MMAE SEMINAR

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E-1 BUILDING – CRAWFORD AUDITORIUM
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Numerical simulations of magneto-rotational turbulence in cylindrical geometry[1]

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Abstract

It has long been assumed that the anomalous transport of angular momentum in accretion discs (e.g. around black holes) is due to turbulence driven by the magneto-rotational instability. A particularly attractive feature is the possibility that the turbulent motions could act as a dynamo thereby regenerating the very magnetic fields necessary to induce the instability in centrifugally stable flows. This being the case, the turbulence in a disc would be self-regulating and depend only on the properties of the disc itself.

It therefore of considerable importance to establish to what extent magneto-rotational turbulence is capable of dynamo action. We address this issue based on the results of numerical simulations of magneto-rotational flows in cylindrical Couette geometry for an incompressible fluid with finite viscosity and magnetic diffusivity. To the best of our knowledge these simulations are the most highly resolved in this geometry to date[2].
We study regimes in which the magneto-rotational instability is strongly supercritical, and its nonlinear evolution leads to the development of turbulence.

We show that in these regimes, the flows indeed act as efficient dynamos and the turbulence persists even in the absence of an externally imposed magnetic field. The mechanism responsible for the saturation amplitude of the turbulence involves both an increase in dissipation and a modification of the background rotational profile. The angular momentum transport is enhanced from its collisional value by a factor of the order the Reynolds number of the fluctuating velocity. Despite approximate equipartition between the velocity and magnetic fluctuations, the anomalous transport is mostly associated with the magnetic (Maxwell) stresses. This is caused by a decorrelation of the velocity fluctuations, and by a correlation of the magnetic fluctuations induced by their kinematic interaction with the background rotational shear.

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