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Fast Radio Bursts detected and localised by the Australian Square Kilometer Array Pathfinder (ASKAP)

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Fast Radio Bursts (FRBs) [1] are bright, millisecond-duration bursts of radio waves that come from galaxies at cosmological ($z \sim 1$) distances. They are interesting for several reasons: (1) Their short duration and high brightness imply very large energy densities, which challenging the physics of the how the radio pulses are produced. (2) They originate from a wide range of galaxy types which poses a challenge to understand the progenitor(s) of the bursts. (3) Measurements of an FRB allow astronomers to measure the integrated column density (through chromatic dispersion), magnetic field (through Faraday rotation), and turbulence (through temporal smearing) of the cold (10^4 K), ionised gas along the line of sight out to the FRB. This means FRBs can be used as tools to study ionised gas on cosmological scales, which is difficult to study using any other observing technique.

We have been using the Australian Square Kilometer Array Pathfinder (ASKAP) to detect and characterise FRBs. ASKAP is an effective FRB machine thanks to its large field of view (30 square degrees) which yields a relatively high detection rate (1 FRB per ~ 2 weeks); adaptable observing modes (so-called "fly's-eye" mode and traditional co-pointing) which enables it to probe a wide range in burst fluence, and high angular resolution, which yields accurate ($\lesssim 1$ arcsecond) localisations.

We have now detected 35 FRBs and obtained accurate positions for 9 of them. Scientific highlights include:

1. Measurement of the dispersion-brightness relation for FRBs by comparing the integrated column density of bright FRBs detected with ASKAP with a fainter population [2]
2. The first localisation of a single FRB to the outskirts of a quiescent, early-type galaxy at $z = 0.34$ [3].
3. Detection of an FRB which passed within 29 kpc of a foreground galaxy, revealing surprisingly low density, magnetisation and turbulence of the ionised material in the halo of the foreground galaxy. [4].
4. Detection of the "missing" baryons in the intergalactic medium by finding a correlation between the integrated column density and host redshift of several FRBs (Macquart et al., in prep.).
5. Finding FRBs in a wide range of galaxy types, in tension with known classes of extragalactic transients which typically congregate in particular galaxy types (Bhandari et al, in press.).

We plan a $\sim$ \$1.4 M upgrade the FRB detection infrastructure at ASKAP over the next 18 months. The new processing backend will search the entire field of view of ASKAP coherently, ingesting data at 400 Gb/s, searching 2 million spatial pixels every millisecond, and computing over 40-trillion data points per second - equivalent to 2 million people watching YouTube. This upgrade will increase the search sensitivity by a factor of 5 and the detection rate by 5–20.

References

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