Observations of the parametric instabilities in the foreshock plasma in interplanetary space

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Nonlinearities of large-amplitude Alfven waves are known to cause various wave-wave couplings and wave mode conversions, and are called the parametric instabilities. While the parametric instabilities are well documented from various analytic and numerical studies, little is known about the observational properties of parametric instabilities in space plasmas. A statistical study is performed using Cluster spacecraft data in the Earth foreshock region to interpret the energy spectra of low-frequency waves as realization of parametric instabilities in the spacecraft frequency range from 0.01 to 0.1 Hz. Frequencies of the density fluctuations are compared to that of the pump Alfven wave (largest-amplitude wave) using about 30 foreshock events in a wide range of plasma beta, from 0.1 to about 10. The foreshock wave study qualitatively supports the theoretical expectation that the decay instability of the pump wave to short-wavelenth density disturbance is the fastest growing mode in low-beta plasmas, while the modulation instability of the pump to long-wavelength density disturbance becomes more competitive in high-beta plasmas. Deviation or mismatsch of the observed wave frequencies of spectral shape to the theoretical expectation of the parametric instabilities is interpreted as a sign of parametric instabilities that occur in a multiple sense in various propagation directions to the mean magnetic field.

Keywords: parametric instabilities, Alfven wave nonlinearities, foreshock region

