UCLA

Plasma Physics Seminar

Physics & Astronomy Building (PAB) Room 3-330
Via Zoom: https://ucla.zoom.us/j/92785449357?pwd=SVBTSko3bTdEUW03dzQwNks1Q2lKZz09
Friday, September 29, 2023
12:30 – 2:30 PM Lunch will be served

Negative Triangularity: The Holy Grail for Tokamak Core-Edge Integration?

Oak Nelson (Columbia University)

Abstract: The pursuit of commercial fusion energy, which could provide a clean and effectively limitless power source for humanity, is often heralded as one of the most important and difficult scientific endeavors of our time. One of the leading approaches for fusion, the tokamak, uses magnetic fields to confine a hot and dense plasma inside a toroidal vacuum vessel. Typically, this configuration can access plasma conditions capable of sustained fusion reactions, but in the process of doing so creates periodic edge instabilities called "ELMs" that release tremendous heat fluxes onto the machine walls. Avoidance of ELMs is essential to power plant operation, but existing techniques to do so are often extremely sensitive to plasma conditions and come with a measurable decrease in plasma performance. Enter negative triangularity (NT). By changing the shape of the plasma cross-section, NT scenarios provide a simple and robust solution to the power-handling problem in tokamaks by eliminating the triggering of ELMs via regulation of the edge pressure gradient with high-n ballooning modes. On the DIII-D and TCV tokamak facilities, NT ELM suppression is found to be fully compatible both with high core performance (simultaneous access to normalized confinement $H_{98y2} \geq 1$, normalized pressure $\beta_N \geq 2.5$ and Greenwald fractions $f_{GW} \sim 1$) and with divertor detachment. Since the NT ELM suppression effect is linked directly to geometry-induced changes in the magnetic shear, NT fusion pilot plants are predicted to maintain advantageous ELM-free edge conditions even in burning plasma regimes. Further, the natural tendency for NT plasmas to avoid H-mode even at high heating power could simplify impurity regulation and auxiliary power control in a reactor setting, and the NT geometry could facilitate larger divertor surfaces for exhaust mitigation. Together, these characteristics suggest that negative triangularity may be able to provide something that no other tokamak scenario can: a robust path to an inherently ELM-free fusion pilot plant.