Numerical simulations of Z-Pinch experiments to create supersonic differentially rotating plasma flows

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March 22, 2012

Abstract

In the context of laboratory astrophysics relevant to accretion discs physics, we aim to study possible setups for a plasma experiment employing pulsed power machines. We carry out our study through direct numerical simulations using the 3D MHD code GORGON. It is found that the setups, based on a modified cylindrical wire array, produce a rotating plasma with typical Mach number about 4, rotation velocity about 30 Km/s, Reynolds number in excess of 10^7 and magnetic Reynolds number of order 1. The plasma is also differentially rotating. The physical parameters of the flow can be varied by properly tuning the setup. Such plasma is particularly interesting for the study of hydrodynamic instabilities relevant to accretion discs and turbulence in differentially rotating flows with high Reynolds number. The material of the rotating flow is ejected in a pair of thermally driven, conical outflows propagating along the rotation axis. This behavior can be compared to some accretion-ejection circulation models for protostars. Different external magnetic field topologies have been tested. A modest uniform vertical field can affect the dynamics of the flow and could be used to study magnetic field entrainment and amplification through differential rotation. A dipolar field potentially relevant

to the study of accretion columns and its experimental feasibility are also discussed.