Massive Stars Near and Far
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Constraining the dynamical mass of the massive binary 9 Sagittarii

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Abstract. Especially in the upper Hertzsprung-Russell diagram, where stellar physics is least understood, obtaining model independent masses is of great value. Spectroscopic binaries that are also resolved astrometrically are an excellent alternative to eclipsing double-lined spectroscopic binaries where dynamical masses can be measured. 9 Sgr is such a massive binary. However, its characterization is troubled by conflicting conclusions from the spectroscopic analysis on the one hand and the interferometric one on the other hand. In this work, we attempt to resolve this tension by applying a novel approach to spectral disentangling of the spectroscopic data to constrain better the mass of 9 Sgr.

Keywords. stars: early-type, stars: binaries, stars: fundamental parameters

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1. Introduction

9 Sgr (HD 164794) is a long-period ($P \approx 9\,\mathrm{yr}$) double-lined spectroscopic binary in the Lagoon nebula. From both the radio synchrotron emission (Abbott et al. 1984) and elevated X-ray emission Rauw et al. (2002a,b); Nazé et al. (2008), it was determined this system contains two massive star components, the winds of which collide and create non-thermal radiation(Pittard & Dougherty 2006; Rauw et al. 2002c; Sana et al. 2004, 2006; Rauw & Nazé 2016). Rauw et al. (2012) determined the first spectroscopic orbit of 9 Sgr and showed that, if the stars are assumed to have masses of similar to their inferred spectral type, the inclination of 9 Sgr should be around 45 degrees. This was later challenged by the interferometric analysis of Le Bouquin et al. (2017), who derived an inclination of 85 degrees, with tight bounds.

In our work (Fabry et al. 2021), we attempt to resolve the existing tension on the mass of 9 Sgr, using the fact that spectral disentangling can reveal whether the radial velocity (RV) semi-amplitudes of Rauw et al. (2012) are representative of the true RV curves.

2. Methods

We rederive the geometrical orbit using archival and new interferometry from PIONIER (Le Bouquin et al. 2011) and GRAVITY (Gravity Collaboration et al. 2017). Similar to Le Bouquin et al. (2017), we find a very high orbital inclination of 86.5 ± 0.5 degrees. Next, we use the technique of spectral disentangling (Simon et al. 1994; Hadrava 1995) to determine the RV semi-amplitudes of the binary, using the Fourier disentangling code from Ilijić (2017). We take a grid-disentangling approach, in which we fix most of the orbital parameters to the ones found from the interferometric analysis, leaving only the semi-amplitudes K_1 and K_2 free. Our method constrains $(K_1, K_2) = (36, 49)$ km s^{-1}, which is significantly different than the values $(K_1, K_2) = (25, 38)$ km s^{-1} of Rauw et al. (2012, 2016). With these RV semi-amplitudes, the dynamical masses inferred are $53^{+7}_{-6} M_\odot$ and $39^{+6}_{-3} M_\odot$ for the primary and secondary respectively, in accordance with their updated spectral type: O3V and O5V.

Subsequent atmospheric analysis with FASTWIND (Santolaya-Rey et al. 1997) and evolutionary modeling by comparing with the stellar evolution tracks of Brott et al. (2011) through BONNSAI (Schneider et al. 2014) shows the components of 9 Sgr are most likely coeval at about 1 Myr and have temperatures and mass loss rates typical for their dynamical mass. This is with the caveat of poorly constrained surface gravities, which is most likely a result of the repeated normalization: first when reducing the raw spectroscopic data and second after the disentangling procedure, which leaves the continuum undetermined.

3. Conclusions

In our work (Fabry et al. 2021), we resolved the tension present in the literature concerning the dynamical mass of the massive binary 9 Sgr. As one of the most massive galactic binaries whose mass is determined model independently, 9 Sgr serves as an important cornerstone when calibrating stellar models in the upper HRD.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S174392132200206X.

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