GALACTIC DYNAMO MODELS

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Abstract. We present the results of 3-d numerical simulations of galactic dynamos. Using reasonably justifiable parameters, kinematic dynamo models are shown to reproduce the gross features of galaxy magnetic fields. The central field morphology is suggestive of an embryonic jet generator.

In recent years there have been considerable advances in the mapping of magnetic fields in spiral galaxies. The observations show that the large-scale or systematic field lines generally lie parallel to the spiral arms, with magnetic intensity decreasing away from the plane of the disc. Towards the centre, the field grows in strength and becomes dominated by the vertical component. The currently favoured theory which explains the existence and form of the large-scale galactic field involves a dynamo process (Moffatt, 1978). Here we present simulations of 3-d galactic dynamos. The model and results are described in more detail in Panesar & Nelson (1992).

The simulations evolve an initially weak seed field according to the dynamo equation

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{v} \times \mathbf{B}) - \nabla \times (\eta \nabla \times \mathbf{B}) + \nabla \times (\alpha \mathbf{B}) \tag{1}$$

$\mathbf{v}$ is the velocity field of the galaxy including differential rotation and a shock induced by a stellar density wave. The second term in (1) is the Ohmic diffusion term. The α coefficient in the last term is proportional to the helicity of the flow. This is the dynamo term where the field is amplified by cyclonic turbulence. As the field strength increases the α-effect diminishes, representing the tendency for the magnetic field to suppress turbulence.

The evolved field patterns are in agreement with the principal observed morphological characteristics as detailed above. In particular the results show a propensity for strong vertical fields at the centre of the disc. The field here is helical in nature with the pitch of the helix decreasing with height, i.e. we have an embryonic jet generator based on the torsional Alfvén wave model for jets.

References

Moffatt, H.K., 1978, Magnetic Field Generation in Electrically Conducting Fluids, Cambridge University Press.

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