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Ion Cyclotron Waves in the Solar Wind Observed near 0.3, 0.7, and 1 AU

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We report the in situ observations of the ion cyclotron waves in the solar wind near 0.3, 0.7, and 1 AU, mostly based on the high-resolution magnetometer data from Helios, Venus Express, and STEREO spacecraft. These waves are circularly-polarized transverse waves, propagating nearly parallel to the magnetic field, and below the local proton gyro-frequency in the solar wind frame. Since these waves often occur when the field is close to the radial direction, the angles between the magnetic field and the solar wind velocity are small, and the waves are unlikely to be generated by pickup ions. Although the waves appear both left-handed and right-handed in the spacecraft frame, this can be explained by Doppler shift. In our scenario, they are all left-handed polarized waves generated closer to the Sun, and are carried out by the super-Alfvénic solar wind. In the spacecraft frame, the anti-sunward waves will be shifted to higher frequencies and the sunward waves will be shifted to lower frequencies with their polarization reversed. We analyze the wave properties of each event to obtain the statistics of the wave power and wave frequency at each heliocentric distance. By comparing these wave properties at different distances, we hope to constrain further their evolution and their generation mechanism.