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Halo-Current Effects in Tokamak Reactors: Hardly Heavenly

Physicists at Princeton plasma physics laboratory decipher the shape and movement of reactor-squeezing ropes of current.

PROVIDENCE—Plasma physicists and fusion reactor engineers call them “halo currents,” but they are hardly angelic.

These powerful currents occur under certain rare fault conditions known as “disruptions.” If unchecked, they can damage components located inside reactor vacuum vessels. But their shape and form are not well known. Do they form thick ropes or are they more like wide ribbons? How fast do they fly around the tokamaks used to confine hot ionized gases known as plasmas?

While reliable methods have been developed to reduce these currents to acceptable levels, scientists want to learn more about the halo currents to improve the design of tokamak fusion reactors.

Now, physicists at the Princeton Plasma Physics Laboratory, using a ring of specially designed detectors on an experimental fusion device called the National Spherical Torus Experiment, are closing in on some answers. Experiments show that halo currents flow in concentrated bands and move quickly, rotating as many as eight times around the vacuum vessel’s inner chamber.

“Improving the understanding of these currents can have important implications for reactor designs,” said Stefan Gerhardt of PPPL, who led the effort to install the sensors that measured the currents. “Engineers will be able to design better experiments if they understand the shape of the currents and the forces they exert on the vacuum vessel.”

Doughnut-shaped fusion devices, known as tokamaks, use strong electrical currents to generate the magnetic fields used to confine the plasma. When key components fail or tokamak operators push against known limits, the heat and current in the plasma can suddenly dissipate, a phenomenon known as a “disruption.” The resulting halo currents flowing in the hot ionized gases can strike the wall of the vessel, possibly causing local damage. If the halo currents flow around the chamber wall many times, and at a rate similar to the natural vibration frequencies of the chamber, they can distort the vessel.

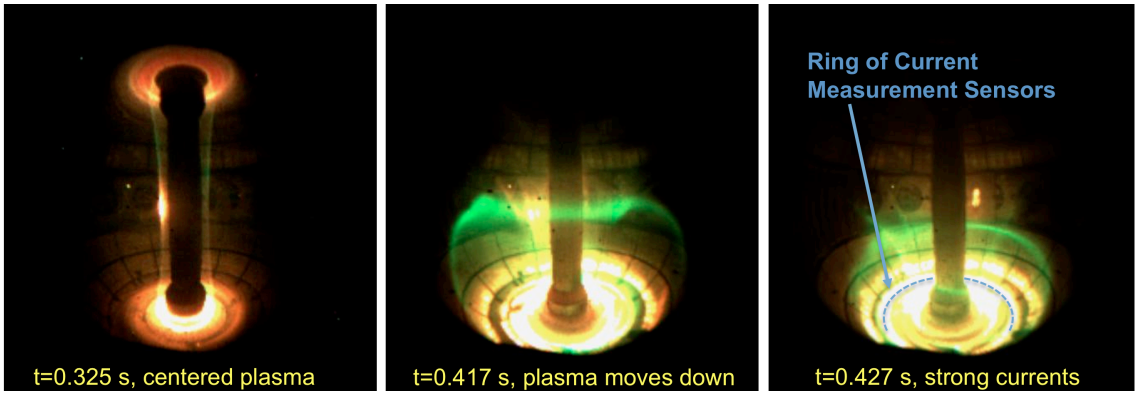

Figure 1. Evolution of the plasma during a disruption, as captured by a fast color camera. The plasma is centered in the left-hand frame, moves downward in the center frame, and lands on the floor of the vacuum chamber in the right frame. Large "halo currents" are observed in the indicated ring of detectors at this time.

"Fortunately, we have observed that the instances with the strongest currents are often those with the smallest motion of the currents," Gerhardt said. "This trend, along with the observations from other tokamaks that these currents can be significantly reduced with strong gas puffing, should diminish the potential for 'resonance' damage to the fusion plant from these currents."

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Abstracts:

PP8.00016	**Characterization of Disruption Halo Currents in NSTX**
Session	**PP8: Poster Session VI: NSTX, Field- Reversed Configurations, Other Magnetic Confinement; Intense LPI and FI; Beams and Coherent Radiation** RoHall BC, Wednesday, October 31, 2012, 2:00 PM–2:00 PM