Significance of MHD Effects in Stellarator Confinement

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Abstract

Substantial progress has been achieved to raise the plasma beta in stellarators and helical systems by high power neutral beam heating, approaching reactor relevant values. In the Wendelstein W7-AS stellarator, quasi-stationary plasmas with volume averaged beta in excess of 3 % could be established at $B = 0.8...1.0$ T [1,2]. The maximum beta could be further pushed up to values of $<\beta> > 4$ % in the Large Helical Device (LHD) at $B = 0.4...0.5$ T [3]. The achievement of high-β operation is closely linked with configuration effects on the confinement and with magnetohydrodynamic (MHD) stability issues.

The magnetic configurations and their optimization for high-β operation within the flexibility of the devices are characterized. A comparative description of the accessible operational regimes in W7-AS and LHD is given. The finite-β effects on the flux surfaces depend on the degree of configuration optimization. In particular, a large Shafranov shift is accompanied by formation of islands and stochastic field regions as found by numerical equilibrium studies [2,4]. However, the observed pressure gradients indicate some mitigation of the effects on the plasma confinement, presumably because of the high collisionality of high-β plasmas and island healing effects (LHD [5,6]). As far as operational limits by pressure driven MHD instabilities are concerned, only weak confinement degradation effects are usually observed, even in linearly unstable regimes.

The impact of the results concerning high-β operation in W7-AS and LHD on the future stellarator programme will be discussed, including relations to tokamak research. Some of the future key issues appear to be: - the control of the magnetic configuration (including toroidal current control), - the modification of confinement and MHD properties towards the low collisional regime, - and the compatibility of high-β regimes with power and particle exhaust requirements to achieve steady state operation.

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