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Quasi-axisymmetric magnetic configurations with magnetic well and improved symmetry at low aspect ratio

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Quasi-symmetry is a continuous symmetry in the magnetic field strength that a stellarator magnetic configuration can have. The neo-classical transport and fast-ion orbit losses in a quasi-symmetric stellarator are expected to be much smaller than in classical stellarators, owing to the cancelation of radial drifts on average. Thus, quasi-symmetric stellarator is an attractive concept as an fusion reactor.

Quasi-axisymmetry (QA) is characterized by the equivalent toroidal symmetry as tokamaks. The relationship between the achievable precision of quasi-symmetry and other physics properties such as the aspect ratio and MHD stability is one of the key perspective of QA stellarator. QA configurations with high precision have been constructed recently[1]. The aspect ratio of these configurations, A_p=6, is is relatively high compared to those of previous QA configurations [2,3] for which A_p~4.

In this study, we present two types of low-aspect-ratio (A_p=4) QA configurations that have been constructed using the new optimization code very recently. Both of these configurations has toroidal periods of two, rotational transform slightly below 0.4, and magnetic well over the entire volume. Fig. 1 illustrates vacuum configurations calculated using the VMEC code[4]. The magnetic field strength can be Fourier-decomposed and written as $B(\psi,\theta,\zeta)=\Sigma_{m,n}B_{mn}(\psi)\cos(-m\theta+n\zeta)$, where ψ is the toroidal flux, and θ and ζ are the Boozer poloidal and toroidal angles[5], and m and n are the poloidal and toroidal mode numbers, respectively. The measure of QA defined as $f_{\mathrm{QA}} \equiv \Sigma_m(B_{m0})^2/\Sigma_{m,n}(B_{mn})^2$ is fairly high for these configurations, as f_{QA}>99.5% over 80% of minor radius. Numerical simulations show impressively small neoclassical diffusion and fast ion losses for both cases. Analysis of finite-beta effect and MHD stability is underway to assess the expected plasma performance. This work is supported by MEXT KAKENHI (grant No. 21K13904) and NIFS Collaboration Research Program (NIFS22KIST036).

References
[1] Landreman, M and Paul, E, Phys. Rev. Lett. **128**, 035001 (2022)
[2] NEILSON, G. H., et al., Phys. Plasmas **7**, 1911 (2000)
[3] Mitsutaka Isobe *et al.*, Plasma Fusion Res. **14**, 34 (2019)
[4] Hirshman S.P. et al., Comput. Phys. Commun. **43**, 143 (1986)
[5] Boozer, A.H. and Kuo-Petravic, G. Phys. Fluids **24**, 851 (1981)

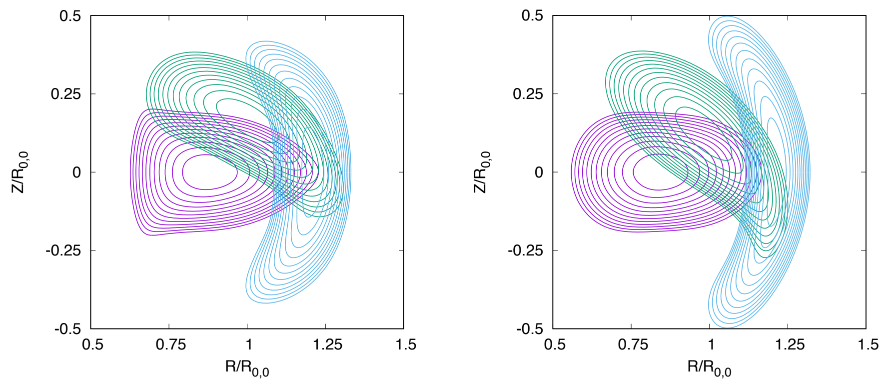

Fig.1 Cross-sections at toroidal angles ϕ=0, π /4, and π/2 of two types of new QA configurations.