Chemistry of protoplanetary disks

Maxime Ruaud*1 and Uma Gorti1,2

1NASA Ames Research Center – Moffett Field, California 94035, United States
2SETI Institute, 189 Bernardo avenue, Mountain View CA 94043 – United States

Abstract

Protoplanetary disks are characterized by strong radial and vertical gradients of temperature, density and irradiation. These variations in the local physical conditions throughout the disk have a strong impact on its chemical structure. The upper layer of the disk, for instance, is largely dominated by gas-phase photo-processes (PDR layer) and mainly hosts atoms, ions and radicals while the attenuation of FUV photons in deeper regions leads to a richer gas-phase chemistry in the molecular layer. In the disk midplane, high densities and low temperatures lead to the freeze-out of almost all gas species at the surface of grains and result in the development of a complex gas-grain chemistry. Recent observations of disks with ALMA reveal that radial chemical substructures are common, likely indicative of an active gas-grain chemical coupling.

Here, I present the results obtained from a new framework in which we self-consistently solve the time dependent gas-grain chemical composition of a protoplanetary disk with a structure obtained from self-consistent thermo-chemical disk modeling including dust physics. We show that chemistry of most observable species is dominated by photoprocesses; not only at the PDR surface, but also on ices close to the water condensation front where photodissociation of ices significantly affects the gas phase composition of the disk. The disk interior, where condensation of ices occurs, can be divided into three main chemical regions depending on local physical conditions: (i) a shielded, inner disk midplane where low FUV fluxes and warm dust (