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Mirror waves in non-Maxwellian space plasmas: Collapse or solitons?

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Abstract. A unified theory of finite-amplitude mirror type waves in non-Maxwellian space plasmas is developed. In the standard mixed magnetohydrodynamic-kinetic approach, the most general equation governing the nonlinear dynamics of mirror waves is derived. In the linear approximation it describes the classical mirror instability with the linear growth rate expressed in terms of an arbitrary ion distribution function. In the nonlinear regime the mirror waves form solitary structures that have the shape of the magnetic holes. The formation of such structures and their nonlinear dynamics has been analyzed both numerically and analytically by using self-similar asymptotics of the magnetic field variations. It was assumed that the background ion distribution function possesses a "plateau" type shape in the region of small parallel particle velocities. Its width is of the order of the particle trapping zone in the mirror hole. Since the depth of the mirror hole increases adiabatically and due to that it develops more slowly than the motion of the resonant particles the particle trapping is irreversible, i.e. is accompanied by bifurcation. It is shown that magnetic collapse that can arise for such nonlinear waves is terminated due to anomalously fast deformation of the ion distribution function in the region of small parallel velocities. This results in the appearance of quasi-stable solitary mirror structures having the form of deep magnetic dropouts. The relevance of the theoretical results to recent satellite observations is stressed.