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The Science of Spherical Tokamak Plasmas: Progress and Promise[1]

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The talk will summarize the development of the low aspect ratio 'Spherical' Tokamak (ST) from early linear magnetic confinement devices, through toroidal pinches, to the emergence of the tokamak in the 1960's. Theoretical predictions given by Peng and Strickler of the exciting physics of extreme low aspect ratio tokamaks (supported by early experiments involving centre rods inserted into existing Rotamaks, Spheromaks and other small-scale experiments), led to the pioneering START experiment at Culham which convincingly demonstrated the potential of the ST concept. There are now many STs world-wide. The largest among these are MA-scale devices NSTX and MAST with plasmas of cross-section comparable to DIII-D and Asdex-Upgrade. The major results include development of start-up methods; the refinement of scaling laws; improved understanding of general tokamak phenomena such as Edge Localised Modes and development of heating and current drive schemes. ST research on over 20 devices has extended the tokamak plasma regime in many ways, notably a factor 4 increase in stable toroidal average beta, and large increases in the Alfven Mach number and ExB flow shear. By exploiting such features, joint experiments with tokamaks of conventional aspect ratio are resolving several key degeneracies of interest to ITER, DEMO and larger future ST devices. Present STs have low toroidal fields sufficient for most physics studies, but for high fusion yield or energy production higher fields are required; importantly, studies on both NSTX and MAST indicate a stronger than expected improvement of performance with toroidal field. Both devices are planning exciting upgrades which feature a considerable increase of toroidal field. Recent designs for a D-T Component Test Facility based on the Spherical Tokamak show the promise of low Tritium consumption and minimum build cost. Such a facility would provide valuable R&D on the scientific and technical issues of fusion power.

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