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Discovery and interpretation of Super-Alfvénic Oscillations in Solar Radio Burst sources

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1 *E*xtended Abstract

Type III solar radio bursts are coherent EM waves generated at the local plasma frequency and its harmonic, via wave-particle interactions triggered by the passage of energetic electron beams originating from particle acceleration sites. These electron beams are constrained to travel along $\vec{B}$ and, in principle, can be used to study the detailed dynamics of the magnetic field bundles along which they travel. However, it had remained a challenge to extract this dynamical information from observations as it gets modified by radio wave propagation effects in the Corona. Making progress here requires spectroscopic snapshot (SS) imaging with good imaging fidelity at sub-second and sub-MHz resolutions, which is only becoming possible now with the availability of new generation of instruments like the Murchison Widefield Array.

We performed SS imaging (160 kHz, 0.5 s resolution) for 4 minutes of MWA data (Nov 3,2014, 06:12:00 – 06:16:00 UT) spanning a bandwidth of 15 MHz centred at 118 MHz. This period has multiple groups of comparatively weak type III bursts ($T_B \approx 10^8$–$10^9 K$) which are temporally and spatially associated with a faint uncatalogued active-region jet seen in all AIA bands (Fig 1). Here we present data from one group of bursts during the period 06:14:08 – 06:14:25 UT. We combine a framework for propagation through turbulent corona with SS MWA solar imaging to reliably separate propagation effects from the underlying variations in observed coronal flux tube properties[1]. We report the discovery of second-scale quasi-periodic oscillations (QPOs) in the area of burst source (Fig. 1) which is anti-phase with the those in integrated flux density. These QPOs are also accompanied by oscillations in position angle of the observed Gaussian source. The source areas when converted to actual sizes, after accounting for scattering effects, came up to be $\approx 100\ Mm$, which are typical flux tube cross sections widths expected at $\approx 1.4\ R_\odot$, the heliocentric heights where radio emission originates from assuming a density model. The large source sizes imply the Alfvén speed required for second-scale oscillations is atleast two orders of magnitude higher than typical. Another possibility is a modulation mechanism operating at the coronal jet region which controls particle acceleration and injection process. The observed length of the reconnecting coronal loops and the extrapolated magnetic field strengths at these regions suggest that these regions can sustain second-scale MHD oscillations. Observed anti-phased intensity and area QPOs can be generated if a fast sausage mode couples with particle acceleration/injection process and modulate accelerated electron beam geometry. However, the observed relative position angle QPOs would require an independent fast torsional mode coupling.

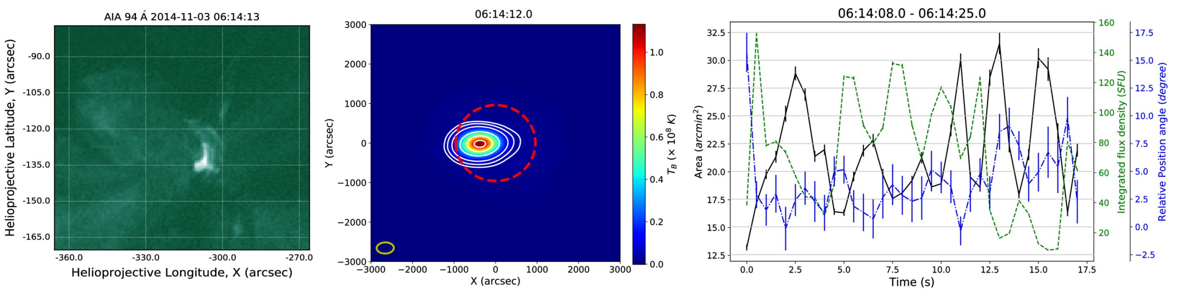

Figure 1. *Left*: AIA 94 Åimage of the weak active-region flare that was co-spatial and co-temporal with the type III bursts. *Middle*: An example 118 MHz image during a type III burst. Contours are plotted at 3%, 5%, 10%, 30%, 60% and 90% of the peak flux. *Right*: The evolution of source area, integrated flux and position angle obtained from the best fit 2D Gaussian model for the group of type III bursts from 06:14:08 – 06:14:25 UT.

References

[1] K. Arzner and A. Magun. Radiowave propagation in a statistically inhomogeneous plasma. *AAP*, 351:1165–1189, November 1999.