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A Faint Near-Infrared/Radio Flare form SgrA*

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During the past decades the analysis of flare emission from Sgr A* helped to put constraints on the emission models and the corresponding physical parameters. In the NIR the source is characterized by a single power-law flux density distribution. There is also evidence for the fact that radio and NIR variability data are described by a single power-law state with a power-law index of 4 similar to the one in the NIR. Here we summarize results of an analysis of NIR K_s-band data taken in the NIR using the High-contrast Coronographic Imager for Adaptive Optics (HiCIAO) at the SUBARU Telescope in May 2012. These observations partially overlap in time with radio data taken with the Australia Telescope Compact Array (ATCA) interferometer. The results are discussed in the framework of adiabatically expanding synchrotron sources as well as the possibility of quasi-simultaneous flare emission at both frequencies. The analysis has also been applied to other NIR/radio flares. The magnetic fields that we derive are in the range of a few to about 30 Gauss.

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1. Introduction

Sagittarius A*(SgrA*) at the center of the Milky Way is the closest super-massive black hole that we can study. It has a mass of the order of 4×10^6 $M_\odot$ and is associated with emission from a compact radio, infrared, and X-ray source (Eckart&Genzel 1996, Ghez et al. 2000, Schödel et al. 2002, Gillessen et al. 2006, Eckart et al. 2017). The surroundings of SgrA* also shows very clear effects that indicate a relativistic environment as one would expect it from a large compact mass. A first detection/test of General Relativity based on the orbital motion of the star S2 has been presented by Parsa et al. (2017; see also Eckart et al. 2018). Studying the variability of SgrA* at all wavelengths leads to an understanding of the sources physics and the corresponding emission process. In addition to jet models (e.g., Markoff et al. 2001, Moscibrodzka et al. 2013, 2014) also hot spot models, using source components orbiting close to the last stable orbit around the SMBH have been involved (Eckart et al. 2006, Gillessen et al. 2006, Meyer et al. 2006, Nishiyama et al. 2009, 2018, Zamaninasab et al. 2010). In most cases the emission is described by a synchrotron self-Compton (SSC) process (Eckart et al. 2012b). A time delay of typically two hours between the NIR/X-ray and the radio domain has been observed (Marrone et al. 2008, Trap et al. 2011, Eckart et al. 2012b, Yusef-Zadeh et al. 2006, Yusef-Zadeh et al. 2008). Here adiabatic expansion of synchrotron clouds (also referred to as 'blobs') is inferred (Eckart et al. 2009, Eckart et al. 2012b, Marrone et al. 2008). In a forthcoming paper (Steiniger et al. 2019) we give a detailed analysis of our observations of the Galactic Center (GC) in NIR K_s band, taken with the SUBARU Telescope, and the ATCA 3 mm observations (Borkar et al. 2016).

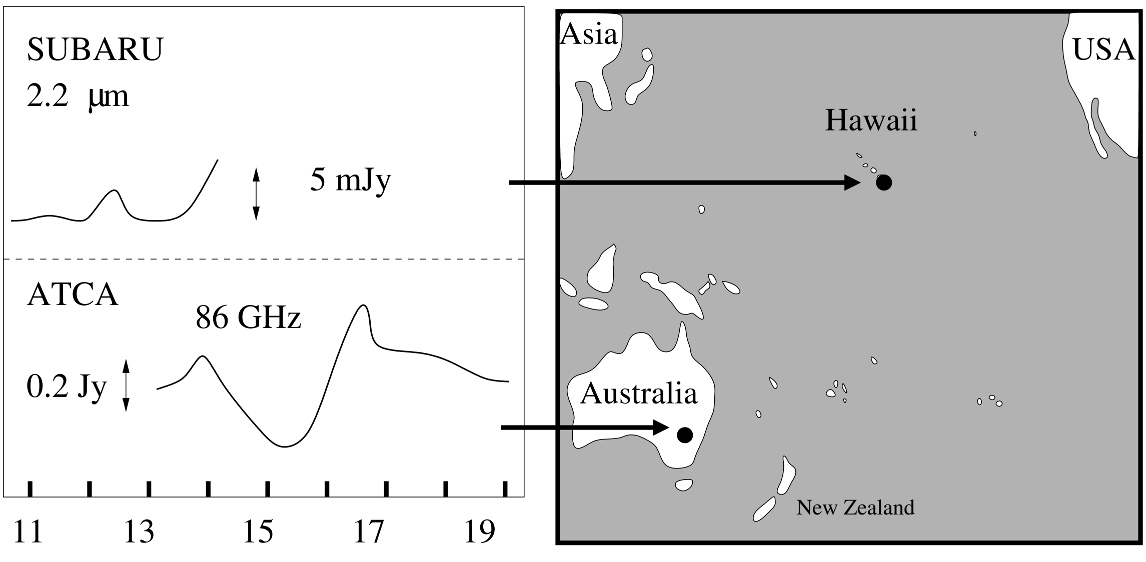

Figure 1: Right: Relative location of the Australian ATCA interferometer and the SUBARU telescope on Hawaii. Left: Sketch of the NIR light curve (top) and the radio light curve (bottom) taken by both stations.

2. A weak NIR/Radio flare from SgrA*

We obtained data from weak flare emission that was simultaneously observed in the NIR using the High-contrast Coronographic Imager for Adaptive Optics (HiCIAO) of the SUBARU Telescope and in the radio domain at a frequency of 86.2 GHz using the Australian ATCA interferometer (see Fig.1). In addition to these data, we assumed that the source size in the radio and NIR are similar and that the X-ray counterpart would have flux densities that fall within the range of X-ray flare strengths observed so far. With this information we use a synchrotron SSC formalism and a self-consistent fitting algorithm and find a set of models with turnover frequencies of 350 GHz and below. Magnetic field strengths range between a few and 30 Gauss. For these flares one then can show that the time it takes to expand is included in the pure radiative cooling time scale of about 5 hours (Blandford & Königl 1979).

This result is quite comparable to those obtain for other flares that have multi-frequency coverage. Since the results for the SUBARU/ ATCA flare are very similar to those obtained on other flare events. This indicates that the assumptions we made in the analysis of the available flare data from SUBARU and ATCA are very reasonable.

The set of flare solutions with turnover frequencies close to 350 GHz are clearly consistent with the findings for significantly stronger flares by Subroweit et al. (2017). Here, the authors found that the bright flares all seem to peak well within the sub-mm-domain. We conclude that the faint SUBARU/ ATCA flare we observed may be of similar nature as the brighter flares. If the flaring source components are adiabatically expanding the length of the flare will be influenced by the time scale of the expansion. This time scale may be longer than the typical time lag between the optically thin flare event observed in the NIR (this component will have an optically thick peak in the overall emission spectrum that will be located in the sub-mm domain) and the radio domain of about 2 hours (see, e.g., Eckart et al. 2008, 2009).

These flaring source components may be located in the inner accretion zone and may be part of the matter rotating around the SMBH close to the last stable orbit. Also a jet cannot be excluded. However, it may be very short (and hence may be looked upon as being and extension of the rotating matter) or it may quickly turn into an outflow with a very low surface brightness (see e.g. Markoff, Bower & Falcke 2007). In any case the emission is likely to originate close to the mid-plane of the overall accretion stream surrounding SgrA*. In that case one part of the orbiting matter will be Doppler boosted and another part on the opposite side will be Doppler de-boosted.

While Subroweit et al. (2017) point out that a dominant fraction of bright flares peaks in the sub-mm domain our analysis using simultaneous SUBARU/ATCA observations also indicates that (depending on the strength of the corresponding X-ray flare) a class of flares that have turnover frequencies well below 300 GHz may also contribute to the sub-mm emission. In this case, the flare components are likely located in an outer region of the accretion zone or possibly in the outer jet and counter jet regions. In those regions, the relativistic electron densities and energies can be expected to be lower and possible mechanisms that confine the source components may be more effective. Fainter flares, like the SUBARU/ ATCA flares we report on here, are very good candidates for flare events that result in or contribute to the quasi continuum radio emission of SgrA* that underlies the brighter flares events.

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