Estimating mass-loss rate in low-mass, evolved eclipsing binaries

Oliwia Ziółkowska · Ksenia Suchomska · Cezary Gałan · Radosław Smolec

[1]Nicolaus Copernicus Astronomical Center, Warsaw

Reimers' mass-loss efficiency

When a star is evolving across the RGB, it loses its mass due to winds which can be described by Reimers' formula (1), where η is a free parameter. Asteroseismic observations (Miglio et al. 2012) of G-K giants from old globular clusters constrain their mass-loss efficiency in the broad range of $0.1 \leq \eta \leq 0.3$.

$$\dot{M}_R = 4 \cdot 10^{-13} \cdot \eta \cdot \frac{LR}{M} \quad (1)$$

In the case of low-mass, post-main sequence stars it turns out that the efficiency of mass-loss significantly changes the shape of isochrones in the mass - luminosity and the mass - temperature dimension. This in turn affects the determination of age.

Isochrone fitting

We fit PARSEC isochrones (Bressan et al. 2012) to two low-mass eclipsing binaries in the Galactic Bulge - OGLE-BLG-305487 and OGLE-BLG-116218. We use χ^2 minimisation with effective temperature, radius and mass (from Suchomska et al. 2021, in preparation) as observables to find the best age and metallicity from our grid. We repeat this process for different values of η.

Results

For each system we present our best isochrone on an H-R diagram (Fig. 1,3) and two mass diagrams (Fig. 2,4). The isochrones on the mass diagrams form three distinct branches: RGB ascend, descend after helium ignition in the core and the AGB ascend, from right to left. The primary component is marked with a blue square and secondary with a red circle. In both cases a non-zero mass-loss is necessary to fit the mass of both stars to a single isochrone.

References

Bressan A., Marigo P., Girardi L., Salasnich B., Dal Cero C., Rubele S., Nanni A., 2012, MNRAS, 427, 127. doi:10.1111/j.1365-2966.2012.21948.x

Miglio A., Brogaard K., Stello D., Chaplin W. J., D'Antona F., Montalbán J., Basu S., et al., 2012, MNRAS, 419, 2077. doi:10.1111/j.1365-2966.2011.19859.x

Acknowledgements

This research is supported by the National Science Center, Poland, Sonata BIS project 2018/30/E/ST9/00598.

OGLE-BLG-305487

For this systems we achieved three solutions of similar quality with ages $7.32 - 10\mathrm{Gyr}$ and with the metallicity within $1-\sigma$ from the spectroscopic value. The primary (blue) component is at the stage of core helium burning, while the secondary (red) is on the RGB. Here we present the solution with the lowest χ^2.

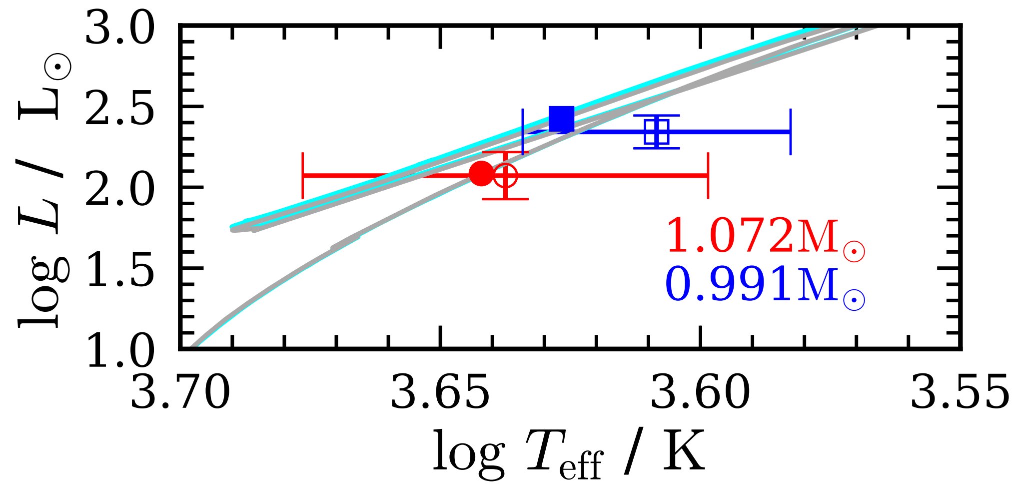

Figure 1: Best solution for OGLE-BLG-305487 with metallicity $[\mathbf{Fe/H}] = -0.3$, age $\mathbf{log}t = 9.8651$ and $\chi^2 = 3.2$.

In Fig. 2 it is visible that the isochrone with no mass-loss (cyan line) is not able to fit both stars simultaneously. A value of $\eta = 0.2$ is sufficient to find a good solution.

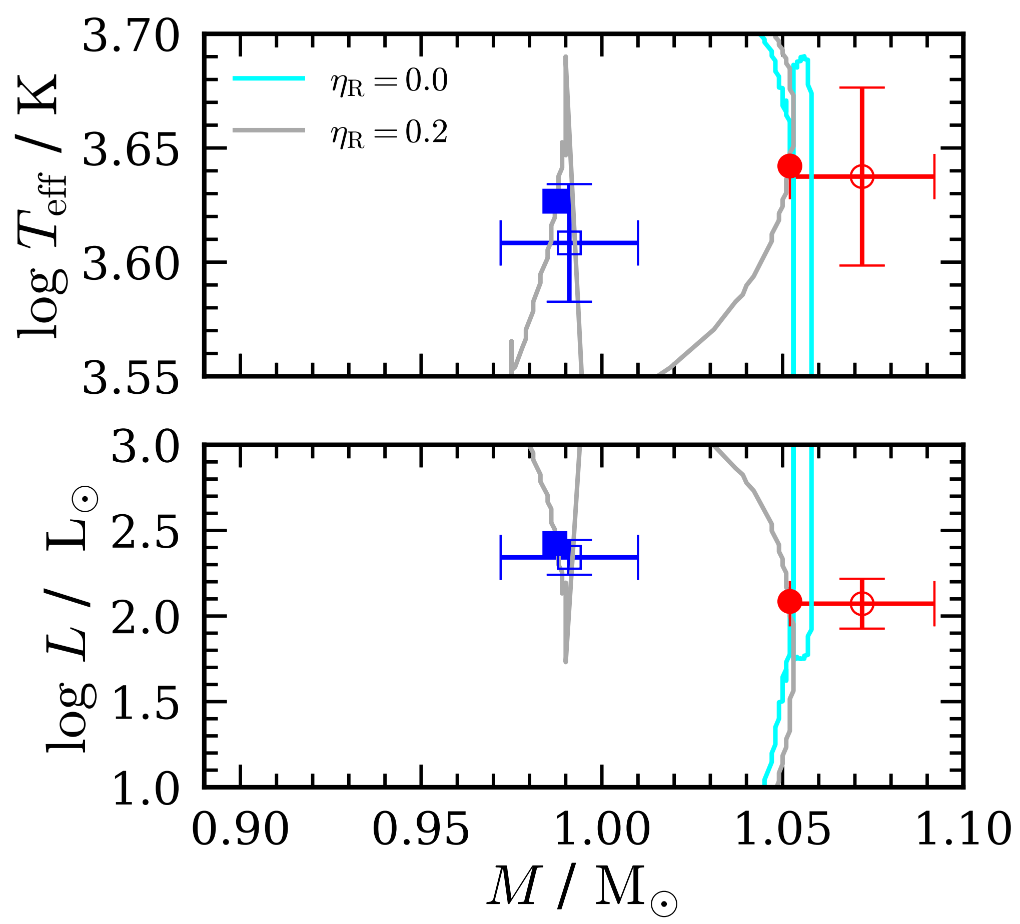

Figure 2: The same as Fig. 1, but as a function of mass.

OGLE-BLG-116218

The only good solution, with age $\sim 10\mathrm{Gyr}$, is found for a metallicity that is $2-\sigma$ away from the spectroscopic value. The primary star is ascending the RGB and the secondary is burning helium in the core. When the metallicity is kept within $1-\sigma$ error, the isochrones predict that the stars should, in fact, be $\sim 500\mathrm{K}$ hotter.

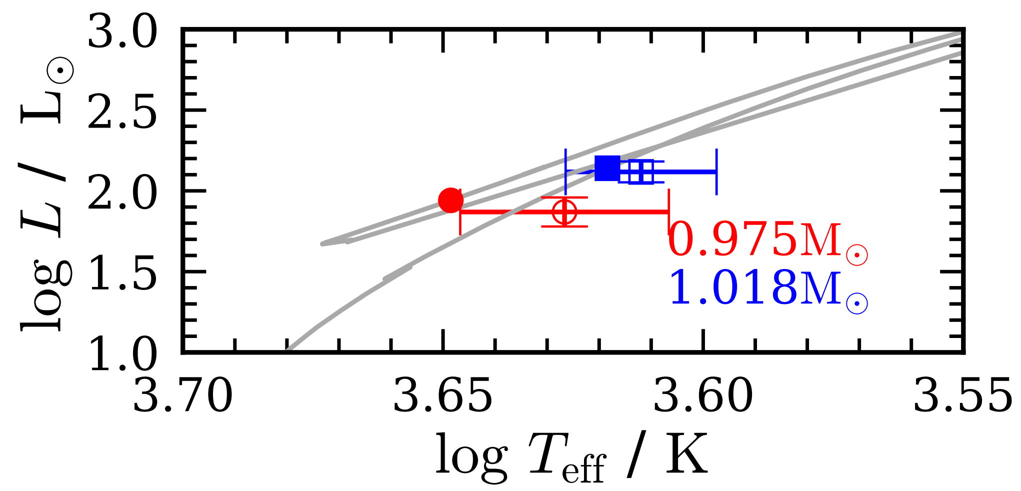

Figure 3: Best solution for OGLE-BLG-112216 with metallicity $[\mathbf{Fe/H}] = 0.0$, age $\mathbf{log}t = 10.003$ and $\chi^2 = 4.42$.

Fig. 4 shows how the mass-loss efficiency affects the shape of the isochrones. The smaller the mass difference, the smaller mass-loss rate is needed to fit both stars on a single isochrone. Here, in particular, the isochrone fitting gives limits to mass-loss rate, mainly $\eta \leq 0.15$.

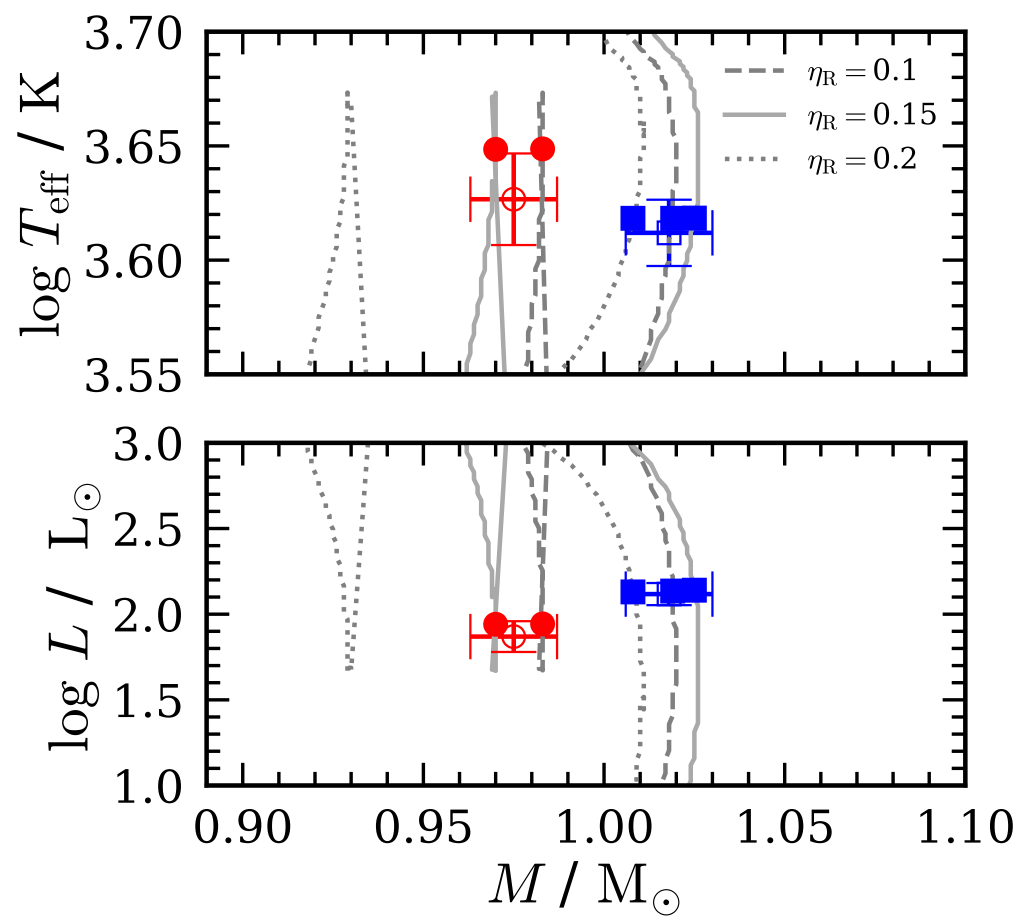

Figure 4: The same as Fig. 3, but as a function of mass. Additionally, two isochrones with different mass-loss efficiencies are shown.