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The MASIV survey: spectroscopic identifications of compact radio sources

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Abstract. Interstellar scintillation (ISS) has been shown to be primarily responsible for the short term intraday variability (IDV) exhibited by extragalactic sources at centimeter wavelengths (e.g. Bignall *et al.* 2006 and references therein). For a source to scintillate its angular size must be comparable to that of the first Fresnel zone (Narayan 1992) which implies microarcsecond angular sizes for screen distances of tens to hundreds of parsecs. This has the potential to probe within a few light months of the central black hole (Bignall *et al.* 2006). The aim of the Microarcsecond Scintillation-Induced Variability (MASIV) survey was to provide a catalogue of at least a hundred AGNs that vary on timescales of hours to days to provide the basis of detailed studies of the IDV population drawn from a well-defined sample.

Keywords. galaxies: active,distances and redshifts,photometry radio continuum: ISM

1. Introduction

The IDV of flat spectrum extragalactic radio sources was discovered by Heeschen (1984) and Heeschen *et al.* (1987). Further studies implied enormous brightness temperatures presenting a serious challenge for the physics if the variations were intrinsic. There is now considerable evidence that IDV in radio frequencies results primarily from scintillation in the turbulent ionized interstellar medium of our Galaxy. The MASIV survey (Lovell *et al.* 2003) was constructed in order to study systematically the IDV-phenomenon with a sample of flat radio spectrum point sources. The sample selection was based on JVAS, CLASS and NVSS catalogues (see the selection in detail Lovell *et al.* 2003). A large sample of scintillating extragalactic sources enables one to examine microarcsecond structure, parent population and the spatial distribution of scintillators, and to probe the turbulent ISM responsible for the scintillation. The MASIV 5 GHz observations were carried out at the VLA in four runs in 2002 and 2003, with the final sample of 443 sources. The variability was inspected by eye from the light curves and using Structure Function analysis. We found that 56% of the sources showed 2-10% rms variations on timescales over two days and the radio faint ($S < 0.3Jy$) sources show more variability than radio bright sources ($S > 0.3Jy$). Further investigation of the physical properties of scintillating AGN was handicapped by the absence of redshift measurement for the majority the MASIV sources. The optical observations reported here were made to address this problem.

Optical follow-up:
Optical identification was a prerequisite for spectroscopic identifications (and redshifts). For this we used all sky GSC2.3, SDSS DR5 and our own imaging data using Nordic Optical Telescope (NOT). The radio bright sample has eight sources with R-magnitude fainter than 22 magnitudes and the radio faint has 29 optically faint sources of which most of them have $R > 22$ magnitudes. Complete optical identification is down to $i \sim 23$ magnitudes. Using the SDSS DR5-subsample the median r-magnitude of the radio bright sample is 18.25 and faint 19.82 (Pursimo *et al.* 2013).

Spectroscopic follow-up:
The low resolution spectroscopic follow-up observations were carried out using NOT, Palomar and Keck telescopes. Pursimo *et al.* (2013) presented redshifts from the literature and 79 new spectroscopic identifications. At the moment the radio bright sample is 96% complete in terms of spectroscopic identification and/or redshift. Only nine sources from the radio bright sample have no data or only low S/N data. The radio faint sample has firm redshift/spectroscopic identification for about 85% of the sample.

2. Results

The main results in terms of the MASIV sample and spectroscopic identification are summarised below. The key results of the MASIV and the radio follow-up observations are introduced in these proceedings by Koay *et al.*

• We found that selecting compact flat spectrum radio sources ~80 % are FSRQ, more than 15% BL Lacs and ~5% of the objects show narrow emission lines. This distribution of sources is similar to that seen in previous blazar surveys such as DXRBS and CBS. However, when selecting the most variable sources based on the light curves or SF-analysis the BL Lac fraction almost doubles in both radio strong and radio weak subsamples.

• The weak lined object (mainly BL Lacs) fraction decreases with the radio flux density from $\sim$ 18% to $\sim$ 10% from radio strong to weak samples.

• The radio and optical luminosities of scintillating and non-scintillating sources were found to be similar, suggesting similar SEDs for both type of sources. Also, at given redshift the ISS and non-ISS sources have similar radio power.

• For broad line objects, we confirm the sharp decrease in the number of ISS sources and in the level of their ISS above a redshift 2. The decrease is compared to a simple model for ISS of flat spectrum radio sources with maximum brightness temperatures that are Doppler-boosted in jets pointing toward the Earth (Lovell *et al.* 2008, Pursimo *et al.* 2013). A similar trend is seen in the present sample which includes 312 redshifts.

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