Radiative transfer

Volker Ossenkopf

1. Physikalisches Institut der Universität zu Köln

Astronomical observations of the interstellar medium can only obtain information from the radiation arriving on earth. However there is no direct way to conclude the properties of the radiating matter. Radiative transfer models are required to compute the relation between these properties and the emergent radiation. Only the results of the computations allow to gain insight into the physical structure of interstellar matter.

Over the last years the numerical simulation of radiative transfer experienced a tremendous progress. In line radiative transfer 2-D models became a standard and first 3-D simulations are performed. In continuum transfer several 3-D codes are available and in the next step the inclusion of the polarisation is addressed. With growing experience from the simulations we realize, however, that a large part of the former knowledge on the interpretation of measurements has to be revised. In the analysis of molecular line data ambiguity of the solutions is the rule, not the exception. The results confirm the general wisdom that numerical models can explain many observations but do not necessarily lead to a true physical and intuitive understanding of radiative transfer in the interstellar medium.

Moreover, we still focus severe problems in all models. The uncertainties start with the dust opacities at long wavelengths, the line frequencies, which are hardly known above 1 THz, and the collision rates, where even the order of magnitude is unknown for some molecules of interest. They continue with problems in the treatment of coherent radiation, partial redistribution, and the representation of maser spots. However, these advanced problems indicate already that many former questions are simply solved. We start to get a better feeling which approximations can be applied in which situations allowing rapid data reduction but acknowledging that there can be no standard way. Each cloud and each molecule may require a different treatment. In the numerical models, molecules with several hundred levels including rotational-vibrational or pure vibrational transitions are going to be simulated. The progress will include the correct treatment of continuum pumping and overlapping lines, and first steps are made to deal with maser beaming, polarisation and partial coherence.

At the moment we cannot yet estimate which approach to develop radiative transfer theory will be most fruitful but we can hope that we will be able to get within a few years reliable data interpretations even from such extremely challenging molecules like water.