ALMA observations reveal dual fragmentation modes in high-mass star-forming cloud

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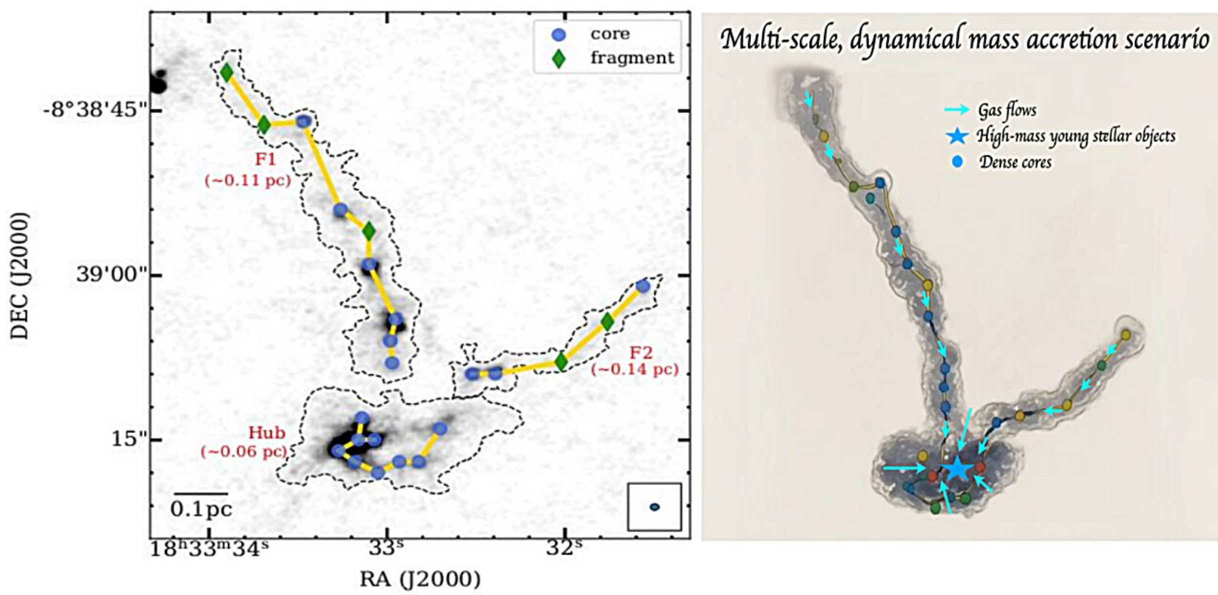

Left: Morphological structure of the HFS in target region I18308, showing core spacing distribution. The HFS molecular cloud consists of two distinct filamentary structures (F1 and F2) and a central hub clump. Right: Artistic illustration of multi-scale dynamic mass accretion. Credit: SHAO

In a study published in [*Astronomy & Astrophysics*](), an international team of astronomers has uncovered for the first time the coexistence of dual fragmentation modes and multi-scale dynamic material accretion within a "hub-filament system" (HFS) molecular cloud.

Using high-resolution observational data from the Atacama Large Millimeter/submillimeter Array (ALMA), they provided groundbreaking evidence for understanding the formation mechanisms of massive stars.

Led by scientists from Yunnan University, the Shanghai Astronomical Observatory of the Chinese Academy of Sciences, and the National Astronomical Observatory of Japan, and involving collaborators from Japan, Mexico, the United States, Germany, Chile, and Taiwan, China, the team conducted observations at a resolution of approximately 3,000 astronomical units (AU) using ALMA at the 1.3 mm wavelength

Targeting the HFS I18308 cloud, a high star-forming region with a textbook example of HFS morphologies, the researchers discovered two distinct fragmentation modes: two hub-composing filaments (F1 and F2) exhibit a cylinder-like fragmentation mode, with the quasi-periodic core spacings regulated by the turbulence-dominated fragmentation mechanism.

In contrast, the central hub clump shows a spherical-like fragmentation mode, with the core spacings regulated by gravity-dominated Jeans fragmentation mechanism.

These findings challenge models predicting a single fragmentation mode across all density scales within molecular clouds (e.g., the global gravitational collapse model).

Notably, the team did not find high-mass prestellar cores surpassing 30 solar masses. Instead, they found that all relatively low-mass cores show a systematic increase in mass and density with evolution.

These observed facts support a multi-scale accretion scenario: low-mass prestellar cores form via Jeans fragmentation in the hub, collapse into intermediate-mass protostars, and grow into high-mass stars through hierarchical mass accretion from the filaments, hub clump, and cores.

More information: L. M. Zhen et al, Hierarchical fragmentation in hub-filament-system I18308 observed as part of the INFANT survey, *Astronomy & Astrophysics* (2025). DOI: 10.1051/0004-6361/202554634