Third Technical Meeting on Plasma Disruptions and their Mitigation

Contribution ID: **76** Type: **Contributed Oral**

Electric field effects during disruptions}

Thursday 5 September 2024 16:40 (25 minutes)

During tokamak disruptions, the magnetic surfaces are broken creating large regions of chaotic magnetic field lines. The physics associated with post-disruption chaotic magnetic fields needs be understood to address force, heat, and runaway electron loading on the walls. Direct simulations are too challenging to allow parameter scans and have uncertainties that can only be addressed by a reliable physics understanding. Even an ideal instability that grows on a timescale τ_I and does not saturate at a small amplitude will lead to a breakup of the magnetic surfaces on a timescale $\sim 10\tau_I$. The ratio of the closest to the average separation between two neighboring magnetic surfaces drops until resistive diffusion across the locations of their closest approach competes with τ_I. As surfaces break, regions of chaos are created. With chaos, each magnetic field line will have neighboring lines that exponentially separate from it with the distance along the line. When followed long enough, a single line will come arbitrarily close to every point in a single chaotic region. The annuli of magnetic surfaces between chaotic regions break by forming Cantori, which are toroidal surfaces punctured by pairs of inward and outward tubes of magnetic flux called turnstiles. In each chaotic region, the parallel current density divided by B relaxes toward a spatial constant by shear Alfv\'en waves. The electric potential Φ_q required for quasi-neutrality produces both a diffusion coefficient that is Bohm-like, $D_q \approx T_e/eB$, and a large scale flow $\approx T_e/eBa_T$ across the magnetic field lines, where a_T is the scale of the large scale difference in the electron temperature T_e. This diffusion and flow are important for sweeping impurities into the core of a disrupting tokamak plasma. These results follow from from general magnetic-evolution properties and from the separation of the electric field in the plasma into the sum of a divergence-free, $\vec{E}_B$, and a curl-free, $\vec{E}_q$, part. The divergence-free part of $\vec{E}$ determines the evolution of the magnetic field. The curl-free part enforces quasi-neutrality. This separation is given by a Helmholtz decomposition, which is unique if a boundary condition is given on the enclosing chamber wall. A deeper understanding of disruption experiments and simulations will clarify the roles of chaos, Alfv\'en waves, quasi-neutrality potentials, and helicity conservation not only in tokamak disruptions but also in magnetic reconnection in general—whether in the laboratory or in space. For more details, see $<$ https://arxiv.org/pdf/2404.09744 $>$. U.S. Department of Energy grants DE-FG02-03ER54696, DE-SC0018424, and DE-FG02-95ER54333 provided support.

Speaker's title

Mr

Speaker's email address

ahb17@columbia.edu

Speaker's Affiliation

Columbia University, New York City

Member State or IGO

United States of America

Primary author: Prof. BOOZER, Allen (Columbia University)

Presenter: Prof. BOOZER, Allen (Columbia University)

Session Classification: Consequences

Track Classification: Consequences