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REANALYZING THE HE ABUNDANCE DETERMINATION IN EXTRAGALACTIC H II REGIONS

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The importance of a good determination of the primordial He abundance (Y_p) has been extensively discussed in the literature. The method generally used to obtain Y_p was proposed by Peimbert & Torres-Peimbert (1974) and makes use of a correlation between the He mass fraction (Y) and metallicity, extrapolated to zero metallicity. Since the statistical uncertainties in the determination of Y_p are very small ($\sim$ 1%), it is essential to discuss possible systematic errors in the determination of Y and consequently of Y_p.

1. TEMPERATURE FLUCTUATIONS

The temperature obtained from the [O III] line intensity ratio is generally used for the determination of the He abundance from empirical methods. However, in many Galactic objects and at least one extragalactic H II region, the obtained Balmer temperature is less than that given by the [O III] lines (Peimbert 1971; Liu & Danziger 1993). We analyzed the effect of temperature fluctuations on the He abundance as well as on the Y_p determination. We concluded that if temperature fluctuations are not taken into account, Y is underestimated in high-temperature (low abundance) regions, while O/H is underestimated in low-temperature (high abundance) regions, resulting in an underestimation of the primordial He abundance. The use of truncated data set, as well as of the lowest-Y H II regions, decreases the effect.

2. THE CLUSTER AGE

A common simplification used in the literature is that the ionizing radiation is provided by stars of a single temperature. However, real H II regions are ionized by a cluster of stars of differing masses and temperatures. Furthermore, since the stars evolve, so do the total ionizing spectrum. Using a time dependent spectrum of a starburst (Cid-Fernandes et al. 1992), we show that for H II regions ionized by a very young cluster ($t = 0.0$ Myr) the He ionization correction factor, icf, is lower than 1, while icf can be larger than 1 for $\log \eta < 0.9$ and [O III]/[O I] > 300 for an older spectrum ($t = 5.4$ Myr). This contests some criteria given in the literature for avoiding objects with icf $\neq 0$ (Pagel et al. 1992; Ballantyne, Ferland, & Martin 2000), and shows that the key parameter for defining the icf value is the cluster age. On the other hand, a single burst can not explain the observed He II/Hβ. In fact, observations show that an H II region can have more than one knot of star formation (Conti & Vacca 1994; Conti, Leitherer, & Vacca 1996).

3. GAS INHOMOGENEITIES

We also analyzed the effect of inhomogeneities in the gas distribution. Comparing homogeneous regions with regions with clumps and valleys the results show that Y_p is overestimated if inhomogeneities are not taken into account.

4. HE ABUNDANCE ADOPTED IN THE MODELS

Photoionization models are obtained in the literature for a wide range of Z for deriving relations between icf and observables. The exact value of the He abundance is assumed to be of second-order importance, since He is not an important coolant. However, for the required precision, the effect of the He abundance must be analyzed. Such an analysis shows that this effect depends on the cluster age. For the range of He/H values assumed in the literature, it can change the icf by up to 10%.

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