Nonlinear evolution of the parametric instability in the high latitude solar wind

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It is well known that in the high speed solar wind streams, especially in the polar regions at distances between 0.3-2.0 AU, the observed fluctuations have an Alfvénic correlation, characterized by a broadband spectrum of outward propagating oscillations with very low density perturbations and highly correlated velocity and magnetic fields fluctuations. This situation, however, changes during the propagation of the wind in the heliosphere, and the presence of both stronger density fluctuations and inward-propagating oscillations are observed.

Arc-polarized Alfvénic fluctuations, observed in the solar wind, are a normal mode of the Magnetohydrodynamics equations and they should propagate undisturbed in a quasi-homogeneous medium like the polar wind. However, they are subject to the parametric instability, in which a large amplitude, monochromatic, Alfvén wave propagating in a compressible media decays generating backscattered Alfvén waves and compressive fluctuations. Such a mechanism could explain the observed decrease of correlation of Alfvénic fluctuations in the solar wind.

In past years, many authors studied the efficiency of such a phenomenon for a monochromatic large-amplitude wave [1] and for a 1D initial spectrum of Alfvénic fluctuations [2, 3]. However, the instability growth rate depends on several parameters, especially the initial spectrum, the plasma beta and the details of the initial perturbation. Only recently [4], a more sistematic study of the instability in a 2.5 dimensional case has been carried out in a more realistic background magnetic field configuration.

We will illustrate the latest results obtained through numerical simulations in a configuration similar to [4], but with different initial conditions. In all cases the instability produces strongly localized, coherent structures, very often accompained by an anti-correlation between magnetic intensity and density fluctuations, which seems to indicate the formation of pressure-balanced structures.

References

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