Abstract for an Invited Paper
for the DPP07 Meeting of
The American Physical Society

Modeling Nuclear Fusion with an Ultracold Nonneutral Plasma[1]

DANIEL H.E. DUBIN, Univ. of California, San Diego

In the hot dense interiors of stars and giant planets, nuclear fusion reactions are predicted to occur at rates that are greatly enhanced compared to rates at low densities. The enhancement is caused by plasma screening of the repulsive Coulomb potential between nuclei, which increases the probability of the close collisions that are responsible for fusion.[2] This screening enhancement is a small but measurable effect in the Sun;[3] and is predicted to be much larger in dense objects such as white dwarf stars and giant planet interiors where the plasma is strongly coupled (i.e., where the Debye screening length is smaller than the mean interparticle spacing). However, these strongly enhanced fusion reaction rates have never been definitively observed in the laboratory. This talk discusses a method for observing the enhancement using an analogy between nuclear energy and cyclotron energy in a cold nonneutral plasma in a strong magnetic field. In such a plasma, the cyclotron frequency is higher than other dynamical frequencies, so the kinetic energy of cyclotron motion is an adiabatic invariant. This energy is not shared with other degrees of freedom except through close collisions that break the invariant and couple the cyclotron motion to the other degrees of freedom. Thus, the cyclotron energy of an ion, like nuclear energy, can be considered to be an internal degree of freedom that is accessible only via close collisions. Furthermore, the rate of release of cyclotron energy is enhanced through plasma screening by precisely the same factor as that for the release of nuclear energy, because both processes rely on the same plasma screening of close collisions.[4] Simulations and experiments measuring large screening enhancements in strongly-coupled plasmas will be discussed, along with the possibility of exciting and studying "burn fronts."

[1]Supported by NSF/DOE grant PHY-0613740 and NSF grant PHY-0354979.
[2]E. E. Salpeter and H. van Horn, *Astrophys. J.* **155**, 183 (1969).
[3]J. N. Bachall L.S.Brown, A.Gruzinov, and R. F. Sawyer., *A&A* **383**, 291-295 (2002).
[4]D. Dubin, *Phys. Rev. Lett.* **94**, 025002 (2005); M. J. Jensen, T. Hasegawa, J. J. Bollinger, and D.H.E. Dubin, *Phys. Rev. Lett.* **94**, 025001 (2005).