FOR IMMEDIATE RELEASE
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Ropes of plasma: onset and stagnation of 3D magnetic reconnection

Experiments capture behavior of stressed magnetic fields

ATLANTA—Magnetized plasmas occupy a large fraction of our cosmic universe; they exist on our sun, in the earth's magnetosphere, and in astrophysical plasmas. They also exist in laboratory magnetic fusion grade plasmas, and in other smaller experiments as well. Energy stored in stressed magnetic fields can produce large-scale explosive events that spontaneously evolve and energize particles, owing to unsteady and impulsive local processes in small volumes of space. The abrupt onset and cessation of these events in astrophysical and laboratory plasmas is a long-standing puzzle. The situation is inherently 3-dimensional (3D), which makes computer simulation difficult and requires experiments capable of reproducing 3D phenomena.

The Reconnection Scaling eXperiment (RSX) shown in Fig. 1 is a unique earthbound plasma physics experiment. It includes fully 3D plasma currents and magnetic fields.

We show the first laboratory example of the onset and 3D magnetic reconnection between flux ropes (plasma "wires") driven by the electromagnetic attraction between the plasma "wires" and a 3D plasma-current-driven instability. Oppositely directed magnetic field lines that are embedded in the colliding flux ropes get pushed into each other, mutually annihilate, and therefore create an electric field. When the inflow speed exceeds a critical threshold, a reconnection current layer is formed. Magnetic flux and pressure rush inwards, and pile up just outside this layer until the pressure grows large enough to support back-reaction forces that stall the inflow and stop the reconnection process. These laboratory results are consistent with computer fluid simulations shown in Fig. 2.

The experimental and computational results exhibit unexpected features not usually considered in 2D models. For a small enough background magnetic guide field, the flux ropes merge and reconnect, but they bounce in a larger magnetic field. Asymmetric reconnection fields and forces on either side of the reconnection layer are also observed. This probably represents the typical case in nature, rather than ideal and symmetric configurations. This work was published in "Experimental Onset Threshold and Magnetic Pressure Pile-up for 3D Reconnection", *Nature Physics* ***5***, 521 (2009).

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Fig. 1 The experimental setup views two magnetized ropes of plasma nearly end on with a fast camera. As the flux ropes become unstable, each rope becomes a helical screw pinch, and gyrates like a barber pole as they "screw" into the external anode. The pair of flux ropes also gyrates. In this way, the instability drives 3D patches of reconnection where the two flux ropes crash into each other. Two time sequences (top) of fast, gated camera images show the evolutions respectively of two and three flux rope instability and reconnection.

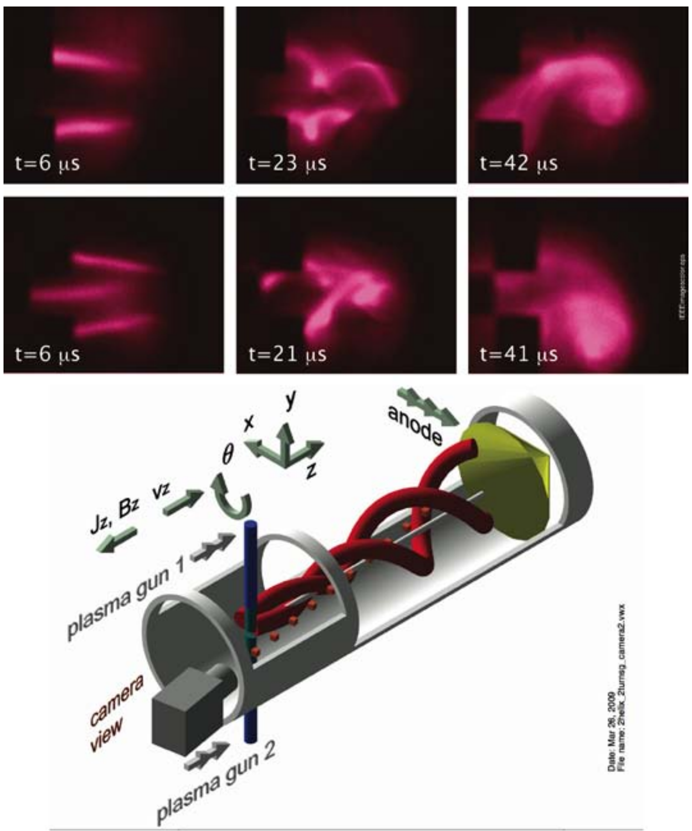
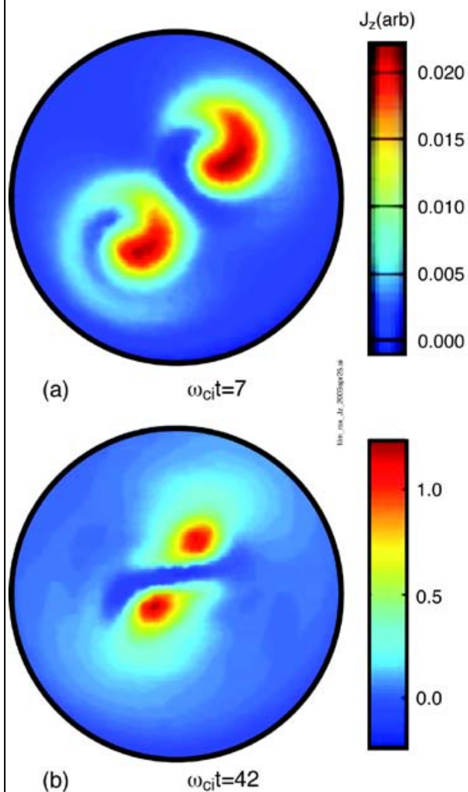


Fig. 2 A fluid computer simulation shows a cross section of the flux ropes as they mutually attract, gyrate and eventually merge. The time units are ion cyclotron orbit times. In Fig 2b there is an "S" shaped reconnection reversed current in between the two flux ropes.



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APS Mini-Conference on Unsteady Reconnection

Tuesday Nov 3, 2009, Regency V

- Session GM9 Mini-Conference on Unsteady Reconnection in Laboratory and Nature I: Reconnection Rate and Dynamics
- Session JM9 Mini-Conference on Unsteady Reconnection in Laboratory and Nature II: Impulsive Reconnection and Onset

Wednesday Nov 4, 2009, Regency V

- Session NM9 Mini-Conference on Unsteady Reconnection in Laboratory and Nature III: 3D Reconnection and Diffusion Region

- Session PM9 Mini-Conference on Unsteady Reconnection in Laboratory and Nature IV: Turbulence and Multiple Reconnections

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