Recent advances of RF systems for magnetic fusion and projection for the next steps

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Research in nuclear fusion is entering an exciting new phase with the start of ITER construction and the setting-up of a broad approach to fusion by the EU and Japan. It is now mandatory to integrate recent advances in the physics and technology of RF heating and current drive into practical and reliable systems in order to ensure the expected objectives of the new programmes.
In this context, the ITER organisation has initiated an internal review of the main subsystems. The ITER heating and current drive systems are an integral part of the review [1]. It aims at establishing a revised ITER design basis with the goal to launch as soon as possible equipment on the critical construction path. In parallel, the JT-60-SA EU/Japan joint venture is entering the detailed design phase and should benefit from the review. It is the purpose of this talk to collect new facts on major aspects of RF systems and to discuss how they can be incorporated in the design basis. Furthermore, we should keep in mind the extrapolation to DEMO conditions which will be based on the results of the programmes planned now.

Reaching thermonuclear conditions in ITER by heating the plasma above the high confinement mode threshold will be the first challenge to meet. Large uncertainty remains on the H mode threshold power and there will be a premium for systems capable of depositing the power centrally preferably via the ion channel and for those capable at the same time of controlling instabilities. Both ECRH and ICRH can perform the central heating function to a high degree. ECH has no rival with regards to controlling local instabilities for reaching high β values; the recent demonstrations in ASDEX and DIII-D are impressive. ICRH is the only heating system left in ITER size plasmas to provide dominant ion heating as demonstrated in the D/T phase of JET. This would result in substantial additional fusion power helping to cross the H mode threshold.
The next challenge to meet in ITER is steady state operation requiring high bootstrap, high β, conditions and efficient off-axis current drive. LHCD will be mandatory for this function while ECH will be again required for the stabilisation of modes occurring in advanced Tokamak modes.
On the technology front, the dominant new features are: - the availability of 1MW/170 GHz gyrotrons, 0.75MW/3.7GHz and 0.3MW/5GHz klystrons operating in quasi steady state - the demonstration of ICRF ELM resilience in JET and ASDEX and remote LH coupling at JET in the ITER relevant conditions. All these advances can be included in the ITER design basis and are the subject of development tasks presently being performed by the ITER partners.

These impressive advances should nevertheless be mitigated with various concerns such as LH and IC antenna coupling in unknown ITER scrape-off plasmas and the robustness of gyrotrons and ECH mirrors harsh conditions. The creativity of RF scientists will once again be in high demand…

[1] Dhiraj Bora., this conference