IONIZATION CORRECTION FACTORS BASED ON CALIFA PHOTOIONIZATION MODELS

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DEFINITIONS

log($Q_{0/1}$) is a measure of the softness of the radiation that ionizes the H II regions.

X accounts for the fractional ionic abundance.

WHY?

The bright emission lines of extragalactic H II regions are the main tool to study the actual chemical composition of the present gas in galaxies at different locations. This information is used to constrain chemical evolution models and thus, to understand the formation and evolution of galaxies in the universe.

The so-called direct method is used when the electron temperature can be determined. Then, the total abundance of one particular element is calculated as the sum of the abundances of all the observed ions. When not all the ions present in a nebulae are observed, we must used ionization correction factors (ICFs) to estimate the contribution of the unobserved ions.

The most reliable ICFs are based on photoionization models but until now, they were based on relatively few models. Here we present a preliminar analysis for nitrogen, neon, and sulfur using a grid of ~3000 photoionization models especially constructed to fit CALIFA observations of H II regions (more details in the talk by C. Morisset and in Morisset et al. A&A, 2016, submitted).

NITROGEN

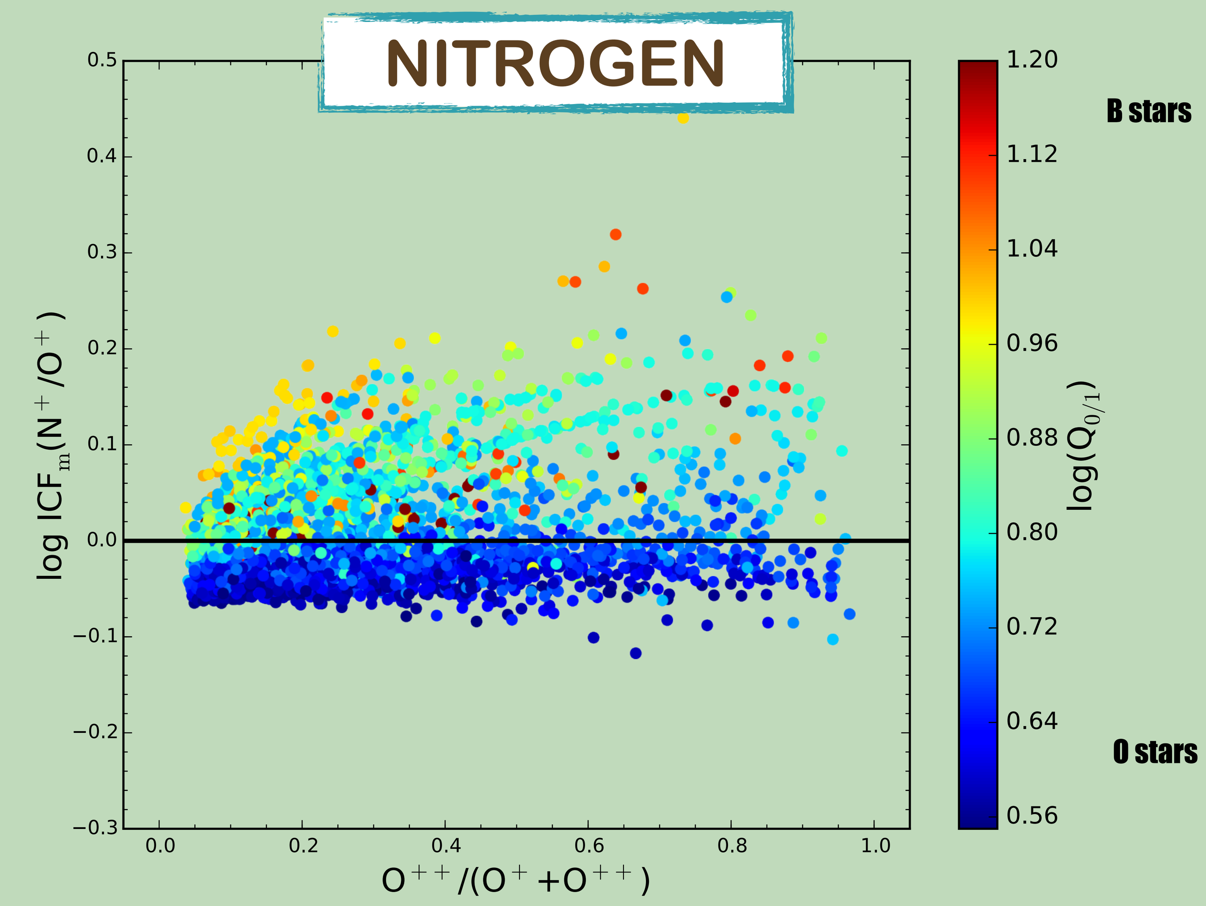

Figure 1. Values of log (x(O$^+$)/x(N$^+$)) as a function of O^{++}/(O$^+$ + O^{++}) for all the photoionization models. The solid line represents N/O = N$^+$/O$^+$.

The N/O ratio is crucial to constrain chemical evolution models. Nitrogen is produced both by low- and high-mass stars and it can have a primary or secondary origin. Fig. 1 shows the values of ICF(N$^+$/O$^+$) as a function of the degree of ionization. The solid line represents N/O = N$^+$/O$^+$. We see from the figure that the usual procedure to estimate the N/O ratio either underestimates (in up to 0.3 dex) or overestimates (in up to 0.2 dex) N/O.

Note that there is a clear trend between the values of ICF(N$^+$/O$^+$) and log($Q_{0/1}$), a measure of the softness of the radiation that ionizes the H II regions. An ICF that takes into account this parameter will help to obtain more accurate N/O abundances ratios.

NEON

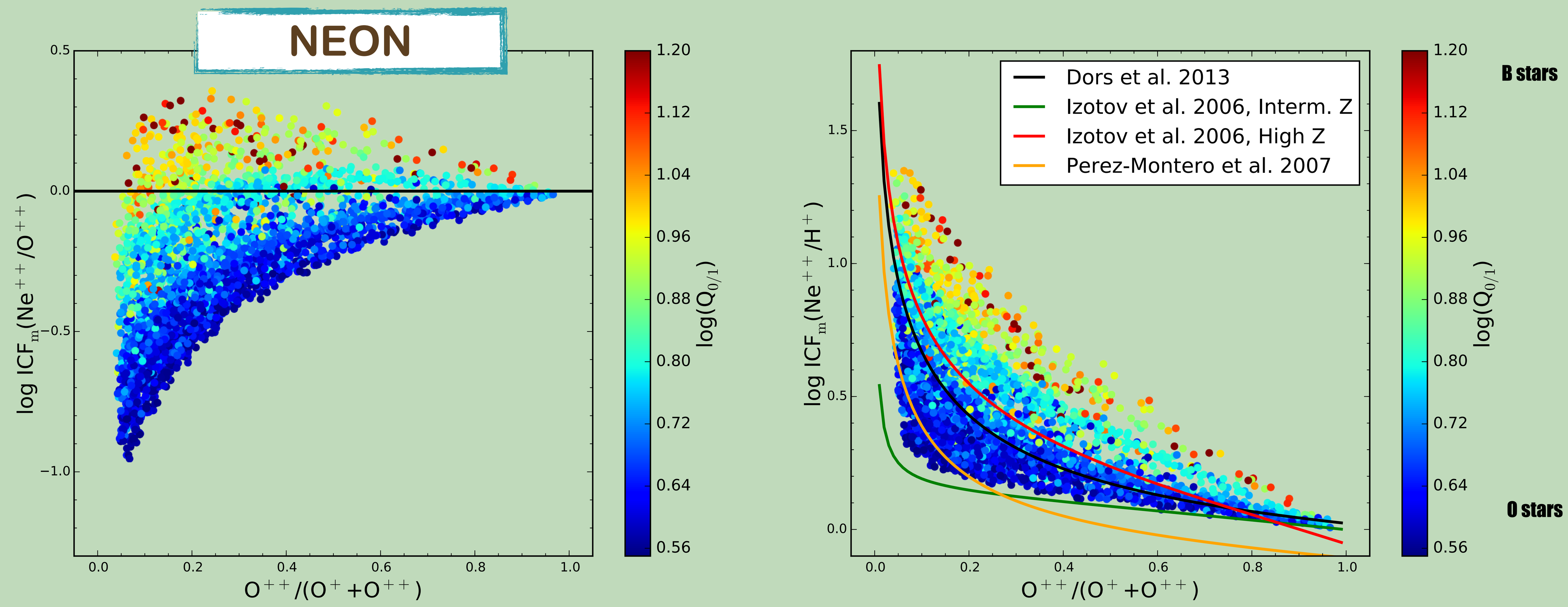

Figure 2. Values of log (x(O^{++})/x(Ne^{++})) and log (x(H$^+$)/x(Ne^{++})) as a function of O^{++}/(O$^+$ + O^{++}) for all the photoionization models. The solid line in the left panel represents Ne/O = Ne^{++}/O^{++}. The solid lines in the right panel represent various ICFs proposed in the literature.

The observational results for the evolution of neon and oxygen abundances are contradictory (see, e.g., Dors et al. 2013, MNRAS, 432, 2512, and references therein). A reliable ICF for neon is necessary to clarify this issue.

The results from our grid of photoionization models are presented in Fig. 2. The left panel shows that the classical Ne/O = Ne^{++}/O^{++} is only valid for a few models (those located on the solid line). In most of the cases, the derived Ne/O ratio is either underestimated (in up to 0.3 dex) or overestimated (in up to 1.2 dex) when using this ICF.

In the right panel we compare several ICFs that have been proposed in the literature for neon (Dors et al. 2013; Izotov et al. 2006, A&A, 448, 955; Pérez-Montero et al. 2007, MNRAS, 381, 125). Different biases are introduced when using the different ICFs. As in the case of nitrogen, an ICF that depend on the softness of the radiation will help to obtain more reliable abundances.

SULFUR

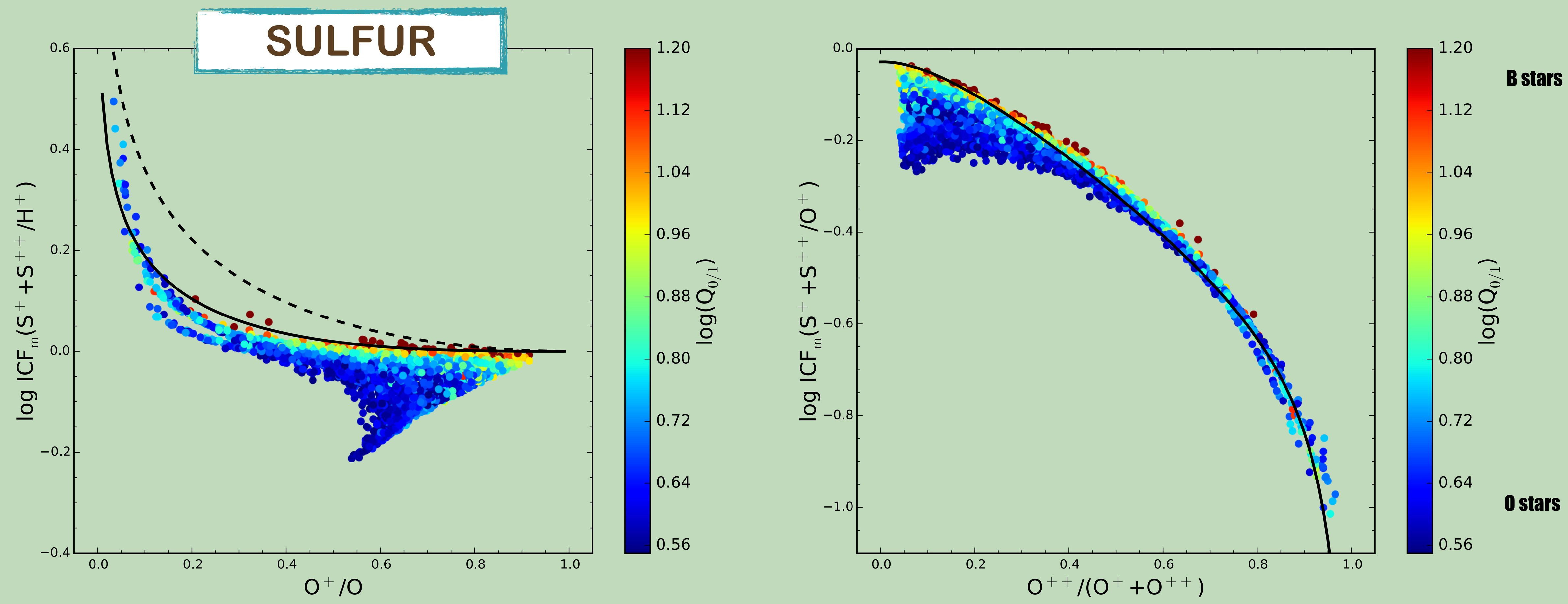

Figure 3. Values of log (x(H$^+$)/(x(S$^+$)+x(S^{++}))) and log (x(O$^+$)/(x(S$^+$)+x(S^{++}))) as a function of O^{++}/(O$^+$ + O^{++}) for all the models. The lines in the left panel represents the ICF from Stasinska (1978) for $\alpha = 2$ (dashed) and $\alpha = 3$ (solid). The line in the right panel represents the ICF proposed by Delgado-Inglada et

The study of sulfur abundances in H II will help to better understand nucleosynthesis in massive stars (for example, if the mass range of the stars that produce oxygen and sulfur is the same).

The most commonly adopted ICF is the one proposed by Stasinska (1978, A&A, 66, 257). Fig. 3 shows the grid of photoionization models together with the ICF suggested by Stasinska 1978 and the ICF proposed by Delgado-Inglada et al. 2014 (MNRAS, 440, 536) for PNe. Both ICFs tend to overestimate (in up to 0.2 dex) the values of S/O, especially for the H II regions with the lowest values of log($Q_{0/1}$), in principle those hosting O stars. Again, a better ICF for sulfur would be one that consider log($Q_{0/1}$).