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Testing the KOSMA-τ 3D PDR code: the Orion Bar PDR

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The components of the interstellar medium (ISM) are continuously heated due to energy input from different sources, one source being the radiation of young and massive stars. Photon-dominated regions (PDRs) describe the conditions where the interstellar far-ultraviolet (FUV; 6-13.6 eV) radiation field determines the energy balance and the chemistry of the ISM.

The KOSMA-τ PDR model simulates the chemical and the physical structure and the line emission of spherical clouds ("clumps") in the ISM. Furthermore, it has been shown that a superposition of spherical clumps, having a specific mass-spectrum and a specific mass-size relation, can be used to mimic the fractal structure of the ISM. Here, we introduce an extension of the KOSMA-τ code, denoted KOSMA-τ 3D that can be used to model star forming regions with arbitrary 3D geometry. Therefore, a 3D compound made of voxels ("3D pixels"), containing clumps with a discrete mass distributions, is assembled. The characteristics defining the individual clumps can vary between different voxels, supporting the analysis of the spatial structure of the region.

A probabilistic approach is used to calculate the averaged FUV extinction caused by the clumps within each voxel. To analyse each individual clump the new code is combined with the KOSMA-τ PDR model. Line emissivities and optical depths of individual clumps are used to calculate the distribution of voxel-averaged emissivities and optical depths, and the radiative transfer through the compound yields full spectral cubes. Hereby, the new code accounts for the intrinsic line widths of single clumps and additionally for a velocity dispersion between individual clumps.

The Orion Bar PDR, a well-known and luminous star forming region with an interesting edge-on geometry, is used as a test-case for the new 3D code. New HIFI/*Herschel* data from the HEXOS guaranteed-time key program and complementary data from the *Caltech Submillimeter Observatory* (CSO) are fitted. Simulation results, based on the clumpy edge-on cavity wall suggested by Hogerheijde et al. (1995), or on a cylindrical filament are presented. Simulations and observations are compared in terms of the layered positions of the emission peaks, the "chemical stratification" and on the line integrated intensities at the peak positions. Most PDR models fail to reproduce this combination. Our best fitting model reproduces the line integrated intensities of many simulated cooling lines within a factor four and the stratification patern within 0.02 pc (or better).

REFERENCES

Hogerheijde, M. R., Jansen, D. J., and van Dishoeck, E. F. (1995) A&A, 294, 792