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Helium-Catalyzed D-D Fusion in a Levitated Dipole

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Fusion research has focused on the goal of a fusion power source that utilizes tritium because the D-T reaction cross section is relatively large. Fusion reactors based on the D-D reaction, however, would be superior to D-T based reactors in so far as they minimize the power produced in neutrons and do not requires the breeding of tritium. The D-D cycle is difficult in a traditional fusion confinement device such as a tokamak because good energy confinement is accompanied by good particle confinement which would lead to a build up of ash making ignition difficult[1]. Therefore D-D fusion requires a magnetic bottle that exhibits excellent energy confinement but poor particle confinement.

We find that a levitated dipole may be meet the necessary requirements for practical D-D fusion power. We have explored a fuel cycle which we call ``helium catalyzed D-D" in which the tritium produced from one branch of the D-D reaction is removed after it has deposited its energy into the background plasma (< 8 % of tritons fuse during slowing down). A dipole is expected to exhibit excellent energy confinement when the pressure gradient does not exceed a critical value. When such a closed field line system ignites it is expected that the pressure gradient will tend to exceed its critical value giving rise to convective flows that serve to maintain the critical gradient and also to cause a rapid circulation of particles between the plasma core and edge[2].

We present detailed calculations of reactor relevant dipole equilibria (β_{max} ~3) and Monte Carlo neutron transport calculations that indicate that the neutron heat deposited into the superconductor of the floating coil (which is internal to the plasma) can be extracted by an internal refrigerator. The heat is then radiated via black-body radiation to the cooled vacuum chamber walls. Additionally a levitated dipole device would be intrinsically steady state and extract power as surface heating permitting a thin walled vacuum vessel and eliminating the need for a massive neutron shield. In addition we will discuss a small D-T based dipole ignition experiment in which an inertially cooled coil would float for ~10 minutes.

[1] W.M. Nevins, Journal of Fusion Energy 17 (1998) 25.
[2] V.P. Pastukhov and N.V. Chudin, Plasma Physics Reports 27, (2001) 907.