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Overview of Spherical Tokamak Research in Japan

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Nationally coordinated research on spherical tokamak (ST) is being conducted in Japan, to strengthen the scientific basis and to broaden future options of ST applications. The research themes to concentrate on are (1) the physics of very high beta plasmas, (2) development of start-up, current drive, and control techniques without the use of the central solenoid (CS), and (3) demonstration of very long pulse operation and the study of steady-state issues. Research elements are developed on several devices optimized for each objective. The basic mechanism of tokamak plasma formation by ECW/EBW was investigated on LATE. The tokamak configuration with closed flux surfaces is formed spontaneously when the equilibrium current changes from the vertical charge separation current to the toroidal return current. Highly over-dense plasmas have been produced, indicating mode conversion to EBW. A maximum plasma current of 66 kA was achieved using 28 GHz on QUEST. Plasma current start-up by LHW is being investigated on TST-2. The most efficient ramp-up was achieved by the capacitively-coupled combline antenna, which excites a traveling LHW with a sharp wavenumber spectrum and high directionality. Experiments with a top-launch antenna, expected to improve single-pass absorption and increase current drive efficiency, have started. The formation of closed flux surfaces by transient coaxial helicity injection (CHI) was verified by internal magnetic probe measurements on HIST. A stable closed flux formation was achieved by high bias flux operation, and the validity of helicity balance was confirmed. CHI electrodes were installed on QUEST under US-Japan collaboration. An RF-driven long pulse discharge of up to 810 s has been achieved on QUEST. Operation with hot metal wall has started, with the aim to control particle recycling by active wall temperature control. Compact toroid injection is being developed as an advanced fueling method. High-power reconnection heating of ST plasmas using axial merging of two ST plasmas was demonstrated in TS-3, TS-4 and UTST. Collaboration on the MAST device has demonstrated that reconnection heating can be extended successfully to larger scale and higher magnetic field. ST plasma stability improvement was accomplished by applying a helical field in TOKASTAR-2, an ST-helical hybrid device equipped with helical field coils.

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