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Analytical theory of neutral current sheets with a sheared magnetic field separating homogeneously magnetized plasma regions

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A new wide class of self-consistent magnetostatic structures with sheared field lines and arbitrary energy distributions of particles in a collisionless plasma is described analytically. A member of that class is a superposition of two neutral current sheets with orthogonal planar magnetic fields and cylindrically symmetric momentum distribution functions of particles. Each planar current sheet satisfies the stationary Vlasov–Maxwell equations and may have complicated self-consistent spatial profiles of the current density and magnetic field [1, 2]. Together they form a transition layer between half-spaces of plasma which have different particle distribution functions and different values of a homogeneous magnetic field.

The resultant configurations may be force-free and can have an almost arbitrary profile of the shear angle of magnetic field, in particular a non-monotonic one. We develop a regular technique to construct such structures and provide a number of new examples, including asymmetric and double-scale sheared current sheets and sheets with the varying direction of magnetic field rotation. We describe limitations on the anisotropy degree of particle distributions and the magnetic-to-particle energy ratio. Those sheets can be either thick or thin with respect to the typical particle gyroradius.

Most of the previously known current sheet families with the sheared magnetic field lines, e.g. [3–6], are included in the suggested class. Various applications of our technique for modeling current structures in space and astrophysical plasmas, both relativistic and non-relativistic, are discussed.

References

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