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The Ionization Equilibrium of Iron in H II Regions

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Abstract. We study the ionization equilibrium of Fe using photoionization models that incorporate improved values for the relevant atomic data. The previously available photoionization models predict concentrations of Fe^{3+} which are a factor of 3–8 higher than the values inferred from emission lines of [Fe III] and [Fe IV]. Our new models reduce these discrepancies to factors of 2–5. We comment on the possible reasons behind the remaining discrepancies, and present an updated ionization correction factor for obtaining the Fe abundance from the Fe^{++} abundance.

1. Results

We use the photoionization code NEBULA (Rubin et al. 1991a,b) updated with new ionization cross sections for Fe^+, Fe^{++}, O^0 and O^+, new recombination coefficients for Fe^{++}, Fe^{3+}, O^+ and O^{++}, all the charge-exchange reactions involving these ions; and NLTE model stellar atmospheres (more details are given in Rodríguez & Rubin 2003). Figure 1 shows the resulting ionization correction factors (ICFs), which imply:

$$\frac{\mathrm{Fe}}{\mathrm{O}} = \mathrm{ICF}\,\frac{\mathrm{Fe}^{++}}{\mathrm{O}^{+}} = \frac{x(\mathrm{O}^{+})}{x(\mathrm{Fe}^{++})}\,\frac{\mathrm{Fe}^{++}}{\mathrm{O}^{+}} = \left(\frac{\mathrm{O}^{+}}{\mathrm{O}^{++}}\right)^{0.09}\frac{\mathrm{Fe}^{++}}{\mathrm{O}^{+}}. \qquad (1)$$

where $x(X^{n+})$ stands for the ionization fraction of the X^{n+} ion. Figure 1 also shows a comparison with the ICFs implied by previous ionization models and with the results obtained by Rodríguez (2003) for several objects with available measurements of [Fe IV] lines. The new model results, although still higher than the measured values, are much closer to them. The remaining discrepancies translate into uncertainties of up to a factor of 4 in the Fe abundances derived for a wide range of objects, from the nearby Orion nebula to the low metallicity blue compact galaxy SBS 0335−052. Thus, resolving this problem has important implications for our understanding of both the evolution of dust in H II regions and the chemical history of low metallicity dwarf galaxies. These remaining discrepancies could be due to: (1) the need for further improvements in the ionization models, (2) errors in the atomic data (in particular the colli-

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sion strengths) used to derive the Fe^{++} and Fe^{3+} abundances (see Rodríguez & Rubin 2003 for a further discussion of these issues).

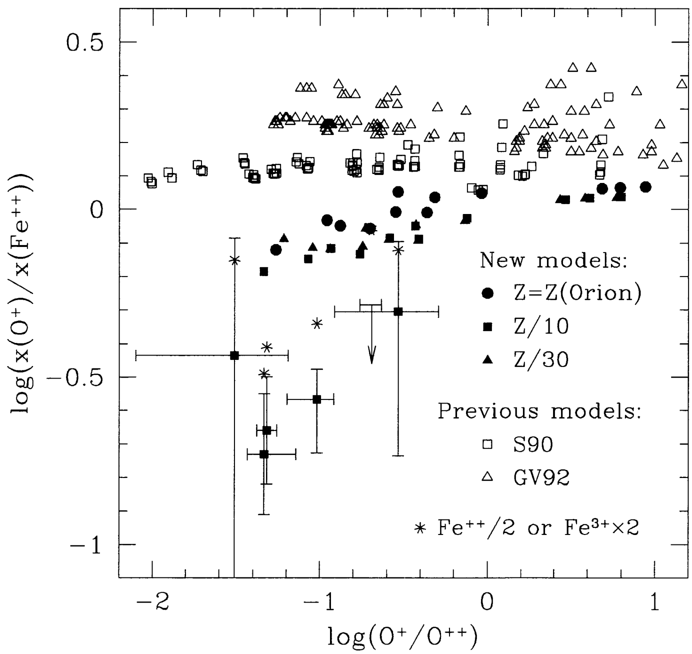

Figure 1. ICFs obtained from our new models compared with the previous model results of Stasińska (1990, S90) and Gruenwald & Viegas (1992, GV92). The squares with error bars show the results obtained in Rodríguez (2003) for objects with available measurements of [Fe IV] lines: from left to right, the planetary nebula IC4846, SMC N88A (position 1), SBS 0335−052, SMC N88A (position 2), 30 Doradus (an upper limit), and M42 (the Orion nebula).

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References

Gruenwald, R.B., & Viegas, S.M. 1992, ApJS, 78, 153 (GV92)

Rodríguez, M. 2003, ApJ, 590, 296

Rodríguez, M., & Rubin, R.H. 2003, astro-ph/0312246

Rubin, R.H., Simpson, J.P., Haas, M.R., & Erickson, E.F. 1991a, ApJ, 374, 564

Rubin, R.H., Simpson, J.P., Haas, M.R., & Erickson, E.F. 1991b, PASP, 103, 834

Stasińska, G. 1990, A&AS, 83, 501 (S90)