Ballooning stability in negative and positive triangularity spherical tokamak plasmas

R. Davies[1], D. Dickinson[1], H. Wilson[1]

[1]*University of York, York, UK*

A particularly promising magnetically confined fusion reactor concept is the spherical tokamak (ST). To be economically competitive, ST power plant designs require a high β (plasma pressure/magnetic pressure) and sufficiently low turbulent transport to enable steady-state operation. A novel approach to tokamak optimisation is for the plasma to have negative triangularity, with experimental results indicating this reduces transport in L-mode, and avoids the deleterious impact of Edge-Localised Modes (ELMs) experienced in standard H-mode operation. However, negative triangularity is known to close access to the “second stability" region for ballooning modes (a pressure-driven plasma instability) [**?**], and thus are expected to impose a hard β limit. Second stability access is likely important in ST reactor design, and this raises the question as to whether negative triangularity is feasible. We address this question by presenting a linear gyrokinetic study of three hypothetical (but reasonable) high β ST equilibria with similar size and fusion power in the range 500-800MW. We find that, by closing the second stability window, the negative triangularity case becomes strongly unstable to long-wavelength kinetic ballooning modes (KBMs) across the plasma, likely driving unacceptably high transport. By contrast, positive triangularity can completely avoid the ideal ballooning unstable region whilst having reactor-relevant β, provided the on-axis safety factor is sufficiently high. Nevertheless, the dominant instability still appears to be KBM, and we explore the role of kinetic effects in destabilising the mode. The KBM growth rate in the ideal MHD-stable region is low, and this could feasibly be stabilised by flow shear or may impose a soft β limit for ST reactors.

References

[1] S. Saarelma, M.E. Astin *et al*, Plasma Phys. Control. Fusion **63** (2021)