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Properties of whistler wave trains at supercritical quasi-perpendicular shock front: CLUSTER observations

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A very important issue of the quasi-perpendicular shock is its nonstationary character and its self-reformation in supercritical regime. While less prominent than for low beta subcritical shocks, whistler waves precursor associated to dispersion at the shock front can be present. Recent simulation work has shown that large amplitude coherent whistler waves can be emitted in the foot region and dominate the whole shock front dynamics. Some theoretical works also relate nonlinear whistler dynamics with the shock nonstationarity. Recent experimental results based on CLUSTER mission has shown as a key signature of the shock self-reformation that the ramp width can reach a very narrow value covering a few electron inertial lengths, that is a dispersive whistler scale. We present results based on CLUSTER data on such whistler wave packets observed both upstream of the front or in the overshoot of supercritical quasi-perpendicular shocks. The multi-spacecraft analysis allows deriving the wave vector, phase and group velocities of the wave trains when observed on the four satellites. Frequencies of a few hertz in the plasma frame and wave-lengths of less than 20 electron inertial lengths are obtained. For wave packets observed in the foot or just upstream from it, group velocity can be directed upstream in the shock frame showing that the Poynting flux evacuates energy outside from the shock front. The maximal distance separating two of the 4 spacecraft allows determining experimentally a lower value for the coherence length of such whistler wave trains as a few ion inertial lengths.