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A quasi-isodynamic stellarator configuration with good confinement of fast-ion and reduced turbulent transport

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The stellarator is an attractive concept for magnetic confinement fusion reactors, as it offers some advantages over the tokamak. Whereas in tokamaks part of the magnetic field is produced by driving a large inductive current in the plasma, the magnetic field of the stellarator is generated by external coils, avoiding the risk of current-driven instabilities and making steady-state operation easier. However, the lack of axisymmetry of the stellarator implies that good confinement is not guaranteed but requires careful tailoring (optimization) of the magnetic configuration. Wendelstein 7-X (W7-X) [1] is the first large stellarator whose magnetic configuration has been obtained using numerical optimization, and its reduced neoclassical transport of thermal species has been recently demonstrated [2]. This result has been a great success for the stellarator line of research and for the optimization effort in particular. However, the confinement of energetic particles, which is crucial for a reactor and improves with β in W7-X, is barely acceptable, and only at high β, around 4%. Furthermore, the first experimental campaigns in W7-X have shown that turbulent transport limits its performance in most plasma regimes.
This work presents a new stellarator configuration [3] of the quasi-isodynamic (QI) type [4] (the same class to which W7-X belongs) that improves in fast ion confinement and turbulent transport with respect to W7-X while keeping all its other good properties. The new configuration, with four periods and aspect ratio A˜10, has been obtained using the optimization suite of codes STELLOPT [5], in which the code KNOSOS [6] has been included and employed to compute novel orbit-averaged quantities that serve as proxies for the confinement of fast ions [7]. Monte Carlo calculations with ASCOT [8] confirmed that the confinement of fast ions is excellent not only for reactor-scale plasmas with β˜4% but also for moderate values of β (˜1.5%), which can be transiently necessary for the operation of a reactor. The effective ripple is smaller than 0.5% in the plasma core and a preliminary evaluation allows us to foresee a small bootstrap current, as expected for QI devices. A significant magnetic well ensures the Mercier MHD stability in the whole plasma volume and the Ballooning stability up to β=5% has also been demonstrated using the code
COBRA [9]. The configuration satisfies the flat mirror property, recently introduced [10]. Partly as a consequence of its flat mirror, this configuration also possesses the maximum-J property already at low plasma β, exhibits reduced Trapped Electron Mode (TEM) turbulent transport, and its neoclassical properties are expected to be robust against error fields. Preliminary sets of filamentary coils that faithfully generate this configuration will also be presented.

[1] G. Grieger et al. Fus. Technol. 21, 1767 (1992).
[2] C. Beidler et al. Nature 596, 221 (2021).
[3] E. Sánchez et al. Nucl. Fusion 63 066037 (2023).
[4] L. S. Hall et al. Phys. Fluids 18, 552 (1975). P. Helander et al. Plasma Phys. Control. Fusion 51, 055004 (2009).
[5] S. A. Lazerson et al. (www.osti.gov/biblio/1617636-7pt).
[6] J. L. Velasco et al. J. Comput. Phys. 418, 109512 (2020).
[7] J. L. Velasco et al. Nucl. Fusion 61, 116059 (2021).
[8] E. Hirvijoki et al. Comput. Phys. Commun. 185, 1310 (2014).
[9] R. Sánchez et al. J. Comput. Physics 161, 576 (2000).

[10] Velasco et al. To be submitted.

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