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Short Time Scale Variation in the Sub-millimeter Flux of Sgr A^*

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Abstract. We report a reliable detection of short time scale variations of less than one hour in the 340 GHz flux of SgrA* . Using the ALMA Cycle 3 data, we obtain 1630 snapshot images with 10 seconds exposure of the 25" × 25" field centered on SgrA* . We measure the intensity of SgrA* relative to those of non-variable sources in the field. The relative flux densities of SgrA* show rapid and large variations ($26-67\%$) over a period of $1-3$ hours. The intensity variation includes two characteristic time scales less than an hour: the longer one is more than a thousand seconds but less than three thousand seconds, and the shorter one is around one minute, or even shorter. Both are found commonly in all the four observing epochs.

At millimeter and sub-millimeter wavelengths, SgrA* shows time variations: Miyazaki et al. (2004) found intra-day variations at 100 and 140 GHz . Further a large amount of monitoring has established a steady characteristic flux density of $\simeq 3$ Jy at the sub-millimeter wavelengths with fluctuations of $30-50\%$ on hourly time scales (Zhao et al. 2003; Eckart et al. 2008; Marrone et al. 2008). Such emission of SgrA* is important to investigate its activity in connection with the black hole. We analyzed the time variation of SgrA* based on series of the snap-shot images. Because the surrounding objects observed at 340 GHz are mostly interstellar gas/dust blobs and early type stars,

they would not show any time variation in an hourly time scale. By comparing with the sum of those flux densities, relative but reliable intensity of SgrA* can be measured. These relative flux densities should be free from the atmospheric effects. Therefore, they are useful to search short time scale variability. By our analysis, we find that the intensity of SgrA* at 340 GHz show time variations with two characteristic time scales that are common to all epochs. The longer one is more than 1000 s and the shorter one is around one–two minutes, it could perhaps be shorter.

According to Machida & Matsumoto (2003), we may observe light curves that contain frequent small-scale flares on the accretion disk due to magnetic reconnections and their intensity modulations due to the Doppler effect of the relativistic rotating disk around the black hole. Probably, the two characteristic time scales of one-two minutes and >1000s correspond to the frequent small flares and their modulations, respectively, in such a scenario.

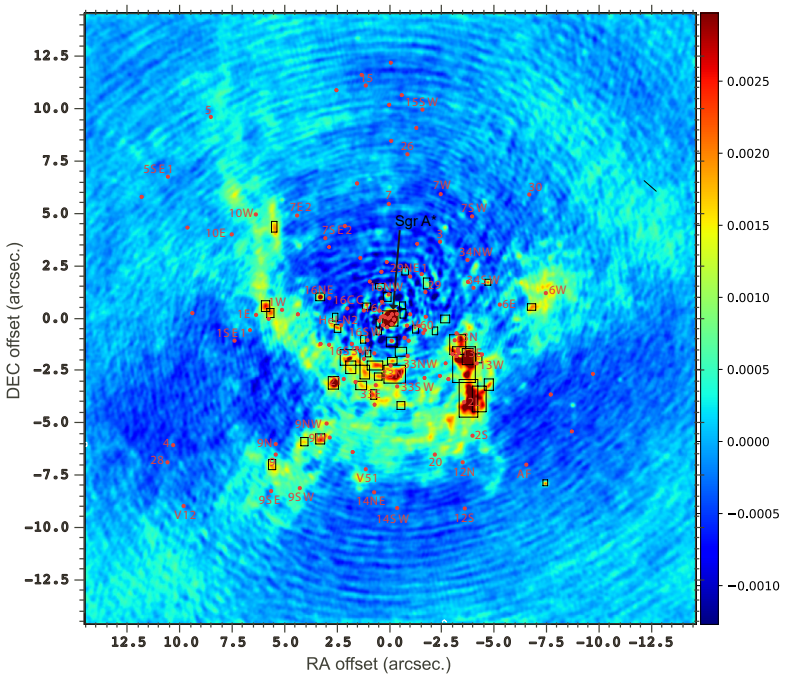

Figure 1. Synthesis image of the Galactic Center region at 340 GHz (continuum) using ALMA. The entire data of the four observing epochs are used. The imaging area is a 25″×25” field centered on SgrA* . The unit of the color bar scale is Jy/beam. The FWHM beam size is 0.″24 × 0.″22, and $PA = -89.^\circ1$. The boxes indicate the area of intensity reference sources we used. The red filled circles show the positions of the infrared sources, mainly the early type stars.

References

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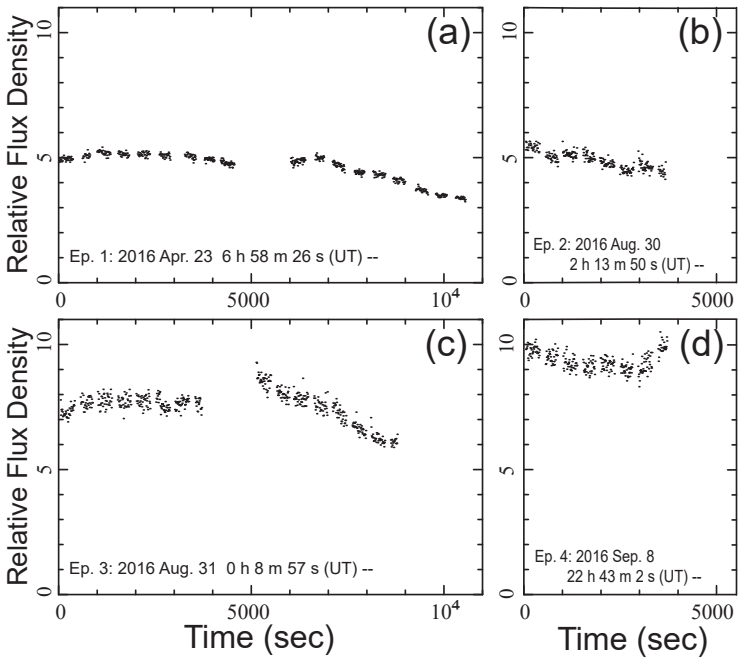

Figure 2. Relative flux density variations of SgrA* in the four observing epochs. Subsets (a), (b), (c), and (d) show variations in Ep. 1, Ep. 2, Ep. 3, and Ep. 4, respectively. The horizontal axis shows the time in seconds and the vertical axis shows the SgrA* relative flux density to those of the surrounding reference objects. Epoch 1 was performed with a low spatial resolution mode, and the scale of its relative flux density is quite different from that of the other 3 epochs. Careful considerations are required for a comparison between them.

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