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Magnetohydrodynamic Motion of Toroidal Magnetic Eddies

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The magnetohydrodynamic evolution of magnetic eddies, within which the magnetic field is purely toroidal and the velocity field is poloidal, is studied analytically and numerically. A new contour-dynamics formulation is obtained by assuming piecewise constant distribution of B_θ/r and used for numerical simulation. Singularity which appears on the contour is removed by a standard regularization technique without damaging global motion. A family of exact solutions which includes Hill's spherical vortex as a limiting special case is found. The exact solution is (like Hill's vortex) unstable, a spike growing from the rear, while the spherical front is almost unchanged. When the velocity field is initially zero, the magnetic eddy first shrinks towards the axis of symmetry; then spherical heads form, which are well described by the exact solution; in consequence, the magnetic energy does not decay to zero, although the lower bound determined by the (zero) magnetic helicity is zero.

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