PDR Diagnostics Study with CLOUDY†

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Abstract

A series of plane-parallel photodissociation region (PDR) models are calculated using the spectral synthesis code CLOUDY(Ferland et al., 1998). These models span a wide range of physical conditions, with gas densities of $n = 10^2 - 10^6\,\mathrm{cm}^{-3}$ and incident far-ultraviolet (FUV) fields of $G_0 = 10^0 - 10^6$ (where G_0 is the FUV flux in units of the local interstellar value), which are comparable with various astrophysical environments from interstellar diffuse clouds to dense neutral gas around galactic compact H II regions. Based on the calculated results, we study the thermal balance of PDR gas and the emission of the [C II], [C I], and [O I] fine-structure lines under different physical conditions. The intensities and strength ratios of the studied lines, which are frequently used as PDR diagnostics, are presented by contour diagrams as functions of n and G_0. We compare the calculated PDR surface gas temperatures T_s with those from Kaufman et al.(1999), and find that T_s from our models are systematically higher over most of the adopted n-G_0 parameter space. The predicted line intensities and ratios from our work and those from Kaufman et al.(1999) can be different by a factor of larger than 10, and such large differences usually occur near the border of our parameter space. The different method for treating the dust grain physics, the variation of H_2 formation and dissociation rates, and the improvement in the radiation transfer of line emissions in our CLOUDY models, are likely to be the major reasons for the divergences. Our models represent an up-to-date treatment of PDR diagnostic calculations and can be used to interpret observational data. Meanwhile, the uncertainties in the treatment of microphysics and chemical processes in PDR models have significant effects on PDR diagnostics.

Key words: Infrared: ISM — ISM: clouds — ISM: atoms — ISM: molecules — methods: numerical

References

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