Molecular Gas Feeding the Circumnuclear Disk of the Galactic Center

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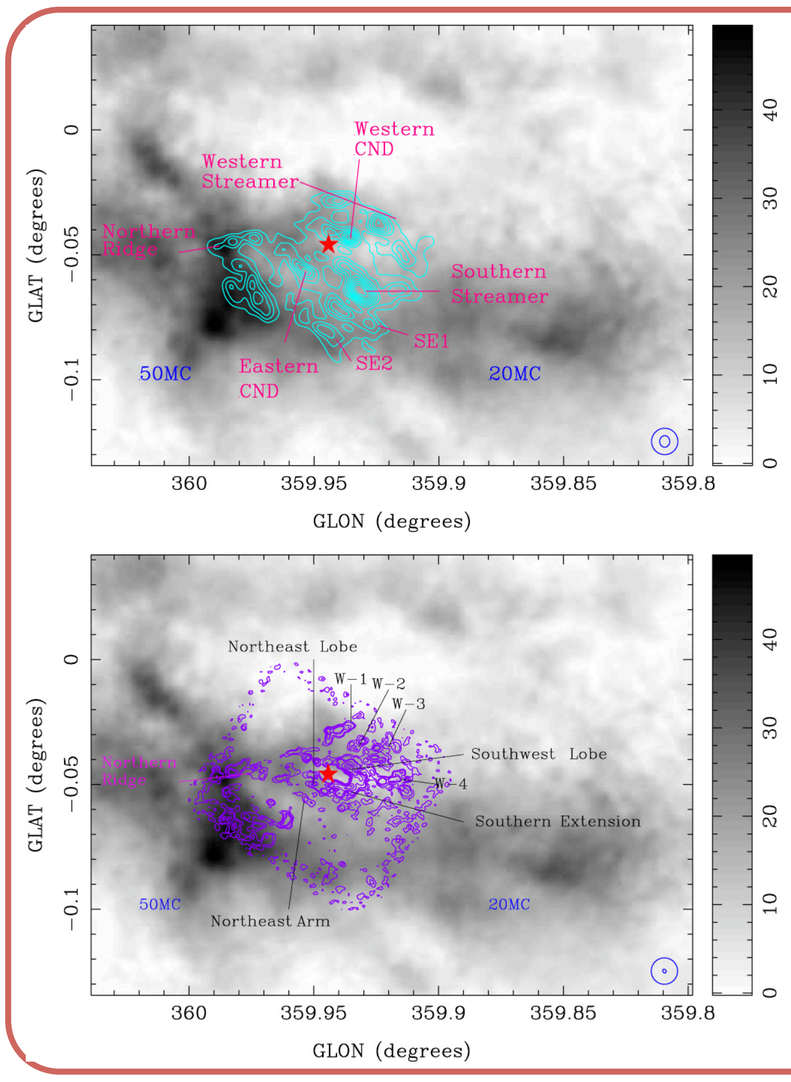
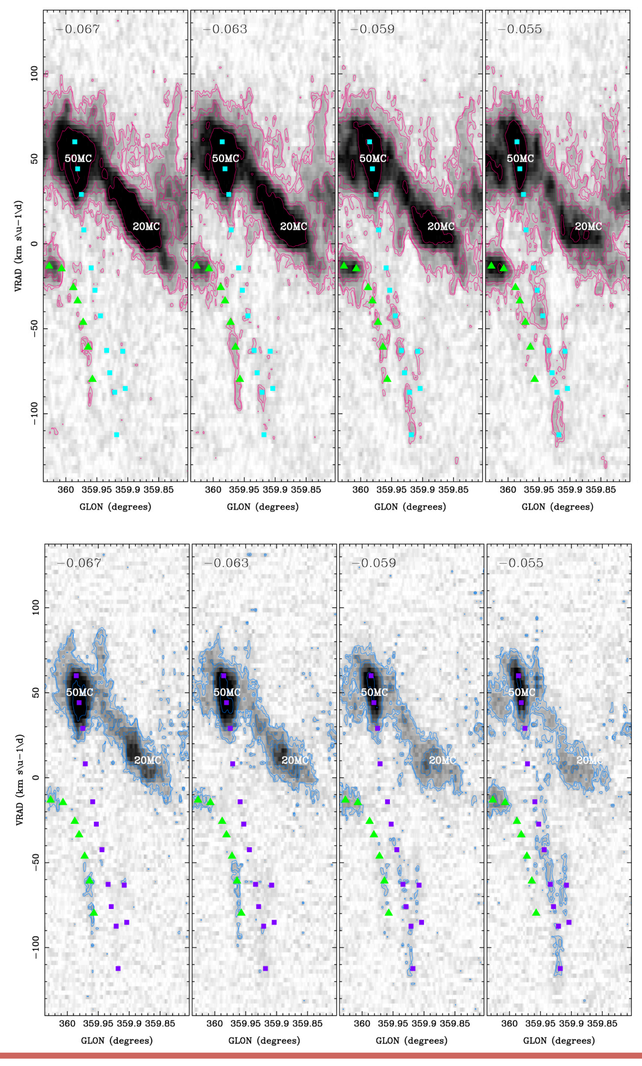
Hsieh et al. 2017, ApJ, 847, 3 (arXiv: 1708.08579)

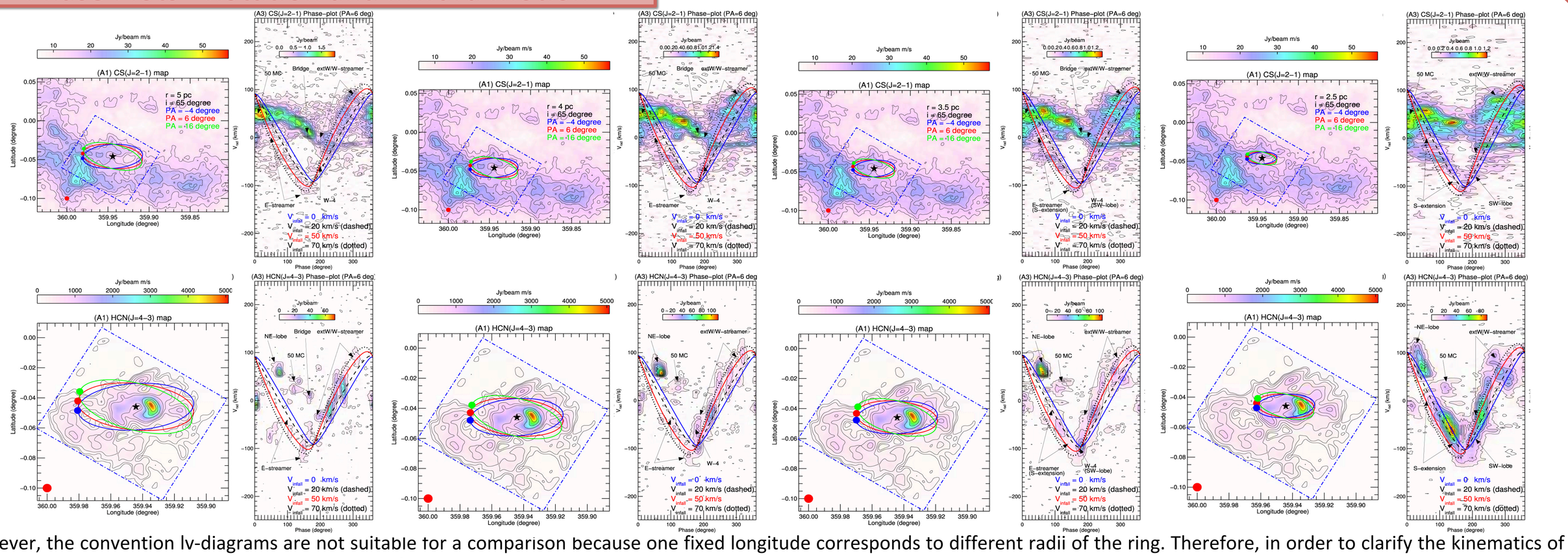




The Formation of Molecular Streamers

The origin of the 2 pc circumnuclear disk (CND) in the Galactic center (GC) has remained unclear in spite of decades of intensive study (e.g. Herrnstein & Ho 2002). The CND is a ring-like molecular structure rotating with respect to the supermassive black hole SgrA*. The CND, being the closest molecular reservoir in the GC, is critical for the understanding of the feeding of the nucleus. The replenishment of the CND itself, therefore, is an important problem. Previous NH3(3,3) observations carried out with the Very Large Array (VLA) have detected several streamers (contours in the top left image; Herrnstein & Ho 2002). The 20 km/s cloud (hereafter 20 MC) and the 50 km/s cloud (hereafter 50 MC) lying 20 pc south of SgrA*, appear to morphologically connect to the CND with several NH3(3,3) streamers. The 20/50 MC are seen in our new NRO 45-m CS(J=2−1) data (gray; Hsieh et al. 2016). The NH3(3,3) streamers are also detected in the high resolution SMA HCN HCN(J=4−3) map (contours in the bottom left image). However, the physical link between the streamers and the 20/50 MC are limited by the small field of view and missing flux of the interferometric maps. In our high resolution CS(J=2-1) map, we found clear evidences of the origins of the streamers in the longitude–velocity diagrams (lv-diagrams) (top right image). The origin of the streamer surrounding the CND might be from the 50 MC. A part of the 50 MC shows elongation in the lv-diagrams from b= −0.067 and seems to be stretched toward the streamers. The stretching of substructures in the 50 MC suggests that the gas is being tidally disrupted and dragged to the inner orbit with progressively higher velocities up to -120 km/s. This tidal stretching is also clearly seen in the CS(J=5-4) data (bottom right image) (Hsieh al al. 2015) *(more information see Hsieh et al. 2017)*

Phase Plots - Rotation and Inward Motion



However, the convention lv-diagrams are not suitable for a comparison because one fixed longitude corresponds to different radii of the ring. Therefore, in order to clarify the kinematics of the connection between the streamers and the 20/50 MC, we show position-velocity diagrams drawn on trajectories along the ring (phase plot; e.g., Jackson et al. 1993). The phase plots extracted at intrinsic radii of 5, 4, 3.5, and 2.5 pc (red elliptical annulus shown in the MOM0 maps) are presented for both the CS(J=2-1) and HCN(J=4-3) data. Starting position (0°) of the trajectory is labeled by the dot, and the phase is counterclockwise. Relative to the lower-velocity components of the 20/50 MC, high-velocity components are seen in both CS and HCN with maximum velocities of -120 km/s and 120 km/s, which correspond to the streamers and the CND from outer (4, 5 pc) to inner (3.5, 2.5 pc) radii, respectively. Pure Keplerian (blue curve) and Keplerian plus infall models are overlaid on the phase plots with corresponding radii from left to right panels (inclination=65°, PA=6°). We find that the gross features of streamers cannot be described by a pure Keplerian motion, where the max/min values are at θ =0 or 180° if the gas was subject to pure rotation. In fact, we find an infall motion (V_{infall} = 20–70 km/s) is needed to explain the gross features of the streamers. The loci of the max/min V_{rad} are at θ = −20 and 160° and indicate that there should be non-negligible radial gas motions, which we found to amount to 20–70 km/s. This range in infall motion defines a band in the phase plot that appears to capture the extended emission of the streamers. Besides, we also find that the fitted curves connect the inner edges of the 50 MC, as it is shown in the lv-diagrams. We further find that the western streamers seem to intersect with the CND with increasing velocities, which suggests replenishing gas for the CND.

Gas Replenishment of the CND though Streamers

Three-color image is shown in the left panel. The blue color shows the CS(J=2−1) data, the red color shows the SMA HCN(J=4−3) data, and the green color shows the SgrA West in the 6-cm. Right: schematic of the configuration of the 20/50 MC, the CND, SgrA East, and the streamers. Our data show that the clumps are ripped away from the 50 MC and form the streamers. The streamers can be described by a Keplerian rotation and by the infall motion. The western streamer intersects with the CND as shown in the phase plots, supplying replenishing gas for the CND. If the accretion rate is constant over 10^5 years, then the lower limits of the accretion-to-mass fractions onto the CND are in the range of 0.02%–2%. An accurate measurement of the CND mass will be essential to evaluate the lifetime of the CND.