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EVN observations of the Ultra Luminous Infrared Galaxies IRAS 23365+3604 and IRAS 07251-0248

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We present high-sensitivity, high-resolution images of the Ultraluminous Infrared Galaxies (ULIRG; $L_{FIR} > 10^{12}$ $L_{\odot}$) IRAS 23365+3604 and IRAS 07251-0248, taken with the EVN at 6 and 18 cm. The images show a large number of compact components, whose luminosities are typical of Type IIL and Type IIn Radio Supernovae (RSNe). Further observations of these ULIRGs will allow us to confirm, or to rule out, their nature. The present observations are part of a project that should result in a significant number of SN detections, providing a direct measurement of the Core Collapse Superova (CCSN) rate and allowing us to estimate the Star Formation Rate (SFR) in our sample of ULIRGs (see [1]).

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1. Observations

We carried out phase-reference observations of these ULIRGs using the EVN+MERLIN at 6 and 18 cm. Nine stations participated in the EVN observations at both 6 and 18 cm. Each observing epoch consisted of approximately 3.5 hours on target at each frequency, using a data recording rate of 1 Gb/sec, thus ensuring a good u-v coverage and a low off-source noise (RMS).

J2333+3901 was the phase-reference source for the target source IRAS 23365+3604 while 3C286, 3C454.3 and 2134+004 were used as fringe finders and bandpass calibrators. We have cleaned the delay and rate solutions from the contribution of the phase-reference source structure. Significant editing, mostly at 18 cm, was also needed to minimize RFI effects. In the case of IRAS 07251-0248, J0730-0241 was the phase-reference source and 3C286 and 3C273 were used as fringe finders and bandpass calibrators.

2. IRAS 23365+3604 & IRAS 07251-0248

IRAS 23365+3604 is an advanced merger at a distance of 252 Mpc with a very high luminosity ($\log(L_{FIR}/L_{\odot}) = 12.13$). IRAS 07251-0248 is a disturbed and/or interacting pair of galaxies at a distance of 344 Mpc and having a $\log(L_{FIR}/L_{\odot}) = 12.32$. Following [2], the expected SN rate for those ULIRGs is approximately 5 and 8 SN yr^{-1}, respectively.

3. Results and discussion

We have obtained the deepest and highest resolution radio images ever of two of the most distant ULIRGs in the local Universe, using quasi-simultaneous observations with the EVN at 6 and 18 cm (see Figure 1). We expect to get a better RMS and u-v coverage in our maps once we add the MERLIN observations.

We found a number of bright, compact components, some of which are suggestive of CCSNe exploding in the innermost regions of those ULIRGs. Indeed, the luminosities inferred for the compact components seen at 6 cm range from $\sim 5 \times 10^{27}$ in IRAS 23365+3604 up to $\sim 16 \times 10^{28}$ erg s^{-1} Hz^{-1} in IRAS 07251-0248 which correspond to luminosities typical of Type IIL and Type IIn SN (bright radio events). We also show overlays of the 6 and 18 cm EVN observations in Figures 1(c) and 1(f). Not all of the 6 cm brightness peaks are coincident with those seen at 18 cm (see Table 1). This is consistent with an scenario where we observe very young SNe, so that their 6 cm emission would now be around their peak, while their 18 cm emission could still be rising. On the other hand, we have also found several 18 cm peaks without a clear counterpart at 6 cm. This can be explained if their emission arises from CCSNe that are already in their optically thin phase, as indicated by their two-point spectral indices.

Our results show that the EVN is a powerful tool to study the central regions of nearby ULIRGs, and can be efficiently used to determine the CCSN rate and SFR in those galaxies. A new observing epoch should allow us to disentangle the nature of the compact objects we have found.

Component	IRAS23365+3604				IRAS07251-0248			
	Coordinates (J2000)		$\sigma_{position}$	$L_\nu \times 10^{28}$	Coordinates (J2000)		$\sigma_{position}$	$L_\nu \times 10^{28}$
	RA	DEC	(mas)	(erg s^{-1} Hz^{-1})	RA	DEC	(mas)	(erg s^{-1} Hz^{-1})
L1	23 39 01.2687	36 21 08.5230	1.3	1.1	07 27 37.6154	-02 54 54.2540	1.4	8.4
L2	23 39 01.2674	36 21 08.4840	1.4	1.1	07 27 37.6129	-02 54 54.2510	0.7	16.0
L3	23 39 01.2653	36 21 08.5260	1.2	1.2	07 27 37.6113	-02 54 54.2510	1.4	8.5
L4	23 39 01.2643	36 21 08.5690	1.0	1.4				
L5	23 39 01.2624	36 21 08.5520	0.8	1.8				
L6	23 39 01.2606	36 21 08.5720	0.7	1.9				
L7	23 39 01.2582	36 21 08.5860	1.2	1.2				
C1	23 39 01.2665	36 21 08.5830	0.8	0.7	07 27 37.6144	-02 54 54.2516	0.5	2.1
C2	23 39 01.2656	36 21 08.5895	1.1	0.5	07 27 37.6129	-02 54 54.2560	0.3	3.2
C3	23 39 01.2605	36 21 08.5895	1.1	0.5	07 27 37.6125	-02 54 54.2540	0.3	3.1
C4	23 39 01.2599	36 21 08.5855	1.1	0.5	07 27 37.6120	-02 54 54.2588	0.4	2.3

Table 1: Parameters estimated from the EVN-observations

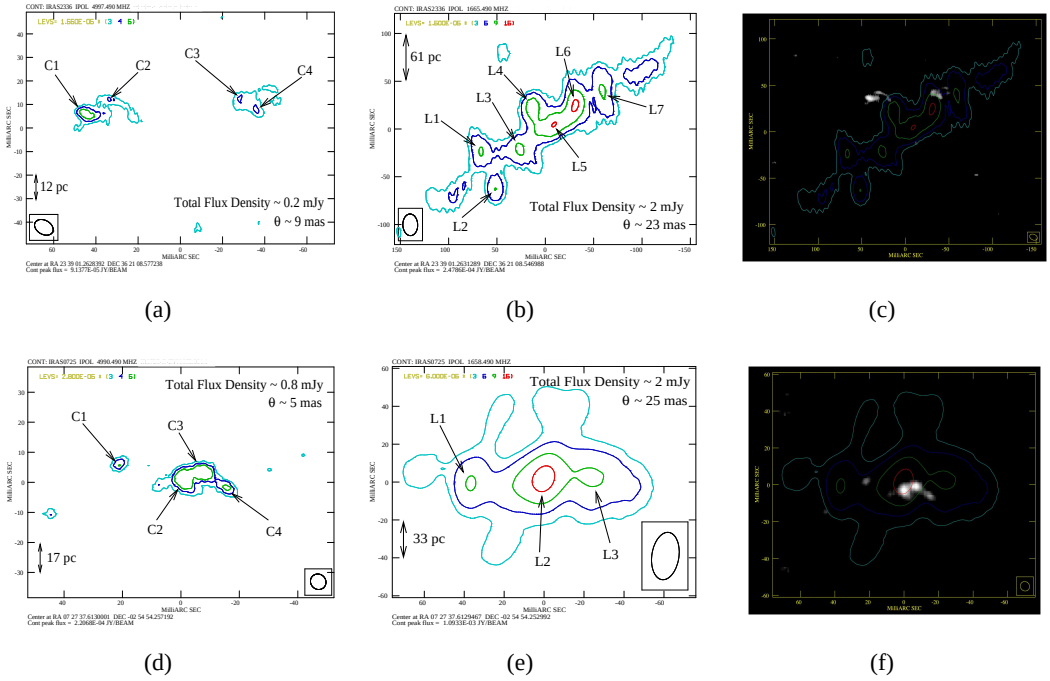

Figure 1: IRAS 2336+3604 at 6 (a) and 18 cm (b), with estimated RMS of about 15 μJy in both maps. IRAS 07251-0248 at 6 (d) and 18 cm (e), with estimated RMS of 28 and 60 μJy respectively. Emission components are marked with C- and L- labels; note that the first component in the C-maps do not correspond with the first component in the L-maps and so on. IRAS 23365+3604 (c) and IRAS 07251-0241(f) contours from observations on 29 February 2008 at 18 cm overlaid on the 6 cm image from 11 March 2008 observations.

References

[1] Pérez-Torres, M. A., Alberdi, A., Romero-Canizales, C., *et al.*, *High resolution radio observations of LIRGs and ULRIGs in the local universe*, in proceedings of The 9th European VLBI Network Symposium, PoS(IX EVN Symposium)027

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