Progress of Research on the KTX Reversed Field Pinch

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The Keda Torus eXperiments (KTX) Reverse Field Pinch (RFP) device has undergone several key upgrades in the last two years to enhance its operational capabilities and provide new experimental and theoretical support for research on RFP physics. With these upgrades, KTX can now be operated under higher confinement regimes and conduct three-dimensional physics research.

In terms of operational capabilities, firstly, the power supply of the KTX Ohmic field has been upgraded to enable discharge with a plasma current exceeding 500 kA. Secondly, a boundary magnetic field feedback control system has been developed to enhance plasma stability and thereby extend pulse durations, aiming for QSH state regulation. This system, in combination with the bias electrode system designed for boundary electric field control, further improves plasma confinement.

In terms of fueling technology, KTX has been equipped with the Compact Toroidal Injection (CTI) system, aiming to access the high-density operational regime. Recent experiments have shown that the CTI has been successfully achieved at a maximum speed approaching 300 km/s, with enhanced fueling capacity enabling a core plasma density of >1.5 n_G. This system can effectively penetrate the magnetic field and diffuse into the plasma core, providing new technical support for future magnetic confinement fusion experiments.

Regarding diagnostic capabilities, KTX has developed a series of high-precision diagnostic systems aimed at conducting in-depth investigations of anomalous transport and quasi-single helicity (QSH) states in the RFP plasma, including: a fast-scanning electromagnetic probe system for high temporal resolution measurement of electromagnetic fluctuations at the plasma edge; a terahertz solid-state source polarimetric interferometer system for high-precision density measurement and magnetic field fluctuation analysis, revealing electron density and internal magnetic field dynamics of the plasma; and a double-foil soft X-ray diagnostic system for precise imaging of the plasma's three-dimensional structure, etc.

In terms of modeling/simulation work, numerical simulations have explored the characteristics and maintenance mechanisms of the QSH state in the RFP device from three aspects. The study indicates that the helicity's impact on magnetic topology is a key factor, and the formation of the QSH state helps improve energy confinement. Simulations of electrostatic drift reveal the important role of drift flows in maintaining the QSH state, enhancing the plasma's self-organization ability. Three-dimensional balance reconstruction analysis has revealed the non-axisymmetric magnetic field distribution under the QSH state and its distinct characteristics compared to the multi-helicity (MH) state, providing important theoretical support for understanding and optimizing the three-dimensional self-organized state in an RFP plasma.

In summary, KTX has been successfully upgraded, laying a solid foundation for in-depth studies of RFP physics. Benefiting from these upgrades, KTX has carried out a number of research activities, and the advanced and interesting results will be presented at the conference.

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