

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

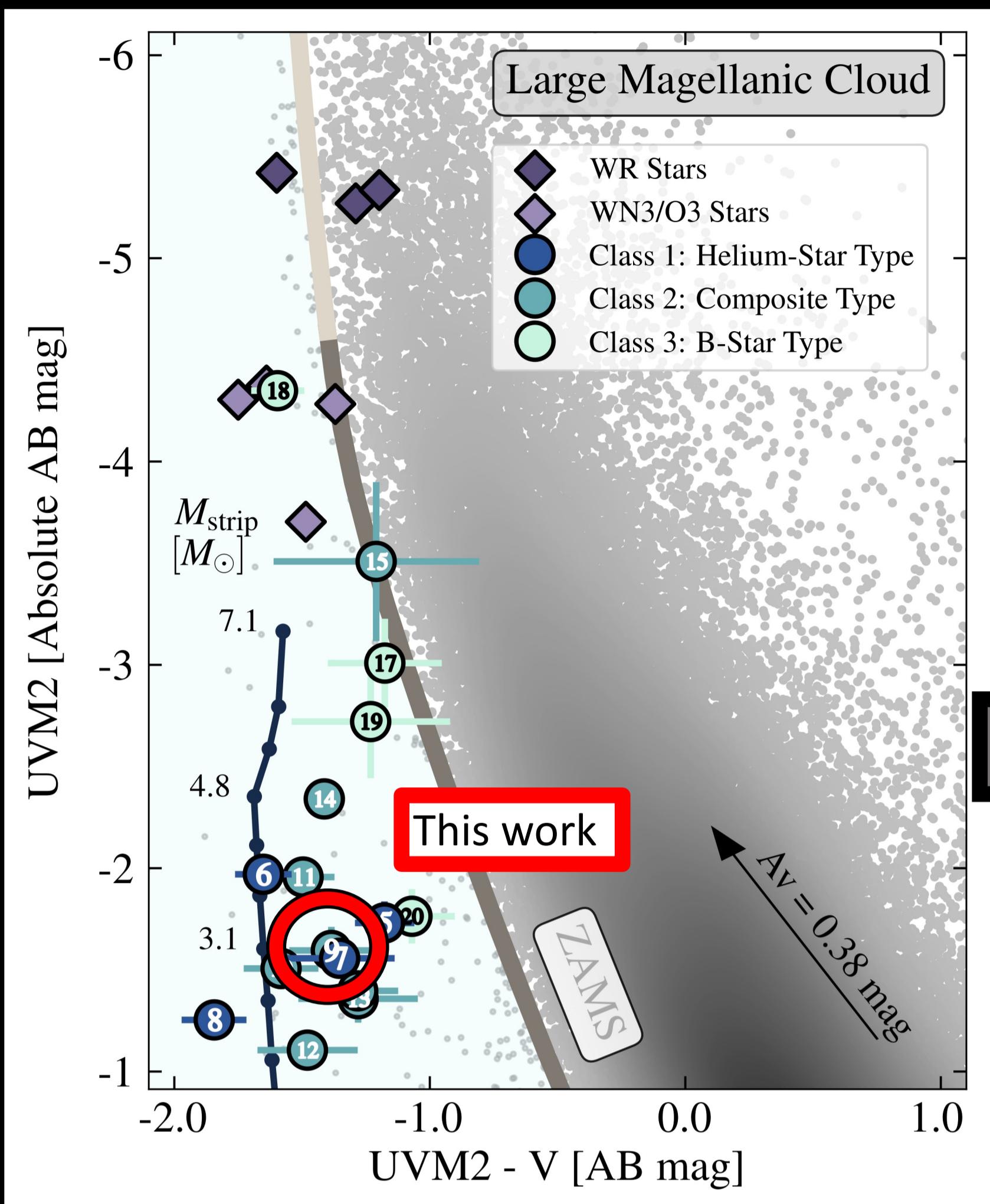
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Discovery of binary stripped stars in the Magellanic Clouds

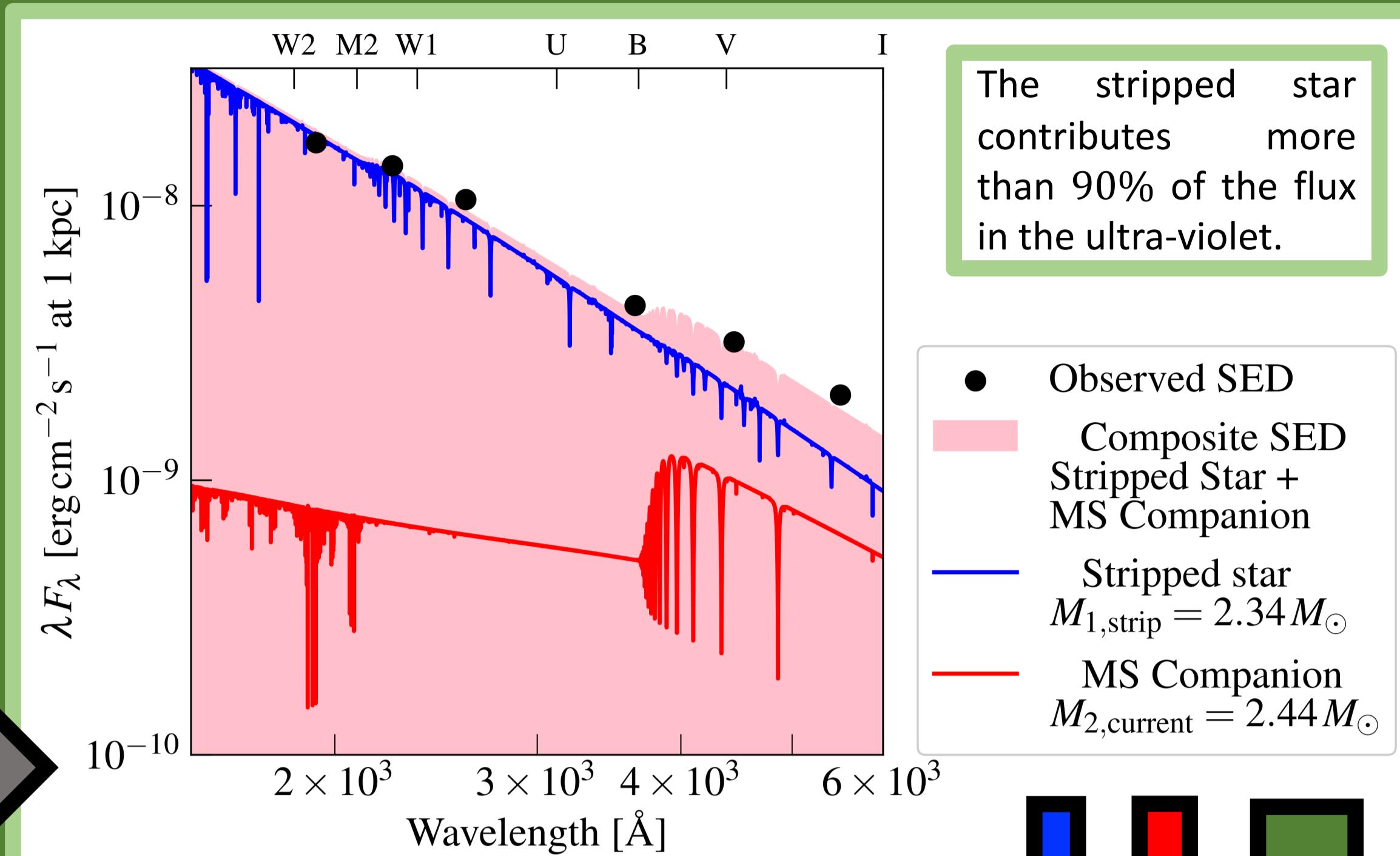
Drout, Götberg et al. (2023) recently discovered a set of stripped helium stars that fill the mass gap between subdwarfs and Wolf-Rayet stars, by identifying stars with UV excess. In these systems, a star with initial mass $\sim 8 - 25 M_{\odot}$ sheds its hydrogen envelope via binary interaction, revealing 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?

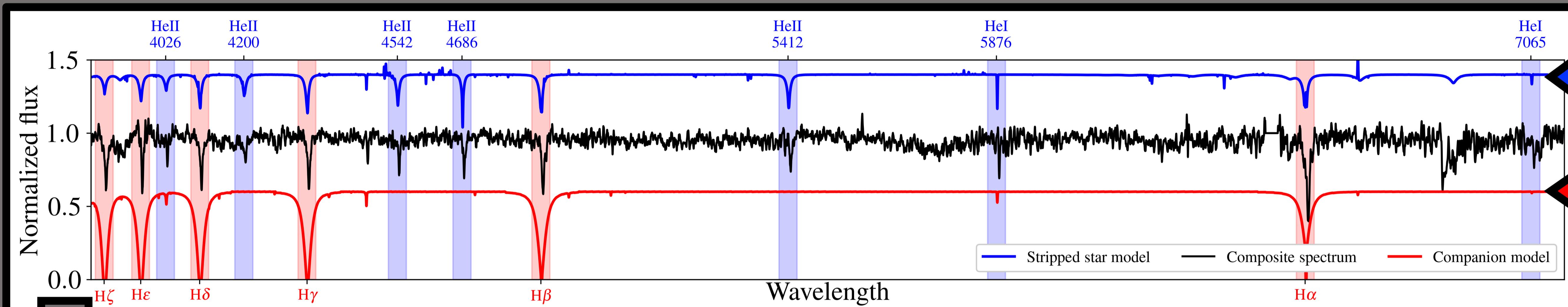


Photometric estimates



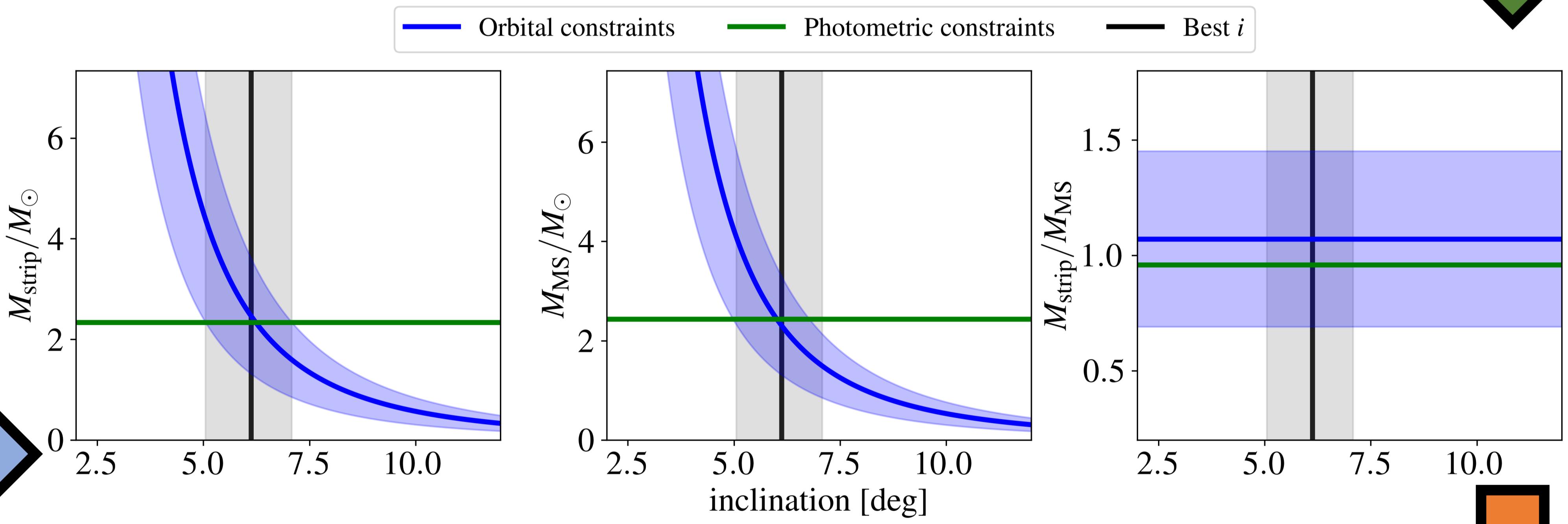
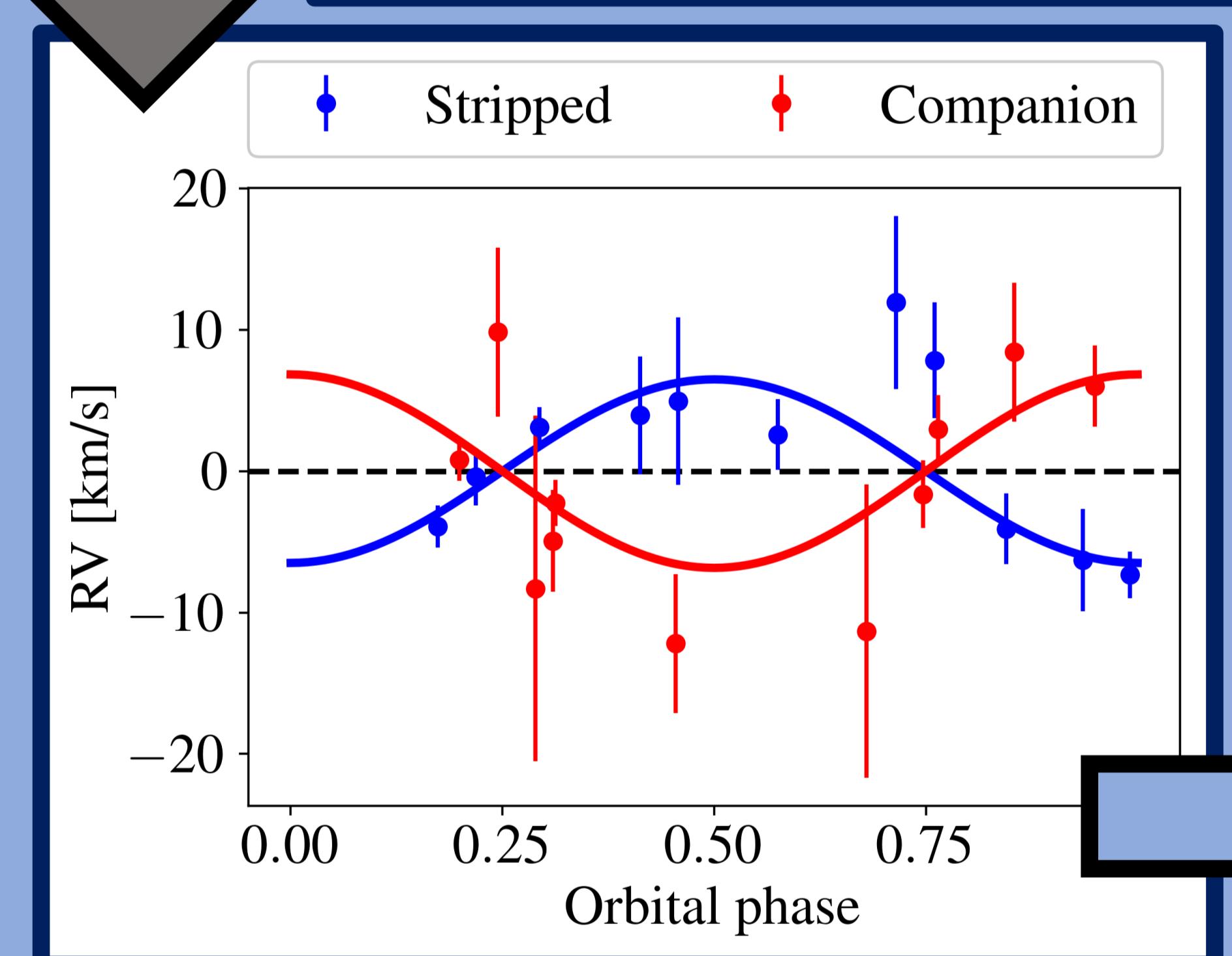
Star 9 showed clear signatures of both a hot star and a B-type MS companion (see below). Fitting the UV-optical spectral energy distribution, we find a best fit with a $2.34 M_{\odot}$ stripped star and a $2.44 M_{\odot}$ MS star.

Double-Lined Spectroscopic Binary: Stripped Star + MS Companion



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

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 $M_{1,\text{strip}} = 2.3 M_{\odot}$ and a MS companion with $M_{2,\text{current}} = 2.4 M_{\odot}$. The evolutionary models of Götberg et al. (2018) indicate that the stripped star had an initial mass $M_{1,\text{init}} = 8.2 M_{\odot}$, 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 aligns exactly with $q = 0.3$.

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?

