Different recipes for the mass-loss rates of O and B stars

J. A. Panei[1,2], F. Figueroa-Tapia[3], M. Curé[3,4], I. Araya[5], L. S. Cidale[1,2], R. O. J. Venero[1,2], and A. C. Gormaz-Matamala[3,6,7]

Abstract

We study the mass-loss rates of the winds for O and B spectral types. We analyze the different mass-loss rate recipes given by de Jager et al. (1988), Vink et al. (2000, 2001, 2021), Krticka & Kubat (2012) for O stars, Krticka (2014) for B stars, Gormaz et al. (2019), Gormaz et al. (2022), and our new mass-loss law (Figueroa-Tapia 2024 in preparation). For this purpose, we calculate, with our stellar evolution code, the Influence of these different recipes on the evolutionary tracks of these spectral types.

The evolutionary code

In this work we perform a comparative study between different mass-loss laws affecting main-sequence O and B stars. To this end, we incorporate different mass-loss rate laws into the stellar evolution code developed entirely in the city of La Plata (Benvenuto, 1988; description of the physics included Panei, et al. 2007). This stellar evolution code has a hydrostatic scheme for solving the stellar structure equations. The resolution scheme is a Henyey-type scheme. The code uses the OPAL opacities (Iglesias & Rogers, 1996) which take into account carbon- and oxygen-rich compositions. The equation of state for low densities takes into account partial ionisation for H and He, radiation pressure and ionic contribution. In the high density regime, partial degenerate electron pressure and Coulomb interactions are taken into account. For high densities the equation of state of Magni & Mazzitelli (1979) is used. The convection theory used is that developed by Grossman, Narayan & Arnett (GNA) (Grossman et al. 1993; Grossman & Taam 1996), this theory is the known as the "Mixing-length Double Diffusive".

Mass loss rates

a) The mass loss rate law used is that proposed by de Jager (1988), which apply to a broad region of the Hertzsprung-Russell diagram (HRD), as shown in Fig. 1. (for metallicity Z=0.01524).
b) For OB stars, we use other laws as follows:

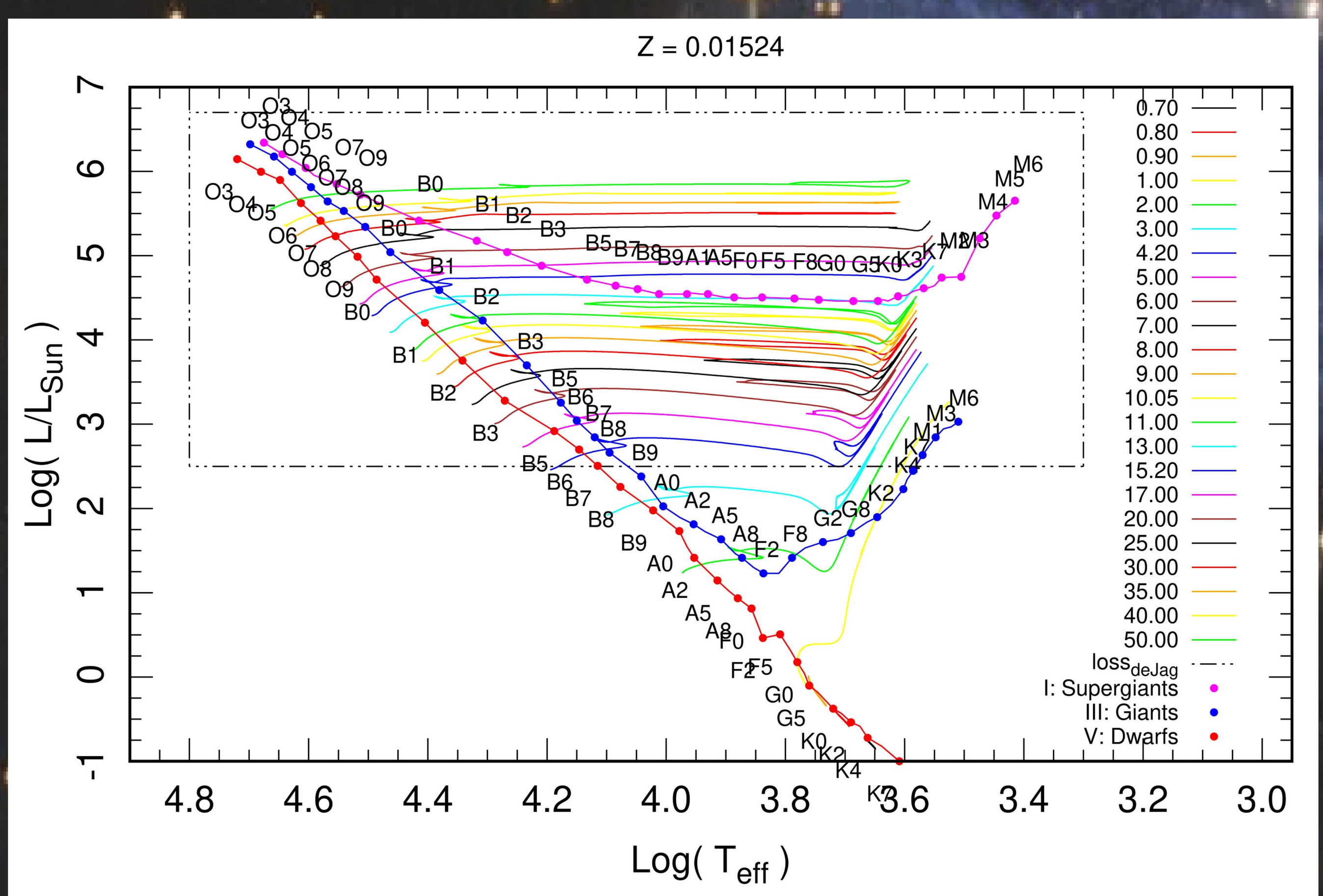

Figure 1: The figure shows the region of validity of the de Jager mass loss law.

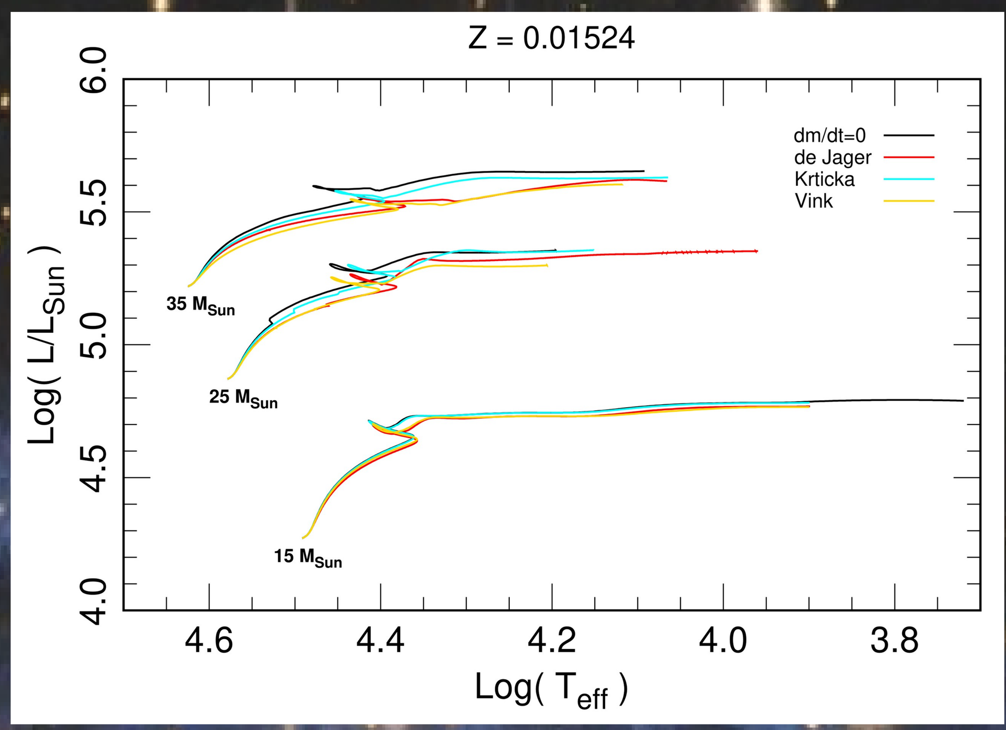

Figure 2: Part of sequences for 15, 25 and 35 M_{SUN} in HRD with different loss-mass rates.

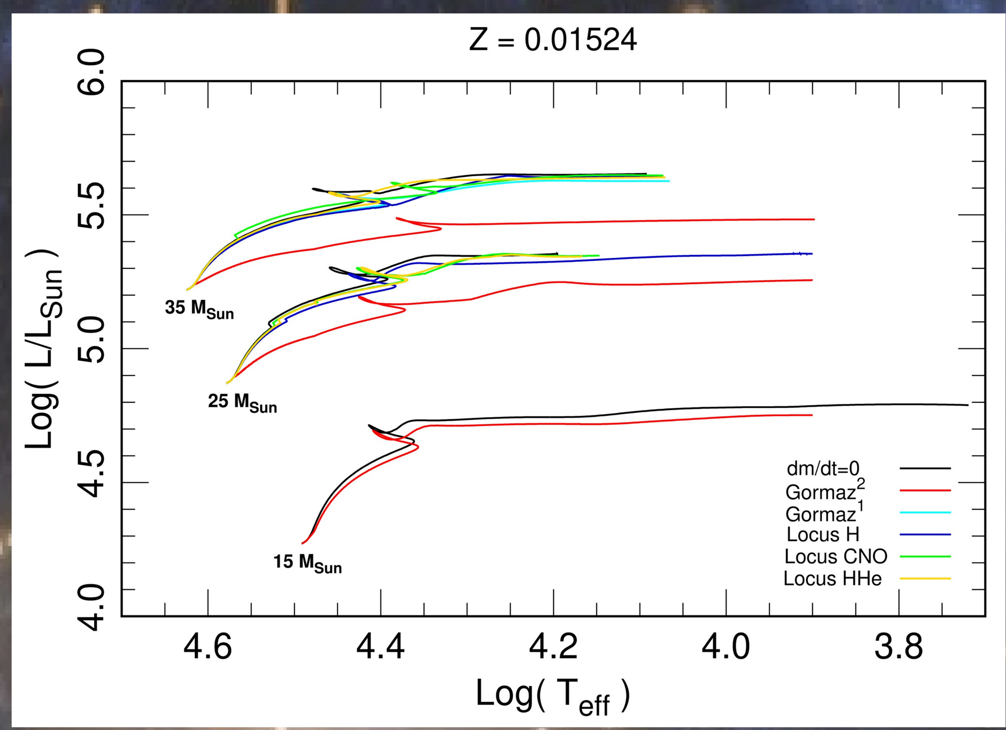

Figure 3: Idem Fig. 2 for other rates.

In Figs. 2 and 3, we depict part of sequences for stellar masses of 15, 25 and 35 M_{SUN}. We can observe how the mass loss rate affects the evolution of the star, depending on the chosen mass loss law. In following figures we depict the employed rates for the three models.

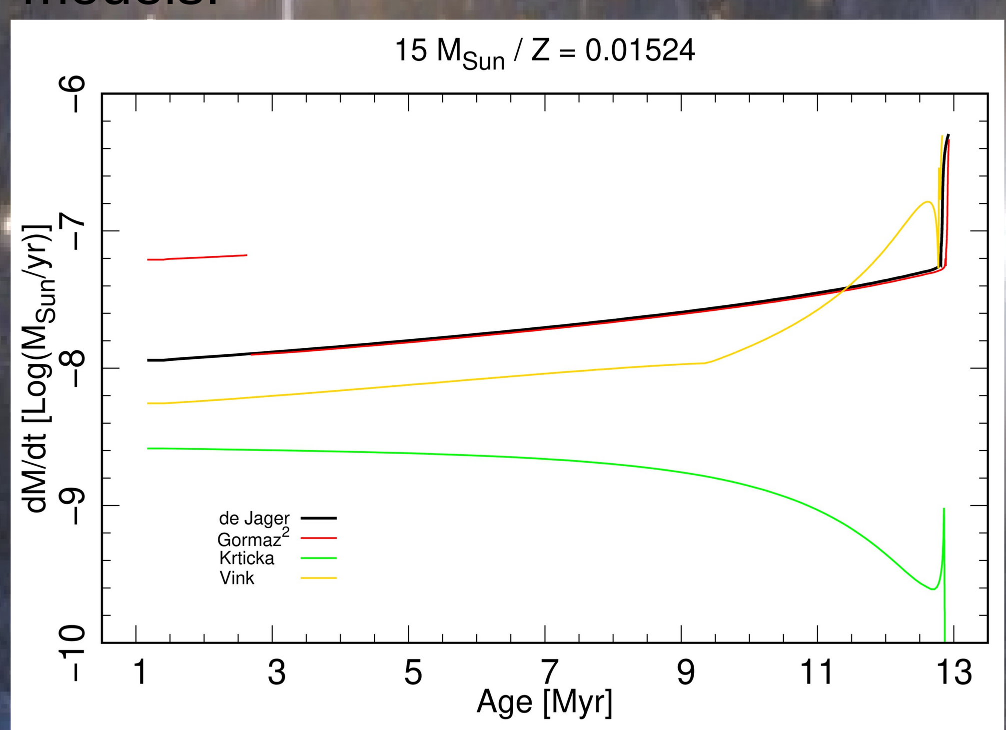

Figure 4: Mass loss rates for 15 M_{SUN} model.

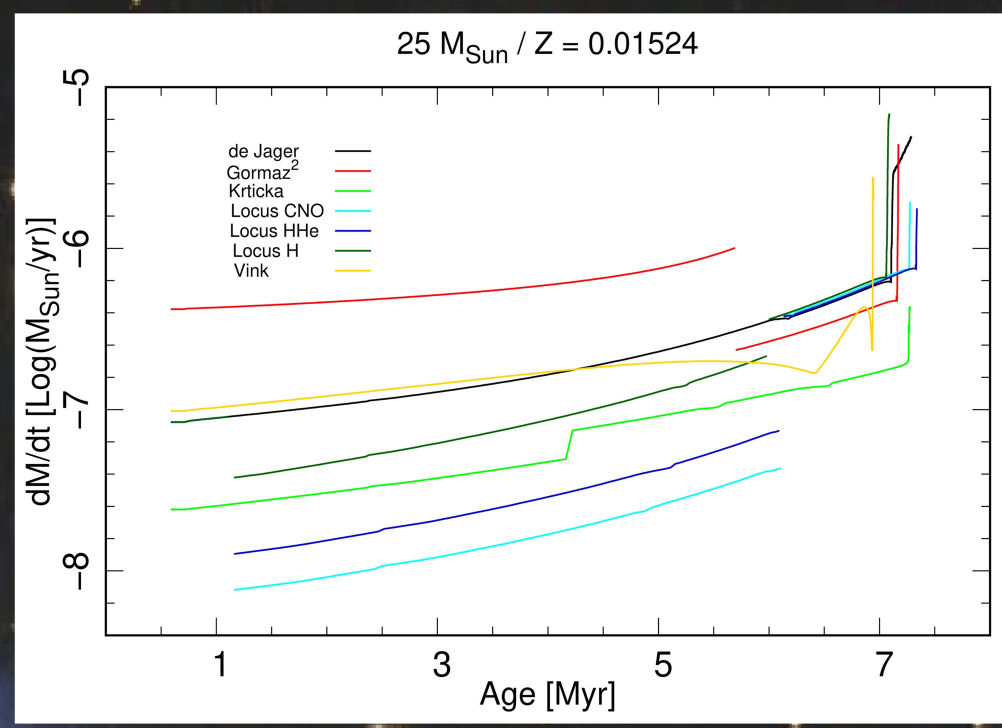

Figure 5: Idem Fig. 4, for 25 M_{SUN} model.

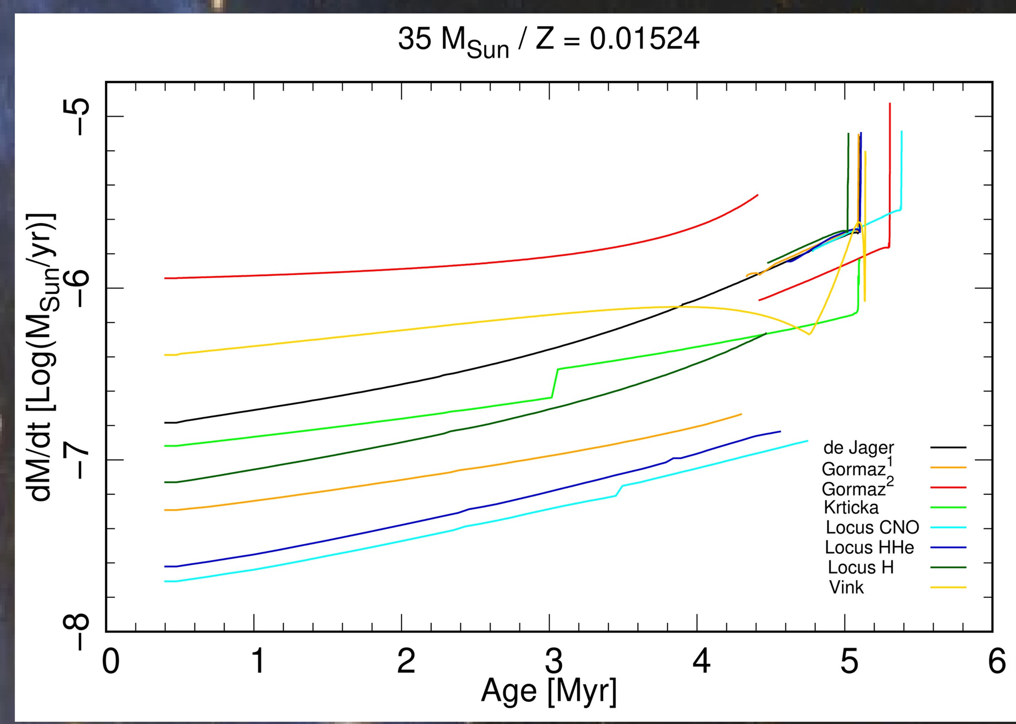

Figure 6: Idem Fig. 4, for 35 M_{SUN} model.

Conclusions

We can observe how important it is to choose an appropriate mass-loss rate when calculating stellar evolution models. The results show how sensitive the modelling of stars is to the chosen law for stellar wind. We are currently working on the calculation of useful expressions for the mass-loss rate. It will depend on surface gravity, stellar radius and effective temperature for different metallicities.

Bibliography

Benvenuto, O. G. 1988, PhD thesis, FCAG-UNLP
de Jager, C., Nieuwenhuijzen, H., & van der Hucht, K. A. 1988, A&AS, 72, 259
Gormaz-Matamala, A. C., Curé, M., Cidale, L. S., & Venero, R. O. J. 2019, ApJ, 873, 131
Gormaz-Matamala, A. C., Curé, M., Lobel, A., Panei, J. A., et al. 2022, A&A, 661, A51
Grossman, S. A., Narayan, R., & Arnett, D. 1993, ApJ, 407, 284
Grossman, S. A., & Taam, R. E. 1996, MNRAS, 283, 1165
Iglesias, C. A., & Rogers, F. J. 1996, ApJ, 464, 943
Krticka, J. & Kubat, J. 2012, MNRAS 427, 84
Krticka, J.2014, A&A, 564, 70
Magni, G., & Mazzitelli, I. 1979, A&A, 72, 134
Panei, J. A., et al. 2007, MNRAS, 382, 779
Vink, J. S., de Koter, A., & Lamers, H. J. G. L. M. 2000, A&A, 362, 295
Vink, J. S., de Koter, A., & Lamers, H. J. G. L. M. 2001, A&A, 369, 574
Vink, J. S., & Sander, A. A. C. 2021, MNRAS, 504, 2051

[1]Departamento de Espectroscopía, Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Argentina
[2]Instituto de Astrofísica de La Plata, CCT La Plata, CONICET-UNLP, Argentina
[3]Instituto de Física y Astronomía, Universidad de Valparaíso, Chile
[4]Centro de Astrofísica, Universidad de Valparaíso, Chile
[5]Vicerrectoría de Investigación, Universidad Mayor, Chile
[6]Instituto de Astrofísica, Facultad de Física, Pontificia Universidad Católica de Chile, Chile
[7]Departamento de Ciencias, Facultad de Artes Liberales, Universidad Adolfo Ibáñez, Chile