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Ignited Spherical Tokamaks as a Reactor Development Facility[1]

LEONID ZAKHAROV, Princeton University, PPPL

The talk presents the concept of Ignited Spherical Tokamaks (IST), which can serve as a neutron fusion source for the Reactor Development Facility. The IST would be uniquely consistent with three objectives of magnetic fusion, i.e., (a) high power density plasma regime (5-10 MW/m^3), and high neutron flux (b) for designing the "first wall" of the reactor (up to the fluence of 15 MW year/m^2), and (c) for developing the tritium cycle. The lithium-based plasma facing components (LiWalls) of an IST provide the pumping boundary conditions for the plasma. When combined with central fueling of the plasma by low energy (E=45-50 keV) neutral beam injection (NBI), the LiWall environment leads to a flat plasma temperature T=E/3. This results in a super-critical ignition regime, with ion-temperature gradient turbulence eliminated, when the energy confinement is close to neo-classical, while the high current density at the separatrix robustly stabilizes the edge-localized modes. Unlike conventional approach to magnetic fusion, the super-critical ignition regime relies on core fueling by NBI and fast expulsion of the α-particles, rather than on their heating the plasma. In this regards, the IST configuration (for the neutron source purposes) and stellarators (as power reactors), rather than tokamaks, have similarity regarding super-critical ignition regime. A separate national program ($\simeq$\$2-2.5 B for $\simeq$ 15 years) can realistically develop an Ignited Spherical Tokamak as a fusion neutron source for reactor R&D in 3 steps (two with DD, and one with DT plasmas), i.e.,

1. A spherical tokamak, targeting achievement of absorbing wall regime with neo-classical confinement in a DD plasma and $Q_{DT-equiv} = 1$,

2. Full scale DD-prototype of IST for demonstration of all aspects of stationary super-critical regime with $Q_{DT-equiv} \simeq 50$.

3. IST itself with a DT plasma and $Q_{DT} \simeq 50$ for reactor technology and α-particle power extraction studies.

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