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Microsecond Sectropolarimetry with ASKAP: New Insights on the Nature of Fast Radio Bursts

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Lasting only of order micro- to milliseconds and detectable out to cosmological distances, Fast Radio Bursts (FRBs) imply an incredibly energetic and hitherto unknown emission mechanism. The fundamental property of FRBs is the radio pulse itself, which is imprinted with the physics of the emission mechanism and intervening plasma through which it propagates. The Australian Square Kilometer Array Pathfinder (ASKAP) is equipped with both a real-time detection system for dispersed radio pulses and a voltage buffer that enables subsequent offline (re-)analysis at microsecond or even nanosecond time resolution and with full polarimetric information. Through correlation and imaging, the origin of the pulses can be ascertained with sub-arcsecond precision, and the enhanced sensitivity provided by a coherent (as opposed to incoherent, in the detection system) summation of the signal means that all detected bursts can be investigated at high signal-to-noise (S/N).

Since 2018, 13 extragalactic Fast Radio Bursts (FRBs) have been detected by ASKAP [e.g., 1], providing an unprecedented sample of localized, temporally-resolved, high-S/N bursts with full spectropolarimetric information. The analysis of this dataset has reinforced a dichotomy in the properties of known repeating FRBs vs. those that appear not to repeat, with the latter being narrower, having a higher degree of circular polarization, and commonly showing pulse-phase-dependent evolution of the linear polarization position angle [2]. Despite these differences in the burst properties, which can be used to probe both local and intervening material, the host galaxies and local environments of repeating vs. apparently non-repeating FRBs do not exhibit clear differences, although the sample of confirmed localized repeaters is small. The increasingly large sample of such FRBs that will be provided by ASKAP over the coming 2-3 years will enable models that purport to explain the diversity of FRB properties to be tested with increasing stringency and will set the stage for precision cosmology using FRBs in the SKA era.

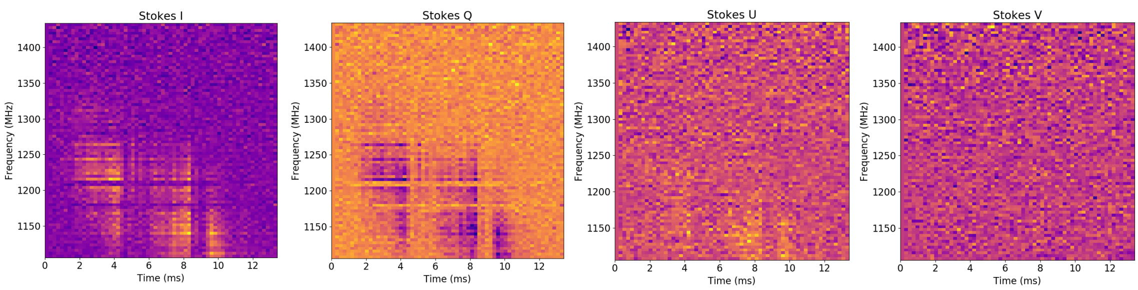

Figure 1. Adapted from [2]. Left to right: the FRB 190711 Stokes I, Q, U, and V dynamic spectra (frequency vs. time), where color represents the flux density. This repeating FRB shows a characteristic downward drift in the central frequency of the sub-bursts of ~15.4 ± 1.9 MHz ms^{-1}.

References

[1] Macquart, J.-P., *et al.*, "A census of baryons in the Universe from localized fast radio bursts", *Nature*, **581**, 7809, May 2020, pp. 391–395, doi:10.1038/s41586-020-2300-2.

[2] Day, C. K., *et al.*, "High time resolution and polarization properties of ASKAP-localized fast radio bursts", *Monthly Notices of the Royal Astronomical Society*, **497**, 3, September 2020, pp. 3335–3350, doi:10.1093/mnras/staa2138.