Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies
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The influence of close binary evolution on the age determination of starburst regions

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Abstract. Using a population number synthesis code and detailed massive star evolutionary calculations, we investigate the effect of close binary evolution on H_α and H_β emission-line strength variation in starburst regions. The H_β line strength especially, is considered as a good age indicator. We demonstrate that the formation of rejuvenated accretion stars (Blue Stragglers) through RLOF lengthens the life-time of the H_β flux and makes the age determination of a starburst regions ambiguous. We separately calculate the effect of Wolf-Rayet stars and of X-ray binaries on H_α and H_β and conclude that both are of minor importance.

1. Introduction

We apply a population-synthesis code in which binary evolution is treated in detail. The description of the binary evolution concerned is given by Vanbeveren *et al.* (1998). Following Osterbrock (1989) concerning the physics of gaseous nebulae, we computed the time-evolution of the equivalent widths of H_α and H_β in a starburst of solar metallicity, where a significant number of interacting binaries are formed.

2. Discussion

Using our population synthesis code, we computed the time-volution of a population of 20 000 stars with solar metallicity, born at the same time, *i.e.*, an instantaneous starburst. The stellar population at birth was generated by a Monte-Carlo simulation according to the prescribed IMF and, in case of binaries, also the initial mass ratio and period distributions. Single star evolution dominates the O-type star population in the early stages, but interacting binaries (by way of accretion stars) start taking over after about 5–6 Myr, eventually becoming the only suppliers of O-type stars after about 7 Myr (Van Bever & Vanbeveren 1998). The same can be said about the respective contributions to the ionizing flux. As a consequence, in the models with close binaries, for epochs larger than 5 Myr, the value of $W(H_\beta)$ remains higher than in the corresponding single star models. It turns out that with respect to $W(H_\beta)$, no distinction can be made between regions with an age between 5 Myr and 9 Myr. From 9 Myrs on, $W(H_\beta)$ starts decreasing again, but remains larger than in the corresponding single-star model at all times.

Two remarks are worth mentioning here:
(1) The way in which the WR spectra are treated, is not really crucial to the results one obtains concerning the Lyman ionizing flux and the Balmer line equivalent widths of a starburst containing a non-negligible fraction of binaries. The reason for this is that for epochs earlier than 10 Myr, the WR stars never contribute more than a maximum of about 20% to the ionizing flux (because of the simultaneous presence of a large number of accretion O stars). The WR stars have a negligible effect on our main conclusions.
(2) In our calculation we assume that $L_X = 10^{38}\,\mathrm{erg\,s^{-1}}$ per X-ray binary and an average photon energy of 10 keV. The difference compared to the calculations without X-ray binaries is practically non-existent. O-type stars emit hydrogen-ionizing photons at rates of $10^{47-49}\,\mathrm{s^{-1}}$, whereas WR stars do so at $10^{48-49}\,\mathrm{s^{-1}}$. With the values quoted above, our X-ray sources produce ionizing photons merely at a rate of the order $10^{45}\,\mathrm{s^{-1}}$.

From calculations with different initial distributions, it is seen that objects having a measured $W(\mathrm{H}_\beta) \lesssim 100$ Å *could* be affected by this phenomenon. Terlevich *et al.* (1991) made a spectrophotometric catalogue of 425 emission-line galaxies and measured their H_β equivalent widths. From these observations, one concludes that 81% of all measured H II galaxies have a $W(\mathrm{H}_\beta)$ smaller than 100 Å and thus *might* be older than would be thought by using single star models only. We believe that this is sufficient reason to treat age-determinations from single-star models only with great caution. In analogy, we made a histogram of the measured $W\mathrm{H}_\beta$ of 29 WR galaxies as measured by Conti (1991). Here as well, 16 of them (55%) have a $W(\mathrm{H}_\beta) \lesssim 100$ Å. This is an important result for the field of WR star population synthesis. There is a huge difference between a starburst younger than approximately 5 Myr and one that is older. In the former, close binary evolution has yet been unable to contribute appreciably to the WR star population, since the first binaries only interact after about 5 Myr. On the other hand, in the latter close binary evolution may contribute appreciably to the WR star population, or even dominate it through RLOF-remnants and massive accretion stars in their helium burning stage! Details of this study can be found in Van Bever & Vanbeveren (1999).

References

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