2023 Helmholtz – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Edge transport and MHD instability analysis in high-performance magnetically confined plasmas

Helmholtz Centre and/or institute:

Forschungszentrum Jülich GmbH

Project leader:

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Department: (at the Helmholtz centre or Institute)

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Description of the project (max. 1 page)**:**

Currently, the most advanced concepts for fusion confinement are the tokamak and the stellarator. The former is toroidally symmetric and 2D; the latter is a 3D device with a smaller degree of symmetry. The tokamak scheme is currently a leading variant for plasma confinement and is therefore being used for the ITER design and is planned for the DEMO reactor. It has recently been realized that 3D effects also play a significant role in this 2D concept. Their influence can be seen in transport and energy confinement, in control of different magneto-hydrodynamic (MHD) instabilities and in the nature of disruption events.

On the Wendelstein 7-X (W7-X) stellarator, the island divertor configuration with three-dimensional (3D) field characteristics has been used to handle the power and particle exhausts. In order to investigate the synergy between 3D edge transport physics and plasma-wall interactions, a group of edge diagnostics and modelling has been developed by Institute of Energy and Climate Research, Plasma Physics (IEK-4), Forschungszentrum Jülich GmbH. Two endoscopes have been designed for visible and ultraviolet spectroscopy and tomography of the plasma edge, along with infrared thermography of the divertor tiles. A multipurpose manipulator, which is used as the carrier either of the probe head for measuring the plasma edge profiles or of samples for plasma exposure studies, was installed at the outside mid-plane on W7-X. A poloidal correlation reflectometer has also been installed at W7-X. The system consists of an antenna array observing the propagation of turbulent phenomena in the mid-plane. To support the scenario design for the upcoming long-pulse high-performance campaign of Wendelstein 7-X, various numerical codes including a 3D non-linear MHD equilibrium code HINT, a 3D MHD instability analysis code MIPS, a full diffusive field diffusion model, and a 3D kinetic neutral particle transport code EMC3-EIRENE have been integrated for a systematic understanding of the beta effect on magnetic topology, 3D edge plasma transport and MHD instability. In principle, this integrated code package can also be applied for edge transport and MHD instability analysis in ELM control/suppression experiments using resonant magnetic perturbations (RMPs) in a tokamak.

This project aims to perform systematic edge transport and MHD instability analysis using the integrated code package in high-beta plasmas on W7-X with an island divertor configuration, and validating the modeling results with multiple edge diagnostics. By means of numerical calculation and experimental observation, this project will also investigate the mechanism and method of forming and controlling the magnetic island at the plasma boundary on the JT-60SA tokamak, and study the effect of 3D fields on the type-I edge localized modes (ELMs).

The team in Forschungszentrum Jülich is looking for a researcher who can support the team in 3D edge plasma transport and MHD instability analysis on either stellarator or tokamak. Understanding of the involved physics as well as required code improvements is part of the project.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

Our team is cooperating with Chinese partners such as Institute of Plasma Physics (Chinese Academy of Science), Southwestern Institute of Physics (SWIP), Shenzhen University (SZU), Donghua University (DHU), and Huazhong University of Science and Technology (HUST). The current collaborations are focusing on the experimental and theoretical studies in plasma devices including W7-X, AUG, EAST, JT-60SA and J-TEXT. The research directions involve MHD stabilities, edge plasma diagnostics and simulations, as well as plasma-wall interactions, and so on.

Required qualification of the postdoc:

- PhD in plasma physics or diagnostic technology
- Experiences with plasma diagnostics or transport studies on the tokamak or stellarator
- Experiences with deep learning methods and neural networks
- Additional skills in spoken and written English with a very good level