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Evaluation of the power fall-off length in ST40 from turbulence simulations

The realisation of magnetically confined fusion power plants offers a safe, clean and inexhaustible source of energy. So far the most promising device for realising such a power plant is the so-called tokamak, a doughnut shaped torus consisting of high field magnets to encase the fusion plasma.
Conventional tokamaks, such as JET in the UK, have a large column in the centre of the doughnut shape, where a large solenoid is placed. This solenoid is used for start-up of the plasma discharge and for inducing a current in the plasma to generate helical field lines, generating a stable plasma configuration. Spherical tokamaks (ST) greatly reduce the size of this central column by stripping
the inboard poloidal field coils and the ohmic heating solenoid and increase the minor radius of the tokamak to create a more apple-like shape.
ST have several advantages over conventional tokamaks, including lower magnetic field requirements to achieve fusion conditions, improved plasma stability and the possibility for smaller devices for net fusion gain, which lower the costs of manufacturing[1]. However, these ST have historically been limited by the lack of space in the central column for magnetic field coils and their shielding, limiting the magnitude of corresponding magnetic field strength and thus the possibility for high fusion power gains. Recent developments in the manufacturing process of high temperature superconductors (HTS) have allowed compact high field magnets to be produced for use in devices on the scale of medium sized tokamaks, which allows for ST with fusion conditions.
Before a fusion reactor sending energy into the grid can be realised, there are a several challenges that need to be addressed. Since ST have a high power density, the corresponding heat load along the magnetic field lines towards the so-called divertor plates will be high. This parallel transport is concentrated along a narrow channel, the width of which is known as the scrape-off layer (SOL)
power fall-off length, denoted λ_q [2]. In order to estimate the heat load that arrives at the divertor plates it is crucial to know λ_q. In this contribution we investigate how this width scales with a variety of different plasma parameters using the numerical plasma model, HESEL[3, 4, 5], for scenarios relevant to ST40, a novel high field spherical tokamak, located at Tokamak Energy Ltd. in the United Kingdom.

References

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