**High performance steady state fusion plasmas in the superconducting stellarator device Wendelstein 7-X**

T. Klinger, Greifswald/Germany

Max-Planck Institute for Plasma Physics, Wendelsteinstrasse 1, 117489 Greifswald

The stable generation of high-temperature and low-density hydrogen plasmas (ion and electron temperature in the range 10-20 keV resp. 100-200 million degree Kelvin) is the basis for the use of nuclear fusion to generate heat and electric power. The most promising path is to use strong, toroidally shaped, twisted magnetic fields to confine the electrically charged plasma particles in order to avoid heat losses to the cold, solid wall elements. Two magnetic confinement concepts have proven being most suitable: (a) the tokamak and (b) the stellarator. The stellarator creates the magnetic field by external coils only, the tokamak by combining the externally created field with the magnetic field generated by a strong current in the plasma. “Wendelstein 7-X” is the most advanced large superconducting stellarator that operates at the Max Planck Institute in Greifswald. With 30 $m^3$ plasma volume, 3 T magnetic field on axis, and 10 MW micro wave plasma heating power, hydrogen plasmas are generated that allow one to establish a technical and scientific basis for the extrapolation to a future fusion power plant. It is a unique feature of Wendelstein 7-X to be able to operate high-power hydrogen plasmas under steady-state conditions, more specifically for 1800 s (note that the world standard is now in the 10 s ballpark). Furthermore, Wendelstein 7-X has recently proven to be at par with tokamak plasma performance for long discharges. This talk provides a brief review of the principles of nuclear fusion and discusses the key physics subjects of optimized stellarators. We summarize the most important findings of the previous performance operation campaigns and put them into the international context of fusion research. An outlook is given towards fusion power as a building block of future energy supply of the world.

[1] National Geographic, November Issue 2025
https://www.nationalgeographic.com/science/article/stars-nuclear-fusion-energy

[1] T. Klinger et al., Nuclear Fusion 2019, 59(11) 112004

[2] A. Dinklage et al., Nature Physics 2018, 14(8) 855