Project Proposal: Advanced Tokamaks and ITER

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While tokamaks are the most highly researched and developed magnetic confinement configuration, they have the fundamental flaw as fusion reactor due to their inherently pulsed nature. Ideally, a practical reactor design would be steady-state in operation so that power could be continually produced and the process could be more efficient. As such, alternative operation designs, called "Advance Tokamaks," are being developed to provide a steady-state alternative to the traditional inductively driven tokamak.

Modifications to operation in these advance scenarios are chosen such that they can work on existing tokamak designs, allowing the study of both approaches. The first significant difference is a purely non-inductive current drive. This includes the self-generated "bootstrap" current, supplemented by external current drives such as ion/electron cyclotron and neutral beam injection. Eventually, current drive consisting of 80-90% boot-strap current would be most economical, using the external sources off-axis to control the current and pressure profiles to avoid instabilities. Next, higher β_N is needed to maintain the bootstrap current, therefore reduction of transport is an issue. Due to the large bootstrap current, a negative magnetic shear develops centrally in the plasma. This shear actually suppresses several instabilities including ballooning and tearing modes. ITG modes are also suppressed by the sheared ExB flow. On top of the benefit of being steady-state, advanced tokamak designs are generally smaller in major radius with improved energy confinement time and higher power density compared to standard inductively driven operation.

For my project, I would like to learn more about these advanced modes of operation, how they could be integrated into ITER, and investigate whether advanced operation is a more practical approach to the future of fusion reactors. My presentation would consist of an explanation of AT operations, the advantaged and issues, as well as a comparison between the two approaches.

Greenfield, Advanced Tokamak Research at DIII-D National Fusion Facility in Support of ITER, Journal of Phys, 2005

Taylor, Physics of Advanced Tokamaks, Plasma Physics of Controlled Fusion, 39, 1997

Meade, Advanced Tokamaks and ITER