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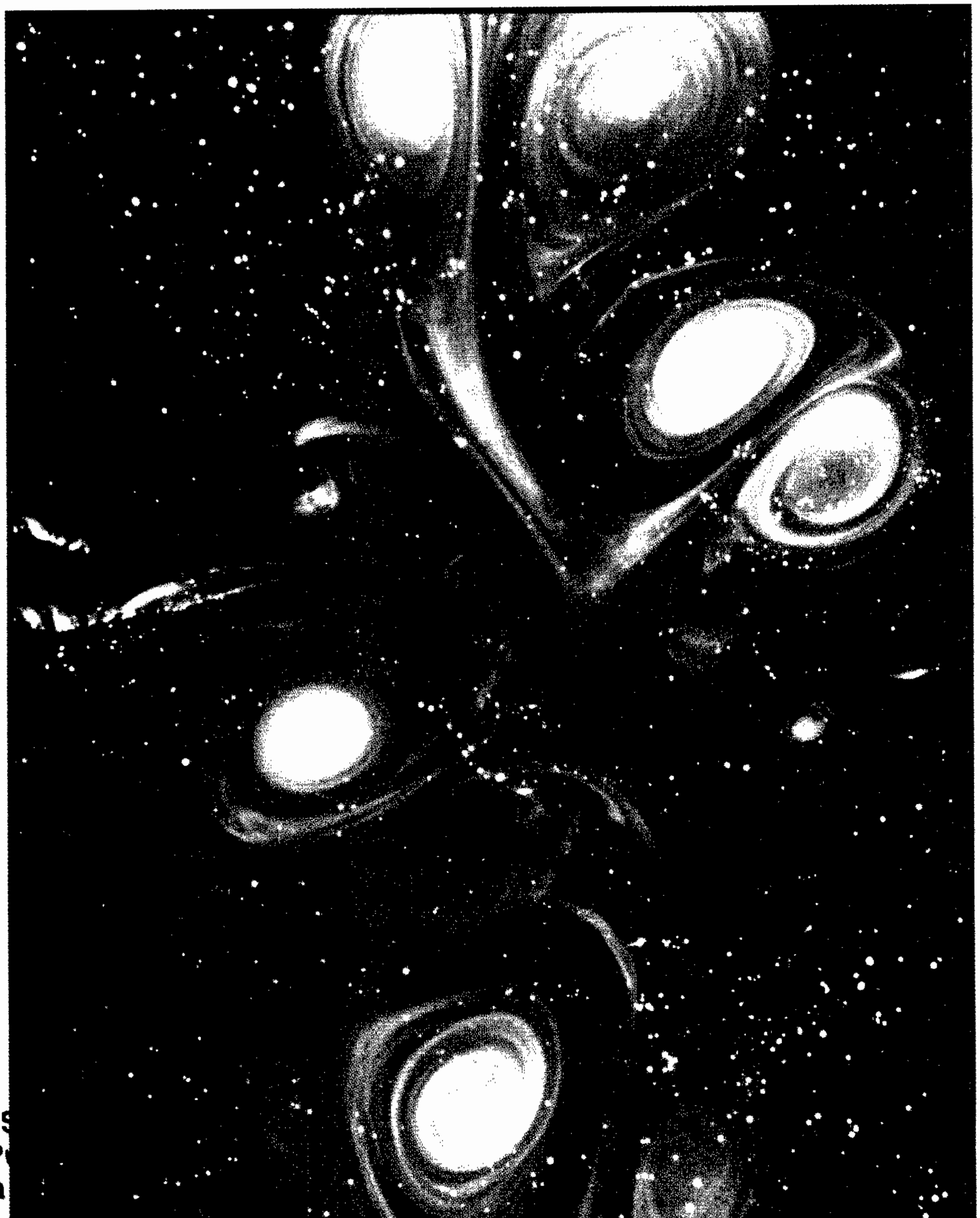

Book of Abstracts

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MHD flow of a power-law fluid over a rotating disk

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Abstract - Magnetohydrodynamic flow of an electrically conducting power-law fluid in the vicinity of a constantly rotating infinite disk in the presence of a uniform magnetic field is considered. The steady, laminar and axi-symmetric flow is driven solely by the rotating disk, and the incompressible fluid obeys the inelastic Ostwald de Waele power-law model. In spite of the severe non-linearities introduced by the rheological model, the three-dimensional boundary layer equations transform exactly into a set of ordinary differential equations in a generalized similarity variable. These ODEs, together with appropriate boundary conditions at the disk and infinitely far away, constitute a two-parameter problem in n and m, n being the power-law index and m the magnetic parameter. The two-point boundary value problem was first solved by shooting and parallel shooting techniques. However, due to the sensitivity to the initial values, a finite-difference approach was eventually adopted.

After first having reproduced the accurate solutions provided by Rogers & Lance (J. Fluid Mech. 1960) of the classical Von Karman swirling flow; i.e. $n = 1$ and $m = 0$, the non-magnetic case $m = 0$ was considered. Earlier results by Mitschka & Ulbrecht (Coll. Czech. Chem. Comm. 1965) was approved for most power-law fluids, showing that the boundary layer thickness decreases monotonically as the power-law index n is increased. This is accompanied by a reduction in the radial outflow, which in turn is compensated by a reduction of the axial inflow towards the disk. For highly shear-thinning fluids ($n < 0.5$), however, a severe ambiguity in the determination of this inflow was revealed.

The MHD flow problem was solved numerically for values of the magnetic parameter m up to 4.0. The effect of the magnetic field is to reduce, and eventually suppress, the radially directed outflow. An accompanying reduction of the axial flow towards the disk is observed, together with a thinning of the boundary layer adjacent to the disk. Consequently, the wall shear stress in the circumferential direction turns out to increase monotonically with increasing m-values, thereby increasing the torque required to maintain rotation of the disk at the prescribed angular velocity. These major effects of the imposition of a magnetic field are found both for shear-thinning ($n < 1$) and shear-thickening ($n > 1$) fluids. The influence of the magnetic field is, however, more pronounced for shear-thinning than for shear-thickening fluids. The magnetic field therefore makes the difference between the various fluids, i.e. between different values of n, more distinct than in the non-magnetic case $m = 0$.