

Fusion reactions in dense matter: Effects of plasma screening

A.I. Chugunov¹, H.E. DeWitt², D.G. Yakovlev¹

¹Ioffe Physical-Technical Institute (St.Petersburg, Russia)

²Lawrence Livermore National Laboratory (Livermore, USA)

We analyze fusion reactions in dense matter composed of atomic nuclei of one or two types. We pay special attention to the Coulomb tunneling problem. We compare the results of the Path Integral Monte Carlo (PIMC) calculations by Militzer and Pollock (Phys. Rev. B **71**, 134303, 2005) of Coulomb tunneling in nuclear reaction in dense one component matter with semiclassical calculations assuming WKB Coulomb barrier penetration through the radial mean field potential. We find a very good agreement of two approaches at temperatures higher than $\sim \frac{1}{5}$ of the ion plasma temperature. We apply the mean field model to the reactions in binary ionic mixtures. We carefully analyze the results of the extensive Monte Carlo calculations of mean field potential in one component plasma and in binary ionic mixtures and describe these results by simple fitting expressions. Respective reaction rates are calculated and approximated by simple analytical expressions applicable in a wide range of parameters. We analyze Gamow-peak energies of reacting ions in various reaction regimes. We discuss theoretical uncertainties of nuclear reaction rates taking the burning in a ^{12}C - ^{16}O mixture as an example.

This work was partly supported by the Russian Foundation for Basic Research (grants 08-02-00837, 05-02-22003), and by the State Program “Leading Scientific Schools of Russian Federation” (grant NSh 2600.2008.2).