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Stable Plasmas in Theoretically Mercier-Unstable TJ-II Configurations

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Stable plasmas in Mercier unstable magnetic configurations are obtained in TJ-II, which is unexpected according to the MHD stability theory. The most feasible explanation is that the plasma tends to self-organize in the unstable regions avoiding the instabilities. This result is relevant for new stellarator design, since the magnetic well is strongly related to the plasma shape, created by complex coils. Relaxing the Mercier stability criterion allows one to build simpler coils, which is easier and cheaper. Moreover, these stellarator results can help to understand the role of triangularity and elongation in tokamaks, since these quantities are related to magnetic well.

Stability Mercier criterion takes into account magnetic well, shear, plasma current and geodesic curvature. Since TJ-II is an almost shearless stellarator, the Mercier stability is governed by the magnetic well and the curvature. Taking advantage of TJ-II flexibility we have varied the magnetic configuration keeping almost constant the rotational transform profile while varying the magnetic well. The heating method was NBI in order to have non negligible β . The experimental results show that we get confined plasmas even in Mercier unstable configurations. The confinement time, normalized to the plasma volume, is similar in all the configurations, once the radiated power is subtracted. It is also shown that the shear layer moves accordingly to the position of the theoretical LCFS as the magnetic well scan is performed, showing that the plasma edge confinement is not severely affected. The plasma turbulence presents changes as the scan is performed, as shown by both the probe and fast cameras, with an increase of fluctuations as the magnetic well is decreased. The Doppler reflectometer does not show significant changes either on the turbulence amplitude or on the spectrum at radial positions of $r/a \approx 0.4-0.6$. The resonance ($n=8, m=5$) is located in the edge: the Thomson scattering measurements show a flattening of pressure profiles in the positions close to the rational in some cases without magnetic well, showing that the pressure profile reacts to the destabilization of the mode. The non-linear evolution of the modes could lead to self stabilization phenomena in stellarators, which could explain that plasmas are well confined even in Mercier-unstable configurations.

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