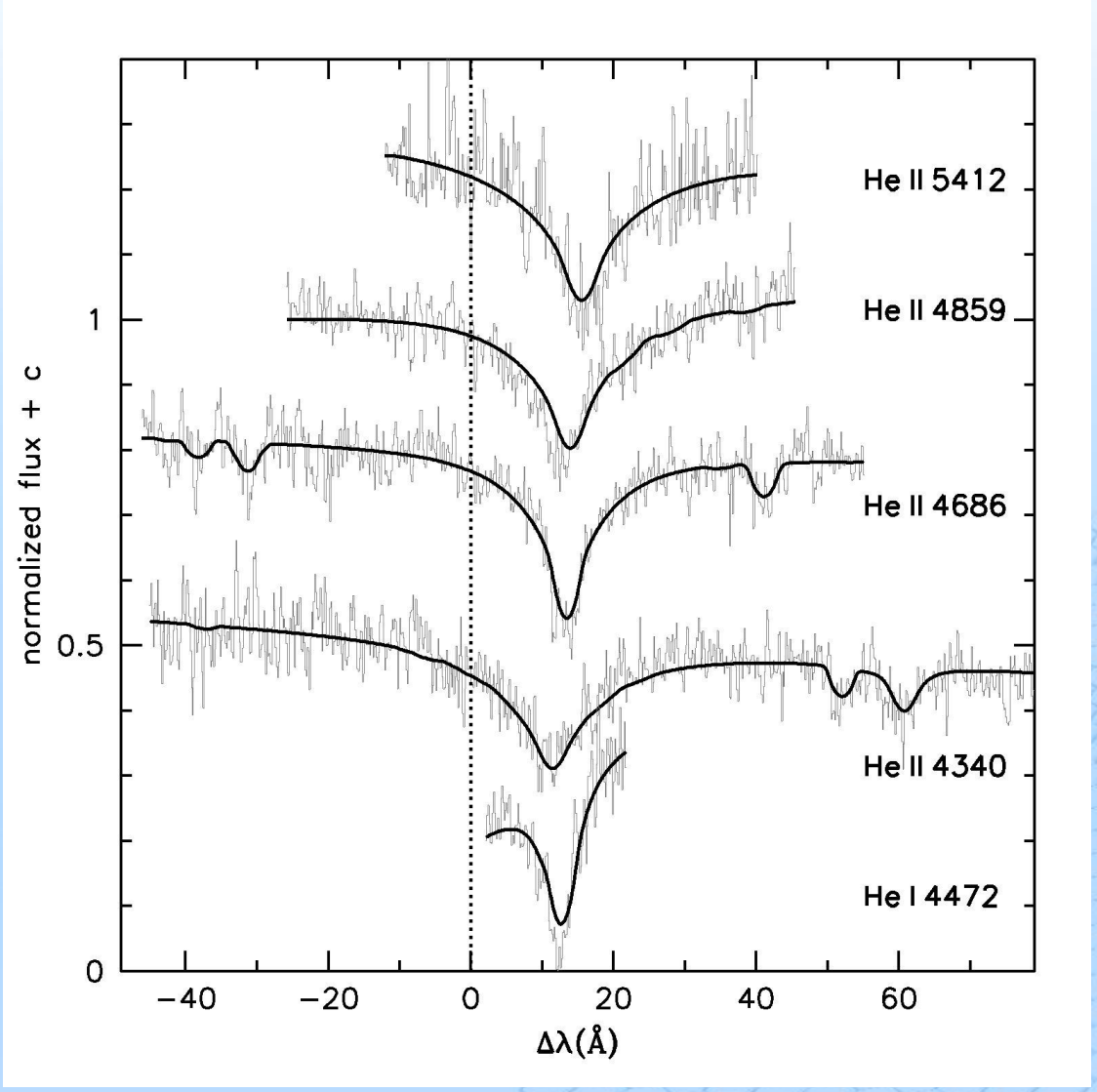


Double-detonation scenario



(Fink et al. 2010; Shen & Bildsten 2014; Dan et al. 2014; Brooks et al. 2015)

Ejected donor remnant



(Geier et al. 2015, Science, 347, 1126)

US 708

Galactic restframe velocity

$v_{grf} = 1157 \pm 53\ km/s$

Fast rotator

$v_{rot}\ sini = 115 \pm 8\ km/s$

Fastest unbound star in the Galaxy

Ejected donor remnant

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STELLAR DYNAMICS

The fastest unbound star in our Galaxy ejected by a thermonuclear supernova

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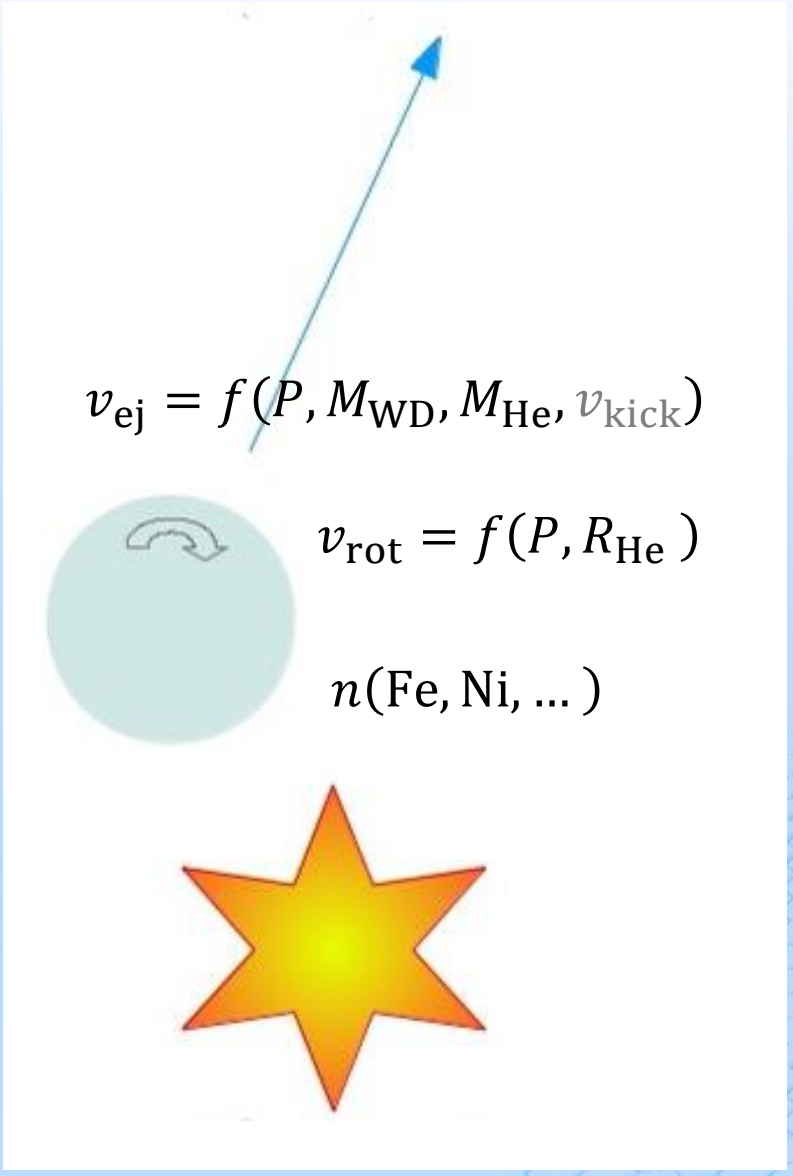
Hypervelocity stars (HVSs) travel with velocities so high that they exceed the escape velocity of the Galaxy. Several acceleration mechanisms have been discussed. Only one HVS (US 708, HVS 2) is a compact helium star. Here we present a spectroscopic and kinematic analysis of US 708. Traveling with a velocity of ~1200 kilometers per second, it is the fastest unbound star in our Galaxy. In reconstructing its trajectory, the Galactic center becomes very unlikely as an origin, which is hardly consistent with the most favored ejection mechanism for the other HVSs. Furthermore, we detected that US 708 is a fast rotator. According to our binary evolution model, it was spun-up by tidal interaction in a close binary and is likely to be the ejected donor remnant of a thermonuclear supernova.

(Geier et al. 2015, Science, 347, 1126)

Ejected donor remnant

(http://bigboxofawesome.com/scientists-have-figured-out-how-fast-the-fastest-star-in-the-galaxy-is/)

Ejected star‘s properties …



Star fills Roche lobe at the moment of ejection

Stellar rotation synchronized to orbital motion

No further loss of mass or angular momentum

Star polluted by SN material?

… related to progenitor properties

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Binary properties of the progenitor:

P = 10-15 min
M_{sdB} = 0.3 M_O
M_{WD} = >1.0 M_O

Original binary: 2-3 M_O stars
→ Young population (thin disk) → Short delay time <1 Gyr

New results from Brooks et al. (2015) suggest CD -30°11223 as possible progenitor

System close to a progenitor

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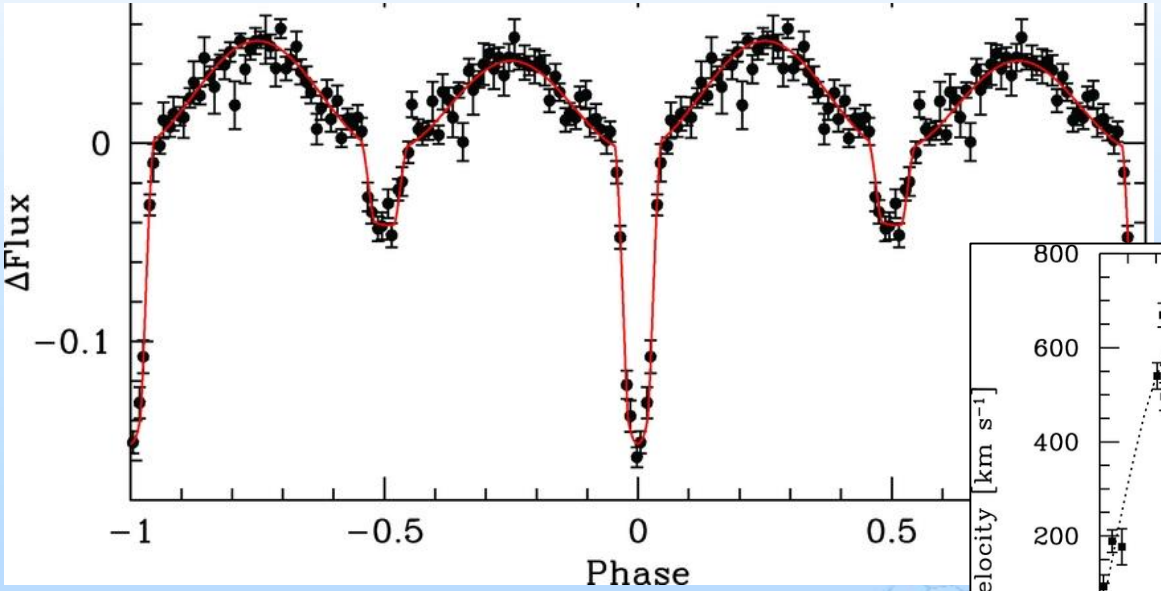
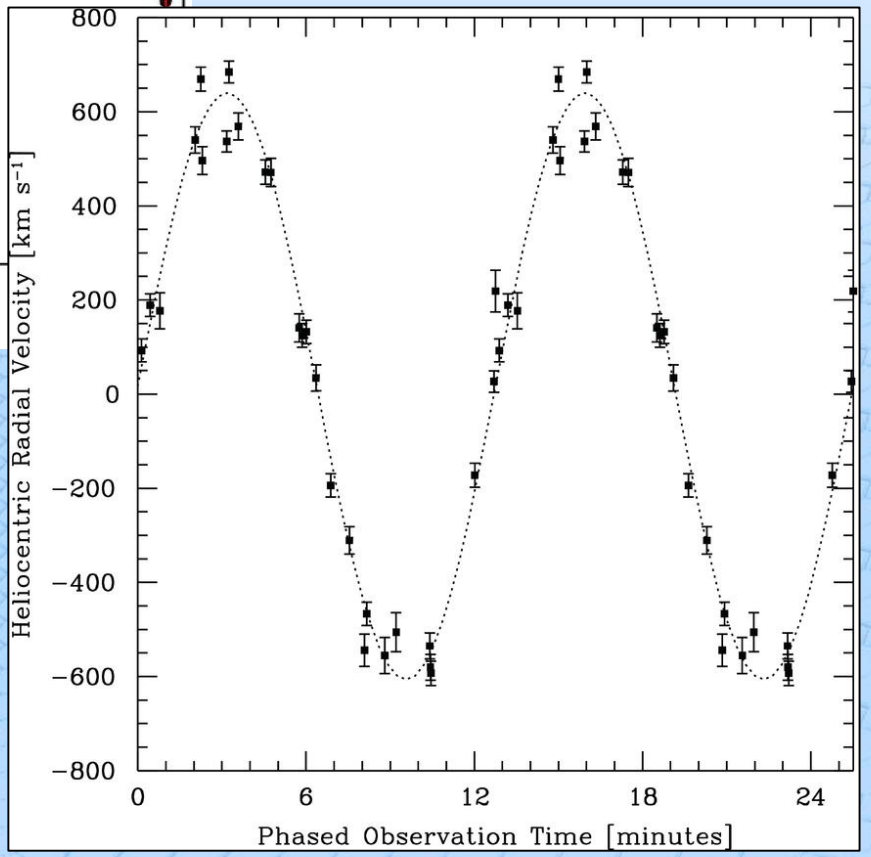


SDSS J0651+2844

(Brown et al. 2011, ApJ, 737, L23)



K = 657 km/s

P = 12.75 min

$M_{He\text{-}WD} = 0.25\ M_O$

$M_{WD} = 0.55\ M_O$

Progenitor properties

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Progenitors:

→ Mass-transfer rate must be in the right range (10^{-8} M_O/yr)

→ He must be accreted from a non-degenerate, core He-burning star (no He-WD)

→ Time from CE to He accretion < Lifetime of sdOB (100 Myr)

→ **Period of post-CE binary < 2 hr**

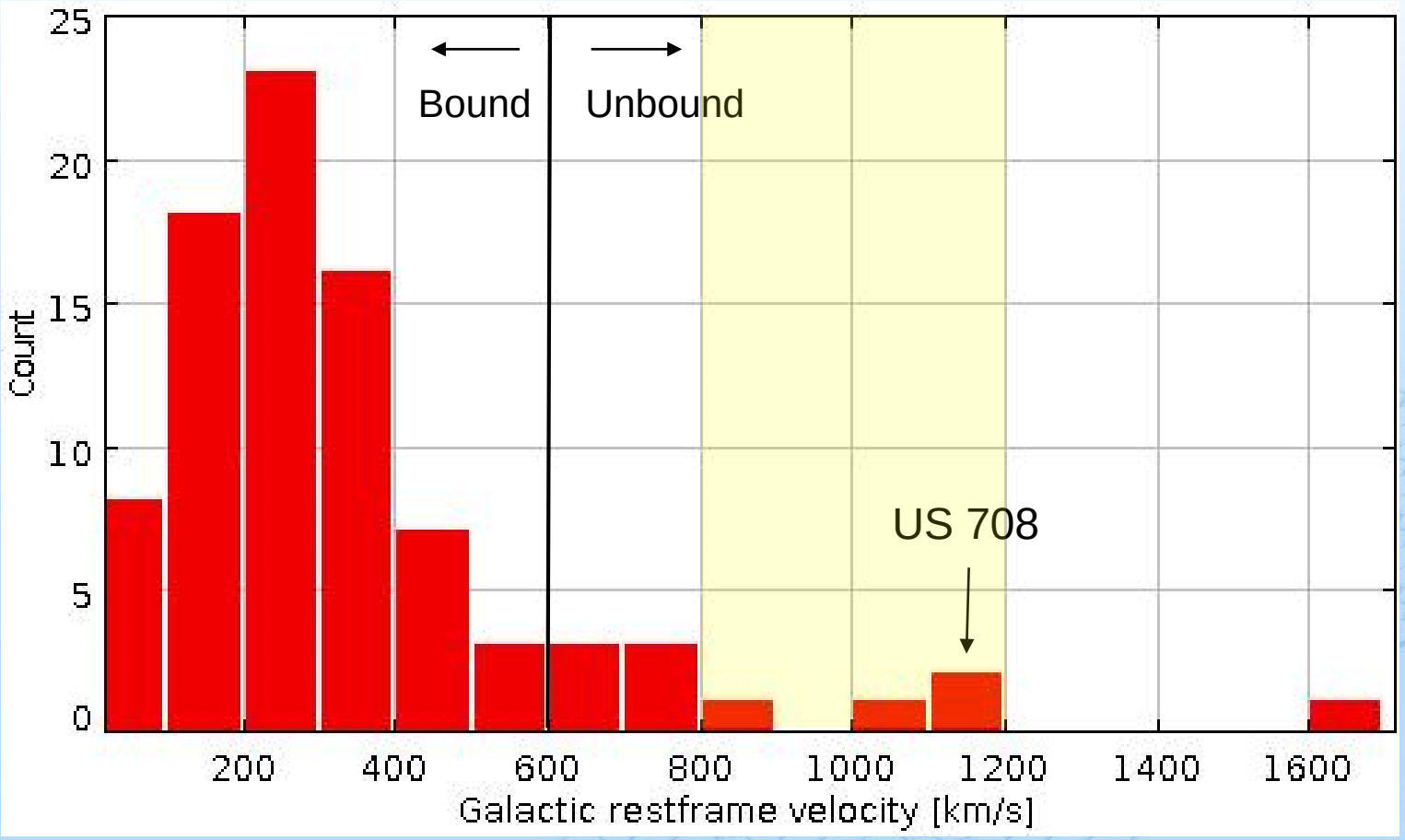
Ejected sdO/B remnants:

→ Young population → Ejected from the Galactic disk

→ Time since ejection < 50 Myr

→ **Ejection velocity < 1000 km/s** (US 708: 998±68 km/s)

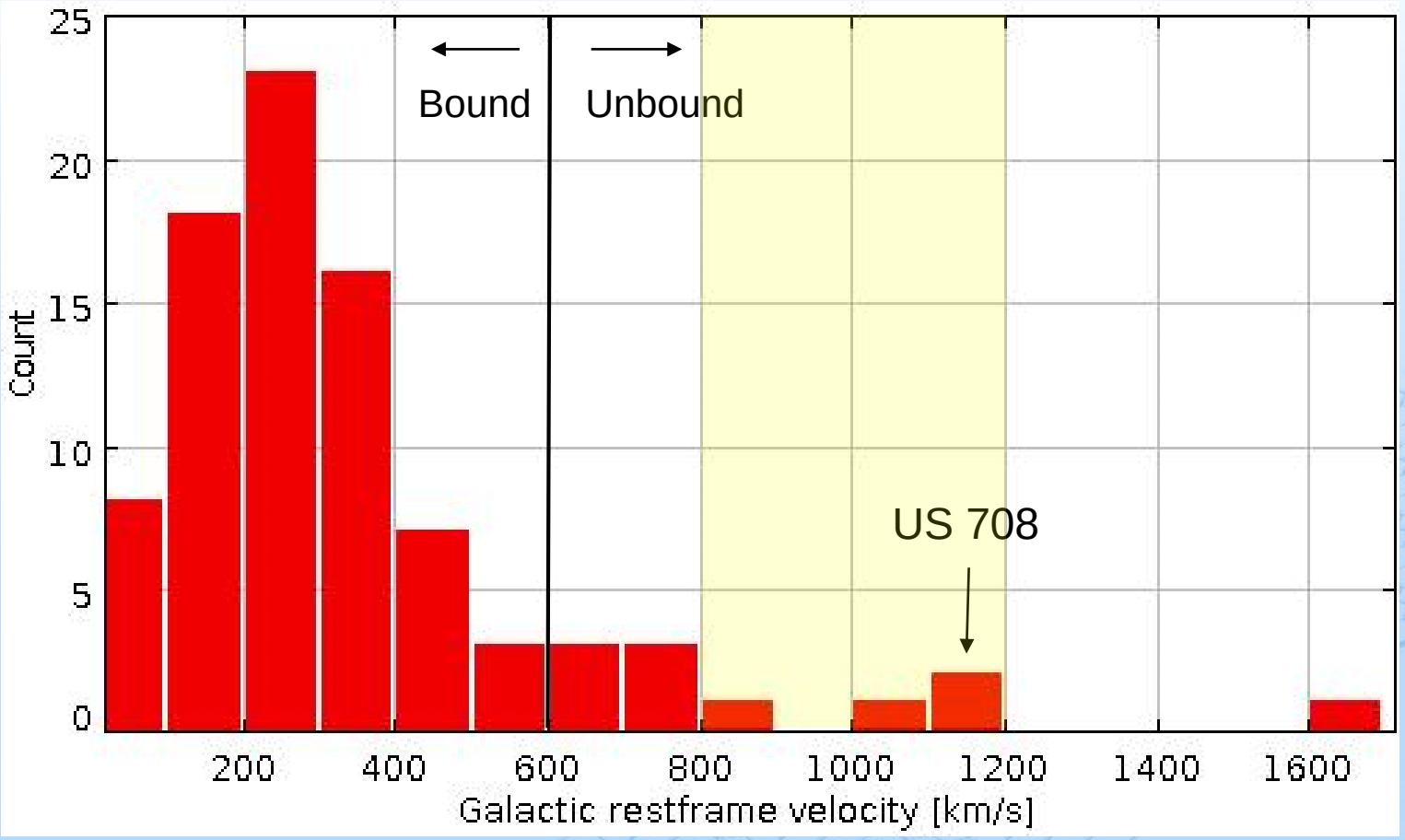
Ejected remnant properties



86 sdOBs (MUCHFUSS) + Proper Motions from PPMXL

High velocity selection (preliminary)

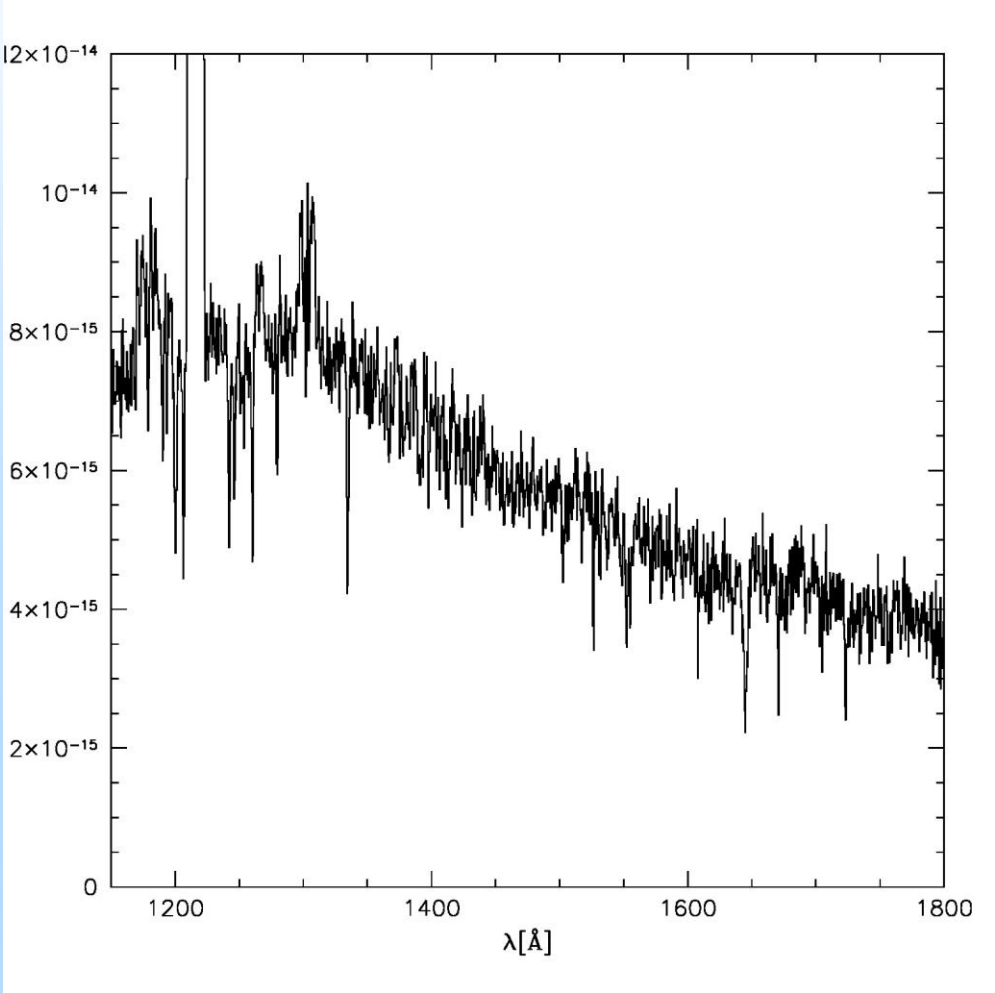
Ejected remnant properties



86 sdOBs (MUCHFUSS) + Proper Motions from PPMXL

Follow-up: XSHOOTER, ISIS, TWIN, Goodman, DBSP

Searching for supernova material



Analysis of HST/COS UV-spectra of US 708

(PhD project M. Schindewolf)

Companions in SN Ia remnants?

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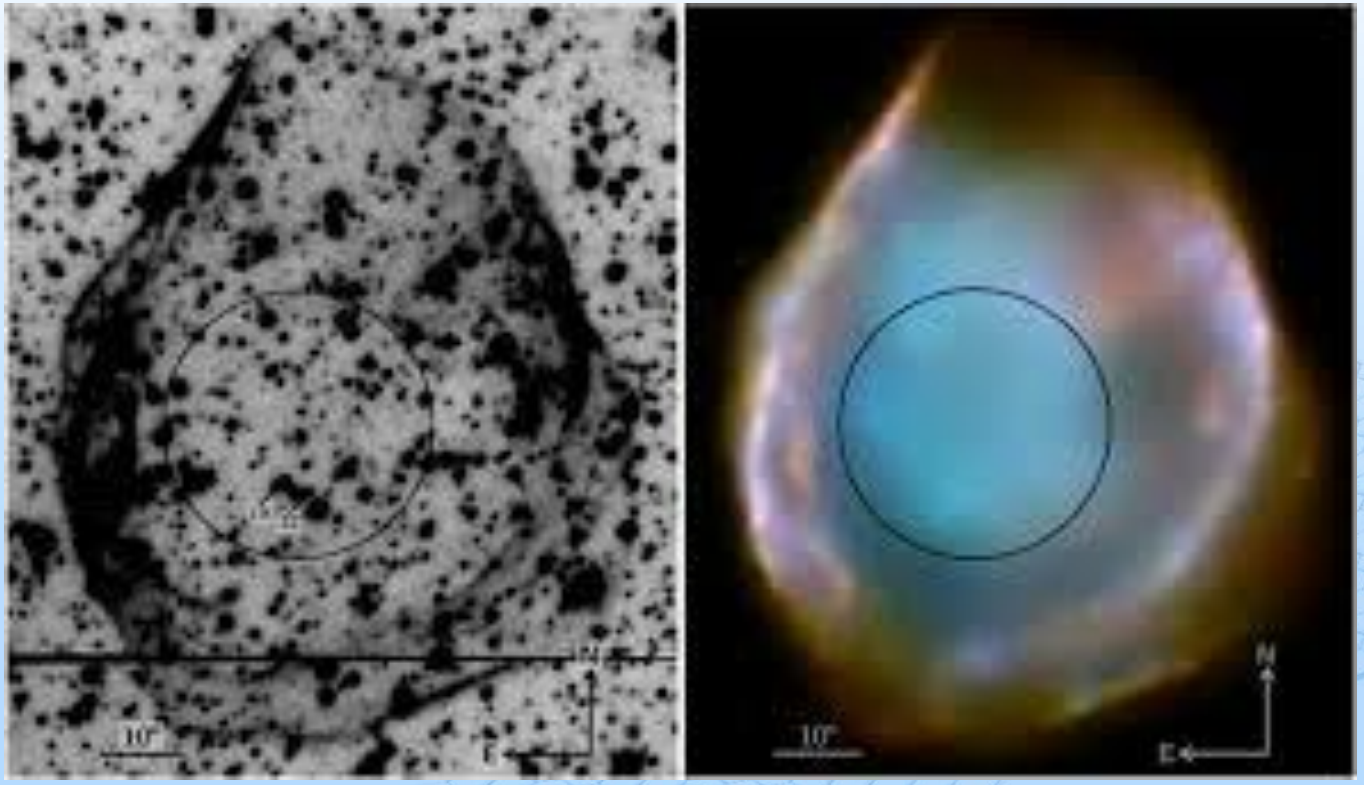
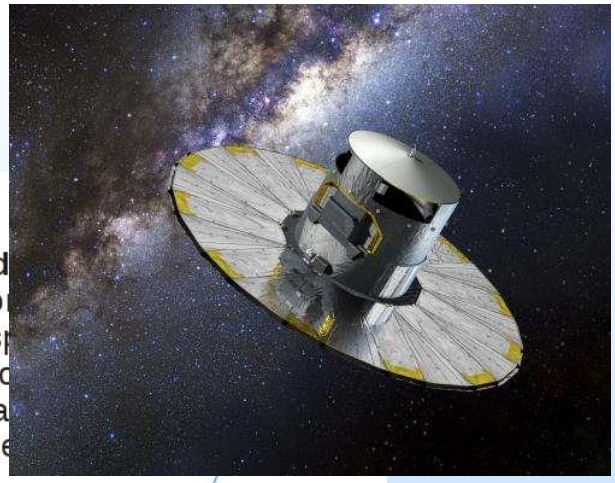
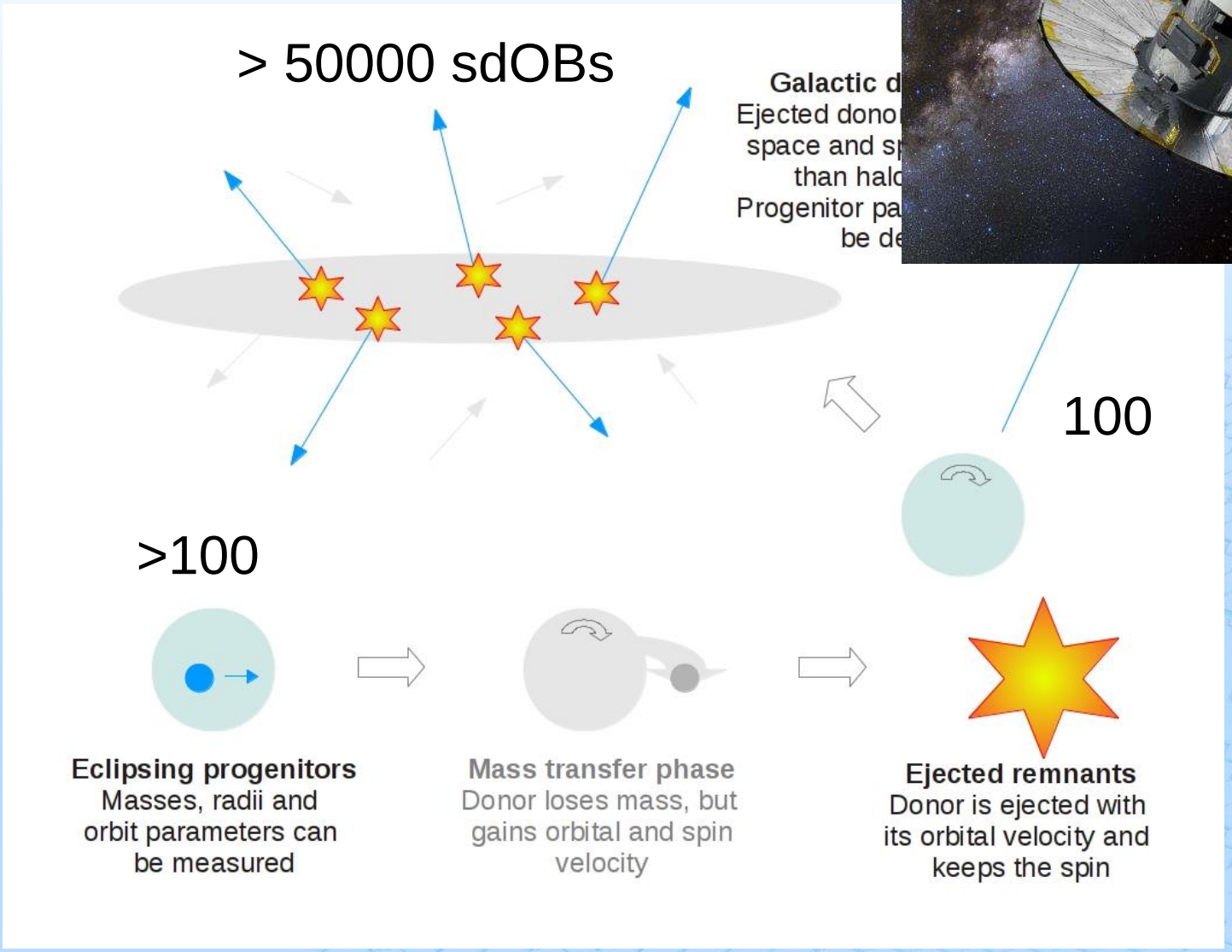


(Pagnotta & Schaefer 2015, ApJ, 799, 1)

MUSE observations of two remnants in the LMC granted
(Collaboration with B. Leibundgut, W. Kerzendorf et al.)

Testing the scenario with Gaia





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