Abstract Submitted
for the DFD11 Meeting of
The American Physical Society

Stability of unsteady flow in a rotating torus RICHARD HEWITT, ANDREW HAZEL, University of Manchester, RICHARD CLARKE, University of Auckland, JAMES DENIER, University of Adelaide — We consider the temporal evolution of a viscous incompressible fluid in a torus of finite curvature; a problem first investigated experimentally by Madden and Mullin (1994), herein referred to as MM. The system is initially in a state of rigid-body rotation (about the axis of rotational symmetry) and the container's rotation rate is then changed impulsively. We describe the transient flow that is induced at small values of the Ekman number, over a time scale that is comparable to one complete rotation of the container. We show that (rotationally symmetric) eruptive singularities (of the boundary layer) occur at the inner or outer bend of the pipe for a decrease or an increase in rotation rate respectively. Moreover, there is a ratio of initial-to-final rotation frequencies for which eruptive singularities can occur at both the inner and outer bend simultaneously. We also demonstrate that the flow is susceptible to non-axisymmetric inflectional instabilities. The inflectional instability arises as a consequence of the developing eruption and is shown to be in qualitative agreement with the experimental observations of MM. Detailed quantitative comparisons are made between asymptotic predictions and finite (but small) Ekman number Navier-Stokes computations using a finite-element method.

Richard Hewitt
University of Manchester

Date submitted: 10 Aug 2011 Electronic form version 1.4