

Perspectives of the PROTO-SPHERA experiment

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The PROTO-SPHERA experiment aims to study the feasibility and the proprieties of a coupled Spherical Torus (ST) / Screw Pinch (SP) magnetic configuration. The scientific objectives can be summarized as follows: 1) build up the ideal MHD stable ST+SP configuration destabilizing the Screw Pinch (its current I_e will rise from 8.5 to 60 kA in less than 1 ms) and "tunneling" through a non-linear unstable kink, namely the same formation scheme successfully developed on the TS-3 device (Tokyo University); 2) compress the ST to the lowest possible aspect ratio $A=R/a$, with an elongation $\kappa>2$, by a fast rise of the current (0.5-1 ms) in the "vertical field" coils, producing in this way a Flux Core Spherical Tokamak rather than a Flux Core Spheromak as in TS-3 and Sphex (UMIST); 3) sustain the coupled configuration by Helicity Injection (HI) from the SP – feed by annular electrodes – to the ST (with maximum current $I_p=240$ kA), through resistive instabilities at the Spherical Torus edge, for at least more than a resistive time (~ 70 ms); 4) compare the ST energy confinement time τ_E with the ones of conventional Spherical Tokamaks of similar size (e.g. START) in order to quantify its possible degradation due to HI.

The first phase of PROTO-SPHERA (named Multi-Pinch) is now operating and some problems concerning the stable Screw Pinch are under solution, but its preliminary results already allow for fixing one of the major concern that forced us to build our experiment in two steps, following the recommendations of the panel held in Frascati (2002). In particular, there was the risk of arc anchoring on the annular anode (built in this shape to handle the high power load of the SP). On the contrary, we observed that the $\mathbf{E} \wedge \mathbf{B}$ drift acts to distribute smoothly the discharge on the anode surface without any evidence of anchoring despite the filamentary kind of plasma arising from the (partially filled) direct heated annular cathode. Furthermore the recent evolution of the so-called Supercapacitors allows us to design the demanding power supplies needed for the Screw Pinch and the compression coils in a robust and easier way, overcoming the problems in overshoot and feedback that was present in the old design. In conclusion, all the technical critical points that could obstacle the final completion of PROTO-SPHERA seems to be overcome.