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Plasma Confinement by Pressure of Rotating Magnetic Field in Toroidal Device

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A novel plasma confinement concept in which plasma is confined in a dynamic steady state by a pressure of rotating magnetic field in a toroidal geometry will be presented. The confining rotating magnetic field is created by AC currents driven by applying oscillating voltages to toroidal and poloidal gaps (insulated horizontal and vertical cuts) in the shell of the torus with 90 degrees phase shift between these voltages. The toroidal component of magnetic field is created by oscillating poloidal current in the shell and the poloidal component of the field is created by toroidal image current on the plasma surface. The confining rotating field is localized in the vacuum layer between the plasma and the toroidal shell, it penetrates plasma on a few skin depths. Plasma discharge is created by the inductive electric field when the gap voltages are applied or by a preionization pulse. Toroidal plasma equilibrium and stability in this concept are achieved due to the realized constraint of conservation of the amplitude of the oscillating magnetic flux through any section of the vacuum layer between the plasma and the conducting shell. The fast rotating magnetic field penetrates plasma and the conducting shell only on a few skin depths such that the magnetic flux is mostly localized in the layer between the plasma and the shell. Toroidal plasma equilibrium in this concept is modeled by: 1) calculating time evolution of plasma column in the torus when the oscillating voltages are applied to the gaps and 2) by calculating the time averaged magnetic pressure on the plasma boundary due to these voltages. These 2-D results will be presented along with the results of 3-D modeling of equilibrium which includes realistic gaps. Plasma stability is analyzed in a simplified cylindrical geometry, demonstrating that plasma boundary is MHD stable under nonrestrictive conditions. Similar results, but somewhat modified by the toroidal effects, are expected in the toroidal geometry. Limitation on the plasma pressure is due to the RF power dissipation in the skin layer of the conducting shell such that a superconducting shell is required for operation at high plasma pressures. Possible application of this concept to efficient fusion reactor depends on availability of superconductors (for the shell material) which can operate in magnetic field 1 T in the MHz frequency range.

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Primary author: Mr SVIDZINSKI, Vladimir (USA)

Presenter: Mr SVIDZINSKI, Vladimir (USA)

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