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Nonlinear mirror instability: humps and holes

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Nonlinear behavior of the mirror instability is investigated using 1-D hybrid simulations. Relatively near threshold these simulations demonstrate the presence of an early phase where quasi-linear effects dominate (*Shapiro and Shevchenko*, 1964). The quasi-linear diffusion is however not the main saturation mechanism. A second phase is observed where the mirror mode is linearly stable (the stability is evaluated using the instantaneous ion distribution function) but where the instability nevertheless continues to develop, leading to nonlinear coherent structures in the form of magnetic humps. This regime is well modeled by a nonlinear equation for the magnetic field evolution, derived from a reductive perturbative expansion of the Vlasov-Maxwell equations (*Kuznetsov et al.*, 2007) with a phenomenological term which represents local variations of the ion Larmor radius. In contrast with previous models where saturation is due to the cooling of a population of trapped particles, the resulting equation correctly reproduces the development of magnetic humps from an initial noise.
Far from threshold the hybrid simulations show that the quasi-linear effects are suppressed and the wave growth rapidly stops forming nonlinear coherent structures in the form of magnetic humps. These humps are not stable but rapidly relax decreasing the fluctuating magnetic energy and may even be transformed to magnetic holes.

References:

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– Shapiro, V. D., and V. I. Shevchenko (1964), *Sov. JETP*, **18**, 1109.