Continuous Grid Inertial Electrostatic Confinement Fusion

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Abstract

Inertial Electrostatic Confinement (IEC) as a concept for fusion power generation has been around since the mid-1960's. Since that time, the concept has been researched and refined as a fringe approach to fusion power, with the general consensus being that fundamental issues such as ion thermalization will remain insurmountable to ever achieving, let alone exceeding, breakeven operation. A particular development path, ongoing since 2000, has sought to address this issue through advancement of the ion confinement mechanism. This has culminated with the current approach, whereby a collection of discrete ion packets recirculate synchronously through the device core. The evolution of the ion packets outside of the fusion core are controlled using similar packet forming techniques as those used in high energy particle accelerators. Space charge in the core of the device is neutralized by the presence of a confined electron population through which the ions pass. Because the ion packets only cross in the device core, the high- and low-angle binary collisions that would otherwise lead to non-radial motion and thermalization instead tend to redistribute the ions onto new radial paths. Small angular spreading of the ion packets is continuously countered through focusing elements along the beam paths outside of the device core. Because the center of mass energy of the ions passing through the core can be maintained within a narrow range, fusion rates can in principle be optimized by targeting peaks of the various fuel cross-sections. In particular, the use of p-^{11}B as an aneutronic fusion fuel is considered, possibly exploiting a narrow cross-section resonance near 150 keV. The highly localized and pulsed radial flux of the fusion products (alphas) lends itself to direct energy conversion, possibly at greater than 80-90% efficiency, while avoiding the need to dump waste heat to a lower temperature reservoir. This is particular attractive for use in space, avoiding the need for the large radiators that would otherwise be needed for thermodynamic power conversion. This paper provides an overview of the concept, walking through a nominal system design to quantify the operating parameters and to identify where the greatest design challenges lie. This paper is submitted for the day 1 session Energetic Reaction Engines.

Keywords: Fusion Energy, Space Power Systems, Inertial Electrostatic Confinement

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