Solar Activity Triggering Interstellar Electron Plasma Oscillations

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Electron plasma oscillations in the frequency range of 2.2 to 2.6 kHz have recently been observed by Voyager 1 at distances beyond 122 AU (Gurnett et al., Science, 2013). These plasma waves occur at the electron plasma frequency $f_{pe} = 8980\sqrt{n_e}$ indicating an electron density of 0.05 to 0.08 cm^{-3}. Given the factor of 50 increase in density from that measured in the outer heliosphere and the similarity of the density to that expected in the interstellar plasma, Gurnett et al. concluded that these observations were made in the interstellar plasma. The plasma oscillations were observed in October – November 2012 and again in April – May 2013. In each instance, the frequency of the emissions increased with time at a rate of about 2.6 Hz/day, strongly suggesting a density gradient upstream of the heliopause. By extrapolating the change in frequency in time back to 25 August 2012, it was inferred that the heliopause was crossed at a distance of ~121.6 AU coincident with the last of 5 boundary crossings where galactic cosmic rays increased to previously unobserved intensities and anomalous cosmic rays generated in the heliosphere disappeared. The extrapolated plasma frequency on 25 August 2012 was about 1.9 kHz.

Previously detected heliospheric radio emissions observed beginning in 1983, 1992, and 2002 drifted from frequencies of about 1.9 kHz upwards to maxima near 3.5 kHz. On the basis of these observations, Gurnett et al. (Science, 1993) inferred that the radio emissions were being generated on a density gradient just outside the heliopause at f_{pe} or its harmonic in response to plasma oscillations excited by an electron beam associated with a global merged interaction region shock. Radio emissions observed in 1983 and 1992 occurred just over 400 days after the two most intense Forbush decreases on record. The recently observed plasma oscillations are almost certainly related to those postulated to be responsible for the heliospheric radio emissions. The plasma oscillations, however, are not continuously observable by Voyager 1. Gurnett et al. (2013) suggested that solar activity associated with the so-called St Patrick's Day solar activity in March 2012 are likely responsible for the plasma oscillations observed in April – May 2013. In this paper we investigate this claim and identify coronal mass ejections on and about 7 March 2012 as the likely triggering events. We use observations from New Horizons on its trajectory to Pluto and low frequency enhancement events in Saturn kilometric radiation by Cassini as indicators of the progress of the resulting solar wind disturbance propagating through the heliosphere toward Voyager 1 as a means of determining the average propagation speed of the associated interplanetary shock. We also investigate X-class flares and associated coronal mass ejections in late summer of 2011 as possible triggers for the plasma oscillations observed by Voyager 1 in the fall of 2012.