P 11: Magnetic Confinement IV

Time: Wednesday 13:45–15:50 Location: KH 02.016

Invited Talk P 11.1 Wed 13:45 KH 02.016

Proxima Fusion - Building stellarators to power the future — •Jonathan Schilling — Proxima Fusion, Munich, Germany

Proxima Fusion is Europe's fastest-growing fusion company, building the first generation of fusion power plants using quasi-isodynamic (QI) stellarators - the clearest, most robust path to putting fusion on the grid. Proxima Fusion is the first spin-out from the Max-Planck-Institute for Plasma Physics and builds on the record-breaking successes of the Wendelstein 7-X stellarator. Its roadmap towards the peer-reviewed Stellaris commercial power plant concept progresses through demonstration milestones including the Stellarator Model Coil and the Alpha demonstration stellarator slated to achieve net energy gain in the early 2030s, culminating in a first-of-a-kind grid-connected fusion power plant within the 2030s. Assembling a world-class team from institutions such as Max Planck IPP, MIT, Google[X], SpaceX, and leading universities, and backed by significant public and private investment, Proxima Fusion accelerates fusion from scientific achievement to industrial-scale reality. Proxima Fusion collaborates across the European fusion ecosystem to solve physics, engineering, and systems-integration challenges, advancing stellarator design, high-performance magnets, and rapid prototyping toward fusion's transformative impact on global energy. This talk will give an overview of Proxima Fusion's roadmap and highlight recent achievements.

Invited Talk P 11.2 Wed 14:15 KH 02.016

Equilibrium and stability in Wendelstein 7-X high beta plasmas — •Henning Thomsen, Christian Brandt, Charlotte Büschel, Edith V. Hausten, Martin C. Kelly, Kian Rahbarnia, Pedro Pons Villalonga, Sara Vaz Mendes, Ksenia Aleynikova, Golo Fuchert, and Niklas S. Polei — MPI f. Plasmaphysik, Wendesteinstr 1, 17491 Greifswald

High plasma pressures, characterized by the plasma beta, are necessary for future stellarator fusion reactors. The Wendelstein 7-X stellarator (W7-X) has been optimized to achieve stable plasma conditions with a volume-averaged beta (the ratio of plasma pressure and external magnetic pressure) of up to $\langle\beta\rangle \approx 5\%$. In the recent campaigns, measurements of magnetic diagnostics and equilibrium reconstructions [1], as well as tomographic inversions of the plasma radiation in soft-X ray range in high beta plasmas ($\langle\beta\rangle \lessapprox 3\%$) have been used to experimentally validate this optimization goal. The measured outward shift of the flux surfaces (Shafranov-shift) is consistent with the predictions. Coherent mode activity has been observed [2] during high beta plasma phases. Pressure driven, non-ideal ballooning modes are possible candidates, since those instabilities were not included in the original optimization of the magnetic configuration of W7-X. A summary of the current status of high beta plasma investigations in the Wendelstein 7-X stellarator will be presented.

[1] E.V. Hausten et. al, this conference
[2] C. Büschel et. al, this conference

P 11.3 Wed 14:45 KH 02.016

Mode activity during high plasma beta at the Wendelstein 7-X stellarator — •Charlotte Büschel, Christian Brandt, Henning Thomsen, Ksenia Aleynikova, Kian Rahbarnia, Edith Victoria Hausten, Martin Clifton Kelly, Sara Vaz Mendes, Pedro Pons Villalonga, Kai-Jakob Brunner, Golo Fuchter, Jens Knauer, Ekkehardt Pasch, Andreas Langenberg, and W7-X Team — IPP Greifswald, Greifswald, Germany

During the last two campaigns of Wendelstein 7-X, starting in October 2024 and lasting until May 2025, high plasma β was achieved in three different plasma scenarios: injection of frozen hydrogen pellets, a combined heating scenario of NBI and ECRH, and operation at reduced magnetic field around 1.8 T. Averaged plasma β values up to $\langle\beta\rangle = 3\,\%$ and core beta values of $\beta_0 = 8.5\,\%$ were reached. This contribution categorizes the different types of mode activity observed at high plasma β and focuses on the characterization of quasi-coherent modes in a frequency range of $f = 20 - 60\,\mathrm{kHz}$. The mode analysis is based on the line-integrated photodiode signals from the soft X-ray multi-camera system installed in Wendelstein 7-X utilizing the high spatial and temporal resolution of 360 photodiodes arranged in one poloidal plane of the plasma. The analysis includes the determination of the poloidal mode number, the ballooning character, the radial location and the propagation direction of the mode. The mode characteristics are analyzed with respect to their correlations to general plasma parameters such as temperature, density and confinement time.

P 11.4 Wed 15:10 KH 02.016

Fully global simulations of electromagnetic turbulence and pressure-driven instabilities in tokamaks and stellarators — •Yann Narbutt[1], M. Borchardt[1], T. Hayward-Schneider[1], R. Kleiber[1], A. Könies[1], A. Mishchenko[1], C. Nührenberg[1], J. Riemann[1], E. Sánchez[2], K. Aleynikova[1], and A. Zocco[1] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstraße 1, 17491 Greifswald, Germany — [2]Laboratorio Nacional de Fusión, CIEMAT, Avda. Complutense 40, Madrid 28040, Spain

Magnetic confinement fusion experiments require high $\beta = \langle p\rangle/(B^2/2\mu_0)$, the ratio of plasma pressure to magnetic pressure, to access high performance. Moderate β can be beneficial reducing for ion-temperature-gradient (ITG) driven turbulence. Typically, however, as β is increased above certain thresholds, pressure-driven instabilities appear which can potentially drive strong outward directed heat fluxes. To investigate these regimes we use the global gyrokinetic code EUTERPE to simulate plasmas in stellarators and tokamaks. Linear and nonlinear simulations, in the stellarator Wendelstein 7-X, show an unexpected absence of such instabilities as well as a reduction of heat fluxes as β rises. Given these results, additional simulations are performed in a tokamak for further understand pressure-driven instabilities from the perspective of global codes. Here, agreement between global gyrokinetics and ideal magnetohydrodynamics confirms that with large values of β pressure driven instabilities can indeed arise. However, in some parameter regimes these appear to be mitigated by kinetic and MHD effects.

P 11.5 Wed 15:35 KH 02.016

Transport investigations in pellet-fuelled plasmas of ASDEX Upgrade — •Florian Gschoesser, Clemente Angioni, Michael Bergmann, Emiliano Fable, Rainer Fischer, Peter Lang, Bernhard Ploeckl, Federico Stefanelli, Dirk Stieglitz, Giovanni Tardini, Hartmut Zohm, and ASDEX Upgrade Team — Max Planck Institute for Plasma Physics, Garching, Germany

Pellets are, for all practical purposes, the only way to fuel plasmas in a future fusion reactor. The injection of such a pellet, formed from cryogenic solid hydrogen, introduces large modifications to the plasma parameters, especially in density and temperature. The resulting momentary transition of the plasma into a non-stationary state leads to transport processes that will be investigated. This talk will focus mainly on two aspects: on one hand, it will address the experimental efforts to achieve reliable and robust profile measurements during a pellet injection; on the other hand, it will present an approach to derive information regarding the transport processes by comparing experimental observations (Thomson scattering, DCN interferometer, IDA) and simulation results (ASTRA). Progressing from lower to higher complexity, the following cases will be discussed: First, "single" repetitive pellet perturbations are analyzed. The second case deals with a high-density quasi-stationary phase, where strong fueling is applied. Finally, the transition from low to high density via a sudden injection of pellets at high frequency is discussed. Some first simulation results and conclusions will be presented.