Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies
Proceedings IAU Symposium No. 193, ©*1999 IAU*
K.A. van der Hucht, G. Koenigsberger & P.R.J. Eenens, eds.

Metallicity dependence of starburst spectra

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Abstract. The impact of chemical composition on the spectrum of stellar population formed in the starburst is studied. The range of metallicities $Z = 0.0001$–0.05–0.1 covers all the compositions observed; depending on age, wavelength region and IMF, the UV-fluxes differ between extreme compositions *at least* ten-fold or more. Independent of age, UV-fluxes shortwards of the Balmer jump monotonically decline with the growth of metallicity. The optical IR wavelenght region are also influenced, with fluxes at $\lambda > 1\ \mu$m differing typically factors 10–50. In the IR the actually brightest emitting composition gets reversed with age.

Starbursts express the ununiformity and complexity of the real global star formation process in galaxies. They are marked by highly enhanced star formation activity and presence of a numerous very young massive star generation. When having an solar-vicinity-like bottom-heavy IMF they cannot be sustained by the gas resources for long. Starbursting galaxies are of diverse sizes and range in composition from about solar to very metal-poor. Given a patchiness of the star formation process, the role of separate starbursts seems to grow towards smaller, lower-mass galaxies. Some very blue low mass dwarfs have yet kept their matter nearly pristine (the extreme cases SBS 0335-052 and I Zw 18 are 41 and 50 times undersolar in metals, Thuan *et al.* 1997) and are maybe undergoing the first substantial star formation event in their history.

We have estimated the effects of chemical composition on the composite spectrum of the forming stellar component on the basis of youngest models in our grid of spectrophotometric evolutionary models (eight compositions in the range $Z = 0.0001$–0.1; age range 4 Myr to 20 Gyr, in $Z = 0.1$ models 10 Myr to 13 Gyr; six IMF slopes; 21 SFR combinations; no gas-dust absorption-reemission; see Traat 1996). The resulting spectral flux distributions for the standard IMF are given in Fig. 1. Note the progressive growth of absorption and decline of flux towards shorter UV-wavelengths with increasing metallicity, with differences in Balmer continuum slowly growing from $\sim$2 right below Balmer limit to $\sim$5 near Lyman jump at 912 Å, progressing also somewhat with the age of stellar generation itself. In the Ly-continuum, fluxes $\sim$ 10–20 times at the age of 4 Myr; the drop-off with time is much more rapid for metal-rich compositions. At 10 Myr, the flux output of the $Z = 0.1$ population is lower than that of $Z = 0.0001$ stars by $\sim$ 100 at the base of the Lyman jump and $\sim$ 6000 at the edge of the He° 504 Å break. The He° flux is weak in very young populations with higher metallicity, as in the illustrated 4 Myr case, but very rapidly fades away.

Somewhat surprisingly, the metal-weak populations are at very early ages, due to the earlier appearance of red supergiants also in the IR brighter than near-solar metallicity stars. This situation gets quickly reversed with aging.

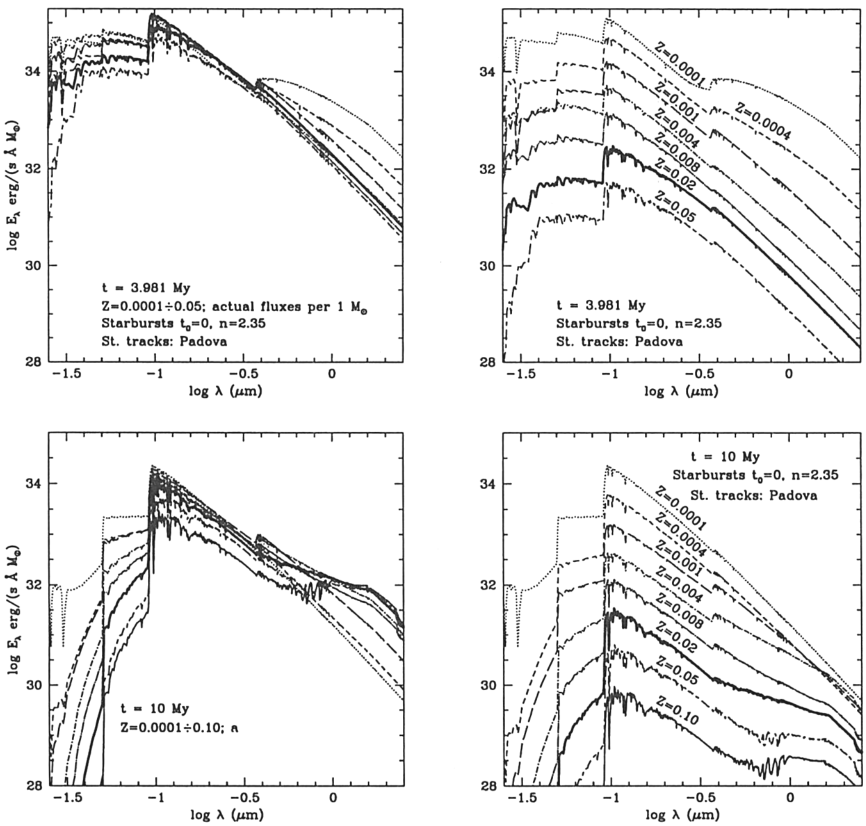

Figure 1. Composition dependence of spectra of the young stellar component in starbursts, assumed to be formed in initial burst (SFR time-scale $t_0 \equiv 0$). Adopted IMF: power-law with the Salpeter slope ($n = 2.35$); spectral fluxes are scaled to the unit mass in luminous stars $0.6\,M_\odot \leq M \leq 120\,M_\odot$. Original spectra for different compositions are depicted on the *left-hand panels*. They are redrawn for clarity on *right-hand panels* with successive downward shifts –0.5 dex to the previous one, with $Z = 0.0001$ curve retaining its true location and $Z = 0.1$ accumulated the maximum shift –3.5 dex.

The possibility, suspected in some starbursts, that a preferential formation of massive stars lowers the IMF slope n, has an easily accountable impact on the resulting spectrum, namely, it reduces the output in the IR and rises the output in the UV, inversely proportional with the n value.

References

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