# Influence of tunneling on electron screening in low energy nuclear reactions in laboratories

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Nuclear reaction rates at astrophysical energies are interesting quantities for their own sake and also in connection with nucleosynthesis in stars. Experimental cross sections for all systems so far studied show increasing enhancement with decreasing bombarding energy over the values extrapolated from the data at high energies. Many attempts have been made to explain the phenomenon in terms of the screening effects by target electrons. In this connection, a puzzling thing is that the observed enhancement in almost all existing data exceeds the value in the so called adiabatic limit, which is thought to give the maximum screening energy.

Using a semiclassical mean field theory, we show that the screening potential exhibits a characteristic radial variation in the tunneling region in sharp contrast to the assumption of the constant shift in all previous works. Also, we show that the explicit treatment of the tunneling region gives a larger screening energy than that in the conventional approach, which studies the time evolution only in the classical region and estimates the screening energy from the screening potential at the external classical turning point. This modification becomes important if the electronic state is not a single adiabatic state at the external turning point either by pre-tunneling transitions of the electronic state or by the symmetry of the system even if there is no essential change with the electronic state in the tunneling region.[1]

We also show the results from constrained molecular dynamics (CoMD) models which make numerical calculations easier than solving the many-body Schrödinger equations. As is well known the molecular dynamics is classical dynamics. In order to treat quantum-mechanical system like target atoms and molecules, we use classical equations of motion with constraints to satisfy the Heisenberg uncertainty principle and the Pauli exclusion principle. The CoMD models is proposed and applied to nuclei in Ref. [2].

[1] S. Kimura et al., Phys. Rev. C 67, 022801(R) (2003)

[2] Massimo Papa et al., Phys. Rev. C 64, 024612 (2001)