Abstract

The work in this thesis focuses primarily on equilibrium and stability properties of collisionless current sheet models, in particular of the force-free Harris sheet model.

A detailed investigation is carried out into the properties of the distribution function found by Harrison and Neukirch (*Physical Review Letters* 102, 135003, 2009) for the force-free Harris sheet, which is so far the only known nonlinear force-free Vlasov-Maxwell equilibrium. Exact conditions on the parameters of the distribution function are found, which show when it can be single or multi-peaked in two of the velocity space directions. This is important because it may have implications for the stability of the equilibrium.

One major aim of this thesis is to find new force-free equilibrium distribution functions. By using a new method which is different from that of Harrison and Neukirch, it is possible to find a complete family of distribution functions for the force-free Harris sheet, which includes Harrison and Neukirch's distribution function. Each member of this family has a different dependence on the particle energy, although the dependence on the canonical momenta remains the same. Three detailed analytical examples are presented. Other possibilities for finding further collisionless force-free equilibrium distribution functions have been explored, but were unsuccessful.

The first linear stability analysis of Harrison and Neukirch's equilibrium distribution function is then carried out, concentrating on macroscopic instabilities, and considering two-dimensional perturbations only. The analysis is based on the technique of integration over unperturbed orbits. Similarly to the Harris sheet case (*Nuovo Cimento*, 23:115, 1962), this is only possible by using approximations to the exact orbits, which are unknown. Furthermore, the approximations for the Harris sheet case cannot be used for the force-free Harris sheet, and so new techniques have to be developed in order to make analytical progress. Full analytical expressions for the perturbed current density are derived but, for the sake of simplicity, only the long wavelength limit is investigated. The dependence of the stability on various equilibrium parameters is investigated.