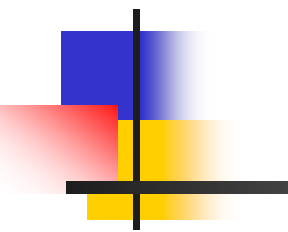




Status of Russian Research on Low Energy Nuclear Reactions in Non-Equilibrium Condensed Matter, Based on Publications in Peer-Reviewed Journals



Andrei G. Lipson¹, Ivan P. Chernov²

¹A.N. Frumkin Institute of Physical Chemistry and Electrochemistry, Russian Academy of Sciences, Moscow 199915, Russia

²Tomsk Polytechnic University, Tomsk, 634050 Russia



Why peer-reviewed journals only ?

- *LENR matter is a new and still show poor reproducibility.* In some sense it is a “Proto-science” (the definition of L. Kowalski).
- In some cases poor experimental equipment (due to lack of funding) and biased interpretation of the results (in hunting for funding): No independent confirmations. One may not to believe in each result!
- It is hard to distinguish the grains of truth from the stream of informational noise (the flux of the artifacts; sometimes- the wizard and shaman’s stuff, etc.).
- Reviewer’s responsibility for publications: they must be respected scientists in the field of journal, though also biased.
- Thus, we have chosen only per-reviewed papers that have been filtered by editors and published under referees responsibility.
- The other picture of Russian activity, based on local conference and seminar proceedings will be shown by Yuri Bazhutov.



What we are studying:

- Under **LENR or CMNS** (in more broad sense) term we understand specific nuclear processes at very low kinetic energy of projectile nuclei (say, $kT < E_{\text{lab}} < 1 \text{ keV}$) that are originated and enhanced by strictly non-equilibrium condensed matter/crystalline lattice environment.
- These peculiarities make LENR (and nuclear cross-sections) drastically distinctive from the nuclear reactions taking place in vacuum/plasma collision.
- In more broad sense the LENR/CMNS effects include nuclear, calorimetric, electrochemical, condensed matter physics, material science and other accompanying aspects. This field can be considered as an interdisciplinary research area.



Some dates and statistics

- After discovery of deuterium role in the Pd cathode during electrolysis (by Fleischmann and Ponce in 1989) many groups in former USSR started their works on LENR.
- To support these works on government level already in April 1989 a special Council on Cold Fusion has been created in USSR Academy of Sciences headed by a vice-president of Academy academician V. Nefedov.
- First all-Union Conference on Cold Fusion in JINR Dubna in March 1991. 14 Russian local conferences and monthly Cold Fusion seminar in PF University, Moscow (N. Samsonenko)
- More than 250 Russian works in peer-reviewed journals since 1989. Though, No government funding from 1993.
- **“Vicious circle: insufficient funding leads to poor research, poor research leads to poor papers, poor papers lead to insufficient funding”** – Bill Collis



Critical Russian Contributions in LENR/CMNS Study: Prior to 1989 F-P announcement

- **First experimental study and accelerating model:** Fractofusion on fracture of deuterated dielectrics: LiD and heavy ice crystals (Klyuev VA, Lipson AG et al., Sov. Tech. Phys. Lett **12**, 551 (1986), Deryaguin BV, Klyuev VA, Lipson AG, Toporov YuP, Colloid J. USSR **48**, 8(1986)). In 1989 TiD_x fracture neutrons: [B.V. Deryaguin et al, Nature, **341**, 492, (1989)].
- **Theoretical consideration:** question on the Coulomb barrier reduction in deuterated crystals, depending on crystallographic direction – excess energy production using deuteron beam and crystalline target:
V.V. Vysotsky and R.N. Kuzmin, Sov.Tech. Phys. Lett., **7**, 981 (1983)

1986 Neutron emission experiment on LiD fracture (Klyuev VA, Lipson AG, Deryaguin BV et al., Sov. Tech. Phys. Lett **12**, 551 (1986))-Confirmed: Kaushik TC, Kulkarni LV, Shyam A, Srinivasan M, Physics Lett. A **232** (1997) 384; *Shyam A* et al, Indian J. Pure and Appl. Phys., vol: 36(2), 56 (2008).

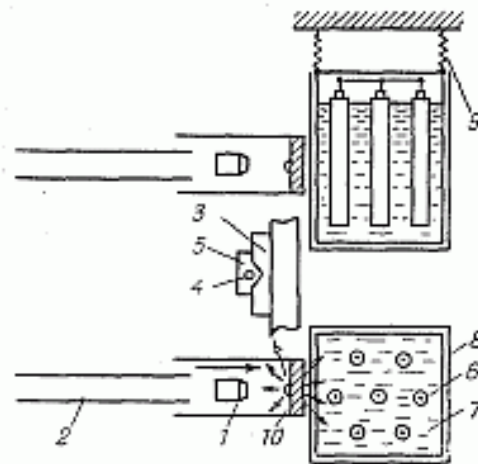


Рис. 16. Схема экспериментальной установки [9]

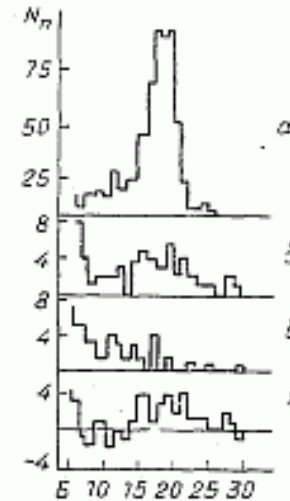


Рис. 17. Гистограмма распределения импульсов по каналам анализатора от источника нейтронов (а), при разрушении мишеней из дейтерида лития (б), при стрельбе по мишеням, не содержащим кристаллов LiD, «импульсный фон» (в) и результат вычитания «импульсного» и космического фонов из амплитудного спектра сбитого при разрушении мишеней из LiD (г)



Critical Russian Contributions after 1989

F-P announcement: I. Experimental

- Neutron emission on cavitation in D₂O with the Ti horn [A.G. Lipson et al, Sov. Tech. Phys. Lett. **16**(9), 89 (1990)]
- Neutron emission and tritium generation upon phase transitions in deuterated ferroelectrics and high-temperature superconductors [A.G. Lipson et al., JETP, **76** (6), 1070 (1993); Tech. Phys. 40, 839 (1995)]
- Neutron emission in deuterated ferroelectrics in the wave of polarization reversal [B.V. Derjaguin, E.I. Andriankin, A.G. Lipson et al. Sov. Phys. Dokl, RAN **334**, 3 (1994); V.D. Dougar Jabon, G.V. Fedorovich and N.V. Samsonenko, Braz. J. Phys., **27**(4), 515 (1997);
Remarkably: last two works were done ahead of the paper by:
- B. Naranjo et al, Nature, **434**, 1115-1117, (2005)

Examples: Neutron Emission in K_2PO_4 single crystal vs. Spontaneous polarization (TSD) during heating through T_c

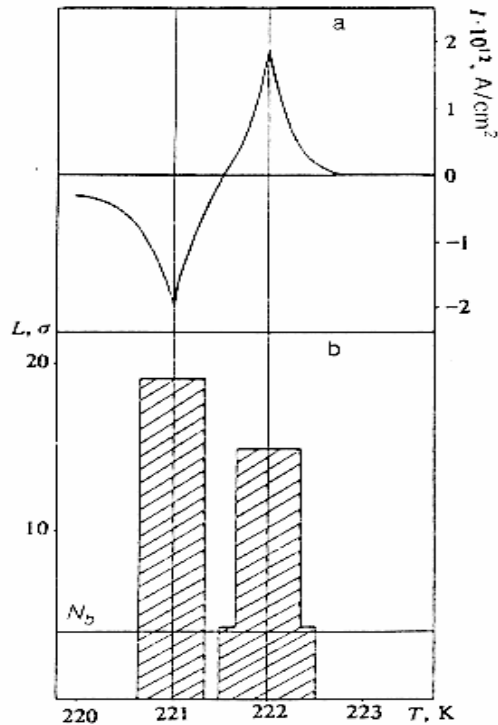


FIG. 4. a—Spectrum of thermal depolarization during the heating of DKDP sample near T_c ; b—corresponding histograms of neutron bursts. Here L, σ is the confidence level of the observed neutron bursts, and N_0 is the average background level.

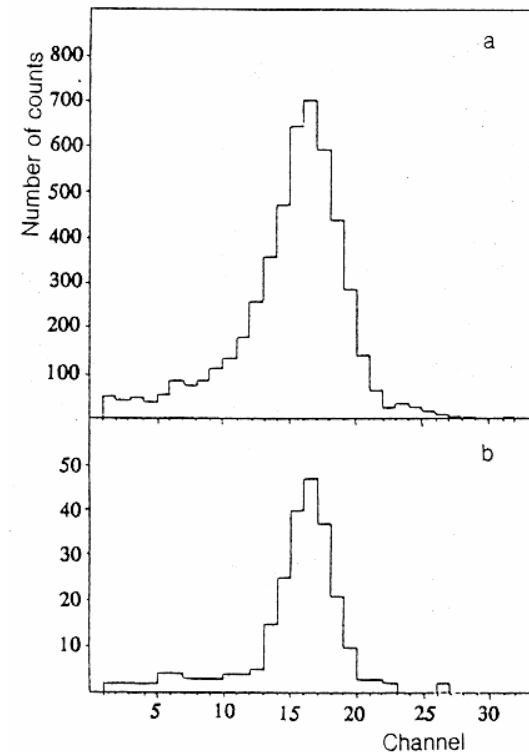


FIG. 1. Distribution of the pulses arriving at the neutron detector among channels of the pulse height analyzer. a—From the Cr^{252} neutron source; b—during temperature cycling of DKDP crystals near T_c .



Critical Russian Contributions after 1989

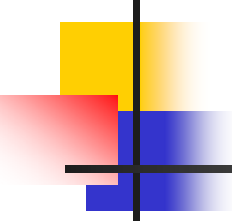
F-P announcement: I. Experimental

- First Glow Discharge application for stimulation of nuclear processes in metal target under deuteron bombardment: A chamber with a Pd foil of 0.1-1 mm thickness in an atmosphere of D₂ at 3-10 Torr was used. Thermistors measured the foil temperature and this served as calorimeter. Also in the chamber were detectors for neutrons, gammas and charged particles (cp's) as well as x-rays.. The Pd foil acted as cathode for a discharge beam of 10-100mA at 100-500V in the chamber. During running, excess heat, neutrons, gammas and cp's were detected
- A. B. Karabut, Ya. R. Kucherov, I.B. Savvatimova, Fusion Technology, 20 (1991) 924; A. B. Karabut, Ya. R. Kucherov, I.B. Savvatimova, « Nuclear product ratio for glow discharge in deuterium », Phys.Lett. A, 170 (1992) 265.



Transmutations observed in glow discharge [Savvatimova IB, Karabut AB, Poverkhnost' (1996)(1) pp.63-81]

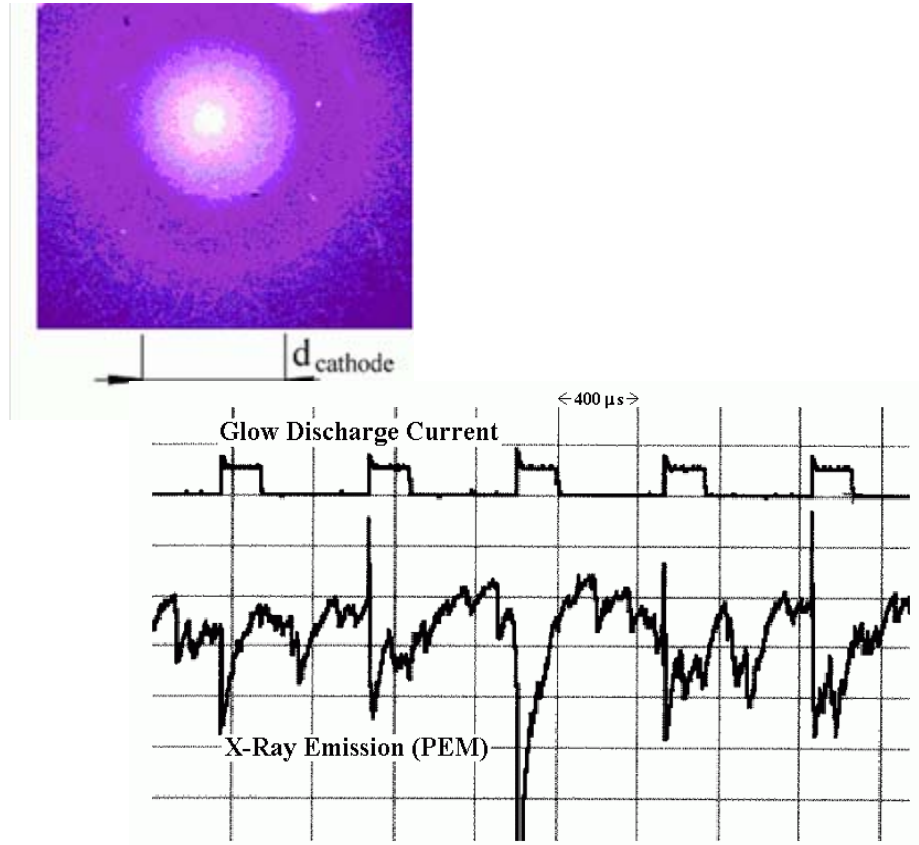
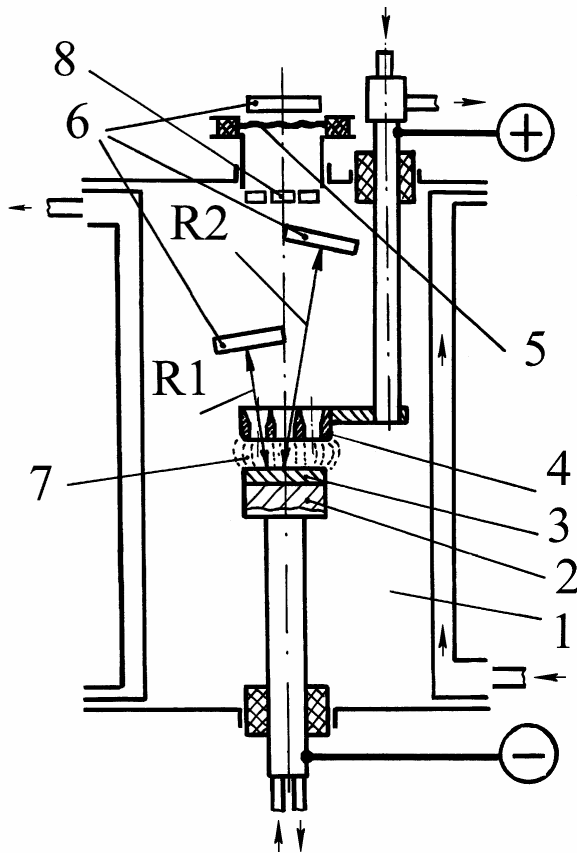
- A Pd cathode was subjected to a glow discharge at 10-40 mA/cm² and 100-500 V in an atmosphere of hydrogen, deuterium and a mixture of both, and the surface analyzed before and after by SIMS, surface MS and microprobe x-ray analysis.
- After discharge in deuterium, and to a lesser extent in the mixture, ¹⁰⁹Ag and ¹⁰⁷Ag were found, greatly in excess of that found when hydrogen alone was used. Other elements apparently generated in deuterium included Br, Rb, Nb, Sr, Y, As and Cd. Also, the ratio of ¹⁰⁹Ag to ¹⁰⁷Ag changed during the experiment in deuterium.



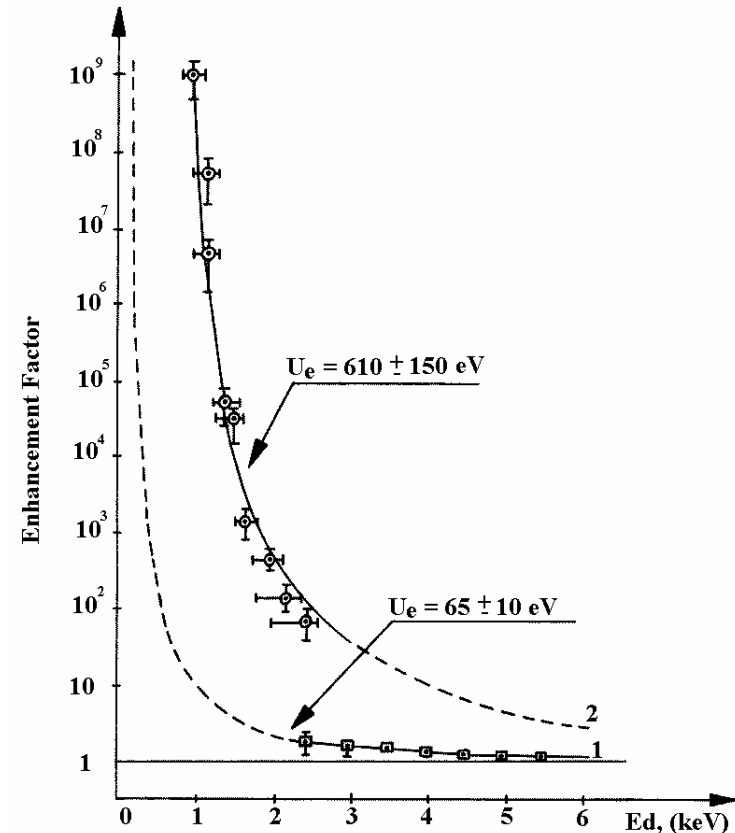
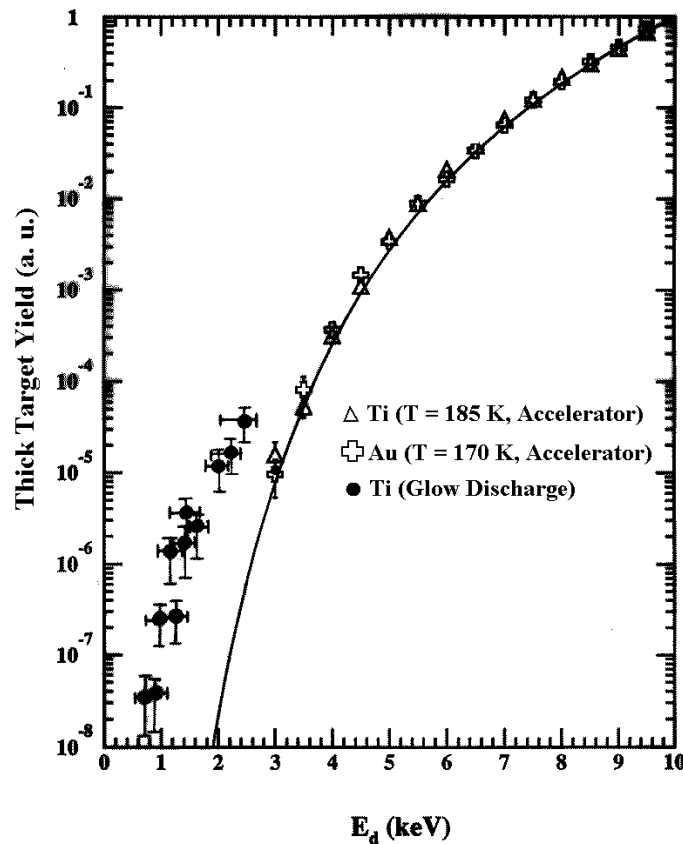
Tritium generation in glow discharge: [Romodanov VA et al., Sov. Phys. Tech. Phys. 36 (5) (1991) 572]

- Gaseous deuterium was put into a glow discharge chamber with various metals, such as Pd, Ti, Zr, etc. Voltages of 100-1000V were applied, while the gas pressure was at 500-15000 Pa. Neutrons were detected, and tritium was enriched by about an order of magnitude.
- Later the neutrons claim has been withdrawn.

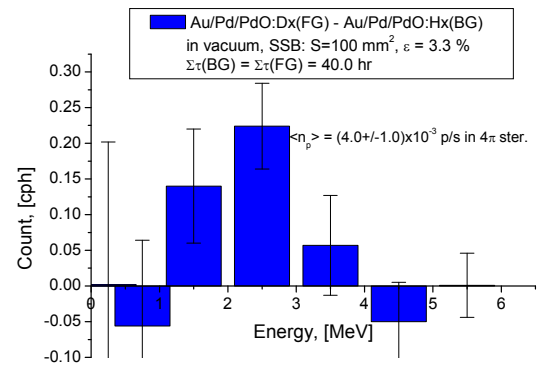
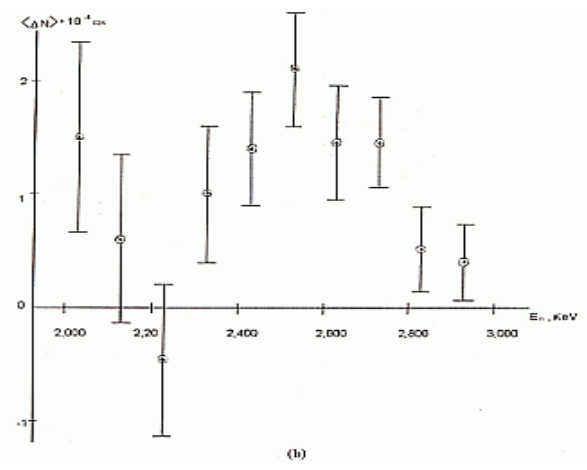
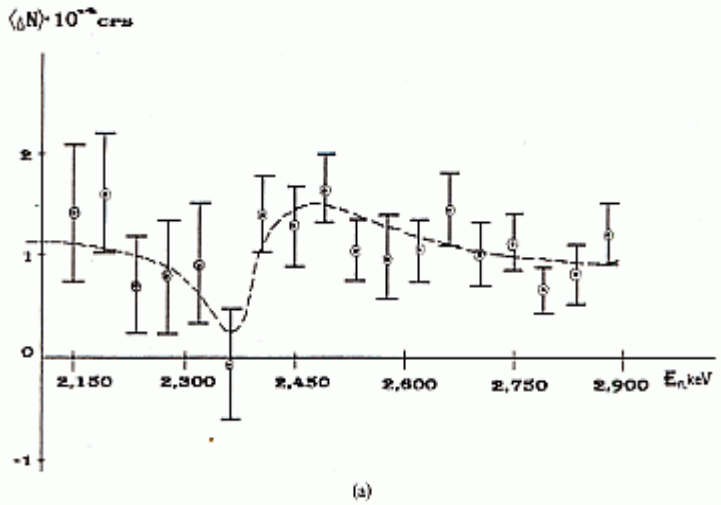
Soft X-ray emission ($E_x = 1.5$ keV) in novel pulsed glow discharge ($U \sim 2$ kV, $I = 500$ mA) developed by A. Karabut [A.G. Lipson, A.S. Roussetski, A.B. Karabut and G.H. Miley, JETP, 100 (6), 1175-1187 (2005)].



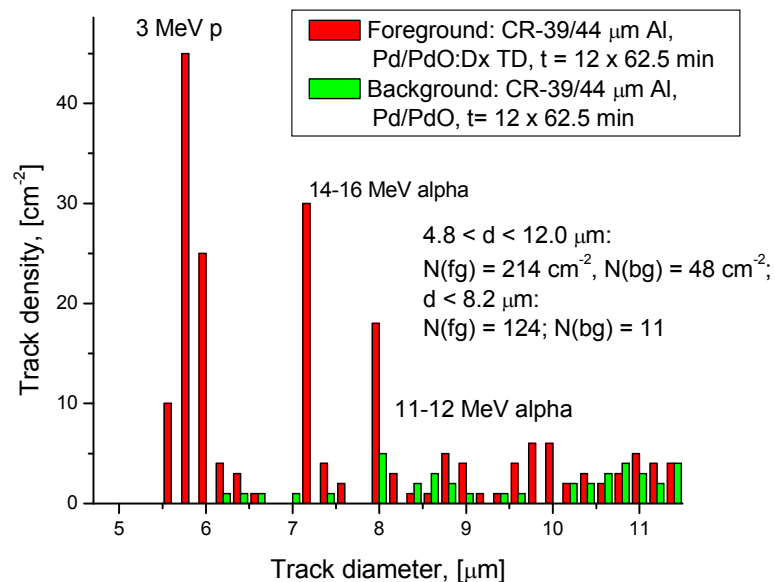
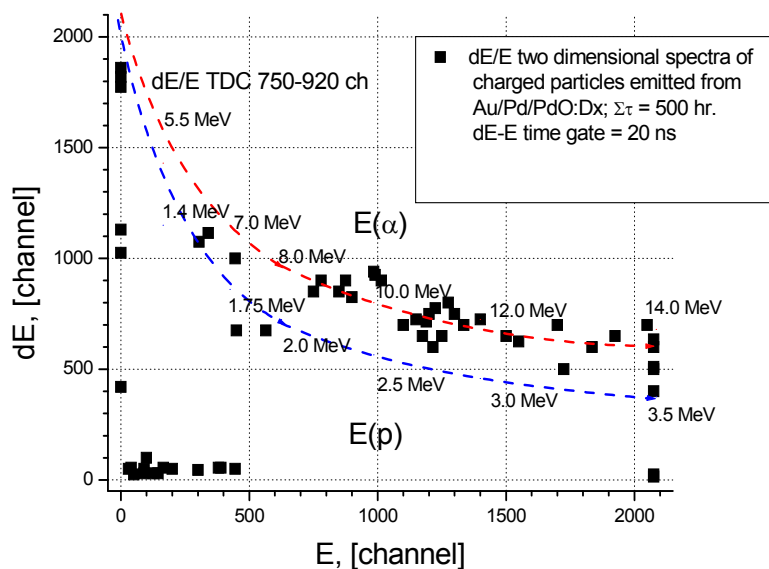
Strong Enhancement of DD-reaction in high-current pulsed glow discharge with the Ti cathode [A.G. Lipson, A.S. Roussetski, A.B. Karabut and G.H. Miley, JETP, 100 (6), 1175-1187 (2005)].

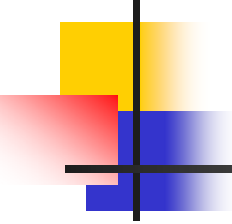


2.5 MeV neutron and 3 MeV proton emissions during exothermic deuterium desorption from Pd/PdO:Dx heterostructure [A.G. Lipson et al, Sov.Tech. Phys. Lett., 18(20), 58, 1992 (neutrons-BF₃), Fusion Tech., 38, 257, 2000 (neutrons NE-213, protons -SSB)].



Energetic alpha emission [Lipson et al, Bull. Lebedev Physics Inst., #10, 22-29 (2001), A.G. Lipson, G.H. Miley and A.S. Roussetski, Trans. Amer. Nuclear. Soc., 88, 638-641, (2003). First CR-39 application for in-situ electrolysis

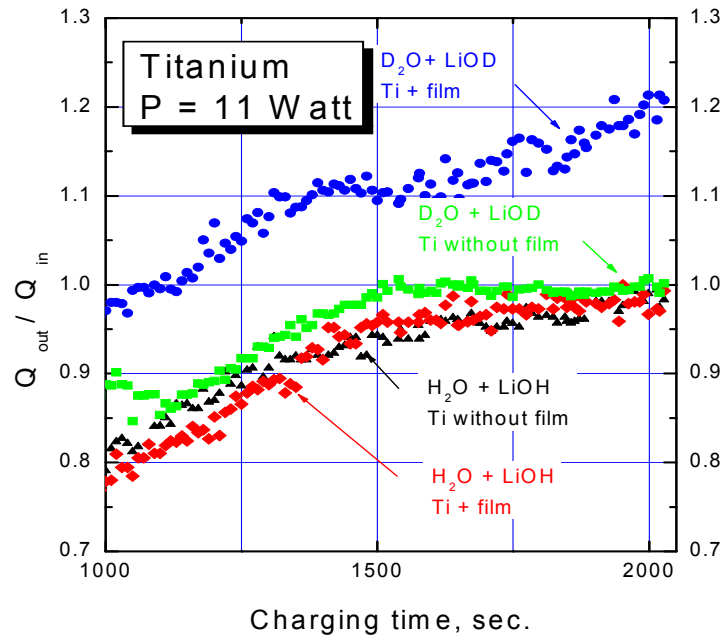




Excess heat studies (with precise flow type calorimeters)

- Excess heat release during deuterium sorption-desorption by finely powdered palladium deuteride (Kirkinskii VA, Drebuschchak VA, Khmelnikov: Europhys. Lett. **58** (2002) 462.
- A steel chamber containing powdered Pd and Pd foil deuteride (prepared by electrolysis) was heated to desorb the deuterium, then cooled again, whereupon the deuterium was absorbed in the powder to a loading of 0.6. Results showed excess heat if deuterium gas was used, but not with hydrogen gas.
- I. Chernov with collaborators have showed Excess heat during electrolysis of the Ti cathode covered by nuclear filters with the micron size holes ($P_{out}/P_{in} \sim 1.2-1.3$).
- S. Tsvetkov et al: ~ 4 % of excess heat in melted LiD.

Example: Excess heat generation in the Ti cathode covered by nuclear filters of micron size holes ($P_{out}/P_{in} \sim 1.2-1.3$).



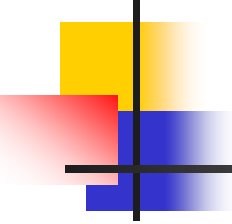
**Excess heat generation.
Titanium cathode.**



Critical Russian Contributions: II

Theory

- Fractofusion accelerator model based on keV deuteron generation in the cracks of dielectric deuterides: [Klyuev VA, Lipson AG et al., Sov. Tech. Phys. Lett **12**, 551 (1986), Deryaguin BV, Klyuev VA, Lipson AG, Toporov YuP, Colloid J. USSR **48**, 8(1986)].
- This accelerator model has been developed and extended to Pd and Ti deuterides by V. Tsarev [V. Tsarev, Sov. Phys. Uspekhi, **160**(11), 1 (1990)].



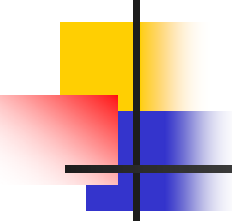
Parametric excitation of crystalline structures as a possible cause of high-energy emissions: G.V. Fedorovich

- The well known phenomenon of high energy (radio- to x-ray) emissions from stressed crystals became more interesting with the discovery of fractofusion. In this paper, a theory is developed, based on parametric excitation of vibration in a system of coupled oscillators, to account for these effects. Alternate layers of Pd and deuterium ions oscillate relative to one another in the PdD crystal and this can lead, in regions of shear stress to energies up to 10 eV or 10^5 K. The screening effects are also considered
- Fedorovich GV, Fusion Technology **24** (1993) 288; *ibid*, **25** (1994) 120.



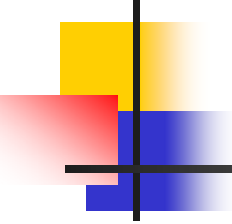
Kirkinskii VA, Novikov YuA;
Europhys. Lett. **46** (1999) 448--453

- The authors use computer calculations to check whether the s- and d-electrons in the host Pd might increase the rate of pp, dp and dd fusion enough to account for the claims. This rests on the idea that pairs to fuse might both reside in octagonal sites, or one of them, briefly, in a tetragonal site. Various involvement of several screening electrons are tried, combining d- and s-orbital ones. Some of the resulting fusion rates are close to, and even exceed, past claims. The paper suggests in summary that high D-loading and high mobility of the D in the lattice would be favorable. Mobility can be enhanced by gradients, sonics, phase transitions etc.
- This theory inspired the experimental efforts of Kirkinski group and allow to explain some results on excess heat production [Kirkinskii VA, et al., Europhys. Lett. **58** (2002) 462]



Ivan Chernov et al. [I.P. Chernov, Yu.I.Tyurin, Ju.P. Cherdantzev, Int. J. Hydrogen Energy 24, 359 (1999); V.M., Silkin, I.P Chernov et. al, Phys. Rev., B 76, 245105 (2007)].

- *Ab-initio* theoretical study of hydrogen desorption from metal hydrides/deuterides with a high hydrogen solubility, showed that excitation of hydrogen subsystem in those deuterides is resulted in plasmon formation leading to generation of strong electric fields ($F \sim 10^8$ V/cm) within a lattice parameter scale ($a \sim 0.3-0.4$ nm). As a result, a mean energy of desorbed protons/deuterons (E_d), escaping from the hydride surface would effectively be increased from kT to the several eV values ($E_d = F \times a \sim 3-4$ eV) or two orders of magnitude, effectively producing "hot" deuterons. Such deuteron acceleration mechanism, alongside with a possible large electron screening in the metal targets with a high hydrogen diffusivity could potentially strongly enhance the yield of DD-reaction in metal deuterides, even at extremely low energy of their excitation.



Example of Exotic theoretical : [N.V. Samsonenko et. al Phys. Lett. A **220** (1996) 297, *ibid.*, **229** (1997) 133]

- This is a follow-up of work by Barut & Vigier, who proposed non-Bohr lower level electron orbits for hydrogen, similar to the Mills theory. This is developed here; the Pauli equation is solved with the Hamiltonian, and the Schroedinger equation as well, using the Barut-Vigier potential. Along with the usual Coulomb states, a tight state at about 40 keV was found.



Resonance collapse of H₂O and ⁶LiD molecules:

V.B. Belyaev et al (JINR, Dubna) [J. PHYS. G-NUC. AND PART. PHYS. 22(7),1111 (1996), PHYS. LETT. B 522 (3) 222 (2001)].

- This interesting theory is considered Fusion reactions in molecules via nuclear threshold resonances (Similar to existing muon resonance in which Belyaev is an expert).
- It is widely accepted that in molecular systems the nuclear interaction plays a negligible role, because of the strong Coulomb repulsion of the nuclei at small distances. We are going to show that this is not always true. The existence of an extended nuclear resonance may lead to considerably enhanced nuclear reaction rates in appropriately prepared molecules. Especially we point out that p + p + O-16, i.e. the constituents of water, can form a Ne-18(1(-)) threshold resonance which decays under energy release into F-17 and a proton.
- The possibility of molecular-nuclear transitions to occur was recently predicted for some few-atomic systems. Among others, the molecule of ordinary water was shown to be a candidate for this effect due to a presence of (1(-), 4.522 MeV)-resonance in the Ne-18 nucleus. The search for traces of nuclear reactions was carried out for condensed and vaporous phases of water, with the use of low-background annihilation spectrometry



V.B. Belyaev et al, Few Body System, 38,
103 (2006).

- In the present report results of new measurements of the probability of molecular-nuclear transitions ${}^6\text{LiD} \rightarrow {}^8\text{Be}^*$ performed with an improved technique are presented. The measuring system consisted of two ΔE - E telescopes, and it provided the identification of nuclear charge Z for every detected event. During more than one month period of measurements only one event that could assumingly be ascribed to the searched effect was discovered.



Some negative CMNS results in Russian (and with Russian coauthorship) publications

- No neutrons and ^3T : Bertin A, Bruschi M, Bystritsky VM et al, Phys. Atomic Nucl. 59 (1996) 744--751 "Negative result of an experiment aimed at verifying the hypothesis that cold and hot nuclear fusion occurs in Ti/(D-T) and ZrNbV/(D-T) systems". Bertin A, Bruschi M, Bystritsky VM et al. Phys. Atomic Nucl. 59 (1996) 752--756. "Negative result of an experiment aimed at verifying a report on cold nuclear fusion in systems of the $\text{Na}_x\text{WO}_3/\text{D};\text{D-T}$ type"; the same authors: Phys. At. Nucl. 59 (1996) 934--937 "Absence of tritium yield in metal-deuterium systems". .
- No transmutations: Change in isotopic ratios in PdDx (Pd isotopes) and TiDx (Li-isotopes) after electrolysis are due to internal strain and enhanced Li diffusivity, respectively:
- A.G. Lipson et. al, "Palladium isotope separation under high mechanical stresses induced in Pd foils upon loading with deuterium", Phys. Solid State, 45(8) – iPd isotopic shifts disappear after PdDx annealing.
- 1409, (2003). IN.N.Nikitenkov, I.P.Chernov, D.Yu., Kolokolov, Yu.I.Tyurin. SIMS investigations of isotope effects at processed solid surface. Vacuum, 2 , 202 (2006). Li isotopic shifts are stimulated by hydrogen migration in TiHx



Summary of Russian Contribution

- The summary of Russian research in LENR shows that in some areas of the CMNS research the Russian contribution had a crucial value. This areas include, but not limited by fracto-fusion, nuclear emissions during acoustic cavitation, glow discharge effects (isotopic shifts and soft X-ray emission first observed by Karabut et al), energetic alpha particle emissions, First application of CR-39 and so on. These contributions must be referred to pioneering results, affecting international development of CMNS.
- Despite of clear evidence and high value of Russian achievements, many works of Russian researchers were ignored and have not been cited (in time) in international publications on LENR and other related fields: Examples – fractofusion, caviation fusion, neutrons emitted from ferroelectrics and so on.
- Notice that main stream Soviet/Russian physics journals (JETP, JETP Lett., Tech. Phys. Tech. Phys, Lett.) have been translated to English (almost simultaneously with the Russian version) by American Institute of Physics. So, references to Russian language are unacceptable.



Conclusions

- Entire works of Russian groups indicate that the question concerning existence of LENR could be answered positively. The numerous Russian works on CMNS in non-equilibrium condensed matter show occurrence of LENR in the form of excess heat and/or nuclear emissions.
- The main problem of Russian LENR studies is a total lack of funding resulting in fragmentation of the research conducted. Low circulation of the results in international community. The concentration of Russian efforts and international cooperation are highly desirable.
- This will allow to perform complete CMNS experiments with simultaneous detection of excess heat, atomic ^4He , ^3T , charged particles (DD-products +energetic alphas), neutron emission and so on.