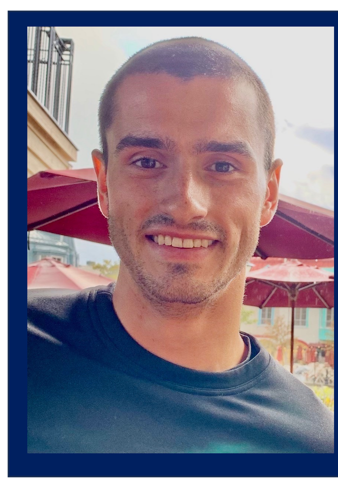
An envelope lost in transport:
Binary stripped helium stars as probes of mass transfer

Alex Laroche (alex.laroche@mail.utoronto.ca), Maria Drout, Bethany Ludwig (University of Toronto), Ylva Götberg (Carnegie Observatories)

University of Toronto



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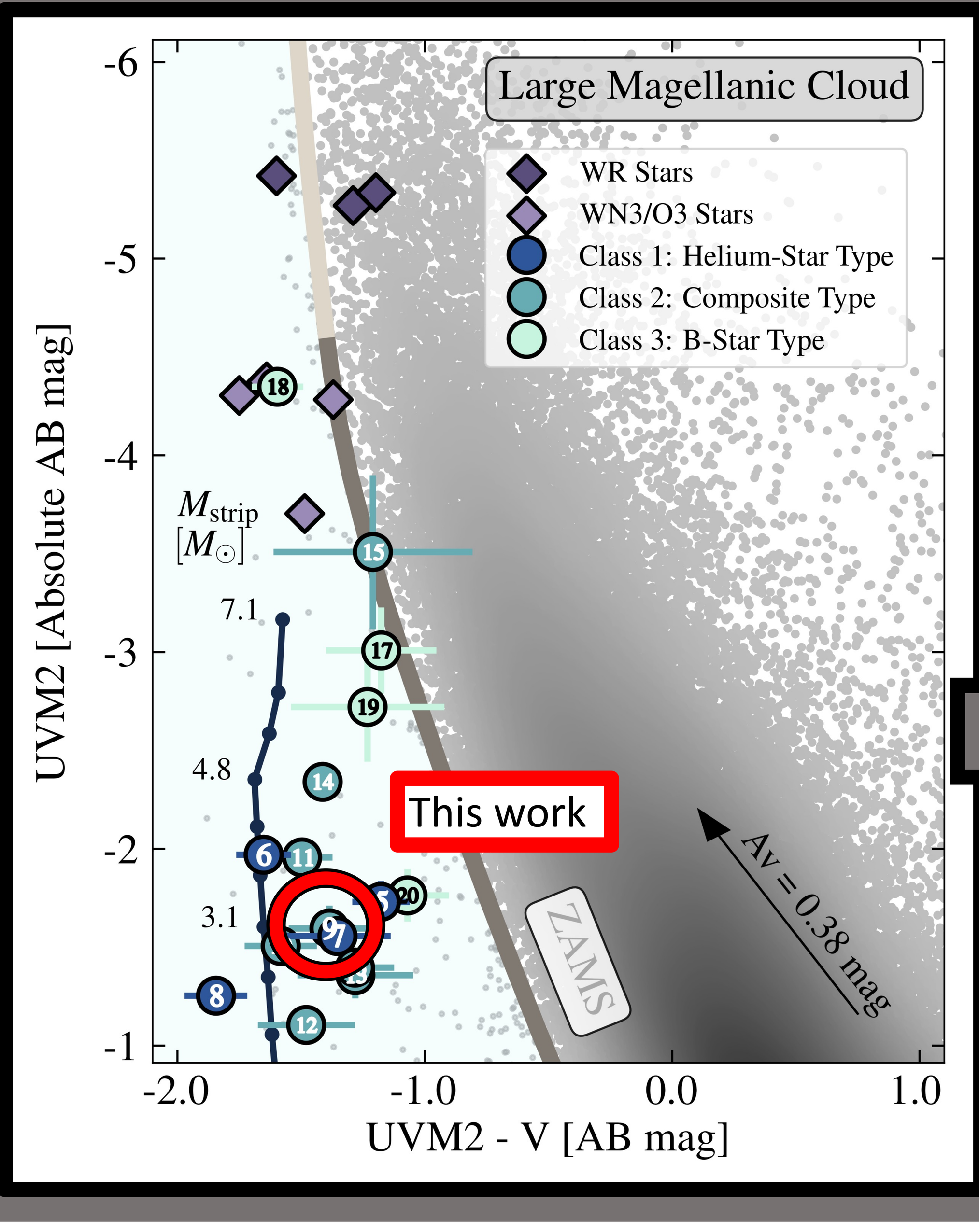
Discovery of binary stripped stars in the Magellanic Clouds

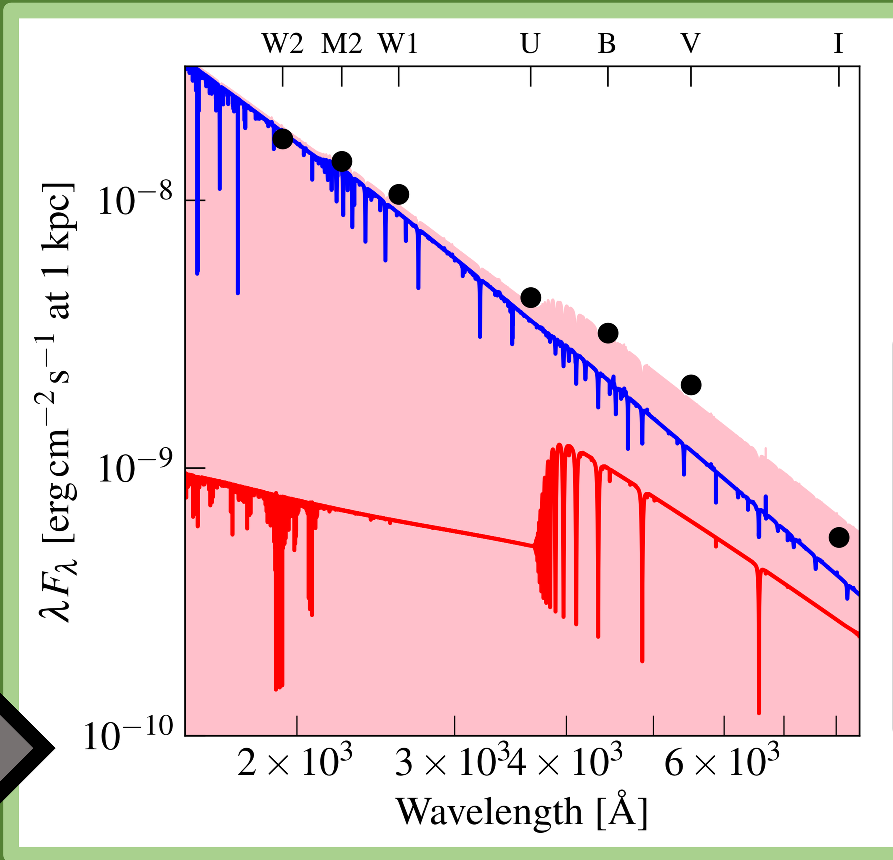
Drout, Götberg et al. (2023) recently discovered a set of stripped helium stars that fill the mass gap between subdwarfs and Wolf-Rayet stars, by identifying stars with UV excess. In these systems, a star with initial mass $\sim 8-25\,M_\odot$ sheds its hydrogen envelope via binary interaction, revealing a helium star with a current mass $\sim 2-8\,M_\odot$. Here, we examine one of the 'composite-type' systems (Star 9) to investigate:



What can stripped stars tell us about binary mass transfer?

- Stable mass transfer?
- Common envelope ejection?
- Mass transfer efficiency?
- Critical mass ratio?

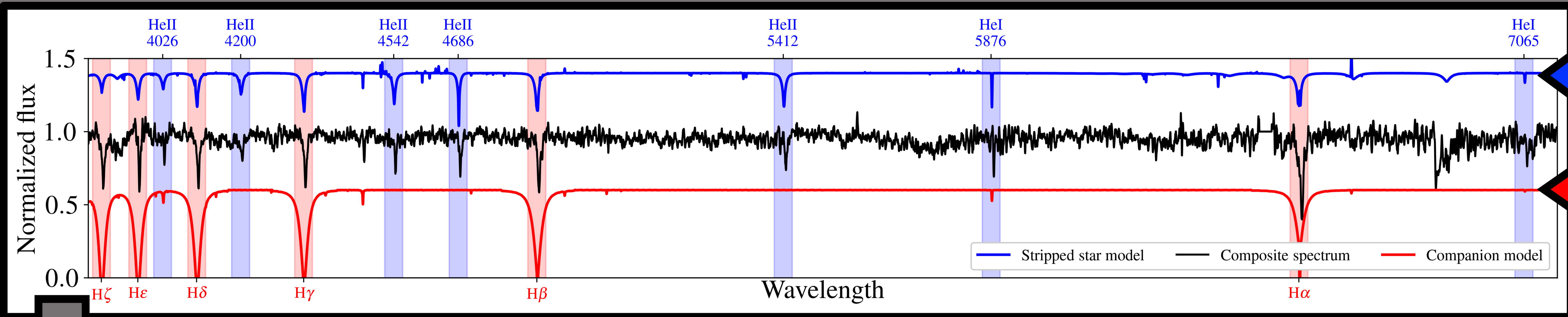
Photometric estimates



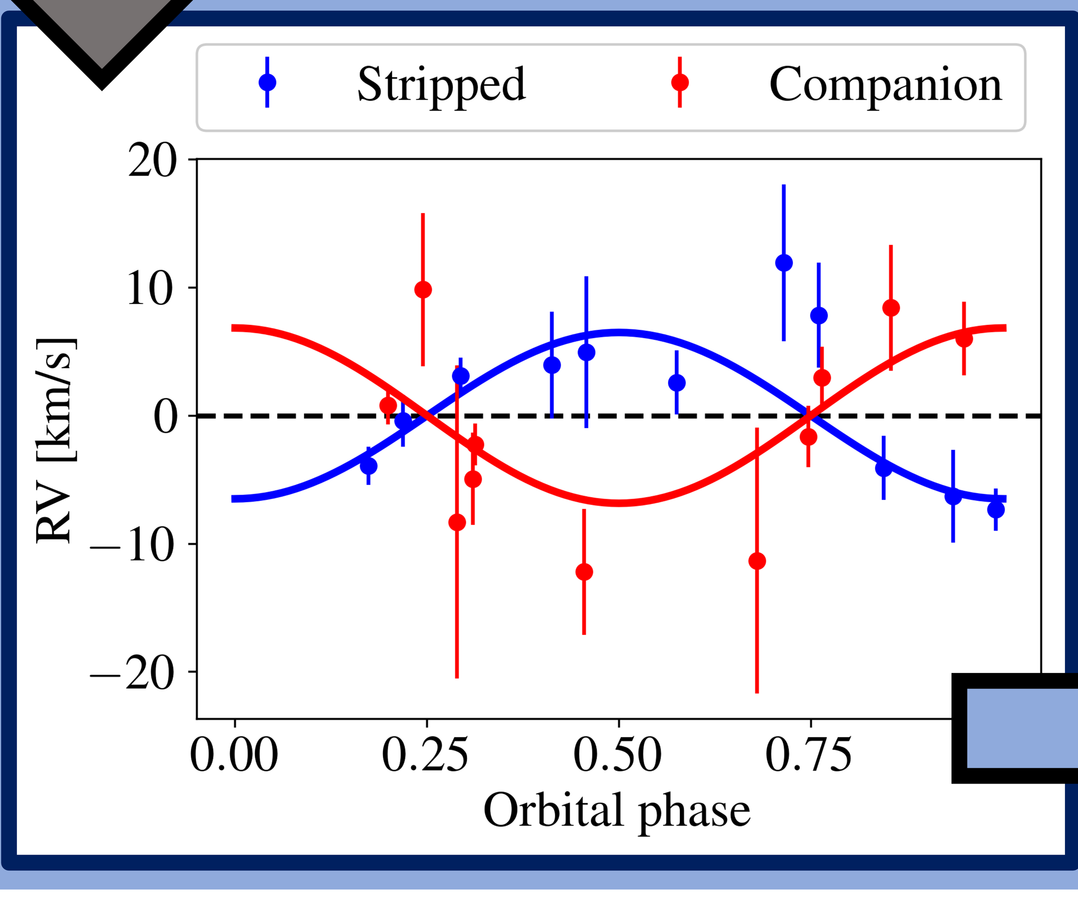
The stripped star contributes more than 90% of the flux in the ultra-violet.

Star 9 showed clear signatures of both a hot star and a B-type MS companion (see below). Fitting the UV-optical spectral energy distribution, we find a best fit with a 2.34 $M_\odot$ stripped star and a 2.44 $M_\odot$ MS star.

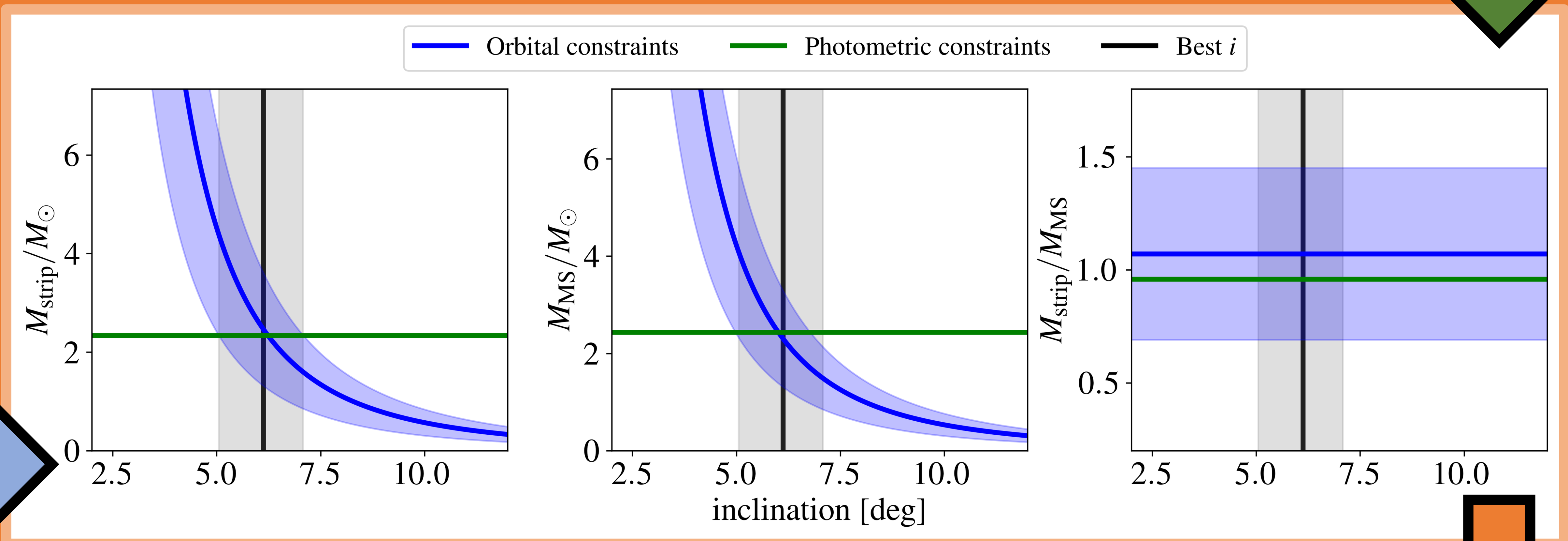
Double-Lined Spectroscopic Binary: Stripped Star + MS Companion



RV fitting reveals a ~23 day orbit with low semi-amplitudes ($K_1 = 6.5$ km/s, $K_2 = 6.9$ km/s)

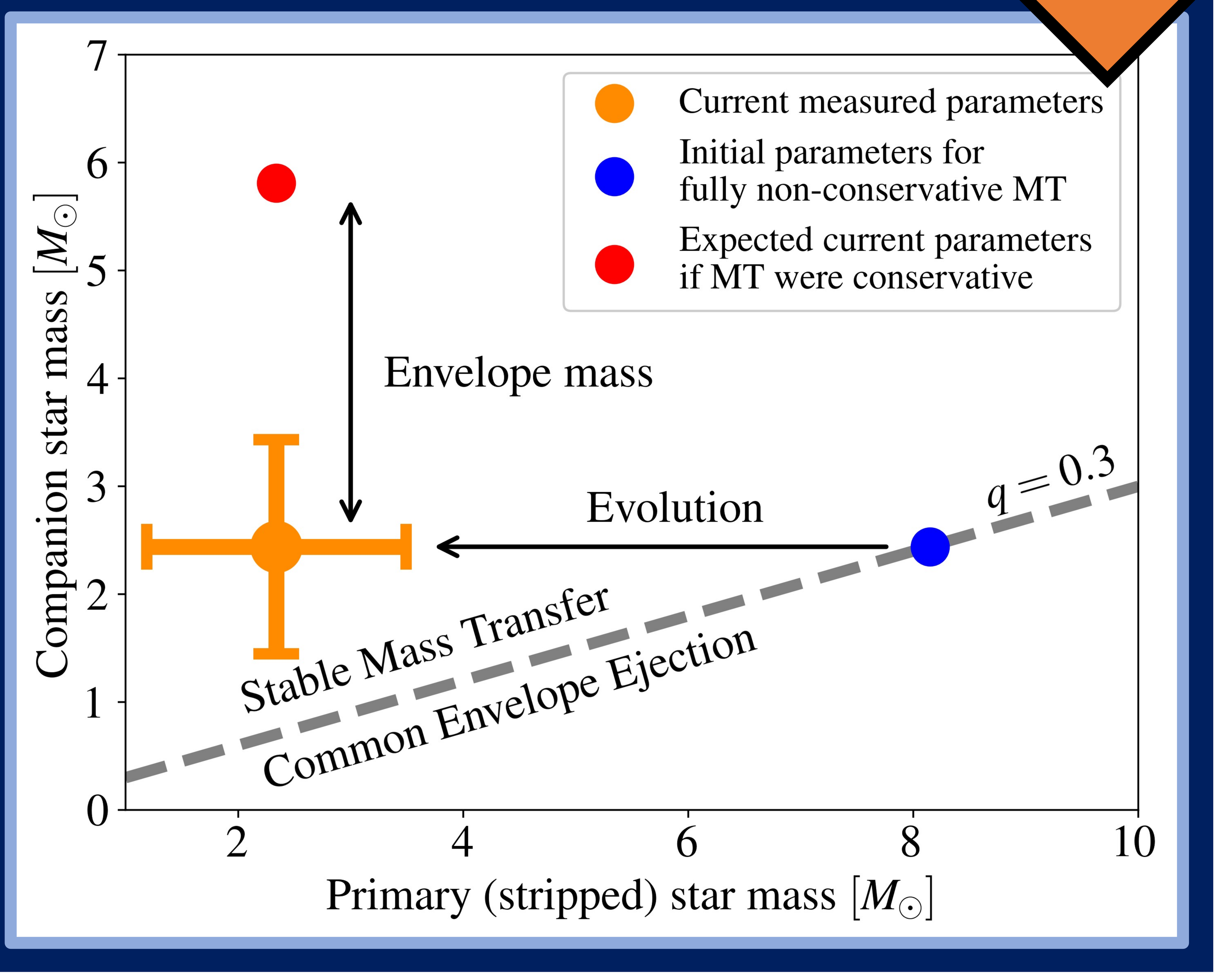


Orbital constraints confirm a current mass ratio of ~1. Masses of individual components agree with photometric estimates for low inclination angles.



Non-conservative mass transfer while straddling the critical mass ratio

Based on SED and orbital fitting, we find that Star 9 is an SB2 likely composed of a helium star with $M_{1,strip} = 2.3\,M_\odot$ and a MS companion with $M_{2,current} = 2.4\,M_\odot$. The evolutionary models of *Götberg et al. (2018)* indicate that the stripped star had an initial mass $M_{1,init} = 8.2\,M_\odot$, losing $\sim 6\,M_\odot$ through binary interaction. Given the massive envelope and the relatively light companion, the system must have undergone **very non-conservative mass transfer**. Indeed, we see evidence of asymmetric outflow around the system in the 2D spectra (see below). Interestingly, for fully non-conservative mass transfer, **the inferred initial mass ratio intersects the critical mass ratio** ($q = 0.3$), which is thought to be the boundary between stable and unstable mass transfer.



Conclusion

SB2 stripped stars are sensitive probes of mass transfer. In particular, the **boundary between stable mass transfer and common envelope ejection** can be tested with such systems. Combining future spectroscopic constraints with current orbital constraints, and repeating our analysis for analogous SB2s, will provide a **vital benchmark for binary evolution codes**.

Asymmetric ejection?