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A comprehensive ionization chemical network for protoplanetary disks

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Ionization plays a critical role in the gas dynamics of protoplanetary disks (PPDs), which is further related with disk evolution and planet formation. While non-thermal ionization mechanisms, such as X-rays and cosmic rays, dominate the bulk regions of PPDs, the innermost regions are characterized by high temperatures (>1000K) with thermal ionization of alkali species and dust thermionic emission. Such processes are expected to dramatically enhance the disk ionization fraction, leading to a revival of the magneto-rotational instability. To better understand the complex ionization processes in PPDs, we develop a comprehensive ionization chemical network that accounts for both thermal and non-thermal ionization. Using this model, we calculate the ionization fraction and the resulting magnetic diffusivities throughout the full range of physical conditions present in PPDs and discuss the implications on the gas dynamics of the innermost disk regions. Our findings provide a robust microphysical basis for future magnetohydrodynamical simulations.

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