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Avoiding plasma instabilities with artificial intelligence

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For stable and efficient fusion energy production using a tokamak reactor, maintaining high-pressure hydrogenic plasma without plasma disruption is essential. Therefore, it is necessary to actively control the tokamak based on the observed plasma state, to maneuver high-pressure plasma while avoiding tearing instability, the leading cause of disruptions. This presents an obstacle avoidance problem for which artificial intelligence (AI) based on reinforcement learning has recently shown remarkable performance. However, the obstacles here, the tearing instability, are difficult to forecast and highly prone to terminating plasma operations. In our recent work, we developed a multimodal dynamic model that estimates the likelihood of future tearing instability based on signals from multiple diagnostics and actuators. This dynamic model not only predicts the possible onset of tearing instability during tokamak operation but can also be used as a training environment for AI that controls actuators to avoid instabilities. In this work, we demonstrate AI control based on reinforcement learning to lower the possibility of disruptive tearing instabilities in DIII-D, the largest magnetic fusion facility in the US. The con- troller maintained the tearing likelihood under a given threshold, under relatively unfavorable conditions of low safety factor and low torque.

Speaker's Affiliation

Princeton University

Member State or IGO/NGO

United States

Primary authors: Prof. KOLEMEN, Egemen (Princeton University); SEO, Jaemin (Chung-Ang University)

Presenter: Prof. KOLEMEN, Egemen (Princeton University)

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