MMS Observations of Ion Cyclotron Waves in the Solar Wind

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Although electromagnetic ion cyclotron waves (ICWs) have been observed in the solar wind by multiple missions at heliocentric distances from 0.3 to 1 AU, there are still open questions on the generation mechanisms for these waves. Detailed analysis of the plasma distribution is needed to examine whether these waves are possibly generated locally.

In the solar wind, there are mainly three types of ion-driven instabilities responsible for parallel-propagating ICWs: ion cyclotron instabilities driven by ion component with temperature anisotropies greater than 1, parallel firehose instabilities driven by ion temperature anisotropies smaller than 1, and ion/ion magnetosonic instabilities driven by the relative drift between two ion components. In the solar wind frame, the waves due to ion cyclotron instability have left-handed polarization, while the waves due to firehose and ion/ion magnetosonic instabilities have right-handed polarization. Depending on the wave propagation parallel or anti-parallel to the magnetic field, the wave frequencies in the spacecraft frame are Doppler shifted higher or lower even with reversed handness. With the plasma data from Magnetospheric Multiscale (MMS) mission, we can examine the possible unstable mode with dispersion analysis and check if the prediction agrees with the observed wave mode. If the plasma measurements of the local solar wind do not support the wave growth, the waves could be possibly generated remotely close to the Sun and propagate away from the source region and are also carried outward by the solar wind flow. If these waves are generated remotely closer to the Sun, the wave properties at different heliocentric distances would help us better understand their sources.

The MMS spacecraft spends long periods of its orbit in the “pristine” solar wind starting end of 2017. From the 2017 December data we find over a hundred events and 42 of them last longer than 10 minutes which are called ICW storm events, and the longest event captured lasted over 2 hours. Although only about 17 of them have the plasma data available, we can perform case studies on these events first to investigate the wave properties and possible plasma instabilities, which will help us investigate the wave generation mechanisms due to local or remote sources.