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The Initial Programme of Wendelstein 7-X on the Way to a HELIAS Fusion Power Plant

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The stellarator concept offers a possible alternative to a tokamak Fusion Power Plant (FPP). One of the missions of the EU Roadmap to the realisation of fusion energy is to develop the stellarator line to maturity. World-wide efforts on different stellarator lines cover a substantial range of candidate magnetic configurations; the EU programme focuses on the optimized, helical advanced stellarator (HELIAS) line. Wendelstein 7-X (W7-X) is the first fully optimized stellarator to proof the concept of physics-based, optimized shaping of the magne-tic field structure to get to plasma performances projectable to fusion in upscaled devices.
To demonstrate reactor potential, W7-X needs to operate reliably at high-power, high-density quasi-continuously with a viable divertor concept. At the same time, basic science issues of 3D plasmas will advance plasma physics. The key for the physics program is steady-state heat and particle exhaust by qualified divertor operation with actively cooled plasma facing components. However, to develop steady-state scenarios aggressively but to avoid technical risks from water cooling, the initial operation phase of W7-X will begin with carbon limiter discharges later replaced by an inertially cooled test divertor for the development of high-performance operation.
Initially, the discharge lengths will be limited to 5-10 s at maximum anticipated heating powers. Critical for later high-performance operation, the development of discharge scenarios at high densities with full density control is one leading objective to develop reliable divertor operation schemes. Fuelling schemes, e.g. with pellets, will be qualified to avoid central density depletion due to thermodiffusion. Furthermore, the behavior of impurities as well as the potential occurrence of edge localized modes will be investigated. Basic issues relevant to FPPs such as the impact of stellarator optimization on turbulent transport and improved confinement modes are part of the plan. The very beginning of the exploitation of W7-X will be a technical demonstration of ECH plasma break-down, X2-heated plasmas and measurements of vacuum flux-surfaces. In this phase, neoclassical electron heat transport will be investigated.
The physics plan to steady-state operation in the initial phase of W7-X and the underlying strategy with regard to a HELIAS stellarator FPP will be outlined.

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