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ALMA Astrometry of the IR Stars in the Vicinity of Sgr A*

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Abstract. We observed Sagittarius A*(Sgr A*) and the surrounding area at 230 and 340 GHz with ALMA in the interval of 14 months to demonstrate the possibility of a new method of search for IMBHs in the Galactic center region. The angular resolutions are ∼ 0.″03 at 230 GHz and ∼ 0.″10 at 340 GHz, respectively. The well-known infrared objects including IRS16 cluster, IRS13E complex, IRS21 cluster and many independent IR stars have been first detected in the sub-mm continuum maps. After subtracting the effect for crowding stars by insufficient angular resolution, we determined the proper motions referencing for Sgr A* of these stars. The proper motions are almost consistent with results from previous observations.

The Galactic center black hole, Sagittarius A*(Sgr A*), has a huge mass of $M \sim 4 \times 10^6 M_\odot$ (e.g. Boehle et al. 2016). It is an open question how Sgr A* acquires the material up to the present mass. There is a possibility that IMBHs had fallen and merged into Sgr A*. We had detected the ionized gas stream associated with the IRS 13E cluster and the ionized gas ring rotating around IRS13E3 (Tsuboi et al. 2017, 2019). The enclosed mass is estimated to be $M_{\rm encl.} \simeq 2.4 \times 10^4 M_\odot$. However, if a some amount of gas does not accrete onto an IMBH, no emission from itself is detected in all wavelengths. Then the existence would be proved only by gravitational effects of stars around it. Therefore precision astrometry using ALMA is important as an alternate method of search for IMBHs In the Galactic center region.

We have observed Sgr A* and the surrounding area including the Nuclear star cluster (NSC) (e.g. Genzel et al. 2010) at 230 GHz (2015.1. 01080.S) and 340 GHz (2017.1.00503.S) using ALMA in the interval of 14 months. We performed the data analysis by Common Astronomy Software Applications (CASA 5.5) (McMullin et al. 2007). The complex gain errors of the data were minimized using the "self-calibration" method. The resultant angular resolutions are ∼ 0.″03 at 230 GHz and ∼ 0.″10 at 340 GHz, respectively. Figure 1 shows the continuum map at 230 GHz. The well-known infrared objects of the NSC have been first detected in the sub-mm continuum maps.

The positions of these objects are derived by 2D Gaussian fitting to the continuum maps. The relative positions referencing for Sgr A* are obtained by subtracting the position of Sgr A* from the positions of these stars after subtracting the effect for crowding stars by insufficient angular resolution. We derived the proper motions in the NSC from the comparison of these relative positions. The proper motions are shown as vectors in Figure 1. They are almost consistent with previous results. In addition, the positional shift of Sgr A* is also detected. The velocity along the galactic plane is ~ -8.1 *mas/year*, which is roughly consistent with that based on the previous long-term VLBA observation (Reid&Brunthaler 2004).

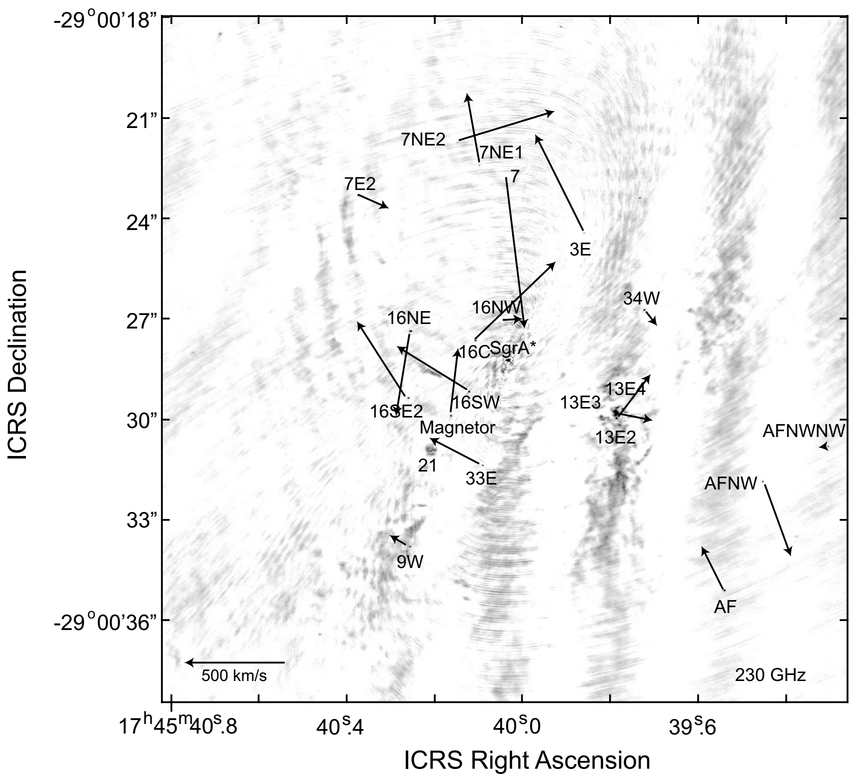

Figure 1. Continuum map at 230 GHz of the Nuclear star cluster. The angular resolution is $0''.037 \times 0''.025, PA = 85^\circ$ in FWHM. Vectors show the preliminary result of the proper motions of IR stars.

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