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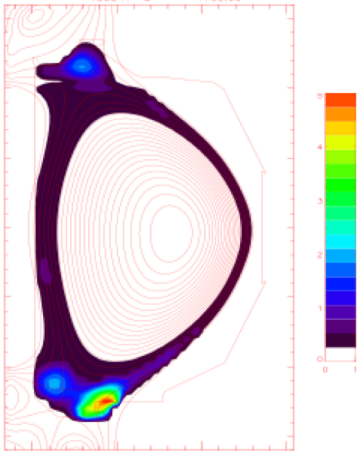
Toward Improving Performance and Fueling in High Power Tokamak Plasmas

Access to a more favorable operating regime may provide a pathway to future fusion-generating tokamaks

The Science

A key ingredient needed for tokamak plasmas to produce significant nuclear fusion power is achieving and maintaining sufficient energy confinement time, temperature, and high density. Usually during high performance H-mode operation in DIII-D, when plasma density is increased, energy confinement decreases and fueling to a desired density becomes increasingly difficult. Scientists have recently reported on a tokamak operating regime, where both energy confinement is found to *increase* as density is raised and plasma fueling to higher density is less difficult. Scientists showed that this improved performance is tied to better plasma stability properties near the edge of the plasma that result at very high heating levels. This improved stability regime, if it can be extended to more reactor plasma-relevant conditions, would improve prospects for a tokamak-based fusion power plant.



Access to an operating regime for tokamaks that could eventually lead to conditions favorable to fusion power generation has been reported by Department of Energy scientists. The plasma cross-section (above) shows how radiated power is distributed along the plasma periphery favorable to heat flux handling on the surrounding vacuum vessel surfaces.

The Impact

This study suggests that higher levels of energy confinement and improved plasma fueling can be simultaneously accessed in highly powered highly shaped tokamak plasmas. This study is a positive step in evaluating the potential in future generation power-producing tokamaks which require a combination of high energy confinement and high plasma density to be commercially viable. High plasma density also increases radiated power near the plasma edge and thus facilitates heat flux handling on the surrounding vessel surfaces. This research offers basic insights into the physics leading to these favorable results.

Summary

Future tokamak power plants that generate fusion energy will require very “high performance” plasma conditions to be economically competitive with other energy sources. Among the most important of these high performance criteria is that energy confinement times be long enough to maintain the high plasma temperature needed to produce adequate fusion power and that reaching the high density levels required do not adversely affect energy confinement. High density helps increase radiative power, which helps spread the high heat loads in a tokamak reactor. This study indicates that there is an operating regime on DIII-D that can be developed toward satisfying these criteria. In addition, as energy confinement is shown to improve with density, fueling is also improved. While there is a long way to go before tokamak fusion power plants can become a reality, this study has provided a positive step toward that goal.

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Publications

T.W. Petrie, et al., “Improved confinement in highly powered high performance scenarios on DIII-D” *Nucl. Fusion* (to be published).

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