Search for Gravitational Lenses in the Southern Hemisphere using the AT20G Survey – An Update

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The AT20G:
The Australia Telescope 20 GHz (AT20G) Survey is an extragalactic blind radio survey done in all declinations of the Southern hemisphere with a limiting flux density of 50 mJy. It has a galactic latitude cutoff of |b|<1.5°. The survey was done using the Australia Telescope Compact Array (ATCA) and has follow-up observations at 18752 and 21056 MHz (with further 4800, 8640 MHz follow-ups of sources below declination of –15°). The AT20G survey has detected ~6000 sources and is at the final stages of completion for data release.

The AT20G and Gravitational Lenses:
Due to the high frequency selection of the AT20G, a much higher fraction (~65%) of the total population are compact flat spectrum continuum sources (AGN). Such sources with uncomplicated cores at sub arcsec resolutions are relatively easy to confirm as lenses. We have embarked upon the search for extended flat spectrum objects, viz. gravitational lenses in the AT20G source population. Gravitational lenses from complete surveys, such as AT20G, are of particular interest as they provide an opportunity to study cosmology through lens statistics. We expect to find between 4 and 7 lenses through our search.

The ATCA, the Survey and the Data:
The ATCA is a 6km long east-west linear array with six 22 meter diameter radio dishes, with 5 dishes on 3km long rails and the 6th antenna fixed at a distance of 3 km from the end of the rail tracks. The ATCA has an additional 214 meter long north spur giving it the capability of working in compact-hybrid configurations.

Theblindsurveywasdoneinaveryquick rasterpattern with detections followed up at 20 GHz in compact hybrid configurations of the ATCA.

The 6km antenna was used to collect data at the maximum baseline of ~4500 m, giving us an indication of extendedness at higher resolution.

The ATCA has an angular resolution of ~12" at H214 configuration and ~0".5 at 4500 m baseline at 20 GHz.

The Source Visibility:
The interferometric visibility of a source is the fourier transform of the intensity of the source being observed (function of wavelength and the geometry of the source) (see fig. 2). Normalized visibilities for each AT20G source (henceforth 6k-vis) have been calculated using:

\[ 6k\text{-vis} = \frac{\text{long baseline visibility amplitudes}}{\text{short baseline visibility amplitudes}} \]

Ideally a compact unresolved source will have a 6k-vis equal to 1 while a source that is extended beyond 0.5 arcsec (for ATCA hybrid configurations) will have a 6k-vis closer to zero. Each source in the AT20G have one or more 6k-vis due to different HA observations.

The Source Spectral Indices:
The spectral indices (\( S_\nu \propto \nu^{\alpha} \)) of the sources were calculated using the ATCA (4.8 GHz) and NVSS or SUMSS fluxes.

Candidates Selection:
All sources showing 6k-vis < 0.9 and Spectral Index > -0.5 are considered lens candidates. Galactic thermal sources showing similar properties have been identified and removed from the gravitational lens candidates list. Theoretically, at 20 GHz a visibility of 0.85 is obtained for a circular gaussian source of size ~ 0.2 arcsec. We have ~ 120 candidates.

Future work:
We intend to do high resolution follow-up of our remaining candidates using the ATCA. We intend to follow up all unresolved extended sources and sources with multiple components at VLBI resolutions. We have also applied for optical imaging observations of the above two sources with Gemini South to identify their optical counterparts and confirm them as lenses. This process will be implemented for all promising candidates before embarking upon the studies of the lens systems themselves and their cosmological implications.

References: