Waiting for G2

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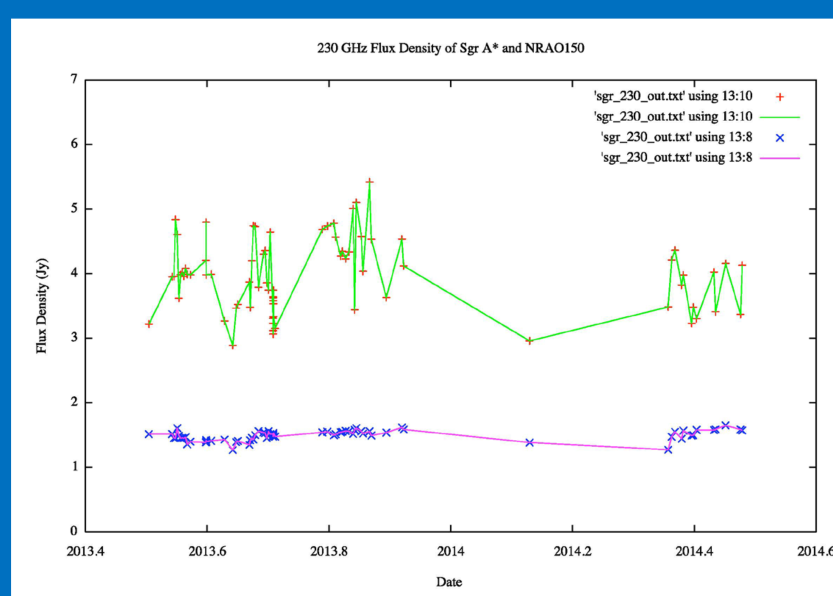

Fig. 1. The flux density of Sgr A (red plusses) and a comparison quasar NRAO 530 (blue crosses) measured with the SMA at frequencies near 230 GHz. The data have been calibrated with respect to a planetary reference, typically Titan. The errors are typically 0.2 Jy.*

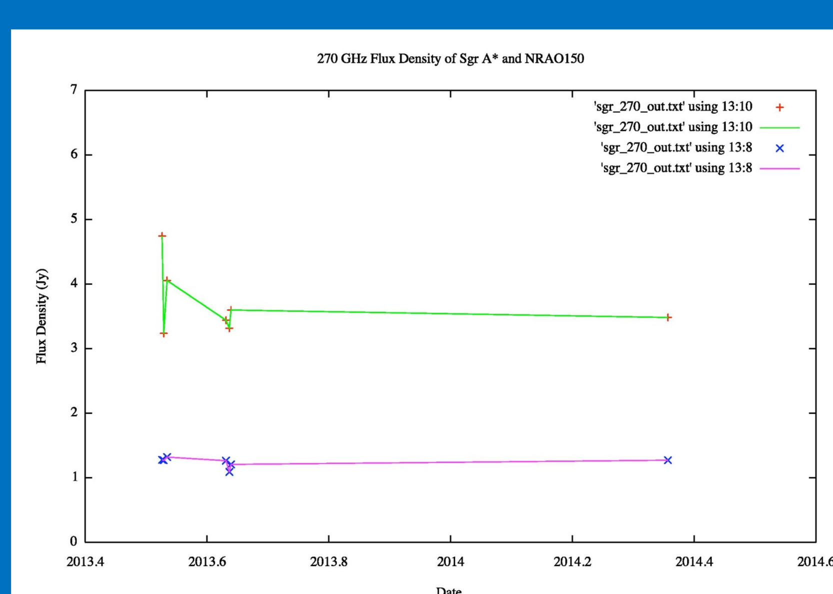

Fig. 2. Same as Fig. 1 but frequencies near 270 GHz.

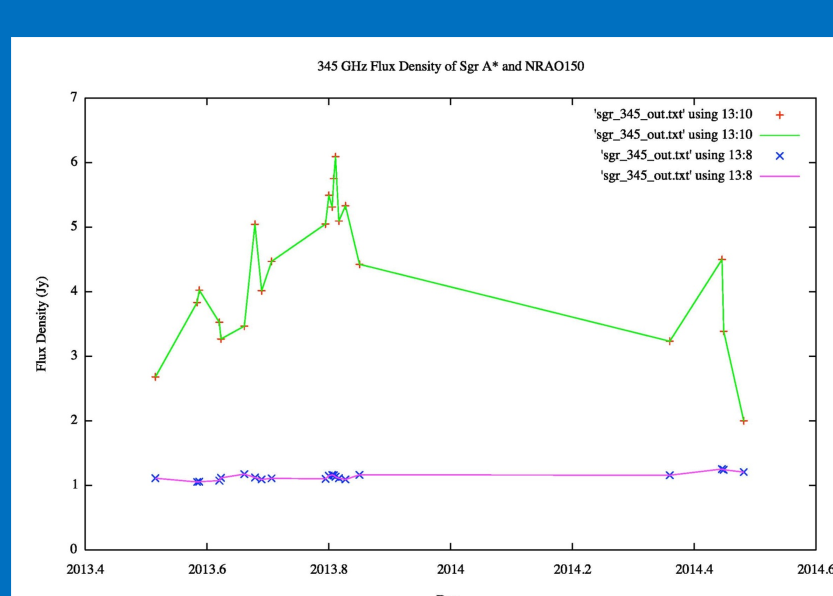

Fig. 3. Same as Fig. 1 but frequencies near 345 GHz.

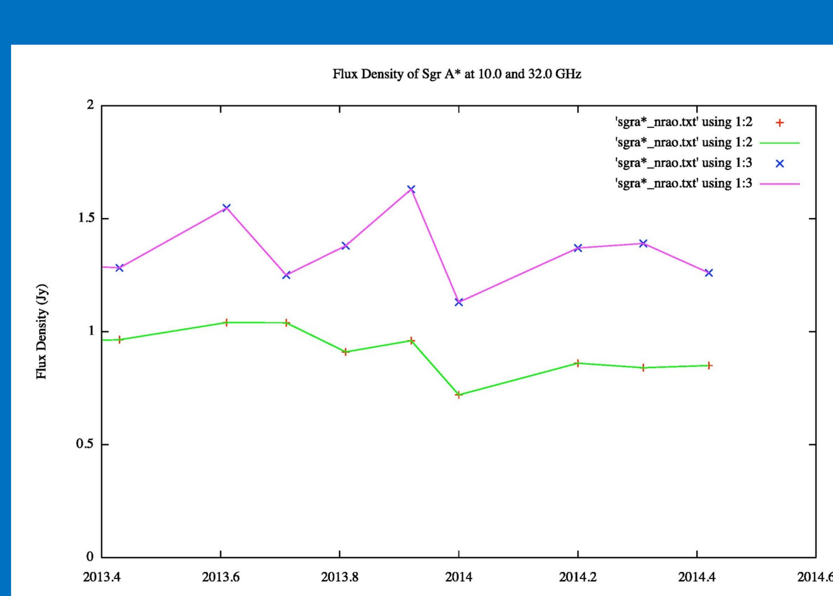

Fig. 4. The flux density of Sgr A at 10.0 GHz (red plusses) and at 32.0 GHz taken from the NRAO website. The statistical errors are less than 2 mJy, but the uncertainty in absolute calibration is 10 percent.*

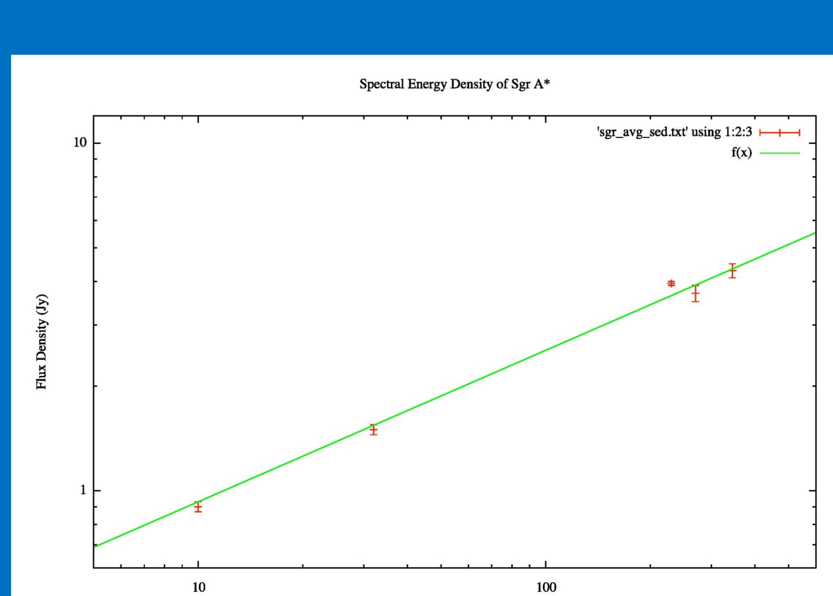

Fig. 5. The average spectral density calculated from the data in Figs. 1–4. The errors are the standard deviations of the mean. No turnover at high frequencies is evident.

Abstract

We have been monitoring the flux density of Sgr A* with the SMA since June 1, 2013, in order to document any unusual changes associated with the breakup of the orbiting body known as G2, which reached perihelion in early 2014. Flux density enhancement is expected at centimeter wavelengths due to shock-induced emission as G2 crosses the plane of the putative accretion disk, or in proportion to the average flux density across the radio spectrum due to the change in accretion rate with respect to the approximate ambient level of about 10^{-8} $M_{\odot}$/yr caused by the infalling debris of G2. We have made snapshot measurements of about 15 minutes' duration as often as possible, to a limit of once per day, using the SMA in whatever configuration and frequency are available. To date, we have measurements on 88 distinct days, roughly uniformly spaced, but with a major gap between November 2013 and March 2014 when Sgr A* was relatively close in angle to the sun. At frequencies between 218 and 355 GHz (1.3 and 0.8 mm wavelength), the flux density was always in the range of 2.0 to 6.0 Jy. This range is consistent with the historical range of variability of Sgr A*. Our data are intended to serve as an alarm to trigger more intensive observations should a substantial change in flux density outside the normal range occur. Our data set is rather irregular in cadence of observations and frequency coverage; it is sub-Nyquist sampled, since Sgr A* has been known to vary on the time scale of hours at the frequencies observed. Nonetheless, the database is an important information source. For example, we have estimated the average turnover frequency of Sgr A* and we have determined the power spectrum of the fluctuations over periods of 1 day to a few months.

G2 was expected to have passed its orbital pericenter by early 2014 (Gillessen et al., 2013). The bow shock created as G2 transited the black hole's putative accretion disk was predicted to produce a spectrum that peaked at about 1 GHz and then declined as ν^{-1}, which would make it undetectable at frequencies above the centimeter band (Sadowski et al., 2013). However, more significant radiation may come from a simple long-term increase in the accretion rate onto Sgr A* as the debris from the breakup of G2 is accreted. A simple estimate of the flux density enhancement factor, *f*, for such a process at any frequency, based on a mass for G2 of 10^{-5} $M_{\odot}$, is

$$f = s/s_{\mathrm{ambient}} \simeq 100 \left(\frac{T}{10\ \mathrm{yrs}} \right)^{-1} \left(\frac{\dot{M}}{10^{-8}\ M_{\odot}/\mathrm{yr}} \right)^{-1}$$

where T is the accretion time, and $\dot{M}$ is the ambient accretion rate. The ambient accretion rate for Sgr A* is 10^{-8} for $M_{\odot}$/yr, with an uncertainty of one order of magnitude (Marrone et al., 2007). Hence, if the accretion rate is 10^{-8} $M_{\odot}$/yr, and the accretion time is 10 years, then the flux density enhancement factor is about 100. However, if the accretion rate is 10^{-7} and the accretion time is 1,000 years, then $f \sim 0.1$, which would be undetectable given the normal fluctuations in flux density.

The flux densities of Sgr A* measured over the past year with the SMA at frequencies of about 230, 270, and 345 GHz are shown in Figures 1–3. No significant change in the radiation characteristics have been observed. In addition, Sgr A* has been monitored with the VLA at intervals of about 2 months. The flux densities at 10 and 32 GHz are plotted in Figure 4. Again, no significant changes have been observed.

If the flux density at each frequency is assumed to be described by a stationary random probability distribution, then the mean spectral energy distribution can be calculated. It is shown in Figure 5. The turnover frequency appears to be above 345 GHz.

Gillessen, R. et al., 2013, ApJ 774:44.
Marrone, D. et al., 2007, ApJL, 654, L57.
Sadowski, A. et al., 2013, MNRAS, 432, 478.