Investigating Cloud-Cloud Collisions and Hub-Filament Systems: Pathways to Massive Star Formation

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Massive stars ($M > 8M_{\odot}$) play a crucial role in shaping the interstellar medium and driving galactic evolution, yet the physical processes governing their formation remain incompletely understood. Massive stars preferentially form in dense molecular environments because it requires high mass accretion rates. In recent years, hub–filament systems (HFSs), in which multiple filaments converge toward a dense central hub, have emerged as promising sites of massive star formation (MSF). However, the origin of HFSs and their relationship to large-scale cloud dynamics remain open questions. In this talk, I will present the major results of my PhD thesis, which combines multi-wavelength (from near-infrared to radio) observations of several massive star-forming regions, including W31, AFGL 5180, AFGL 6366S, and G321.93–0.01, with magnetohydrodynamic simulations to investigate the formation of HFSs and their connection to cloud–cloud collisions (CCCs). Using continuum and molecular-line observations, multiple HFSs are identified within these regions, spanning a range of physical characteristics and evolutionary stages. Kinematic analyses of CO isotopologue data reveal signatures consistent with CCCs in all investigated regions. The observations suggest that cloud collisions can create the conditions necessary for HFS formation and sustained mass accretion. To test this scenario, I analyze magnetohydrodynamic simulation data from Inoue et al. (2018) and show that the combined effects of turbulence, collisional compression, magnetic fields, and gravity naturally lead to the formation of HFSs, providing theoretical support for the observational results. The combined observational and numerical findings establish a strong link between CCCs, HFS formation, and MSF, suggesting that cloud collisions may play a fundamental role in assembling the dense filamentary networks that facilitate the growth of massive stars.