Effect of Medium Inhomogeneities on Infrared Observations of Photon Dominated Regions

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Dense molecular clouds are the primary sites of star formation. They consist mainly of molecular gas and dust. Photon dominated regions (PDRs) are typically located at such boundaries of these clouds, which are under the influence of the far-ultraviolet (FUV) radiation from the nearby massive stars. Intense radiation heats the gas and the dust at the edge of the PDR, and attenuates then gradually, when it penetrates deeper into the cloud. The edge of the PDR corresponds to the ionization front, where the ionized gas recombines to neutral atomic gas (H_I). Deeper in the cloud, when the dissociating FUV photons are sufficiently attenuated, hydrogen becomes molecular. Also, dust properties exhibit evolution in this region. Infrared radiation dominates the emission of PDRs. It originates from dust grains as they re-radiate the absorbed FUV radiation as thermal emission in the infrared range. The intensity and the spectrum of this continuum radiation depend on the dust temperature, grain size distribution, and dust composition.

The goal of this study is to find out how medium inhomogeneities affect the intensity, spectrum and spatial distribution on infrared observations. Thermal dust emission continuum is examined at infrared wavelengths by performing 3D numerical simulations with the radiative transfer program Scattering with OpenCL (SOC) in a setup, which corresponds to the Orion Bar photon dominated region. As background information the imaging data and spectroscopic data profiles of the James Webb Space Telescope (JWST), the results of previously accomplished numerical simulations and studies of homogeneous and inhomogeneous medium are utilized. Finally, it is considered how the results may affect the conclusions drawn on the medium structure and dust properties in PDRs.

In the simulations it was observed that the composition of dust populations and size variations of dust grains influence the intensity of the radiation. The inhomogeneity of the matter affects the IR-observations of PDRs so that the radiation intensity peak near the PDR edge is lower than it is when the matter is modeled to be homogeneous. On the other hand, the radiation intensity of the inhomogeneous medium is higher deeper in the cloud. Inhomogeneity causes also secondary peaks in the decaying part of the emission profile curve. This is also seen in JWST observations. The results indicate that with increasing depth the FUV-radiation field decreases slower in inhomogeneous matter than it does in homogeneous matter.

The inhomogeneity of the medium in the PDRs affects the infrared observations. When constraining the properties of dust by comparing the results of model simulations with the space telescope observations, the accuracy of the dust models is improved when the inhomogeneity of the medium is considered.