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Molecular Hydrogen emission from protoplanetary disks: effects of X-ray irradiation and dust evolution

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Abstract. We have made a detailed model of the physical structure of protoplanetary disks, taking into account X-ray and ultraviolet (UV) irradiation from a central star, as well as dust size growth and settling towards the disk midplane. Also, we calculate the level populations and line emission of molecular hydrogen from the disks, which shows that the dust evolution changes the physical properties of the disk, and then the line ratios of the molecular hydrogen emission.

Thanks to recent high resolution and high sensitivity observations, it has become possible to detect molecular hydrogen line emission from protoplanetary disks in various wavelength bands. Meanwhile, since dust particles are believed to evolve in the disks as the first step of planet formation, it is of great interest to find its observational evidence.

Our model calculations of the physical disk structure, and the level populations and line emission of molecular hydrogen from the disks (e.g., Nomura & Millar 2005) show that the level populations are controlled by the X-ray pumping if the X-ray irradiation is strong and the UV irradiation is weak. When the UV irradiation is strong, the level populations are controlled by the thermal collisions if there are enough small dust particles, or by the UV pumping process if the dust particles grow and settle. The excitation mechanism changes depending on the properties of dust grains (Figure 1) because with the decrease of small dust particles, the gas temperature drops due to the decrease in the grain photoelectric heating rate (Aikawa & Nomura 2006), and the thermal collision processes becomes less efficient. This results in a change of the line ratios of molecular hydrogen, which could be observable as evidence of the dust evolution in the disks.

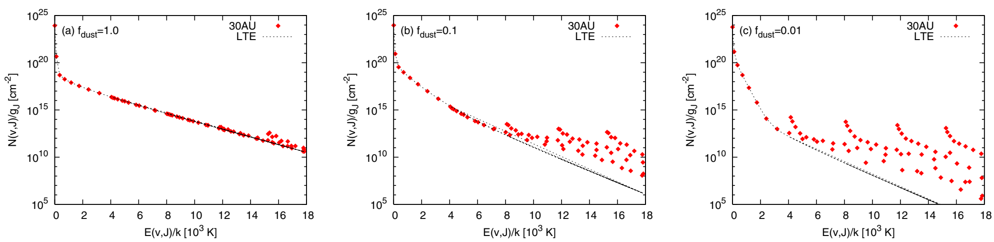

Figure 1. The level populations of molecular hydrogen, integrated vertically at the disk radius of 30AU, for various $f_{\rm dust}$, a parameter for the total surface area of dust particles per unit volume of the gas, normalized by that of the dense cloud dust model.

References

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