The Role of Ice Compositions and Disk Dynamics for Snowlines and the C/N/O Ratios in Active Disks

The elemental compositions of planets define their chemistry, and could potentially be used as beacons for their formation location if the elemental gas and grain ratios of planet birth environments, i.e. protoplanetary disks, are well understood. In disks, the ratios of volatile elements, such as C/O and N/O, are regulated by the abundance of the main C, N, O carriers, their ice binding environment, and the presence of snowlines of major volatiles at different distances from the central star. We explore the effects of disk dynamical processes and ice compositions on the snowline locations of the main C, O and N carriers, and the C/N/O ratios in gas and dust throughout the disk. The gas-phase N/O ratio enhancement in the outer disk (exterior to the H2O snowline) exceeds the C/O ratio enhancement for all reasonable volatile compositions. Ice compositions and disk dynamics individually change the snowline locations of CO and N2 by a factor of 2-3, and when considered together the range of possible CO and N2 snowline locations is ~10 - ~70 AU in a standard disk model. Observations that anchor snowline locations at different stages of planet formation are therefore key to develop C/N/O ratios as a probe of planet formation zones.