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A consistent model of extra-galactic double radio sources must evidently involve all aspects of the source from the underlying power source to the production of the radio lobes. Here, we give an overview of our work on the different aspects of a self-consistent model which includes gravitational accretion of fluid with angular momentum as the power source, the production of hydrodynamic or relativistic particle-beam jets, and the formation of expanding radio components.

Axisymmetric accretion flows of perfect fluids with angular momentum have recently been studied (Scott and Lovelace 1981a). We find that an empty vortex funnel about the symmetry axis may occur as determined by the conservation of energy and angular momentum. The funnel becomes cylindrical far from the accreting object with a width varying linearly with the specific angular momentum of the fluid.

Vortex funnels, as well as hydrodynamic jets have been found to occur in viscous incompressible flows with angular momentum (Lovelace, et al. 1981). In this case, dimensional analysis implies a self-similar form for the axisymmetric flows so that the Navier-Stokes equations reduce to a set of non-linear ordinary differential equations. These equations have been solved analytically for flows with constant specific angular momentum and numerically for more general flows. Vortex funnels and jets occur for a wide range of parameters. The jets require a source of momentum at the origin along the $\pm z$ axes, which is possibly due to radiation pressure (Davidson and McCray 1980) or to electromagnetic effects (Lovelace 1976, Lovelace, et al. 1979).

Close to a central black hole, the accreting fluid forms an accretion disc in the equatorial plane. The rotating disc and an axial magnetic field, which is "amplified" by the accretion, generate an electric field which acts to produce oppositely propagating beams of ultra-relativistic particles, and, through a cascade process, oppositely propagating electron-positron beams or jets (Lovelace, et al. 1979). The vortex funnel of the accretion flow, which traps an axial magnetic field, provides a path of egress from the central source along which particle beams can propagate freely, i.e., ballistically.

The relativistic particles stream outward, in the $+z$ directions, along magnetic field lines which may initially be closed. When the energy density in particles exceeds that in the magnetic field, the particles stretch the field lines, giving rise to a highly elongated field configuration as indicated in Figure 1. The beam front, where the magnetic field reverses directions, advances with a speed which can be derived from the conservation of momentum of the relativistic particles magnetic field, and ambient medium (Scott and Lovelace 1981b). Relativistically expanding radio components on the scale of parsecs result for plausible values of the parameters.

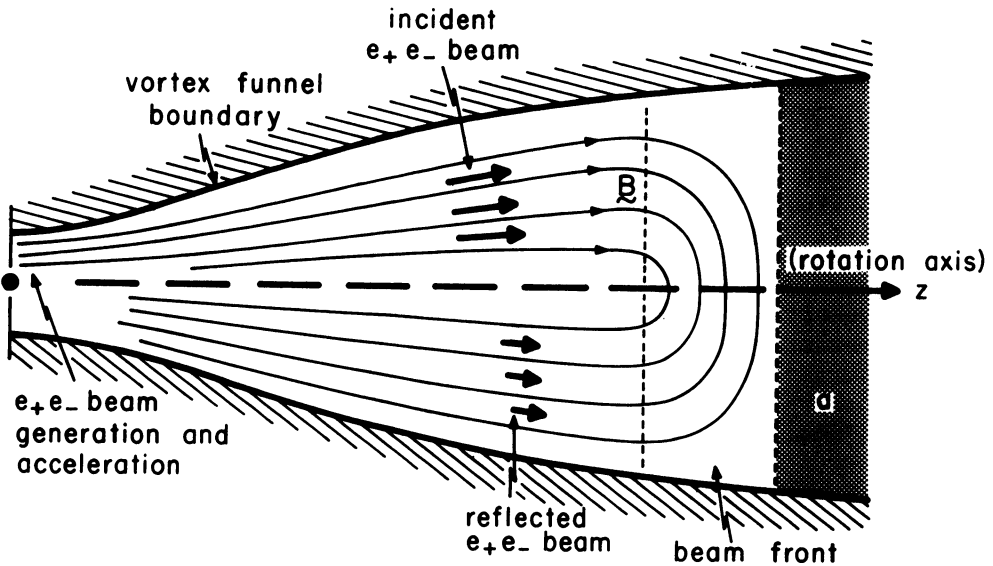


Figure 1. Schematic drawing of beam, vortex funnel geometry. The region (a) may be occupied by an ambient medium.

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