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NIR triggered observations of Sgr A* at 43 GHz

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Abstract. The compact radio and near-infrared (NIR) source Sagittarius A* has been observed in the context of two NIR triggered global VLT and VLBA campaigns at 43 GHz (7 mm) on May 16-18 2012 and October 4 2014. While on October 4 2014 Sgr A* remained in a quiescent state, a NIR flare on May 17 2012 is accompanied by an increase in flux density of 0.22 Jy at 7 mm delayed by 4.5±0.5 h. Additionally, Sgr A* seems to develop a weak secondary radio off-core component of 0.02 Jy at a position angle of 140° and an angular distance of 1.5 mas shortly before the peak of the flare. This spatial extension and the time delay are in the range of expected values for events casually connected by adiabatic expansion.

Keywords. Galaxy: nucleus, galaxies: active, galaxies: fundamental parameters.

1. Introduction

The super-massive black hole at a distance of ∼8.0 kpc is associated with the compact radio source Sagittarius A* (Sgr A*), which is flaring on timescales ranging from 7-10 min (sub-flares) to 1-2 h (main-flares) (e.g., Eckart *et al.* 2002). Current models try to explain these outbursts by magnetic turbulence and adiabatic expansion. The position, the source structure and the full width at half maximum (FWHM) Gaussian size of the compact radio source Sgr A* can be used to discriminate between these models.

2. Overview

Two equally setup, NIR-triggered 7 mm VLT and VLBA campaigns have been performed on May 16 - 18 2012 and October 4 2014 in order to analyze the flaring behavior of Sgr A*. In 2012 three six-hour long sessions using the full VLBA have been triggered by a NIR flare at 5:30 UT with total flux values up to 6.64 mJy. This flare is followed after 4.5±0.5 h by a 7 mm outburst with flux values peaking at 1.41 Jy (see Fig. 1 (a); details in NIR: Shahzamanian *et al.* 2015, 7 mm: Rauch *et al.* 2016).

In October 4 2014 the VLT showed excess K-band IR activity which triggered two hours of 7 mm VLBA observations. The three NIR exposures with a total integration time of ∼19 minutes, 400 s each suffer from decreasing weather conditions (UT times: 23:32:05, 23:47:04, 23:54:09; seeing: ∼1.1″, ∼1.3″, ∼1.5″, respectively). We adopted the resolution of the K-band continuum images to a common seeing value, corrected for positional offsets and averaged the images. Subtracting the results from individual exposures results in a 3σ upper limit with a dereddened flux density of 1.7 mJy. For the first exposure we

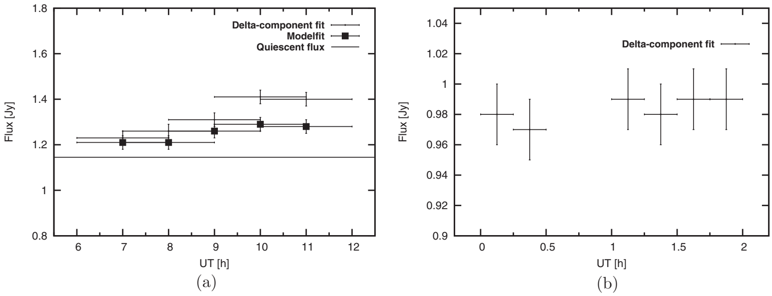

Figure 1. VLBA fluxes of Sgr A* at 7 mm (LCP), observed in a duty cycle of 60s, with an integration time of 6 s at 2 Gbps (8 IF channels at 32 MSamples/s of 2 bit). (a) May 17 2012 5:45:00 - 12:13:55 UT (Rauch *et al.* 2016). (b) October 4/5 2014 00:01:46 - 02:08:23 UT.

find a marginal detection of Sgr A* (2-3 σ) with a dereddened flux around 1.5 - 2.2 mJy. The corresponding light curve and Direct Fourier Transform (DFT) of the 7 mm VLBA observations show only a small flux variations of 0.012 Jy (0.05 Jy DFT) which lies within the error limit of 0.02 Jy and is therefore considered as quiescent (see Fig. 1 (b)).

During the flare on May 17 2012 a weak secondary component of 0.02 Jy separated by 1.5 mas at a position angle of 140° is shown in a frame covering two hours shortly before the peak (Rauch *et al.* 2016), while in October 2014 Sgr A* was best fit by a point source on all time ranges. Such a double component structure together with the corresponding time delay can be translated into an expansion speed of 0.4±0.3 c for an expelled gas, showing that these events can be casually connected by adiabatic expeansion. This asymmetric source structure offers non-zero closure phase values in the range of 1 - 2 σ, while simulations of artificial data sets show that such a weak secondary component is still hidden within the random scattering of modeled closure phases. The same applies for the 2014 data, which includes a few single closure phase values up to 40° above 3 σ, but simulations based on models of Brinkerink *et al.* (2016) and Ortiz-León *et al.* (2016) show lower phase values. Only an easily detectable very bright or remote secondary component would be capable of producing such values and the abundance of their observational evidence classifies these phases as outliers.

3. Implications

Sgr A* shows a double component structure with a secondary component of 0.02 Jy at 1.5 mas at a position angle of 140° (east of north) during a flare event on May 17 2012. While it is not possible to completely exclude weather or other random observational effects to be the cause of this reported extended source structure, the complete set of hints and robustness tests points towards a real data feature. Such a two component structure would exclude the hot spot model, because of the large separtation of the components, and point towards a temporary jet anchored at Sgr A* (Rauch *et al.* 2016 and references therein).

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