Non-linear mirror instability

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Slow dynamical changes in magnetic-field strength and invariance of the particles' magnetic moments generate ubiquitous pressure anisotropies in weakly collisional, magnetized astrophysical plasmas. This renders them unstable to fast, small-scale mirror and firehose instabilities, which are capable of exerting feedback on the macroscale dynamics of the system. By way of a new asymptotic theory of the early nonlinear evolution of the mirror instability in a plasma subject to slow shearing or compression, we show that the instability does not saturate quasilinearly at a steady, low-amplitude level. Instead, the trapping of particles in small-scale mirrors leads to non-linear secular growth of magnetic perturbations, $\delta B/B \sim t^{2/3}$. Our theory explains recent collisionless simulation results, provides a prediction of the mirror evolution in weakly collisional plasmas and establishes a foundation for a theory of non-linear mirror dynamics with trapping, valid up to $\delta B/B = O(1)$.

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