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Plasma Physics Seminar

Physics & Astronomy Building (PAB) Room 3-326

Via Zoom: https://ucla.zoom.us/j/92785449357?pwd=SVBTSko3bTdEUW03dzQwNks1Q2lKZz09

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Two-stage approach to accelerate the progress of fusion reactor development from science to engineering: Detour or Ultra-fast-track?

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Abstract: Assuming all the scientific goals in ITER are fully met, are we ready to commercialize fusion reactor? A simple answer is ‘no’, as we all are aware of the dire need of DEMO to hone all the engineering skills in confidence. Then, how long and how much would be required for us to complete the reality check to our satisfaction? Such a sobering question motivates some of us to seek for any short-cuts, if existent. Considering the ITER-size device requires a huge amount of resources, as well as a very long-term commitment, it is quite natural to not only list up the key elements required for the next-generation device, but also keep an eye on a smaller device, if feasible. Arguably the most noticeable influx to fusion community comes from the advent of high temperature superconducting (HTS) magnets several years ago [1], suggesting the possibility of exploring higher magnetic field fusion plasmas which, in principle, could help us effectively miniaturize a fusion reactor. In that regard, the latest accomplishment of 20T HTS magnet at 20 K with 20 kA for SPARC sheds a positive light on every aspect [2], while significant technological challenges are still posed for fusion reactor. To speed up the whole R&D cycle of fusion reactor developments, a two-stage approach is proposed. While the DD fusion under high magnetic field (>10T) can be mastered primarily for heat exhaust handling first, the DT fusion can be later integrated with all the proven technologies, including self-sustained tritium breeding and blankets for power extraction. Roughly, each device can be designed within 3 years, constructed for 5 years, and then operated for 10 years. Specifically, Ultra-fast-track Fusion Reactor (UFR) is proposed for DD fusion study first as a domestic program, while Fusion Demo Reactor (FDR) is to be constructed for DT fusion study later. Since UFR is targeting 1) fusion reactor design, 2) high magnet field magnet technology, 3) power handling divertor, 4) reactor materials, 5) heating and current drive technology in high magnetic field, along with fusion diagnostics, the on-going KSTAR research outcomes, along with the KFE emphases on blanket and tritium handling technology, can be fully utilized altogether for the FDR design and construction in an integrated manner.

Tentatively, UFR (B_T=10.8T, R=1.8m, a=0.5 m, I_p= 6 MA, P_{AUX}=25 MW) is envisioned to possess KSTAR-like (SPARC-like) shape under ITER-grade heat flux on divertor, featured with super X-divertor. Although the HTS magnets are primarily considered for high magnetic field, Plan B allows for the adoption of low temperature superconducting (LTS) magnets at the time of UFR construction decision. Similarly, while the fully non-inductive current drive is proposed without central solenoids (CS), slim- CS would be alternatively planned, as well. Indeed, the unprecedently high magnetic field requires us to newly develop a suite of RF sources (ICRF, LHCD, ECCD, Helicon), whose availabilities could forfeit or reduce the need of neutral beam injector (NBI). Surely, various concepts and ideas are being collected and shared to map out the blueprint of two-stage approach for fusion reactor, while a preliminary conceptual snapshot will be introduced and discussed at the meeting.