# THE FRACTION OF O-TYPE SUPERGIANTS IN OUR GALAXY IN THE LMC AND IN THE SMC: AN EVIDENCE OF THE CORRELATION BETWEEN MASS LOSS RATE AND CHEMICAL ABUNDANCE

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The distribution of the spectral types of the WR stars in our galaxy is different at different distances from the galactic center. This distribution is also different in all three galaxies, in our, in the LMC and in the SMC. These results have been interpreted as due to the dependence of the mass loss rate from the original chemical abundace which is known to be different in these objects.

On the other hand it has been proposed by Chiosi et al. (1974) and confirmed by Bisiacchi et al. (1978) that most of the O supergiants should be stars in the hydrogen burning phase. These authors also find evidence that the large relative number of supergiants among th O and early B type stars must be related to the longer time spent by the evolutionary tracks with mass loss at the low gravity region. Recently, a new empirical formula has been proposed by Chiosi (1980) for the mass loss rate as function of the luminosity and temperature of the stars. New evolutionary models calculated by Chiosi (1980) with this formula extend the hydrogen burning phase to lower gravities, lower temperature and higher luminosities. This results are illustrated in Figure 1 where the evolutionary tracks calculated by Chiosi (1978) in the conservative case, with $\alpha$= 0.9, and by Chiosi (1980) with the new empirical formula, are presented in the log g, log $T_{eff}$ plane.

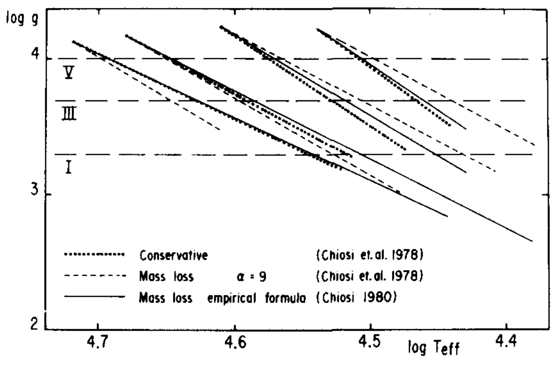


Figure 1.

Based on these previous results we decided to analize the possible variation of the fraction of supergiants among the known O stars as function of the distance from the galactic center. As we have seen earlier the fraction of



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O supergiants must be, from theoretical point of view, strongly dependent on the mass loss rate. If the original chemical composition affects in some manner the rate of mass loss, we would expect the number of supergiants among the O stars to vary due to gradient of the chemical composition present in our galaxy (Peimbert 1978). From the General Catalog of O Stars given by Cruz-González et al. (1974) we have obtained the fraction of stars of luminosity class V, III and I in the direction of the galactic center (galactic longitude between 30° and 330°) and of the anticenter (galactic longitude between 150° and 210°). The results are presented in Table 1; the second set of fractions is obtained only for stars with distance from the sun larger than 1 Kpc.

TABLE 1. Fraction of stars for luminosity class

| $l^{II}$ | V | III | I |
|---|---|---|---|
| $30° > l^{II} > 330°$ | .40 | .25 | .35 |
| $150° < l^{II} < 210°$ | .79 | .11 | .11 |
| Stars with d>1 Kpc | | | |
| $l^{II}$ | V | III | I |
| $30° > l^{II} > 330°$ | 0.39 | 0.25 | 0.36 |
| $150° < l^{II} < 210°$ | 0.85 | 0.08 | 0.07 |

The fraction of supergiants diminishes from the center to the anticenter direction by a factor of 4. We interpret this result as an indication of a different chemical composition in the two regions. From rough interpolation between Chiosi's models for different mass loss rate and for different chemical compositions we evaluate that a variation of a factor 5 in the mean mass loss rate is necessary to reproduce this result.

A similar analysis comparing the fraction of O supergiants in our galaxy, in the LMC and in the SMC will also be interesting. Unfortunately, a complete study of the luminosity class for the O stars in the MC's has not been done. We decided then to analize the HR diagrams for supergiants and O stars given by Humphreys (1978) for our galaxy and by Dennefeld (1979) and references therein, for the MC's. We have taken all stars which lie above the evolutionary track of 25 $M_\odot$ stars in the HR diagram. We have then estimated the number ratio of the stars falling in the hydrogen burning zone ($N_H$) to those falling in the helium burning zone (yellow supergiants $N_{YS}$). The two zones have been defined with the conservative evolutionary tracks given by Chiosi (1978). The result is presented in Figure 2 as function of the nitrogen abundance of the three objects.

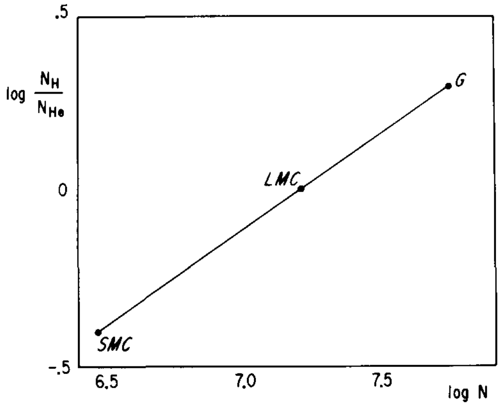


Figure 2.

To interpret this result, we compare this figure with Figures 3 and 4 in which the number ratio of the WC/WN stars and of the WR/ Yellow Supergiants is presented for our galaxy for the LMC and for the SMC as function of the nitrogen abundance.

Note that going from the galaxy to the SMC the relative number of yellow supergiants increases, the relative number of WR stars decreases and the number of WC stars decreases also. All these facts seems to indicate a variation of the mass loss rate due to different chemical abundance in the three objects.

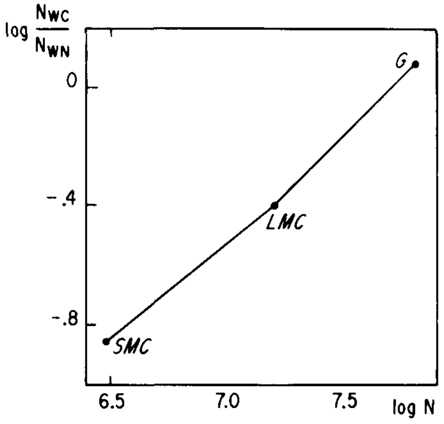


Figure 3.

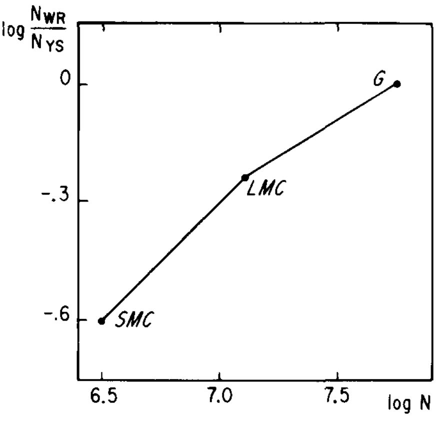


Figure 4.

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## DISCUSSION

CONTI: I note on your figure 2 that the count of numbers of core H to core He burning stars in the galaxy is about 3. Isn't this is conflict with our concept that the core H -core He burning life-times are in the ratio 10?

BISIACCHI: We must take in to account that this value depends on the border you define between the hydrogen burning region and the helium burning region. In this case, the border has been defined with conservative models and this choice may not be realistic. What is independent from the border you use is the variation of this ratio from the galaxy to the SMC; we have confirmed this fact using another border defined by mass loss evolutionary tracks. I must note also that a systematic difference in luminosity between yellow supergiants and main sequence stars burning hydrogen is expected from the tracks. The factor 10 between life time must be corrected for this reason also.

LAMERS: Is it possible to derive from your observed relations the dependence of $\dot{M}$ on Z; in particular the value of d(log $\dot{M}$) / d(log Z)?

BISIACCHI: Yes, it is possible: interpolating between Chiosi's models calculated for different chemical compositions and different mass loss rates, we evaluate that a variation of a factor 5 in the mean mass loss rate is necessary to reproduce our result on the variation of the fraction of supergiants in the galaxy. If you consider that the variation of Z between the two samples must be of a factor 5, you will have a $\frac{dM}{dZ}$ of the order of the unity.

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DOPITA: To what extent can stochastic variations in massive star formation rates alter quantitatively your conclusions?

BISIACCHI: I dont't know what stochastic variations will produce; but if you change the initial mass function in the sense to produce less massive stars in the direction of the anticenter, you will explain the fault of supergiants in this direction . We have not considered this possibility to interpret our results because the birth rates obtained by Tammann for the M.C.'s are very similar to that of our galaxy.

BASU: Is not the difference between the fractions of O supergiants in the directions of the galactic centre and the anticentre a natural consequence of the higher rates of star-formation in the galactic centre direction where gas density as well as the frequency of the galactic shock formation are both higher? The same probably is the cause for the observed chemical gradient.

BISIACCHI: You must change not only the rate of star formation. You must change the initial mass function.

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