The Role of Hub-Filament Systems in the Formation of High-mass Stars

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Characterizing filamentary structures seen in Infrared Dark Clouds (IRDCs) is crucial to constrain the initial conditions of high-mass star formation (HMSF). Filamentary structures are prevalent in molecular clouds (e.g., Andre et al. 2010). Structures that are the converging point of multiple filaments, at least 3, are defined as Hub-Filament System (HFS). Recently, HFS has attracted attention as a site where high-mass stars form (Kumar et al. 2020). We investigate how HFSs contribute to the formation of high-mass stars from the earliest stages of cluster evolution.

The ALMA Survey of 70 μm dark Clumps in Early Stages (ASHES, Sanhueza et al. 2019, Morii et al. 2023) observed 39 IRDC clumps using ALMA 1.3 mm continuum at 1.2” angular resolution (∼5000 au or 0.02 pc). A total of 839 star-forming cores with masses between 0.06 and 81 $M_{\odot}$ were identified. By combining ASHES 1.3 mm continuum and 250 μm continuum by Herschel Hi-GAL survey, we find that 17 of the 39 ASHES clumps are embedded in HFSs. The distributions of core properties, including mass, differ significantly between cores embedded in HFSs and those that are not. We find, for the first time, statistical evidence that cores on scales of 5000 au embedded within few pc scale HFSs are systematically more massive than cores located in clumps that are not associated with HFSs. This discovery further strengthens the picture that HFS play a fundamental role in the formation of high-mass stars, influencing the mass assembly process from the earliest evolutionary stages, including the IRDC phase.