A Massive Star Odyssey, from Main Sequence to Supernova
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Synthetic UV spectra of starburst regions with massive close binaries

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Abstract. We present the evolution of synthetic ultraviolet spectra of starburst regions having a significant fraction of binaries. The population synthesis program uses an extended library of stellar evolutionary tracks of single stars and binaries computed with the most recent stellar wind mass loss rates during RSG, LBV and WR stages. In the case of binaries we account in detail for the effects of Roche lobe overflow, mass transfer and mass accretion, common envelope evolution, the spiral-in process, asymmetric kicks to neutron stars as a result of their supernova explosion, *etc.* The most important synthesized line profiles are those of Si IV λ1400 and C IV λ1550, two P-Cygni lines prominent in O-type stars. The main effect of the close binaries is to extend the UV bright lifetime of the starburst due to the appearance of accretion stars. But more importantly, our computations show that a spectrum of a single star model of about 6 Myr old is effectively undistinguishable from that of a binary rich model of about 10 Myr old. This indicates a possible age degeneracy, reminiscent of the influence of binaries on the commonly used optical age indicator $W_{H\beta}$.

1. Introduction

Since massive stars radiate most of their light in the ultraviolet, it is logical to study the influence of binaries on the UV part of starburst spectra using our binary population synthesis (PNS) code (Vanbeveren *et al.* 1998). Robert, Leitherer & Heckman (1993) published a library of observed normalized UV spectra (1200 - 1850Å) for solar metallicity massive stars (including WR stars), which has been updated by de Mello, Leitherer & Heckman (2000) to include a higher-resolution library for B-type stars. All OB and WR spectra now have a resolution of 0.75Å. Stellar continua for non-WR stars were obtained from Lejeune, Cuisinier & Buser (1997), while those of WR stars are from Schmutz, Leitherer & Gruenwald (1992).

As discussed by Robert *et al.* (1993) and Leitherer, Robert & Heckman (1995), the most prominent stellar features of massive stars in the UV are the P-Cygni profiles of the C IV λ1550 and Si IV λ1400 resonance lines. The latter is very strong in the early stages after the starburst, but its profile rapidly weakens after a few Myr. N V λ1240 is almost as strong as Si IV λ1400, but this line is severely contaminated by interstellar Lyα. Our calculations show that WR stars do not affect the theoretical simulations of the evolution of the UV spectral region. This means that the results do not depend on uncertainties in the physics of WR stars.

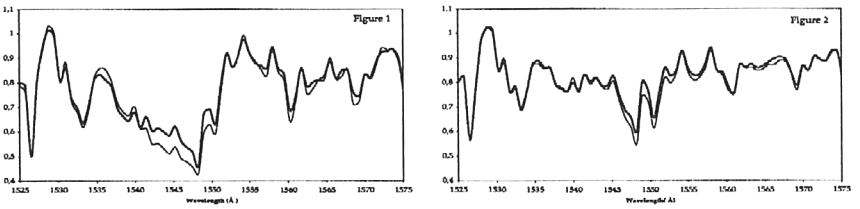

Figure 1. *Left:* Comparison of the predicted C IV line profile of a single star model (thin line) of 6 Myr with a binary model (thick line) of 10 Myr. *Right:* Comparison of the predicted C IV line profile of a single star model (thin line) of 10 Myr with a binary model (thick line) of 21 Myr.

2. Simulations

For the comparison of the single star and binary models, we concentrated on C IV λ1550 which is the strongest line. Our simulations show that the C IV λ1550 line displays a P-Cygni profile for a much longer time in the binary model than it does in the single star model. This is due to the rejuvenation of the secondary star by accretion of matter during Roche lobe overflow in Case A and Case Br binaries. These secondaries become more massive and more luminous, therefore producing a more intense C IV line .

The foregoing has the consequence that in the UV (as in the optical, see Van Bever *et al.* 1999), an age ambiguity is introduced by the presence of binaries in the starburst. To illustrate, Figure 1 left (resp. right) shows the predicted C IV line profile of a single star starburst which is 6 Myr (resp. 10 Myr) old with the binary model of 10 Myr (resp. 21 Myr). Both show an almost perfect fit.

3. Conclusion

As with $W_{H\beta}$, mass transfer and merging in close binaries introduce an age ambiguity in the UV spectrum of young starburst. Binaries produce a rejuvenation of the burst after 5 Myr which is clearly visible in the evolution of the C IV λ1550 line. Also, WR stars do not affect the UV spectrum, meaning that our conclusions do not depend on uncertainties concerning their physics.

A more extended discussion can be found in Belkus *et al.* (2002).

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