The origin of Fast Radio Bursts, still an open question

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Abstract

FRB 150418 is the first Fast Radio Burst (FRB) with a proposed counterpart. Keane et al. (2016) claimed that the galaxy WISE J0716−19 is the host of this event. Such association would provide extremely important clues about the possible extragalactic origin of the FRBs. It is still a mystery what kind of events produces the FRBs. We observed the proposed host galaxy with the European VLBI Network (EVN) during four epochs at 5 GHz, revealing a compact and persistent radio source located in the center of the galaxy. These data, together with contemporaneous observations, strongly support the presence of an active galactic nuclei (AGN) in the galaxy with variability on short timescales due to refractive scintillation. Therefore, WISE J0716−19 would not be related with FRB 150418.

Fast Radio Bursts (FRBs)

FRBs are transient sources characterized by emitting a single bright pulse of short duration (sub-millisecond). Initially discovered by Lorimer et al. (2007), nowadays we have detected ∼20 of these systems. Only one repeating FRB has been observed up to now (Spitler et al. 2016). The origin of FRBs remains unknown, mainly due to the poor localization of these events.
Both Galactic and extragalactic origins have been proposed. It is possible that they are due to young, highly magnetized neutron stars, or to cataclysmic events. The observed pulses resemble the ones observed in pulsars, but the high dispersion measure (DM) agrees with extragalactic sources. This would indicate that these pulses must be extremely powerful.

The possible association of FRB 150418

Keane et al. (2016) reported for the first time a localization of a FRB. A follow-up observation with the Australian Telescope Compact Array (ATCA) after the detection of FRB 150418 with the Parkes Telescope leaded to a detection of a transient source located in the center of an elliptical galaxy, WISE J0716−19, located at a distance of $z = 0.492 \pm 0.008$. This transient would thus be associated with an afterglow originated by the FRB.
This association was widely discussed and criticized (see e.g. Williams & Berger 2016a,b; Vedantham et al. 2016; Akiyama & Johnson 2016). Additional radio observations one year after the FRB show a compact source consistent with a regular scintillating Active Galactic Nuclei (AGN).

High resolution radio observations

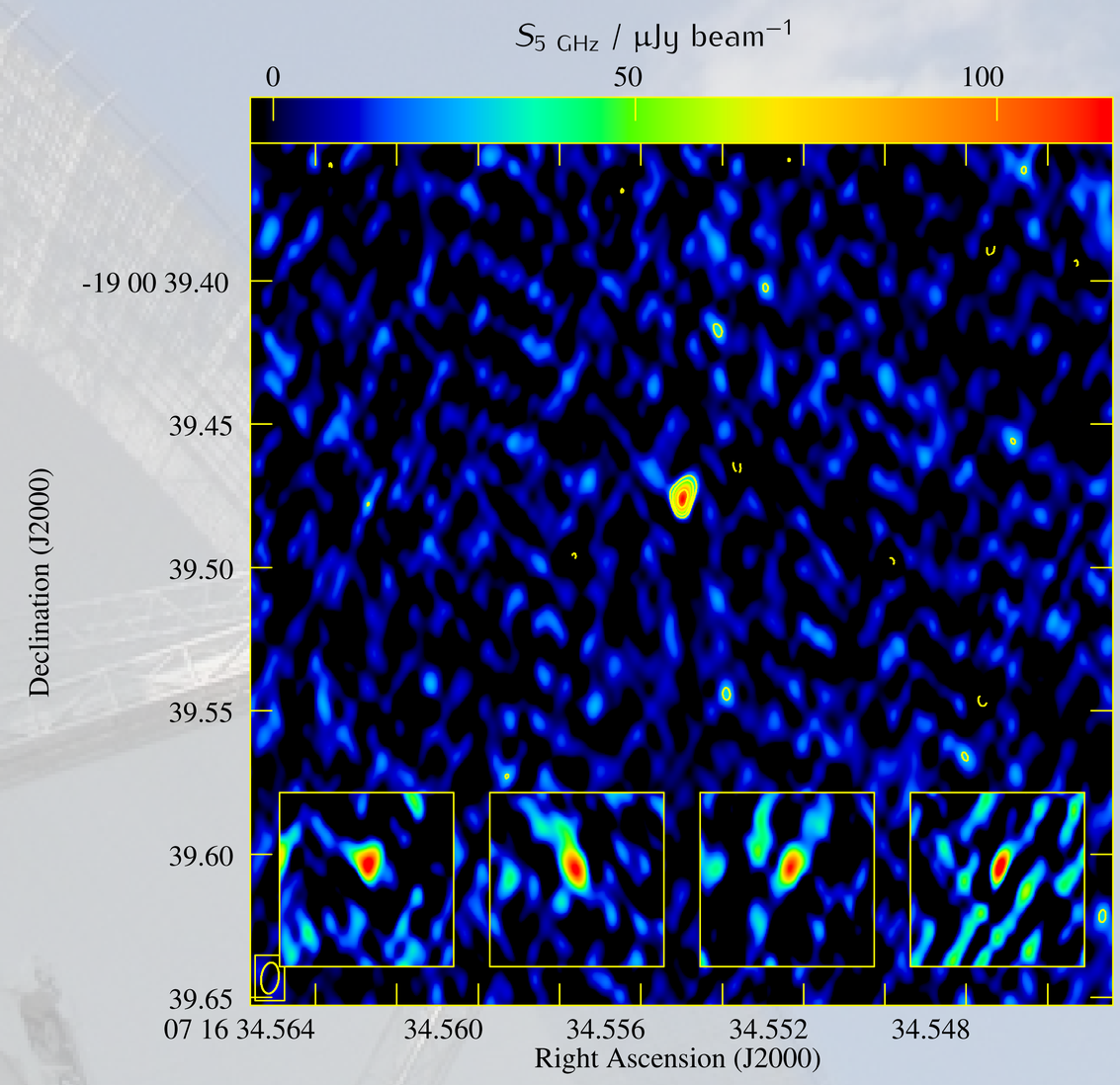
We conducted four radio observations with the European VLBI Network (EVN) between March and June 2016 to study in detail the compact radio emission of WISE J0716−19. We observed at 5 GHz with the following stations: Effelsberg, Westerbork, Jodrell Bank, Medicina, Noto, Onsala, Torun, Yebes, and Hartebeesthoek. The data was correlated in real time at JIVE with the so-called e-VLBI technique. Preliminary results were published by Marcote et al. (2016a,b). The detailed results of this work can be found in Giroletti et al. (2016).

Discussion

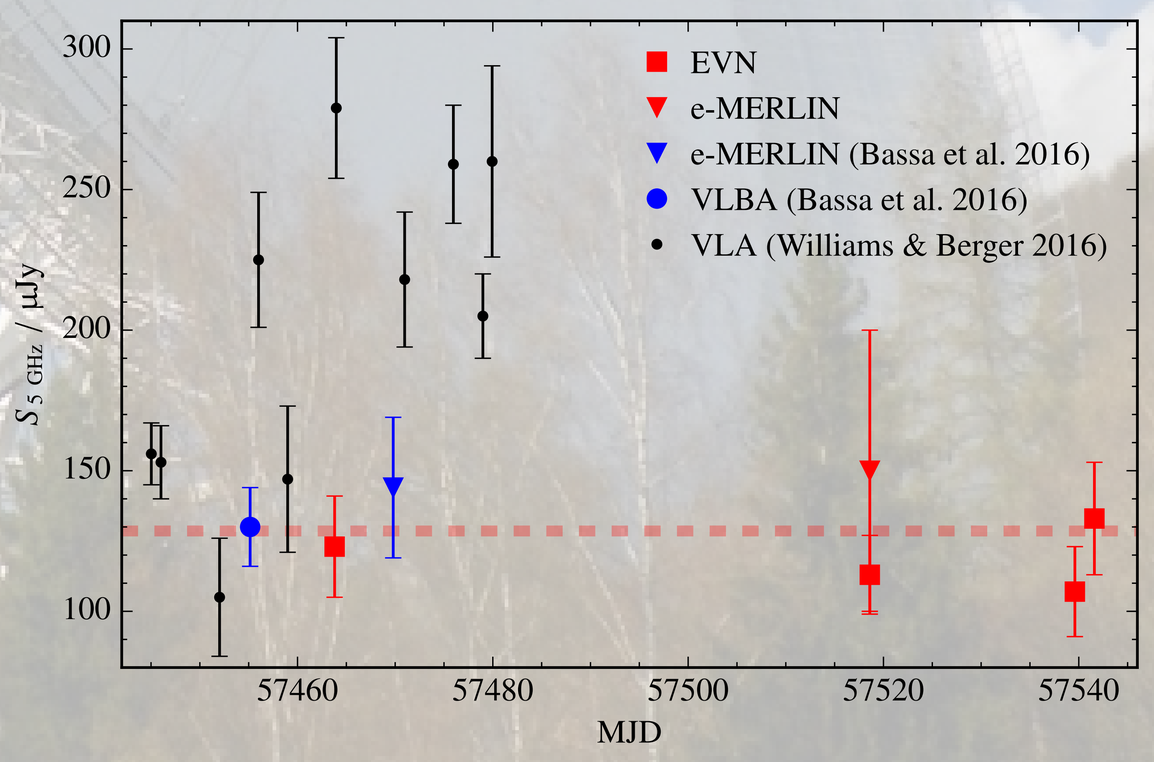
The EVN results show that the compact radio emission of WISE J0716−19 (which is unresolved) is stable within uncertainties on day-to-month timescales. These measurements are also compatible with the two VLBI observations published in Bassa et al. (2016). The observed emission implies a monochromatic luminosity of $L_{5\,\mathrm{GHz}} = (1.13 \pm 0.15) \times 10^{23}$ W Hz^{-1} and a brightness temperature of $T_\mathrm{B} \geq 10^{8.5}$ K.

Surprisingly, significant variability is observed in the VLA data (Williams & Berger 2016a,b), which could point out the presence of rapid variability on hour timescales, consistent with extrinsic variability originated by refractive scintillation in the ionized interstellar medium of the Milky Way.

All these data thus support the scenario of a compact AGN that produced the variable emission initially associated with FRB 150418 due to refractive scintillation.



EVN images of WISE J0716−19 at 5 GHz. The main panel shows the average image obtained by combining the four observations. Contours start at 3 times the rms noise level of 8.9 μJy beam^{-1}. The bottom panels show the source as seen in the four different epochs (2016 March 16, May 10, 31, and June 2).



Light curve of WISE J0716−19. Red symbols show the measurements obtained in this work (squares represent EVN data and triangles e-MERLIN data). The two other published VLBI results are shown in blue (VLBA data with a circle and e-MERLIN in a triangle; Bassa et al. 2016). The VLA data is represent in black circles (Williams & Berger 2016a,b). All the VLBI measurements are compatible with a constant flux density of ∼ 130 μJy (red dashed line).

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