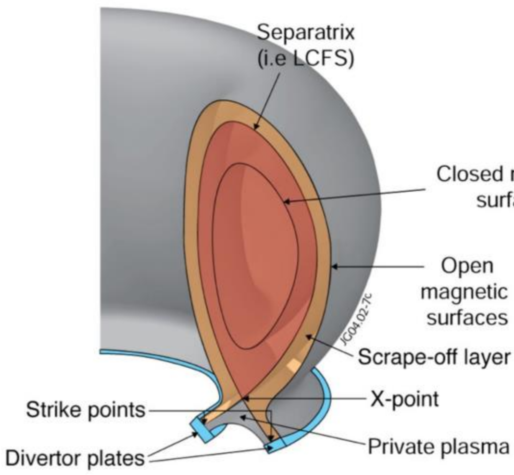
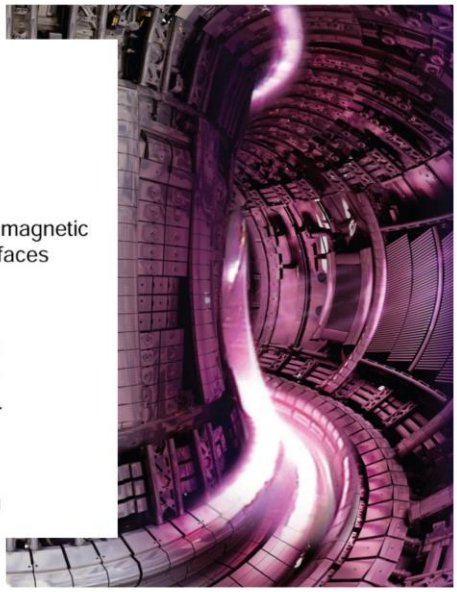
Fusion and plasma physics – summer project proposals

The Fusion and Plasma Physics research group is seeking to recruit interested and motivated students for the summer 2024 period. We offer topics suitable both for Bachelor's theses and special assignments, potentially leading to Master's theses. Further information about the group itself can be found from our website: https://www.aalto.fi/department-of-applied-physics/fusion-and-plasma-physics. The overview of the projects will be presented in the department common info session.





Neutral gas transport in the JET sub-divertor (instructor: Timo Kiviniemi, Ray Chandra)

Hydrogen molecules and atoms play a critical role in cooling the edge of fusion plasmas to temperatures necessary to interface it with the surrounding (solid) walls. Removal of these species is accomplished via pumps in the divertor (sub-divertor). Understanding of the flow of molecules from the divertor to the pump, and the backflow, are instrumental in achieving optimal pumping conditions. The project focuses on simulating the neutral dynamics in the sub-divertor in the JET tokamak using the neutral Monte-Carlo code EIRENE, on assessing the flow regimes and toward developing understanding of gas flows in closed and pumped vacuum systems. The project is set up for both new students in the field of plasma physics toward a Bachelor's thesis and a special assignment. Prior knowledge in the programming language Python is desired to develop post-processing analysis tools.

Impurity transport in JET (instructor: Roni Mäenpää)

The walls of the Joint European Torus (JET), previously the world's largest operational tokamak, are made of beryllium, tungsten, and Inconel alloy. Plasma-wall interactions inevitably result in some erosion of the wall materials, which dilute the fusion plasma and cause a cooling effect via radiation. Some regions of the wall are eroded faster than material is deposited onto the wall by the plasma, whereas layers of deposited material are formed in other regions. Understanding the erosion and deposition processes is important for predicting the lifespan of the wall components and for avoiding contamination of the fusion plasma.

The proposed project uses the core-edge coupled code JINTRAC and the Monte Carlo simulation code ERO2.0 to predict the erosion, transport, and deposition of JET wall materials in several plasma scenarios representative of typical JET experiments. The predicted erosion and deposition rate of each material is used to estimate the deposit layer thickness and the material composition as functions of time at different wall locations. Prior knowledge in the programming language Python is desired to develop post-processing analysis tools.

ASCOT5 modeling of TCV tokamak in IMAS (Instructor: Seppo Sipilä)

ITER needs tools to model discharges and plan the operation. There is a systematic framework under which all ITER modeling should be carried out. This framework is called IMAS (integrated modeling and analysis suite). This framework allows for example to compare two different codes guaranteeing that the input data for them is identical. ASCOT has been installed in the IMAS for a long time. Currently, the version ASCOT4 is actively used. However, the most recent version ASCOT5 is being adapted to IMAS currently. Within this project, the student would carry out benchmarking activity using IMAS infrastructures to make sure that the importing of the ASCOT5 is done properly. Thereafter, more physics relevant simulations are run to validate the IMAS modeling against existing experimental measurement under different plasma conditions. This exercise includes running simulations for TCV tokamak (experimental machine from EPFL) within the IMAS as part of an international activity.

Scrape-off layer conditions in ASDEX Upgrade helium plasmas (instructors: David Rees, Mathias Groth)

Predicting the plasma and neutral conditions in the scrape-off layer in tokamaks – the outermost plasma layer connecting the burning plasma in the core to the device vessel wall – is one of the most critical, yet challenging tasks in fusion energy research and development. Helium plasmas were performed in the ASDEX Upgrade tokamak to elucidate the role of atoms versus hydrogenic molecules, and their impact on plasma detachment.

In the proposed project, the physics of the scrape-off layer, and the analytic two-point model for hydrogenic and helium plasmas derived. The predictions from these models will be compared to measurements in ASDEX Upgrade deuterium and helium plasmas, and to predictions from an edge fluid code. Prior knowledge in the programming language Python is desired to compare the results.