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Performance of Polywell™ Inertial-Electrostatic Confinement for Applications

J.F. Santarius and K.H. Simmons

Fusion Technology Institute
University of Wisconsin, Madison 53706

Recent ideas[1,2] have motivated a fresh look at fusion based on inertial-electrostatic confinement (IEC). Inertial-electrostatic-confinement devices electrostatically focus ions into a dense core. The electrostatic potential is generated by either grids or magnetically trapped electrons (the Polywell[1] concept). Work will be reported on modeling Polywell particle and power balance, with an emphasis on moderate-Q (fusion power/input power) producers of fusion neutrons and protons for various applications. Because electrostatic potentials of 10–100 kV can be created with relative ease, both D-T and advanced fuels, such as D-^{3}He, can have significant reactivities. Potentially, therefore, useful fluxes of fusion products (neutrons and protons, for example) can be generated even at low Q values. The analysis is performed by the Mathematica computer code SAFE (Spherical Advanced Fusion Evaluator). Parametric dependencies and optimized reference cases will be exhibited.

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6FP17

Numerical Simulation of the Polywell Device

Kim H. Simmons, and John F. Santarius

Fusion Technology Institute
University of Wisconsin, Madison 53706

Recent ideas concerning inertial-electrostatic confinement (IEC) of fusion plasmas coupled with recent experimental results have motivated looking at the problem of confinement of these plasmas in both the gridded (pure electrostatic) and magnetically assisted (via confinement of high beta plasmas in a magnetic cusp) configuration. Questions exist as to the nature of the potential well structure and the confinement properties of high beta plasmas in magnetic cusp configurations. This work focuses on the magnetically assisted concept known as the Polywell^{TM}. Results will be reported on the numerical simulation of IEC plasmas aimed at answering some of these questions. In particular we focus on two aspects of the Polywell, namely the structure of the magnetic cusp field in the Polywell configuration and the nature of the confinement of a high beta plasma in a magnetic cusp field. The existence of line cusps in the Polywell is still in dispute. A computer code for modeling the magnetic field structure and mod-B surface has been written and results will be presented for the Polywell. Another source of controversy is the nature of the confinement of a high beta plasma in a magnetic cusp, and in particular in the Polywell. Results from 2-D Particle In Cell (PIC) simulations aimed at answering some of these questions will be presented.

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6FP18

Plasma physics simulations of double potential wells in an Inertial Electrostatic Confinement (IEC) device*

Ivon V.Tzonev, George H. Miley, Rick A. Nebel†

Fusion Studies Laboratory
100 NEL, 103 S. Goodwin
Urbana, IL 61801-2984
USA

The formation and behavior of double potential wells in an IEC fusion device[1] was investigated using IXL - a one-dimensional code that solves the Poisson - Vlasov equations for a collisionless spherical plasma.[2] IXL results represent an important limiting case where space charge effects dominate. The formation of a deep and stable double well is essential for good ion confinement, hence successful development of the IEC device as a future power source.[3]

The dependence of the double well depth and width on the plasma parameters (ion and electron currents, radial and perpendicular energy spread, ion and electron injection energies) was studied. The changes of the ion and electron densities and the fusion rate in the presence of the double well were investigated. The fusion core radius and its variation with plasma parameters were evaluated.

The most favorable conditions for 80% - 100% deep second well formation (relative to the first well height) were shown to be high perpendicular ion energy spread (3keV-14keV), low perpendicular electron energy spread (3eV), low radial ion energy spread (±0.1eV-±0.5eV), and high ion and electron currents (30A-60A).

The observed double well structures and ion densities follow the ideal model developed by Hirsch,[4] despite the introduced high angular momentum.The ion core radius varies in the range 0.2cm -1.3 cm (with 7.5 cm cathode grid radius). This confirms that the IEC dense plasma core can be maintained at high perpendicular ion energies.

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† T-15 , MS K717, LANL , Los Alamos, New Mexico 87545, USA