Perspectives of the PROTO-SPHERA experiment

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The scientific objectives of the PROTO-SPHERA experiment, that aims to replace the metal center post of a Spherical Torus (ST) with a Screw Pinch plasma (SP), can be summarized as follow: 1) build up the ideal MHD stable ST+SP configuration destabilizing the plasma central column (raising its current I_e from 8.5 kA to 60 kA in less than 1 ms) and "tunneling" through a non-linear unstable kink; 2) compress the ST to the lowest possible aspect ratio A=R/a, with an elongation $\kappa>2$, by a fast rise (0.5-1 ms) of the current in the PF compression coils, producing in this way a Flux Core Spherical Tokamak rather than a Flux Core Spheromak already obtained in TS-3 or Sphex; 3) sustain the coupled configuration by Helicity Injection (HI) from the central plasma column – fed by annular electrodes – to the ST (with a toroidal current up to I_p=240 kA), through resistive instabilities at the torus edge, exceeding at least one resistive time-scale (~70 ms); 4) compare the ST energy confinement time τ_E with the one of conventional Spherical Tokamaks of similar size (e.g. START), in order to assess any possible degradation due to HI.

The first phase of PROTO-SPHERA is producing the central column plasma only. Its first results have already removed the major concern that the Screw Pinch plasma could attach itself on a restricted portion of the annular anode, due to the unexpected and favorable effect of the **E∧B** drift. The major components to be built in order to complete the PROTO-SPHERA machine are: 1) the variable current PF compression coils that are more sophisticated than the already built constant current PF shaping coils, due to the fast current rise required for the ST formation; 2) an extension from 54 to 324 cathode emitters in order to drive I_e=60 kA; 3) the upgrading of the SP plasma power supply and the new variable current PF compression coils power supply. The recent development of the so-called Supercapacitors can allow to design in a robust and simple way the power supplies required for the fast rise of the Screw Pinch current and the compression PF coils currents, overcoming the overshoot and feedback problems inherent in such demanding components.

In conclusion, at this moment it seems possible to overcome all the most critical technical points that could have hindered the final completion of PROTO-SPHERA machine.