A Reexamination of Electron Density Diagnostics for Ionized Gaseous Nebulae

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We present a comparison of electron densities derived from optical forbidden line diagnostic ratios for a sample of over a hundred nebulae. We consider four density indicators including the [O II] $\lambda3729/\lambda3726$, [S II] $\lambda6716/\lambda6731$, [Cl III] $\lambda5517/\lambda5537$ and [Ar IV] $\lambda4711/\lambda4740$ doublet ratios. Except for a few H II regions for which data from the literature were used, diagnostic line ratios were derived from our own high quality spectra. For the [O II] $\lambda3729/\lambda3726$ doublet ratio, we find that our default atomic data set consisting of transition probabilities from Zeippen (1982) and collision strengths from Pradhan (1976) fit the observations well, although at high electron densities, the doublet ratio yields densities systematically lower than those given by the [S II] $\lambda6716/\lambda6731$ doublet ratio, suggesting that the ratio of transition probabilities of the [O II] doublet, $A(\lambda3729)/A(\lambda3726)$, given by Zeippen (1982) may need to be revised upwards by approximately 6 per cent. Our analysis also shows that the more recent calculations of [O II] transition probabilities by Zeippen (1987) and collision strengths by McLaughlin & Bell (1998) are inconsistent with the observations at high and low density limits, respectively, and can therefore be ruled out. We confirm the earlier result of Copetti & Writzl (2002) that the [O II] transition probabilities calculated by Wiese et al. (1996) yield electron densities systematically lower than those deduced from the [S II] $\lambda6716/\lambda6731$ doublet ratio and that the discrepancy is most likely caused by errors in the transition probabilities calculated by Wiese et al. (1996). Using our default atomic data set for [O II], we find that $N_{\rm e}$([O II]) $\leq N_{\rm e}$[S II] $\approx N_{\rm e}$[Cl III]$< N_{\rm e}$[Ar IV].

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