The winds of Luminous Blue Variables and the Mass of AG Car

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Abstract. We present radiation-driven wind models for Luminous Blue Variables (LBVs) and predict their mass-loss rates. A comparison between our predictions and the observations of AG Car shows that the variable mass loss behaviour of LBVs is due to the recombination/ionisation of Fe\textsuperscript{iv}/\textsuperscript{iii} and Fe\textsuperscript{iii}/\textsuperscript{ii}. We also derive a present-day mass of 35 $M_\odot$ for AG Car.

1. Introduction

The strong winds of LBVs show a wide variety of mass-loss behaviour. During their S Dor-type variations they expand in radius at approximately constant luminosity. In some cases the mass loss increases while the star expands (e.g. R 71), whereas for others (e.g. R 110) the behaviour is the exact opposite: as the star expands, its mass-loss rate drops. Recent radiation-driven wind models of OBA supergiants show that stars change their wind characteristics at spectral types B1 and A0, where $\dot{M}$ jumps upwards by factors of five, due to Fe recombinations. In this poster, we investigate whether these “bi-stability jumps” can also explain $\dot{M}(T_{\text{eff}})$ of LBVs.

2. Mass Loss Predictions

Our method is outlined in the poster by de Koter & Vink (these proceedings). The full study is presented in Vink & de Koter (2002). Typical LBV results are shown in the first figure, for three values of $v_\infty/v_{\text{esc}}$. It shows that there are ranges in $T_{\text{eff}}$ where $\dot{M}$ is predicted to increase, and ranges where $\dot{M}$ decreases. The decreases are due to a growing mismatch between the positions of the driving lines (mostly in the UV) and the location of the flux maximum which shifts towards the optical for cooler stars. The increases are due to recombinations of Fe\textsuperscript{iv} to Fe\textsuperscript{iii}, and Fe\textsuperscript{iii} to Fe\textsuperscript{ii}. UV observations have shown that these “bi-stability” jumps occur at spectral types B1 and A0 (Lamers et al. 1995).
3. Comparison with the observed Mass Loss behaviour of AG Car

The second figure shows a comparison between our models (dotted line) and the Hα mass loss rates for AG Car (Stahl et al. 2001). It shows that the observed and predicted mass loss agree within 0.1 dex. Note that we have applied a corrective shift of $\Delta T_{\text{eff}} = -6000$ K to our predictions to account for an inaccurate calculation of the ionisation balance of Fe. The applied shift is consistent with constraints set by observations of supergiants which show that the jumps indeed occur at spectral types B1 and A0. As $\dot{M}(T_{\text{eff}})$ displays such a complex behaviour with fluctuations in $\dot{M}$ of over more than 0.5 dex, this is a surprisingly good result. It shows that the mass-loss variability of AG Car is due to changes in the ionisation balance of iron.

4. The Mass of AG Car

The predicted mass-loss rates are not only a function of $T_{\text{eff}}$, but also of Mass. This sensitivity of $\dot{M}$ to Mass offers the opportunity to constrain LBV Masses. Comparing the AG Car data with $\dot{M}$ predictions for different masses results in a best fit to the present-day Mass of 35 $M_{\odot}$ for AG Car.

5. Conclusions

- LBV winds are driven by radiation pressure.
- The mass loss behaviour of LBVs (of up to over 0.5 dex) during their S Dor-type variation cycles can be explained by the ionisation and recombination of Fe IV/III and Fe III/II.
- The $\dot{M}(T_{\text{eff}})$ behaviour of AG Car can be matched when we adopt a mass of 35 $M_{\odot}$.

References

Lamers H.J.G.L.M., Snow T.P., & Lindholm D.M., 1995, ApJ 455, 269
Stahl O., Jankovics I., Kovacs J., et al., 2001, A&A 375, 54
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