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The First Stages of Planet Formation and The Clumps That Failed

Understanding whether self-gravitating disks can fragment during the early, violent phases of disk evolution is central to understanding the first stages of planet formation. If fragments can form, transient clumps can concentrate and process solids or form massive planets quickly and directly. Whenever the self-gravity of a disk becomes comparable to the combined stabilizing effects of shear and thermal pressure, a disk will become unstable and form spiral structure. Disks can be driven to a gravitationally unstable state through prodigious mass infall from a surrounding envelope, and the resulting spiral arms can drive mass transport and strong shocks. If mass transport and shock heating are sufficiently high, then gravitational instabilities will self-regulate, allowing spiral structure to persist throughout the unstable regions of the disk. If, instead, self-regulation fails and asymmetries continue to grow in amplitude, then fragmentation of spiral structure into bound clumps becomes possible. Nonetheless, even if fragments form in a disk, their survival is uncertain. In this talk, I will highlight clump destruction mechanisms and the consequences for their disruption on disk evolution and planet formation.