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Measuring the Properties of the Gravitational Lens PKS 1830–211

J. E. J. Lovell[1], P. M. McCulloch, S. P. Ellingsen, & C. J. Phillips
Physics Department, University of Tasmania, Hobart, Australia

J. E. Reynolds, D. L. Jauncey, M. W. Sinclair, W. E. Wilson, A. K. Tzioumis, E. A. King, & R. G. Gough
Australia Telescope National Facility, Epping, NSW, Australia

R. A. Preston & D. L. Jones
Jet Propulsion Laboratory, Caltech, Pasadena, CA, USA

P. R. Backus
SETI Institute, Mountain View, CA, USA

Abstract. PKS 1830–211 is the strongest known radio gravitational lens by almost an order of magnitude and has the potential to provide a measurement of H_0, provided the lensing system can be parameterized. Attempts to identify optical counterparts, to measure redshifts, have so far proved unsuccessful and this has lead to radio and millimetre spectral line observations. We present our discovery of an absorption system at $z = 0.19$. A brief description is also made of our ATCA observations to measure the lensing time delay for this source.

The lensed image of PKS 1830−211 possesses a symmetric morphology, comprising two compact, flat-spectrum components of similar brightness located on opposite sides of a 1 arcsec ring. This suggests a close alignment of the lensed source behind the lensing mass. Moreover, there is evidence of unusually high rotation measures in some parts of the source which argues that the lensing galaxy is probably a gas-rich spiral (Nair, Narasimha, & Rao 1993) and suggests the possibility of detecting molecular absorption.

We undertook a survey in June 1995 for redshifted HI and OH absorption with the Parkes 64 m radio telescope, as part of a cooperative observation program with the Project Phoenix group (Tarter 1996). We detected only a single absorption feature with two sub-components of similar amplitude, centered at 1191.1 MHz with an overall line width of approximately 50 km/s. VLBI observations were made in September 1995 with four telescopes of the Australian Long Baseline Array (LBA) (Jauncey et al. 1994); Hobart, Coonabarabran, Parkes and five antennas of the Australia Telescope Compact Array (ATCA) acting as a phased array. S2 recorders (Wietfeldt et al. 1991) were used, operating in dual polarization (LCP and RCP) with 4 MHz bandwidth centered on 1191.0 MHz. The VLBI data were correlated at the ATNF VLBI correlator.

Our VLBI image (Figure 1) shows the compact components of PKS 1830–211, but little of the low brightness ring which is heavily resolved at this resolution. Figure 1 also shows the absorption spectrum of each component, clearly demonstrating that the two velocity components of the absorption system obscure different parts of the source. The low velocity component is heavily resolved and therefore must be obscuring only the extended ring while the high

[1]Now at Institute of Space and Astronautical Science, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229, Japan. E-mail: jlovell@vsop.isas.ac.jp

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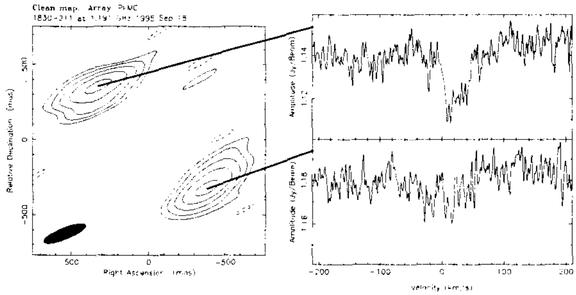

Figure 1. Our VLBI continuum map of PKS 1830–211 (left) and the spectra at the positions of the two continuum components (right).

velocity component is resolved only partially and covers the NE component but is weak or absent in the SW component.

We believe that our detection is probably HI absorption in an intervening galaxy at a redshift of 0.1926 ± 0.0001 and that there is a significant body of evidence to suggest that this system and the $z = 0.89$ system (Wiklind & Combes 1996) are both partaking in the lensing. Firstly, the lens evinces a quite paradoxical appearance at high resolution (Garrett et al., these Proceedings, p. 313). Secondly, attempts to model PKS 1830–211 with a single, simple gravitational potential have achieved only modest success, and have produced markedly different models (Kochanek & Narayan 1992; Nair, Narasimha, & Rao 1993). The results presented here suggest that the absorption system at $z = 0.19$ may be responsible for this striking disparity in the two images by causing additional lensing distortion of the NE image, thus forming a compound gravitational lens. We are continuing to investigate the nature of the $z = 0.19$ galaxy with VLA polarization observations and follow-up single dish spectral line observations.

We are using the ATCA to measure the lensing time delay by monitoring the flux densities of the two compact components of PKS 1830−211 regularly at 8.6 GHz. Results from ~1 year of observing suggest a time delay of 14 ± 7 days, much shorter than that measured by van Ommen et al. (1995). Our observations are continuing with a sampling rate of around 5 days to constrain this measurement further.

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References

Jauncey, D., et al. 1994. in *IAU Symp. 158: Very High Angular Resolution Imaging*, eds. W. J. Tango & J. G. Robertson (Dordrecht: Kluwer), 131–133.

Kochanek, C., & Narayan, R. 1992. *ApJ*, **401**, 461–473.

Nair, S., Narasimha, D., & Rao, A. 1993. *ApJ*, **407**, 46–59.

Tarter, J. 1996. in *The Search for Extraterrestrial Intelligence (SETI) in the Optical Spectrum II*, eds. S. A. Kingsley & G. A. Lemarchand, Proc. SPIE, **2704**, 24–34.

van Ommen, T., et al. 1995. *ApJ*, **444**, 561–566.

Wietfeldt, R. D., et al. 1991. in *Frontiers of VLBI*, eds H. Hirabayashi, M. Inoue & H. Kobayashi (Tokyo: Universal Academic Press), 177–181.

Wiklind, T., & Combes, F. 1996, *Nature*, **379**, 139–141.