SUPERSONICALLY ROTATING PLASMAS FOR MAGNETIC FUSION: THE MARYLAND CENTRIFUGAL EXPERIMENT

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Rotating plasmas for magnetic confinement offer significant improvements over the tokamak, including the possibility of steady state operation, a much simpler coil configuration, and the existence of a long uniform magnetic solenoidal region that is technically ideal for reactor design. The concept requires the application of a large static electric field perpendicular to a linear magnetic field to generate supersonic ExB rotation. Centrifugal forces limit end losses along the strong axial magnetic field; this field provides conventional cross field confinement. The azimuthal ExB rotation velocity is strongly sheared in the radial direction, which is predicted to stabilize MHD instabilities and produce viscous ion heating to thermonuclear temperatures.

The Maryland Centrifugal Experiment (MCX) is designed to test these concepts. MCX has a magnetic mirror geometry of 2.6m length, maximum mirror field 1.9T, and maximum midplane field 0.3T; an inner coaxial core is driven by a 10 kV capacitor bank, producing the radial electric field which drives azimuthal rotation. MCX produces high density ($n>10^{20}$ m^{-3}) fully ionized plasmas which rotate supersonically with azimuthal velocities in the range of 100 –250 km/sec for discharge times exceeding 8 ms. Ion temperatures are ~ 30 eV. Sonic mach numbers in the range 1-4 and Alfven mach numbers 0.2 to ~1 have been achieved. The plasmas are quasi stable for many milliseconds, much longer than MHD instability timescales; plasma lifetime is limited only by the size of the capacitor bank. There is spectroscopic evidence of radial velocity shear sufficient to satisfy the simplest criterion for MHD stability, but magnetic probes show significant fluctuations. Clear evidence of centrifugal confinement is observed for some parameters. New diagnostics are now being commissioned to quantitatively link MHD stability and velocity shear. Future upgrades of MCX will increase the midplane magnetic field to 1T and the applied voltage to 20 kV to test scaling, in particular the nature of any velocity limiting mechanisms. A possible application of this concept as a volume neutron source will be discussed.