

The gravitational lens J1131–1231 — How to avoid missing an opportunity

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So far the lens J1131–1231 has been studied only at optical and X-ray wavelengths. A detection in the radio was almost missed as a result of an incorrect position and archive problems. A direct analysis of NVSS *uv* data — in contrast to the catalogue or images alone — provided sufficient evidence of a detection to justify further radio investigations. The system was subsequently observed with MERLIN and the EVN in e-VLBI mode. Even though MERLIN seems to show the lensed star-forming regions *and* the compact cores, a preliminary analysis of the EVN data only shows an AGN in the lens itself but not the *lensed cores*. Additional VLA observations will be carried out soon.

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1. Introduction

The background source in RXS J1131–1231 consists of an irregular star-forming galaxy with a Seyfert core at $z = 0.658$. While the core is quadruply imaged, the host galaxy is distorted into an Einstein ring of $3''.6$ diameter. J1131–1231 is unrivalled in the amount of detail in the lensed image configuration, providing a wealth of constraints for lens modelling purposes. Many of the components are highly magnified so that a detailed study of the background source becomes possible. As noted by [3] and [1], the flux ratios of the Seyfert cores deviate considerably from the model expectations. Possible explanations are substructure in the mass distribution, differential dust extinction or microlensing.

2. Motivation for radio studies

In contrast to optical wavelengths, radio observations are not impaired by microlensing and dust extinction, and are therefore essential to resolve flux anomalies like observed in this system.

The NVSS [2] catalogue lists an extended source of 29 mJy close to the optical position of the lens. Fitting directly to the NVSS visibility data, we found that this source actually consists of at least three sub-components, one of which (6 mJy) is consistent with being the radio counterpart of the lens. Using an archived VLA snapshot, we were later able to confirm this identification (Fig. 1). The maps show an AGN (0.75 mJy) with jets *in the lensing galaxy*, and possible counterparts of the lensed Seyfert core (0.5–1.3 mJy each) and star-forming regions (1–2 mJy). The total flux density is consistent with our initial estimate from the NVSS visibilities. In addition (not shown here), we see two radio lobes connected to the AGN in the lensing galaxy. These lobes correspond to the other two subcomponents of the NVSS source.

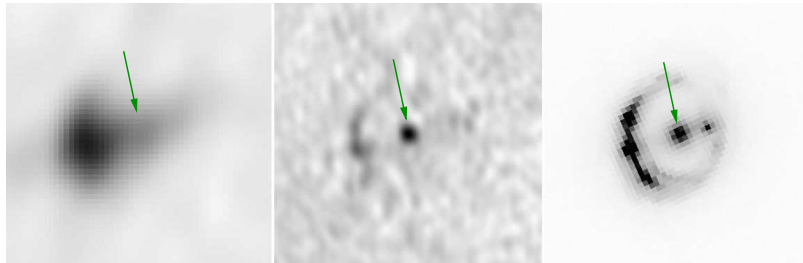


Figure 1: VLA snapshot maps in L-band and C-band with an HST image for comparison. The arrows mark the position of the lensing galaxy which seems to harbour an AGN.

3. Higher resolution

In May 2008 we observed the system with MERLIN in L-band. Fig. 2 shows a preliminary map produced after removing interfering sources with an own peeling algorithm. We are inclined not to trust all the components before our exploration of the reliability is completed.

Most of the emission detected seems to originate from the star-forming regions. The compact Seyfert core is weaker than expected from the VLA observations.

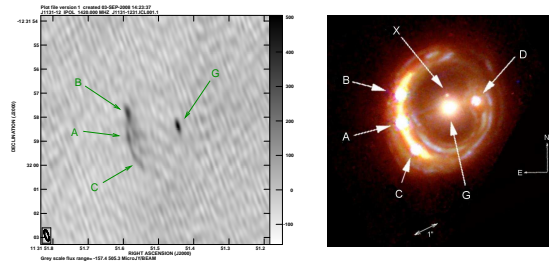


Figure 2: Preliminary L-band MERLIN map, 40 h at frequencies 1420 and 1658 MHz, compared to the HST image, adapted from [1], at the same orientation and scale. The lensing galaxy’s core *G* and the arc connecting *A, B, C* are clearly visible.

In order to explore the feasibility of detailed VLBI studies, we recently carried out a short (1 h on source) e-VLBI experiment at 18 cm, using six telescopes (Cm, Mc, Ef, JB1, Tr, Wb) with a data-rate of 512 Mb/s. We clearly detected the core of the lensing galaxy at a flux level of ~ 0.5 – 0.7 mJy but see no hints of the lensed Seyfert core images down to $< 100 \mu\text{Jy}$. This supports the evidence that most of the lensed radio flux is due to star formation in the background source.

4. Future projects

Further VLA time has now been granted to observe this system at C-band in A-configuration to produce a much deeper version of Fig. 1 (centre) and allow a comparison with the L-band MERLIN map. In addition to studying the lensed source and the mass distribution of the lens, this system offers the rare opportunity to see a background source *through* the jet emanating from the AGN core of the lensing galaxy. This can potentially be used to study the physical conditions in the jet.

5. Conclusions

J1131–1231 has been detected at radio wavelengths and shows structures of the lensed star-forming galaxy. It offers the opportunity to study physical conditions in an AGN jet via propagation effects acting on radiation from the lensed background source.

Original visibility data of radio surveys are an invaluable source of information being superior to maps alone. Without the availability of NVSS visibilities, the information from the survey catalogue or maps alone would not have been sufficient to motivate further investigations.

If you are conducting a radio survey — and can afford it — please store the visibilities!

References

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