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Plasma control for EAST long pulse non-inductive H-mode operation in a quasi-snowflake shape

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Advanced magnetic divertor configuration is one of the attractive methods to spread the heat fluxes over divertor targets in tokamak because of enhanced scrape-off layer transport and an increased plasma wetted area on divertor target. Exact snowflake (SF) for EAST is only possible at very low plasma current due to poloidal coil system limitation. However, we found an alternative way to operate EAST in a so called quasi-snowflake (QSF) or X-divertor configuration, characterized by two first-order nulls with primary null inside and secondary null outside the vacuum vessel. Both modeling and experiment showed this QSF can result in significant heat load reduction to divertor target [1]. In order to explore the plasma operation margin and effective heat load reduction under various plasma conditions and QSF shape parameters, we developed ISOFLUX/PEFIT shape feedback control. In experiment, we firstly applied the control of QSF in a similar way to control the single null divertor configuration, with specially designed control gains. Reproducible QSF discharges have been obtained with stable and accurate plasma boundary control. Under Li wall conditioned, we have achieved highly reproducible non-inductive steady-state ELM-free H-mode QSF discharges with the pulse length up to 20s, about 450 times the energy confinement time by using low hybrid wave, ion cyclotron resonance wave (ICRH) and electron cyclotron resonance wave (ECRH) for the plasma current drive and heating. The capability of the QSF to reduce the heat loads on the divertor targets has been confirmed. This new steady-state ELM-free H-mode QSF regime may open a new way for the heat load disposal for fusion development.

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