Mirror Mode Analysis for Magnetic Depressions in the Solar Wind [1]

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Abstract

Regions of depressed magnetic fields, called "magnetic holes", have been observed in the solar wind, and *Winterhalter et al.*[1] have suggested that these magnetic depressions are the result of the mirror mode instability. Classical double adiabatic MHD theory, which assumes zero divergence of the parallel heat flux, predicts mirror instability when the pressure anisotropy $p_\perp/p_\| > 6$. However, as explained by Kulsrud, the instability threshold decreases from $p_\perp/p_\| > 6$ to $p_\perp/p_\| > 1$ when the divergence of the heat flux is included in a kinetic analysis for a uniform magnetic field [2]. The instability, near threshold, is a resonant particle instability involving low velocity particles along the field (*Southwood et al.*) [3]. Thus the pressure anisotropy (due to the majority non-resonant particles) is unlikely to change significantly as the instability grows. It is proposed that nonlinear saturation of the instability is due to the creation of local magnetic mirror wells in which particles become trapped, resulting in the reduction of the divergence of the parallel heat flux and the restoration of the instability threshold to a value between 1 and 6. The instability threshold , with particles trapped in local magnetic mirror wells, is estimated, and preliminary calculations indicate that the threshold increases from $p_\perp/p_\| > 1$ to $p_\perp/p_\| > 1.86$ as the fraction of trapped particles increases from zero to unity. Thus, if the initial pressure anisotropy is $1.86 > p_\perp/p_\| > 1$, the slowly growing mirror mode creates local magnetic mirrors that shuts off the instability when a significant fraction of particles are trapped.

[1] Winterhalter, D., M. Neugebauer, and B. E. Goldstein, et al., (J. Geophys. Res., 99), 23,371 -23,381, 1994.
[2] Kulsrud, R.M., *Handbook of Plasma Physics*, Vol. I, North-Holland Publishing Company, (1983).
[3] D. J. Southwood and M. G. Kivelson, (J. Geophys. Res., 98), 9181-9187, 1993.

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