Dual-Frequency Observations of 140 Compact, Flat-Spectrum Active Galactic Nuclei for Scintillation-Induced Variability

J. Y. Koay[1*], J.-P. Macquart[1], B. J. Rickett[2], H. E. Bignall[1], J. E. J. Lovell[3], C. Reynolds[1], D. L. Jauncey[4,5], T. Pursimo[6], L. Kedziora-Chudczer[7], and R. Ojha[8,9]

ABSTRACT

The 4.9 GHz Micro-Arcsecond Scintillation-Induced Variability (MASIV) Survey detected a drop in Interstellar Scintillation (ISS) for sources at redshifts $z \gtrsim 2$, indicating an apparent increase in angular diameter or a decrease in flux density of the most compact components of these sources, relative to their extended emission. This can result from intrinsic source size effects or scatter broadening in the Intergalactic Medium (IGM), in excess of the expected $(1+z)^{1/2}$ angular diameter scaling of brightness temperature limited sources resulting from cosmological expansion. We report here 4.9 GHz and 8.4 GHz observations and data analysis for a sample of 140 compact, flat-spectrum sources which may allow us to determine the origin of this angular diameter-redshift relation by exploiting their different wavelength dependences. In addition to using ISS as a cosmological probe, the observations provide additional insight into source morphologies and the characteristics of ISS. As in the MASIV Survey, the variability of the sources is found to be significantly correlated with line-of-sight Hα intensities, confirming its link with ISS. For 25 sources, time delays of about 0.15 to 3 days are observed between the scintillation patterns at both frequencies, interpreted as being caused by a shift in core positions when probed at different optical depths. Significant correlation is found between ISS amplitudes and source spectral index; in particular, a large drop in ISS amplitudes is observed at $\alpha < -0.4$ confirming that steep spectrum sources scintillate less. We detect a weakened redshift dependence of ISS at 8.4 GHz over that at 4.9 GHz, with the mean variance at 4-day timescales reduced by a factor of 1.8 in the $z > 2$ sources relative to the $z < 2$ sources, as opposed to the factor of 3 decrease observed at 4.9 GHz. This suggests scatter broadening in the IGM, but the interpretation is complicated by subtle selection effects that will be explored further in a follow-up paper.

Subject headings: galaxies: active — (galaxies:) intergalactic medium — (galaxies:) quasars: general — ISM: structure — methods: data analysis — radio continuum: ISM

1. Introduction

It is well established that the intraday variability (IDV) observed in many compact, flat-spectrum active galactic nuclei (AGN) at centimetre wavelengths is predominantly caused by scintillation in the turbulent and ionized inter-

*e-mail: kevin.koay@icrar.org

[1]International Centre for Radio Astronomy Research, Curtin University, Bentley, WA 6102, Australia

[2]Department of Electrical and Computer Engineering, University of California, San Diego, La Jolla, CA 92093, USA

[3]School of Mathematics and Physics, University of Tasmania, TAS 7001, Australia

[4]CSIRO Astronomy and Space Science, Australia Telescope National Facility, Epping, NSW 1710, Australia

[5]Mount Stromlo Observatory, Weston, ACT 2611, Australia

[6]Nordic Optical Telescope, Apartado 474, 38700 Santa Cruz de La Palma, Spain

[7]School of Physics and Astrophysics, University of New South Wales, Sydney, NSW 2052, Australia

[8]NASA, Goddard Space Flight Center, Greenbelt, MD 20771, USA

[9]Institute for Astrophysics & Computational Sciences, The Catholic University of America, 620 Michigan Ave., N.E., Washington, DC 20064, USA