Resonant Surface Capture Model

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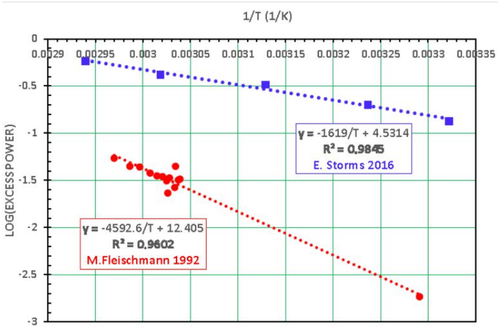
Concept: The essence of resonance is to put the peak of wave function at the nuclear edge; thus, the deuteron would deliver a neutron to the surface of target nucleus; then, cause the capture of neutron by the target nucleus. When this resonance is at very low energy, the resonant elastic scattering (diffusion process) is maximized; and the consequent capture (excess heat) is maximized as well. Both are featured by an exponential factor, $\boldsymbol{Exp}[-\frac{\boldsymbol{E_0}}{\boldsymbol{T}}]$ which leads to the straight line in temperature (T) dependence of excess heat in semi-logarithmic plot (Fig.1). The blue straight line was first published by E. Storms, later derived by M. Miles using Eyring theory, and now reconfirmed by Fleischmann and Pons' 1992 data (red line) and Tsinghua Univ. data (see another abstract). Indeed, the straight line implies this resonant surface capture model.

Equations for Average Rate of Diffusion and Excess Heat:

$$< \sigma_{Elastic} v > = \left(\frac{\mu}{2\pi k_B T}\right)^{\frac{3}{2}} \int_0^\infty \left(\frac{\pi}{k^2}\frac{4}{W^2+1}\right)\cdot v \cdot Exp\left[-\frac{\mu v^2}{2k_B T}\right]\cdot 4\pi v^2 dv \propto Exp\left[-\frac{E_0}{T}\right]. \quad (1)$$

$$< \sigma_{EX} v > = \left(\frac{\mu}{2\pi k_B T}\right)^{\frac{3}{2}} \int_0^\infty \left(\frac{\pi}{k^2}\frac{4}{W^2+1}\right)\left|\int \Psi_f H_{int} \Psi_i\, d\tau\right|^2 \cdot v \cdot Exp\left[-\frac{\mu v^2}{2k_B T}\right] 4\pi v^2 dv \propto Exp\left[-\frac{E_0}{T}\right]. \quad (2)$$

Here, $\Psi_i = WF_0 + G_0$, G_0 $(F_0)$is an exponentially increasing(decreasing) function near the nuclear surface, and resonance appears when $W \le 1$, $W^2 \equiv (\theta^2 w)^2 = \left(\frac{Exp\left[\frac{2\pi}{k\, a_c}\right]-1}{2\pi}\cdot w\right)^2$; $(1/\theta)^2$is the Gamow penetration factor; E_0 is the resonance energy assumed at low energy which is close to the activation energy of diffusion coefficient, E_a.



Calculation: The average rates in (1) and (2) are calculated based on the H. A. Bethe's solar energy model (1938) and the J. R. Oppenheimer's deuteron stripping reaction model (1935). It shows:

(1)Width of this resonance is proportional to 1/Log[θ] instead of $(1/\theta)^2$; therefore, the average over Maxwell distribution is not negligible even if the resonance energy is as low as the thermal energy;

(2)Weak gamma emission of Pd cathode wires is from the slightly excited target nucleus during this stripping reaction because the energetic charged particle carries away most of the reaction energy as first proposed by T. Passell (2015).

(3)NAE or **NAZ** is created by this resonant elastic diffusion process, which generates the mother state of nuclear transition. This transition probability is maximized by this resonance as well. A deuterium flux is necessary to create this mother state in terms of resonant elastic scattering.

(4)Positive feed-back effect in temperature is a result of this exponential temperature dependence $\boldsymbol{Exp}[-\frac{\boldsymbol{E_0}}{\boldsymbol{T}}]$. The micro-crater on Pd surface is the evidence of this effect;

New Finding: Big difference between low energy resonance and usual resonance caused by the big difference in the behaviour of θ^2. For d+Li6, resonance at 2000 K, $\theta^2 \sim 10^{4090}$ and varies rapidly with energy; then, resonance appears at $\boldsymbol{W^2 \le 1}$ instead of $\boldsymbol{W^2 = 0}$. It makes the elastic scattering cross-section **step-wise** and makes the reaction cross-section **peak-wise**, at $E \sim E_0$ (in contrast, for d+T resonance at 100 keV, θ^2=13.3 and varies slowly, and resonance may appear at $\boldsymbol{W^2 = 0}$).

Prediction: More fuels are available for this resonant surface capture reaction provided that the target nucleus has an energy level very close to the thermal energy (e.g. d+Li6, p+B10, etc.). High electric charge number Z is no longer a problem. The best candidate would be the gadolinium (**Gd**), which has the largest capture cross-section of thermal neutron.