Experimental results from the SPECTOR device at General Fusion

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Abstract

General Fusion (GF) is operating a new sequence of plasma devices called SPECTOR (**Sph**erical **C**ompact **Tor**oid) capable of generating and compressing plasmas with a more spherical form factor, avoiding the concave liner geometry used on previous compression tests at GF. SPECTOR forms spherical tokamak plasmas by coaxial helicity injection into a flux conserver (R= 19 cm, λ_{Taylor} = 23.9 m^{-1}, minor radius of 8.3 cm) with a pre-existing toroidal field created by ≤ 500 kA of current in an axial shaft. The initial poloidal flux of up to 30 mWb and toroidal plasma current of 100 - 300 kA is formed rapidly in the spherical flux conserver during a Marshall gun discharge (850 kA peak, 90 μs duration), and then resistively decays over a time period of ~1.5 ms. SPECTOR 1 has an extensive set of plasma diagnostics including a surface magnetic probe array, 3 interferometer chords, visible and VUV spectroscopy, multi-point Thomson scattering as well as a 4-chord FIR polarimeter system in development. SPECTOR 2, 3 are mobile test platforms that can be transported out of the lab for compression tests. Plasma facing surfaces include plasma-sprayed tungsten and bare aluminum, and can be coated with ~5 μm of vacuum deposited lithium for the purpose of gettering impurities out of the base vacuum and to reduce the gas recycling coefficient of the wall. Working gas has included helium and deuterium. Experimental characterizations have been made of formation dynamics, MHD mode activity, evolution of plasma profiles during its lifetime, and trends in FWHM magnetic lifetime with respect to system control parameters. Control of safety factor profile $q(\psi)$ can be achieved through a choice of the amount and axial distribution of poloidal gun flux and the amount of shaft current. Grad-Shafranov equilibria are reconstructed from the surface magnetic data using Caltrans/Corsica. Ideal and resistive MHD stability can be tested with DCON and NIMROD over a range of pressure and current profile parameters. Realistic compression scenarios have been simulated using the 3D MHD code VAC. The SPECTOR geometry is stable for a wider range of plasma parameters than previous experiments at GF. Relatively hot ($T_e \geq 350$ eV) and dense (~10^{20} m^{-3}) plasmas have achieved energy confinement times $\tau_E \geq 100$ μs and are now ready for field compression tests.