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ITER's Design Physics Basis and Research Plan

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The ITER project's mission is to demonstrate the scientific and technological feasibility of fusion power for peaceful purposes and the facility is now under construction at Saint Paul-lez-Durance (France). The ITER reactor is based on the tokamak concept of plasma magnetic confinement, in which the fusion (deuterium-tritium) fuel is contained in a toroidal vessel. The ITER tokamak is designed to generate 500 MW of fusion power for periods of 300 to 500 seconds with a fusion power multiplication factor, Q, of at least 10 (Q ≥10). ITER will also aim at demonstrating long fusion power production pulses, of at least 1000 seconds, with a fusion power multiplication factor of 5 and, ultimately, of approximately 1 hour duration (only limited by hardware design limits) when fully non-inductive operation is demonstrated.
The paper will cover the main aspects of the ITER reactor design, construction and planned operation:
a) The main features of the ITER tokamak reactor design.
b) The basic physics design principles of the ITER tokamak and of the key ancillary systems required for the operational scenarios considered to achieve the project's mission.
c) The research plan from non-nuclear hydrogen and helium plasmas to nuclear operation with deuterium-tritium plasmas leading to the demonstration of high Q fusion power.
This will include an in depth description of the key physics processes that need to be understood in detail and controlled for the achievements of ITER's high Q goals including:
1) The reduction of the overall turbulent transport level to achieve the required energy confinement.
2) The control and mitigation of plasma magnetohydrodynamic instabilities, chiefly disruptions, edge localized modes and neoclassical tearing modes, etc.
3) The control of the power fluxes to the components that protect the vacuum vessel wall from the plasma and the minimization of the contamination of the plasma by impurities produced in plasma-wall interactions.
4) Heating and fuelling of the plasma by external means to ensure that the thermonuclear plasma conditions required to achieve high fusion gain are established in the tokamak.
The paper will address the present understanding of these above, their implications for ITER operation and expected fusion performance, and the status of R&D on these issues for ITER, with emphasis on their unresolved aspects and possible ways to address them by new experiments, theoretical developments and simulations.

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