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On stellarator optimisation

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In this talk, I will give an overview of how stellarators can be optimised for improved performance and discuss the benefits thereof. Several stellarators have been optimised for favourable MHD and/or neoclassical transport properties, and some of these efforts have paid off handsomely in terms of plasma performance. Most dramatically, pellet-fuelled discharges Wendelstein 7-X have achieved confinement in excess of what would have been possible had the neoclassical transport not been reduced by optimisation of the magnetic-field geometry [1]. A world record for the Lawson triple product in high-temperature stellarator plasmas was set in these experiments. Even under such optimal conditions, turbulent transport still accounts for most of the energy losses, which raises the question whether turbulence could be suppressed, or at least reduced, by further tailoring the magnetic geometry. If successful, such optimisation could further, perhaps dramatically, enhance the performance of stellarators. There is some ground for optimism from the fact that some “turbulence optimisation” is already inherent in the W7-X design since trapped electrons do not reside in regions of unfavourable magnetic curvature. This feature is theoretically expected to reduce turbulence from trapped-electron modes [2,3,4], and there is experiment evidence that such reduction indeed takes place [5], thus providing confidence in our ability to theoretically predict turbulent transport and reduce it by a judicious choice of the magnetic geometry. Looking ahead to future stellarators, the key question is how to simultaneously optimise MHD properties, reduce neoclassical and turbulent transport, and improve alpha-particle confinement whilst still allowing for an attractive and robust divertor solution. I will describe two recent major initiatives to address this question.

[1] C.D. Beidler et al, submitted to Nature (2020).
[2] J.H.E. Proll et al, Phys. Rev. Lett. **108**, 245002 (2012).
[3] P. Helander et al., Nucl. Fusion **55**, 053030 (2015).
[4] J. A. Alcusón et al., Plasma Phys. Contr. Fusion **62**, 025005 (2020).
[5] P. Xanthopoulos et al., Phys. Rev. Lett. **125**, 075001 (2020).