Cold Fusion Continues

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Cold fusion continues

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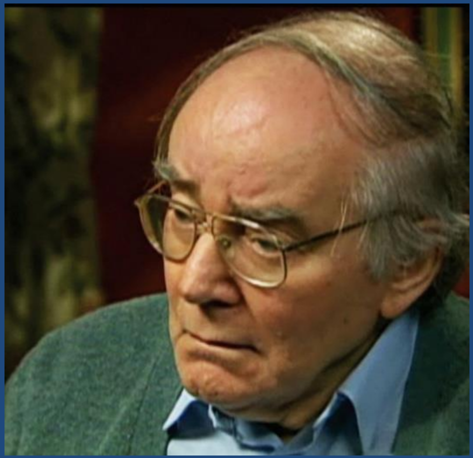
Abstract

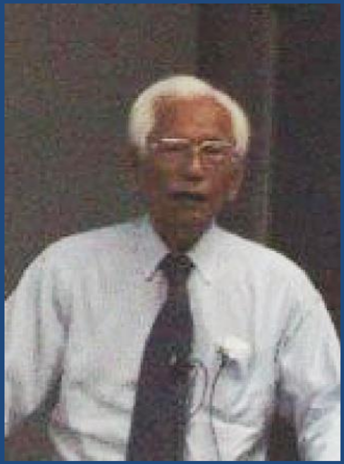
Accelerator experiments on fusion show a significant increase in the probability of interaction when target nuclei are imbedded in a conducting crystal. These experiments open a good perspective on the problem of so-called cold DD nuclear fusion. Here this approach is applied to another fusion processes, and some possible drawbacks are discussed.

Brief introduction to the history of cold fusion
The key players in cold fusion



Martin Fleischmann
D+D in Pd
1989

Michael McKubre
D+D in Pd
1992-now



Yoshiaki Arata
D+D in Pd (ZrO_2)
1998-2008

The probable theory of cold fusion

ЯДЕРНАЯ ФИЗИКА, 2012, том 75, № 2, с. 174–180

ЯДРА

ХОЛОДНЫЙ ЯДЕРНЫЙ СИНТЕЗ

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Поступила в редакцию 21.03.2011 г.; после доработки 01.07.2011 г.

ISSN 1063-7788, Physics of Atomic Nuclei, 2012, Vol. 75, No. 2, pp. 153–159. © Pleiades Publishing, Ltd., 2012.
Original Russian Text © E.N. Tsyganov, 2012, published in Yadernaya Fizika, 2012, Vol. 75, No. 2, pp. 174–180.

NUCLEI
Experiment

Cold Nuclear Fusion*

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For DD fusion:

$$\sigma(E) = \frac{S(E)}{E} e^{-2\pi\eta} \qquad 2\pi\eta = \frac{31.4}{\sqrt{E}}$$

S(E) – convenient parameterization, called astrophysical factor.

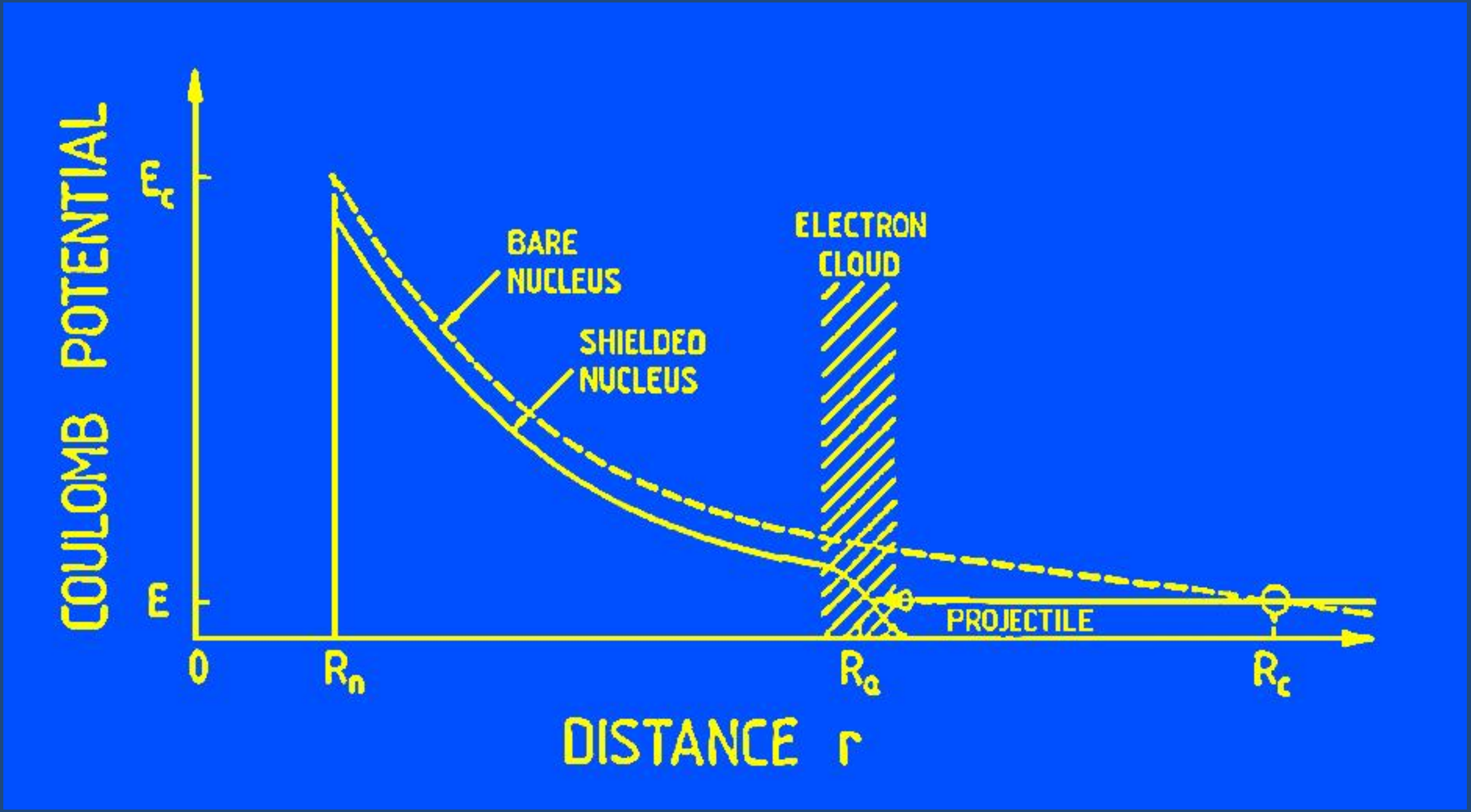
For electron screening:

$$E_{eff} = E + U_e \qquad U_e = e^2 / R_a$$

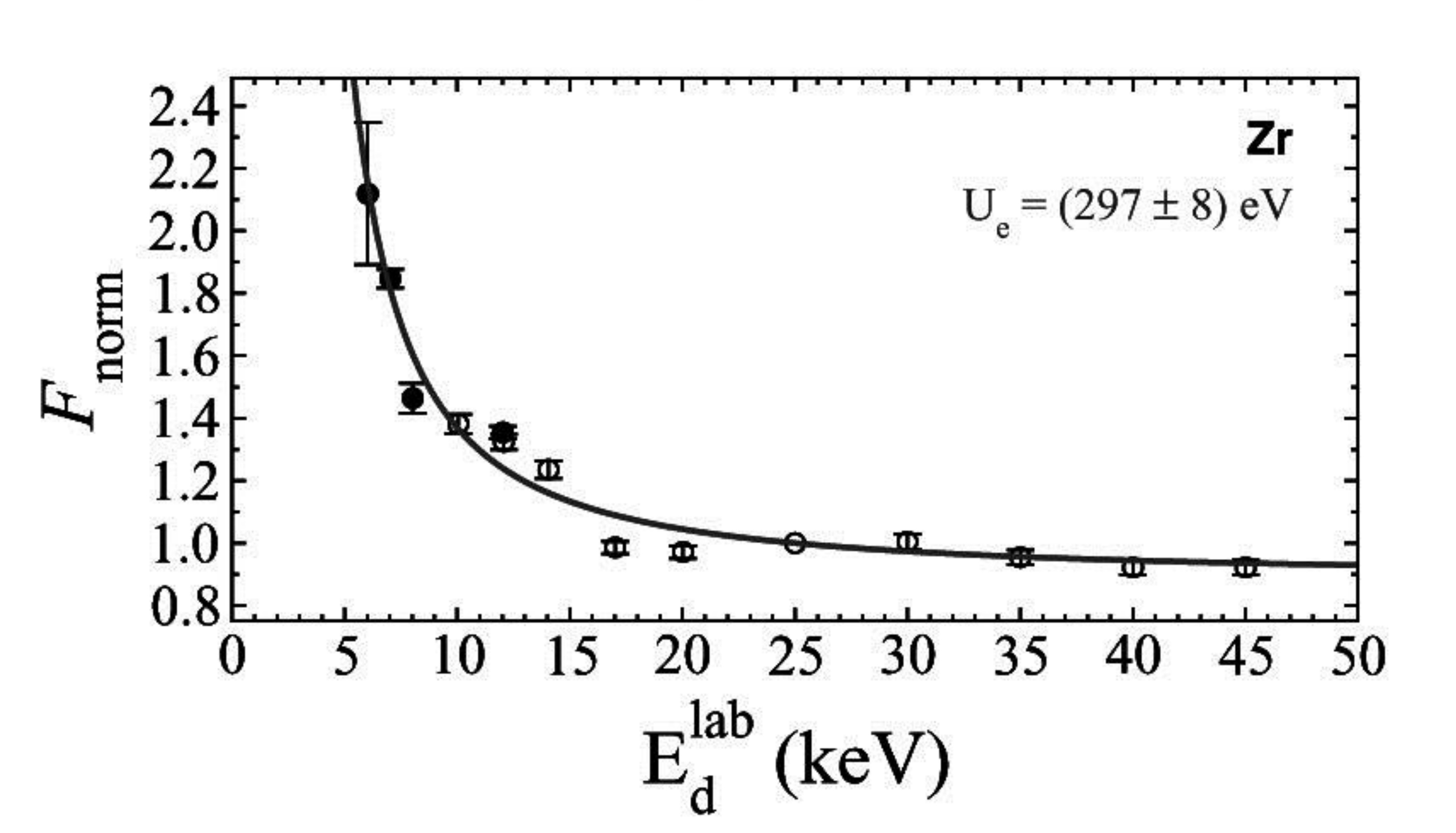
For free D-atoms U_e = 27 eV

H. J. Assenbaum, K. Langanke, and C. Rolfs, Z. //Phys. A 327, 461 (1987).

Electron screening potential in fusion process

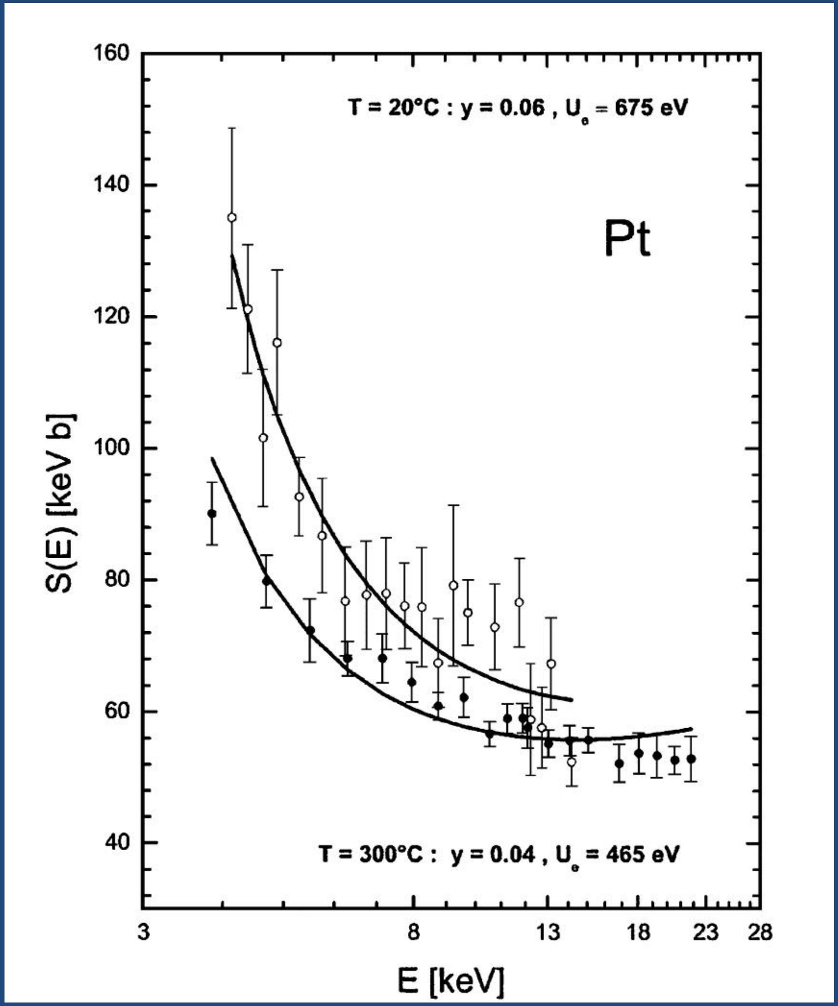


Normalized astrophysical factor S(E) for DD fusion, when the target is imbedded in Zr. Unusually high electron screening potential, about 10 times larger than for free atoms.



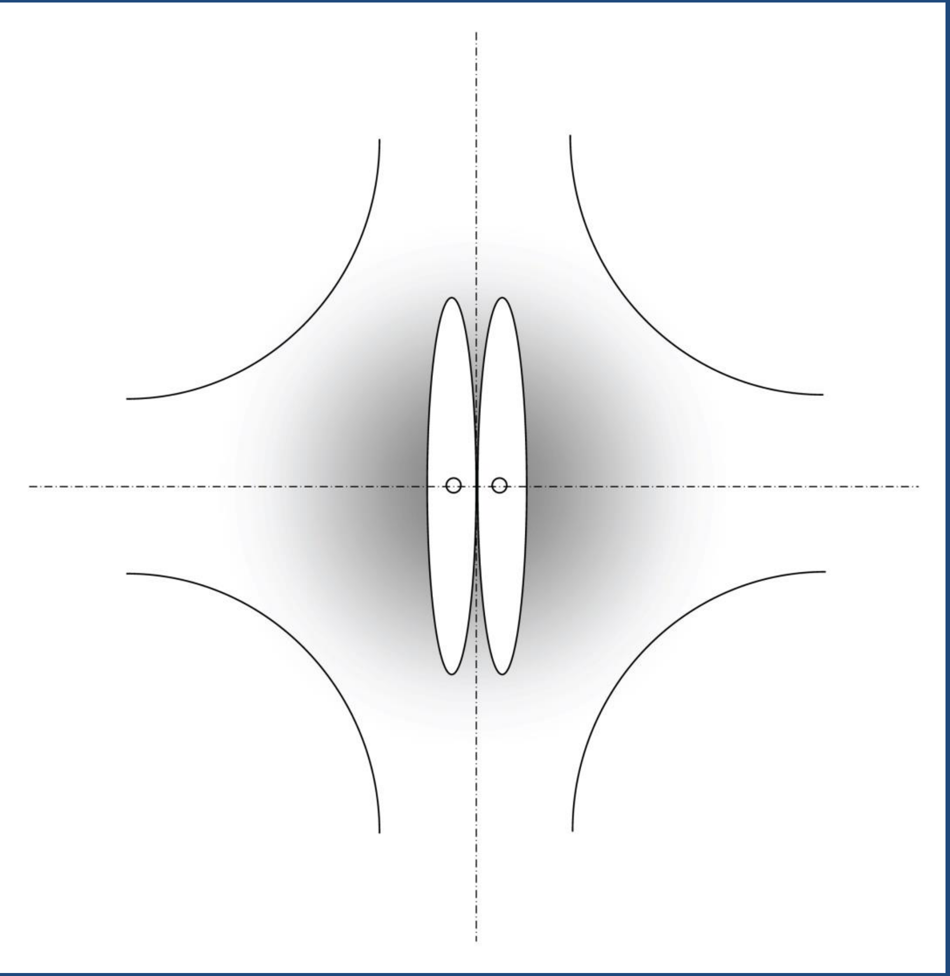
A. Huke, K. Czerski, P. Heide, *et al.,Phys. Rev. C 78,* 015803 (2008).

S(E) for DD fusion, the target is imbedded in Pt
U_e=675 eV



F. Raiola, B. Burchard, Z. Fu. lo. p, *et al., J. Phys.G31,*1141 (2005); Eur. Phys. J. A 27, s01, 79 (2006).

DD in a single conductive crystal cell.
Chemical catalysis is the beginning of the process.
Revival of piezo-fusion idea of Zeldovich-Gershtein.



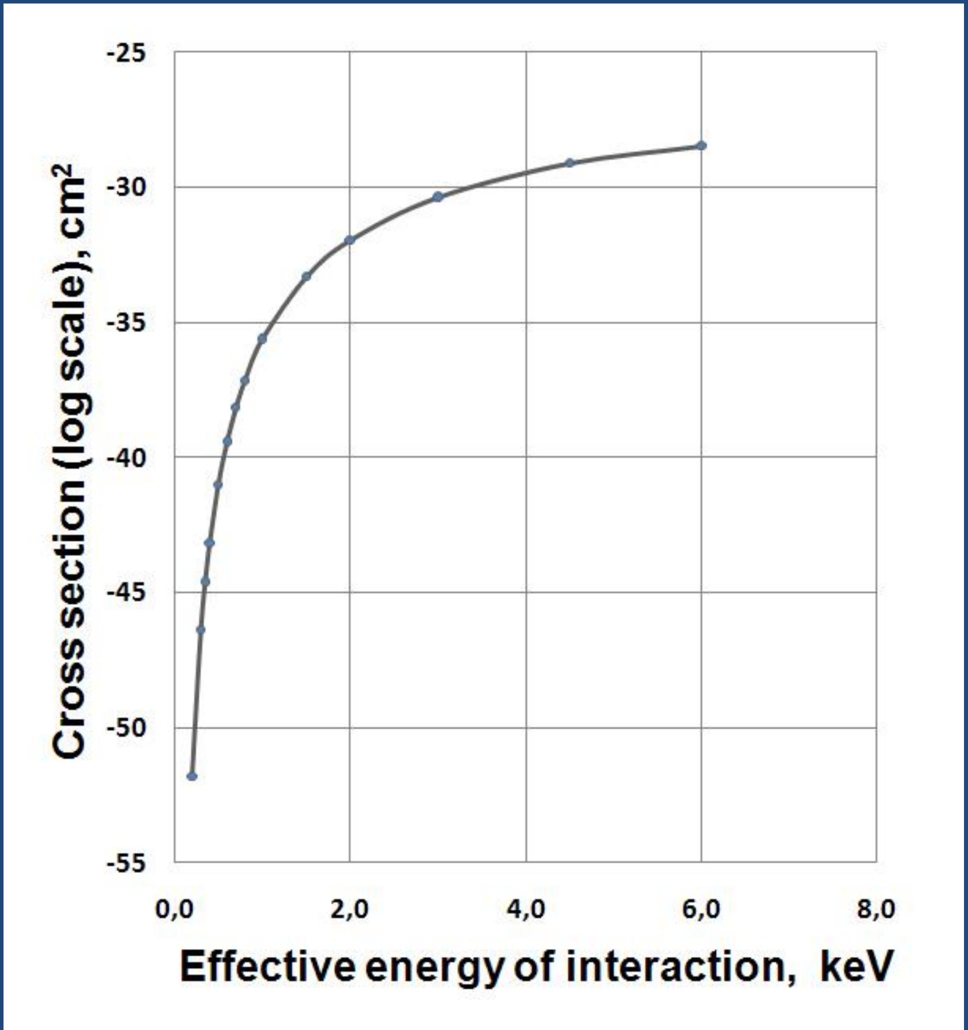
In quantum mechanical consideration of fusion process screening potential is equivalent to additional energy

Ya. B. Zeldovich, S. S. Gershtein, 1960

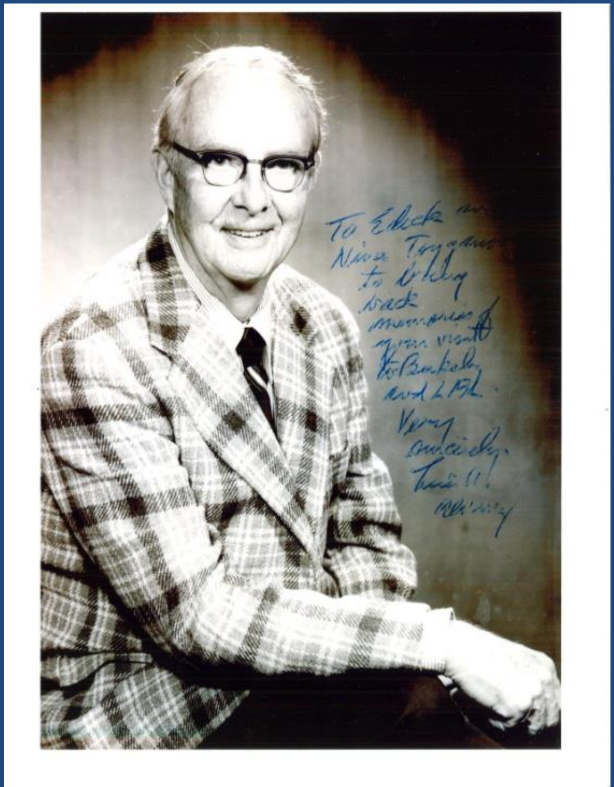
Dreams on piezo-fusion:

$$B = \exp\left\{-\frac{2}{\hbar}\int_{x_1}^{x_2}\sqrt{2M\,(U\,(x) - E)}\,dx\right\} = \exp\left\{-\frac{2}{\hbar}\sqrt{2M\bar{\bar{U}}}\,(x_2 - x_1)\right\}$$

Cross section of DD fusion *vs* effective energy of interaction for single collision ("hot" fusion). Very sharp dependence on the effective energy.



In addition to the direct interaction of the two single nuclei, when sub-barrier penetration through the Coulomb potential and the formation of the compound nucleus became possible, discussions began about 50 years ago on a different type of processes (μ-catalysis) that lead to the fusion of elements with the release of energy. In this connection it is interesting to quote the first experimental work on μ-catalysis by L. W. Alvarez, who examines the event in the liquid hydrogen chamber, indicative H + D μ-catalysis. Referring to the 1954 theoretical work of Ya. B. Zeldovich, Alvarez wrote:

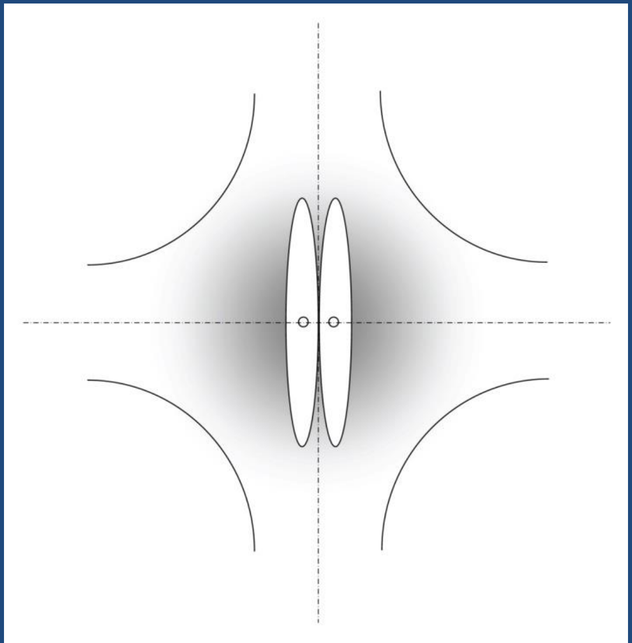


Luis W. Alvarez (1976)

"The meson, in effect, *confines the two nuclei in a small box.* Rough estimates of the barrier penetration factor (approximately 10^{-5}) and the vibration frequency (approximately 10^{17} per second) indicate that the time required for a nuclear reaction between H and D should be small compared with the life of the μ meson."

L.W. Alvarez et al., Physical Review Series II, v. 105, 1957, p. 1127-1128

Process in conductive crystal reminds μ–catalysis

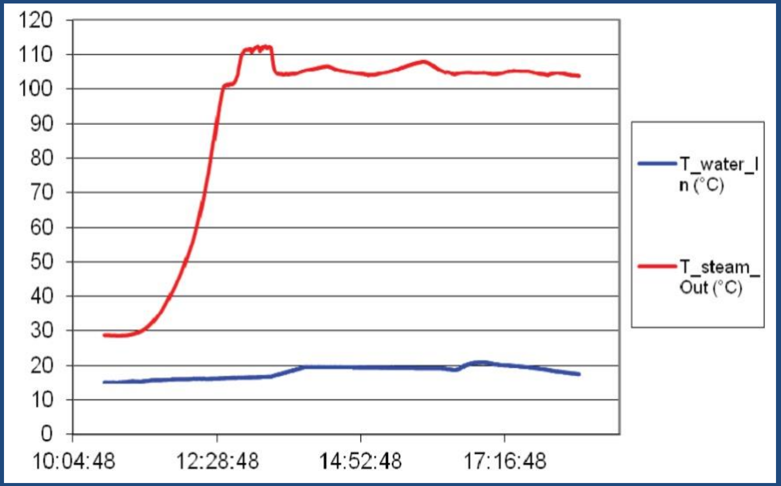


Rate of DD fusion in crystalline “box” (cold fusion)

Crystal type	Screening potential U, eV	Oscillation frequency ν, s^{-1}	Barrier permeability P	Rate of DD fusion λ, s^{-1}
Palladium	300	0.74×10^{17}	1.29×10^{-25}	0.95×10^{-8}
Cobalt	640	1.58×10^{17}	8.99×10^{-18}	1.42
Platinum	675	1.67×10^{17}	2.52×10^{-17}	4.21

Recent Rossi results

Andrea Rossi and his colleague Sergio Focardi demonstrated at the University of Bologna (Italy) their 0.5 MW power plant on October 28, 2011.

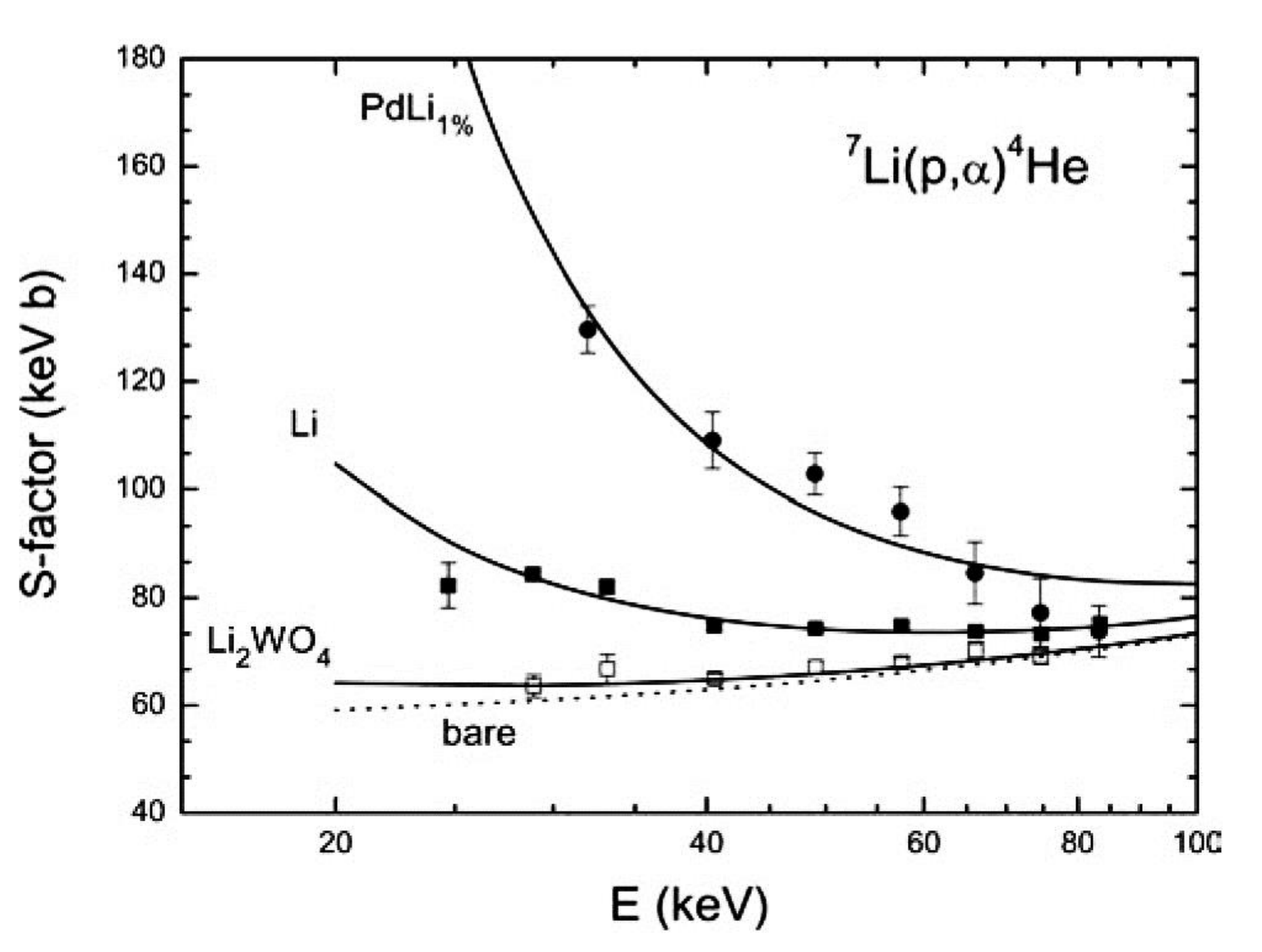


The power plant was capable to continuously produce heat for about 5 hours. Based on this graph and the water flow rate the estimated thermal power of this plant was found to be about 0.5 MW.

Rossi’s plant is a significantly modified set-up of the Bologna University and the University of Siena installation. Results of studies conducted with that installation were published in 1998 in *Il Nuovo Cimento*. The authors of that article believed that hydrogen gas interacted with a nickel rod resulting in the release of heat in excess of what could be explained by chemical reactions in the setting. This work was largely ignored by the scientific community because of the rather small amount of heat produced.

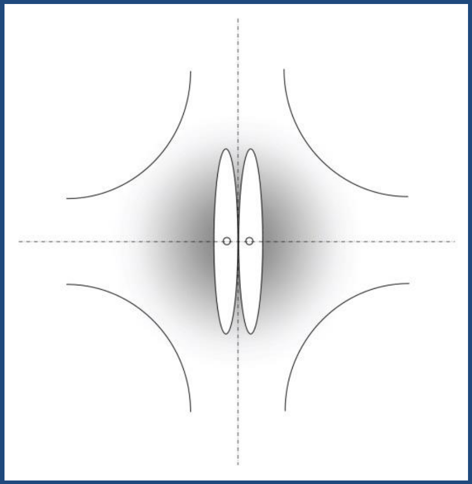
Andrea Rossi improved the installation of Bologna and Siena universities, by replacing the nickel rod with microcrystalline nickel powder and by mixing the powder with an unnamed catalyst. In our opinion, this catalyst could be platinum micro-crystals. Rossi has done a great job of optimizing the methods for implantation of nickel atoms in the micro crystals of the catalyst using high-temperature diffusion and microwave radiation.

H+Li: ^{7}Li target is imbedded in Palladium

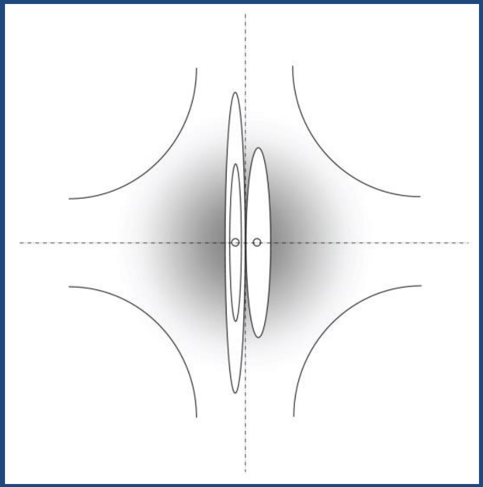


C. Rolfs, Nucl. Phys. News **16 (2), 9 (2006).** A. Huke, **K. Czerski**, P. Heide, *et al.,Phys. Rev. C* ***78,*** 015803 (2008). **F. Raiola**, B. Burchard, Z. Fu. lo. p, *et al., J. Phys.G****31,*** 1141 (2005); Eur. Phys. J. A **27, s01, 79 (2006).**

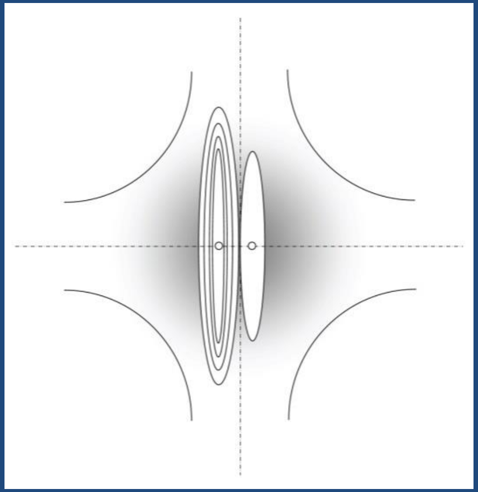
Different fusion pairs in host crystalline cell



D+D



H+Li

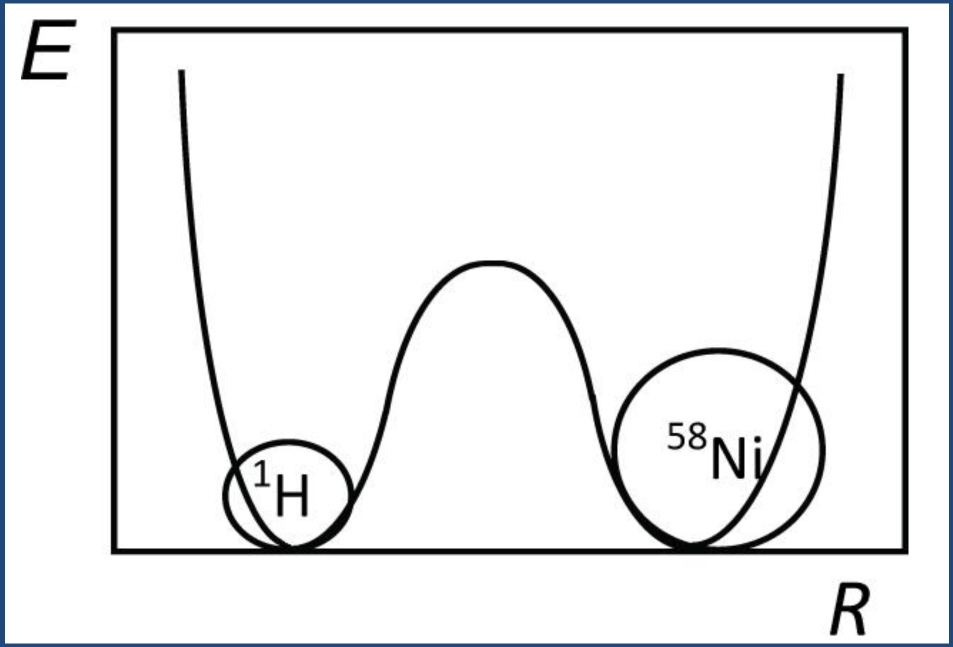


H+Ni

The following are the processes that would have to happen in the case of natural isotopic composition of nickel:

68.27%	$^{58}Ni+^{1}H \rightarrow ^{59}Cu^{*} \rightarrow ^{59}Ni+\beta^{+}+\gamma+\nu_e$	1.3 min
26.10%	$^{60}Ni+^{1}H \rightarrow ^{61}Cu^{*} \rightarrow ^{61}Ni+\beta^{+}+\gamma+\nu_e$	3.3 min
1.13%	$^{61}Ni+^{1}H \rightarrow ^{62}Cu^{*} \rightarrow ^{62}Ni+\beta^{+}+\gamma+\nu_e$	9.7 min
3.59%	$^{62}Ni+^{1}H \rightarrow ^{63}Cu^{*} \rightarrow ^{63}Cu+\gamma$	^{63}Cu stable
0.91%	$^{64}Ni+^{1}H \rightarrow ^{65}Cu^{*} \rightarrow ^{65}Cu+\gamma$	^{65}Cu stable

Given the natural isotopic composition of nickel, approximately 95% of the fusion reactions in Rossi's case would have to be accompanied by the emission of e^{+}- e^{-} annihilation gamma rays with energies of 511 keV. According to participants in repeated demonstrations of installation, this gamma radiation does not take place. Why?



This frame depicts intermediate state of compound nucleus (say, ^{1}H+^{58}Ni) in potential well in transition period. We believe Coulomb pushing ^{58}Ni cluster to the boundary of strong interaction well could stimulate (agitate) the α-decay of ^{58}Ni cluster merging with ^{1}H. Here *E* denotes potential, *R* – distance, on arbitrary scale. With this kind of process, the fusion energy will be released by low energy electrons through virtual photons, and low energy α-decay.

In any case, using separated nickel ^{63}Ni and ^{64}Ni isotopes could solve the problem.

In connection to our approach to physics of cold fusion processes, many other pairs of fusing nuclei could be considered as possible promising candidates.

For example, the advantage of the very efficient fusion reaction H+Li (using separated isotope of ^{7}Li) over the reaction with nickel is that lithium could be used in a liquid form which would allow it to penetrate better into the micro-crystals of platinum (or other catalyst). ^{8}Be* is the intermediate compound nucleus of this reaction and will not produce any harmful decay radiation except two low energy α-particles, which is easy to deal with.

Cold fusion process H+^{11}B –> ^{12}C with 15 MeV energy release also looks very promising. Depleted ^{11}B is readily available for semiconductor industry.

Chemical aspects of these processes have to be taken into careful consideration.

Some recent results on H+Ni cold fusion without additional catalyzer could be found in F. Piantelli report on ISCMNS 2012 Workshop in Siena:

http://world.std.com/~mica/cft.html

In our opinion, Andrea Rossi’s experiences deserve urgent attention of the professional physics community. It seems to us that Rossi’s method is far from optimal, although it looks relatively cheap.

The authors thank Dr. M. McKubre for useful discussions on the matter. The authors express apologies to Mr. A. Rossi for a possible inaccurate citation of his results.

Спасибо за внимание!