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ECE/NE/PHYSICS 922
Seminar in Plasma Physics
Mondays
12noon – 1610 Engineering Hall
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Oct 23 - Noah Hurst, UW-Madison
"Non-disruptive tokamak operation far beyond traditional safety factor and density limits"

Abstract:
Non-disruptive tokamak plasmas have been produced in the Madison Symmetric Torus (MST) at low field (B_T = 0.13 T) with edge safety factor 0.6 < *q(a)* < 2, below the traditional disruptive stability limit of *q(a)* = 2 [*Phys. Plasmas* 29, 080704 (2022)]; and (separately) with density up to 10 times the Greenwald limit, n_G. Achievable values of *q(a)* and n/n_G appear to be limited only by hardware and not by instabilities. Low-*q(a)* operation is possible due to MST's thick, conductive, close-fitting shell with resistive wall time 800 ms that inhibits resistive wall modes during the 50 ms discharges, and high-voltage, high-bandwidth feedback power supplies capable of sustaining the plasma current in the presence of large resistance and/or rapid MHD dynamics. Plasmas with 1 < *q(a)* < 2 and *q(a)* < 1 have been studied previously in other devices, but our work is novel in that steady, controlled equilibria are obtained with detailed internal diagnosis. Measurements reveal self-organized *q(r)* profiles with *q(0)* near unity, irregular fluctuations, and decreased confinement for 1 < *q(a)* < 2; and strong, coherent helical structures for *q(a)* ≤ 1. Nonlinear MHD simulations conducted with *q(a)* ≥ 1.5 using the NIMROD code also find *q(0)* near unity. The capability for $n > n_G$ is thought to be enabled by the advanced power supplies, and the thick shell may also play a role. While other devices have obtained n/n_G as high as 2, the values $n/n_G \sim 10$ reported here are unprecedented. In the range $1 < n/n_G < 2$ the Ohmic power and impurity radiation scale strongly with density, but for $n/n_G > 2$ the current profile collapses and the scalings weaken. These results may help inform future tokamak design efforts in order to mitigate the disruption problem and extend operational stability boundaries.

Bio:
Dr. Hurst attended UW-Madison as an undergraduate, where he was introduced to plasma physics as a student research assistant at MST. He completed his Ph.D. at UC San Diego under the guidance of Prof. Cliff Surko, where his research followed an unusual trajectory involving antimatter technology, non-neutral electron plasmas, and two-dimensional fluid dynamics. He received the Marshall N. Rosenbluth Outstanding Doctoral Thesis Award in 2019 for his experimental work on electron plasma ExB vortex dynamics subject to external strain flows. After continuing this project as a postdoc at UC San Diego, he moved back to Madison to accept a postdoc position studying tokamak plasmas at MST. He continues to work at MST as a WiPPL research scientist with interests in plasma stability, self-organization, and runaway electrons.