RADIO EMISSIONS AND ELECTRON PLASMA OSCILLATIONS DETECTED IN THE LOCAL INTERSTELLAR MEDIUM BY VOYAGER 1

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For over thirty years the plasma wave instruments on the Voyager 1 and 2 spacecraft, which were launched in 1977, have been detecting transient radio emissions in the frequency range from about 2 to 3 kHz. In 1993 a strong case was presented that these radio emissions were generated when an interplanetary shock propagating outward from a strong solar event interacted with the heliopause. The heliopause is the boundary between the hot solar wind plasma flowing outward from the Sun and the relatively cool interstellar plasma. The radio emissions were postulated to be generated by mode conversion from electron plasma oscillations stimulated by electron beams streaming out ahead of the shock, as occurs for Type II solar radio bursts. In late August 2012, Voyager 1 passed through the heliopause into the interstellar plasma at a heliocentric radial distance of 121 astronomical units (AU). Since entering the interstellar medium the plasma wave instrument has detected three, and maybe four, distinct plasma oscillation events that are associated with shock waves from the Sun propagating through the interstellar plasma. In two of these cases the existence of the shock wave was directly confirmed by Voyager 1 magnetic field measurements, and in the other case (or cases) indirectly confirmed by variations in energetic particle intensities. Radio emissions generated by the plasma oscillations were also observed, confirming the basic hypothesis first proposed in 1993 for the origin of the 2 to 3 kHz radio emission. The relationship between the shock wave, the electron plasma oscillations, and the radio emission has a remarkable similarity to the plasma oscillations and radio emissions observed upstream of planetary bow shocks, only on a vastly larger scale. In particular, the plasma oscillations are observed in a spatially limited region called the “foreshock,” in which electron beams accelerated at the shock propagate upstream along magnetic field lines connected to the outward propagating shock.