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Filamentary Flows and Clump-fed High-mass Star Formation in G22

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Abstract. G22 is a hub-filament system composed of four supercritical filaments. Velocity gradients are detected along three filaments. A total mass infall rate of 700 $M_\odot$ Myr^{-1} would double the hub mass in about three free-fall times. The most massive clump C1 would be in global collapse with an infall velocity of 0.26 km s^{-1} and a mass infall rate of 5×10^{-4} $M_\odot$ yr^{-1}, which is supported by the prevalent HCO$^+$ (3-2) and ^{13}CO (3-2) blue profiles. A hot molecular core (SMA1) was revealed in C1. At the SMA1 center, there is a massive protostar (MIR1) driving multipolar outflows which are associated with clusters of class I methanol masers. MIR1 may be still growing with an accretion rate of 7×10^{-5} $M_\odot$ yr^{-1}. Filamentary flows, clump-scale collapse, core-scale accretion coexist in G22, suggesting that high-mass starless cores may not be prerequisite to form high-mass stars. In the high-mass star formation process, the central protostar, the core, and the clump can grow in mass simultaneously.

Keywords. ISM: clouds – ISM: kinematics and dynamics – stars: formation – stars: massive

1. Introduction

The two extensive debated high-mass star formation scenarios have plotted largely different pictures of mass accumulation process. Extensive investigations show that the prevalent filaments are the most important engine of forming stars, especially for the high-mass ones (André *et al.* 2014). How the gas flows detected in filaments help individual cores grow in mass is still a key open question. In this work, a filamentary cloud G22 is extensively investigated to reveal a promising mass accumulation scenario.

2. Mass accumulation process in G22

G22: a collapsing hub-filament system. With a distance of 3.51 kpc, the G22 cloud contains ten *Spitzer* infrared dark clouds (IRDCs). These IRDCs are mainly distributed in in a hub-filament system. As shown in Figure 1 (b), systematic velocity changes are detected along filaments F1, F1, and F3 based on ^{13}CO (1-0) observations. The differences between the velocities of the filaments and the junction as a function distance to the center shows monolithically increasing profiles for F1, F2, and F3 (see Figure 1 (c)). This suggests that gas is transfered to the hub region along these filaments with an estimated total mass infall rate of 700 $M_\odot$ Myr^{-1}.

G22-C1: a collapsing high-mass clump. Located at the hub region, C1 is the most massive clump with a mass of 466 $M_\odot$. Prevalent blue profiles are detected toward C1 (see Figure 2 (b)), suggestive of clump-scale global collapse. The estimated mass infall rate is 5.2×10^{-4} $M_\odot$ yr^{-1}

G22-C1-SMA1: A collapsing hot molecular core. At the center of C1, a hot molecular core SMA1 with a gas temperature higher than 220 K is detected. The spectrum of ^{13}CO

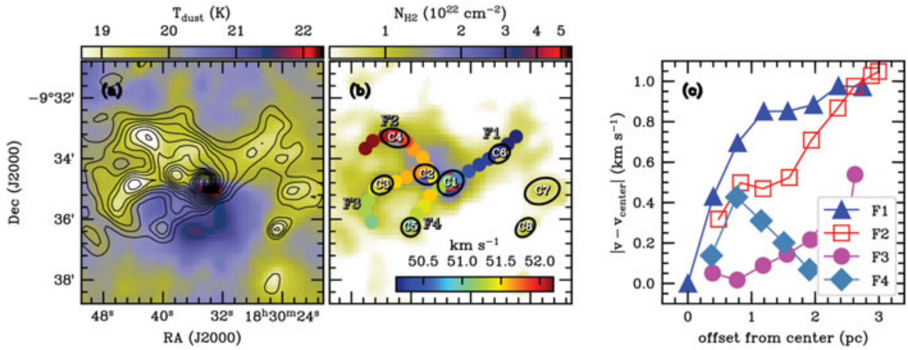

Figure 1. (a) Dust temperature map from SED fitting with column density overlaid as contours. (b) Velocity centroids of ^{13}CO (1-0) spectra extracted along filaments overlaid on top of the N_{H_2} map. The eight clumps, designated as C1 to C8, are shown as open ellipses. (c) LOS velocity of ^{13}CO as a function of distance from the potential well centers, i.e., clump C1 for F1, F2, and F4, and clump C2 for F3

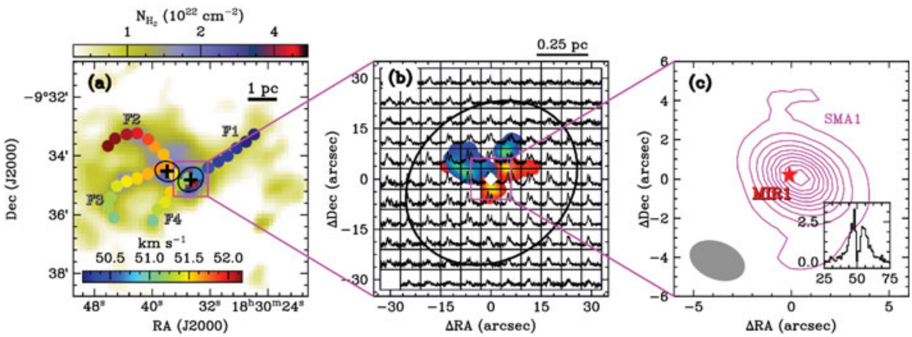

Figure 2. (a) Velocity centroids of ^{13}CO (1-0) extracted along filaments overlaid on the N_{H_2} map. (b) Spectra of JCMT/ ^{13}CO (3-2) overlaid on SMA/CO (2-1) outflows. The large ellipse delineates clump C1. (c) A close-up view of the SMA 1.3 mm continuum. The mono-core is designated as SMA1. A filled star shows the MIR source SSTGLMC G022.0387+00.2222 (MIR1) from the GLIMPSE survey. The insert plot shows the ^{13}CO (2-1) spectrum at the SMA1 peak.

(2-1) and C^{18}O (2-1) show blue profiles (see Figure 2 (c)), indicating infall motions in SMA1. The estimated mass accretion rate is about 7×10^{-5} $M_{\odot}$ yr^{-1}.

3. Conclusions

Inward motions have been detected along filaments, in the center clump and dense core. The continuous mass growth from large to small scales suggests that high-mass starless cores might not be prerequisite to form high-mass stars. The deeply embedded protostar, the core, and the clump can simultaneously grow in mass.

Reference

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