A semianalytical model for the observational properties of the dominant carbon species at different metallicities

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ABSTRACT

We present a simple, semianalytical approach to compute the line emission of C^+, C^0 and CO in Photodissociation Regions of varying metallicity that depends on very few parameters and naturally incorporates the clumpiness of the interstellar medium into the calculations. We use it to study the dependence of the $I_{[CII]}/I_{CO}$ and $I_{[CI]}/I_{CO}$ line ratios on the metallicity. We show how to modify it to include the effects of density and radiation field, and we have compared it with observational data. We find that the model explains the observed trend of enhanced [C II]/CO line ratio with decreasing metallicity as the natural result of the augmented fraction of photodissociated gas in a clump. We show that enhanced [C II]/CO ratios can be produced by lowering the upper limit of the clump size distribution, as may happen in 30 Doradus. We also find that the available data favors a [C I]/CO intensity ratio essentially independent of metallicity, albeit the paucity of observations does not exclude other possibilities. This is difficult to understand if most of the C^0 is produced by UV photons as is the case with C^+. Finally, we study the prediction of the model for the trend of the X_{CO} factor with metallicity. Comparison with previous observational studies yields good agreement.

Subject headings: ISM: abundances — ISM: general — galaxies: ISM — radio lines: ISM

1. Introduction

1.1. Photodissociation regions and the metallicity of the ISM

A photodissociation region (PDR or photon dominated region) is that portion of the interstellar medium where ultraviolet (UV) radiation dominates the physical and chemical processes. The first theoretical studies of PDRs (e.g., Tielens and Hollenbach 1985a;