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SUMMARY ABOUT THEORETICAL RESULTS OF THE 9TH INTERNATIONAL CONFERENCE ON COLD FUSION

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For summarizing theoretical papers of the ICCF9 conference, a short reminder should be given about some significant experimental results that can form a basis for a theory of low energy nuclear reactions (LENR). For a more historic view, the motivation for the Fleischmann-Pons experiment or the Preparata effect were well explained while-as an unusual view-L. Case reported that experiments may be understood by a simple chemical process involving catalytic surface properties. This could also explain why heat production happens in some cases and not in other cases. Contrary to this is the history of the observation of neutron emission from palladium compounds [1] or from deuterated palladium [2] that indicate nuclear processes. Today we have the significant result of Tian, Li et al [3] that the reaction of palladium wires after reacting with a hydrogen atmosphere during a current discharge, when the energy input was stopped and the gas evacuated, generated “heat after dead” for 43 hours producing about 3.6kW/cm^3 or 13 keV/atom Pd. There are further the clear measurements of the change of the isotope ratio of lithium against that of natural lithium after the proton or deuteron reactions in palladium (Passell) [4]. Miley et al. [5] reported in a series of repeated cases that the reacting Pd/Ni layers after proton intake emitted alphas as seen in CR-39 foils evaluated in Dubna. This is similar to observations by Li et al [6] where some of the patterns in CR-39 were identified to be produced by alphas but also by MeV nuclei of larger size than helium. The reaction products from these LENR showed bremsstrahlung of less than 25 keV energy (Miley) in numbers comparable with the patterns in the CR-39. Several other experiments of heat production and/ or nuclear synthesis or splitting were reported at the conference to be furthermore checked, but the report from the Mitsubishi Research Center (Itoh et al) as specially underlined by Tom Dolan, with the generation of Pr, Mo or Ba need special attention. The before mentioned cases of Miley et al or Li et al, however, are fully reproducible and transparent for any repetition.

Of the “twenty theories” and models that had previously been reported on cold fusion, some were discussed at the conference. In addition, there were still suggestions that cold fusion phenomena are really hot fusion in disguise (Kuhne). Similar also, a more detailed treatment following the lines of micro pinch processes was presented (Stringham) based on experiments going back to Los Alamos activities, using ultrasonic stimulation of deuteron interaction with palladium including sonoluminescence (indeed different from the ORNL bubble fusion experiments). A theoretical consequence was discussed also by Arata et al. using ultrasonic interaction with deuterated palladium. In that case the assumption is that palladium lumps may occur between picno-nuclear lumps of deuterium atoms with a density of 10 g/cm^3. Arata is aware that this 50 times solid-state density of electrons at low temperature produces a Fermi-pressure of 100 Mbar. Other contributions discussed effects that a “forth fundamental force” may be involved (Filimonv) or phase changes are the reason for cold fusion, explained by “coherent quantum electrodynamics” (de Ninno et al). Several authors are still basing their theories on localized lattice states, e.g. Qiugquan Gou with describing the PdD compound as an ionic crystal, or a the lattice focal model (Takahashi). The original lattice dynamic theory of Julian Schwinger is being followed up by several authors, e.g. S. & T. Chubb (including broken gauge symmetry), P. Hagelstein and others.

Hagelstein postulated a strong demand in saying “what the public needs only is a coherent explanation” about cold fusion. Following the crystal effects as basis of the cold fusion, he uses the Wigner strong nuclear force theory with resonating group model techniques. Hagelstein extended this into "resonating lattice group techniques" by adding a crystal term to the Hamiltonian. One result is that optical phonon modes should move helium nuclei to a distance of 10 fm(Fermi) for the necessary reactions. He proposed that there should be a further confirmation of the claim by Kasagi that 100 keV deuteron bombarding deuterium targets produce a reaction d + 2d = ^{4}He + n + p + Q and to look for the reaction d + (p+d) = ^{4}He + p + Q.

Other theoretical contributions were to explain the reactions of protons with the iron in the inner of the Earth (Novikov), or chaos thermodynamics for light nuclei which may react in liquid lithium fluid cooled nuclear reactors (F. G. Mao et al.). For models to understand the reduced distances between nuclei in palladium, Kozima discussed neutron "drops", while Tsuchiya reported on the application of the Kim-Zubarev model with Bose-Einstein condensation of deuterons in the lattice in order to arrive at interesting short distances for the nuclear reactions.

After having mentioned these various models, attention should be given how an important substantial result was presented. It was very interesting to see how the new *theory of selective resonant tunneling* by Xing Zhong Li was followed up. Li produced the *very first theoretical explanation of the DT fusion cross sections*. It should be underlined that despite the intense work on nuclear fusion reactions over nearly sixty years, there was never an explanation why the hot fusion reaction occurs at a distance more than hundred times the nuclear diameters. This observation applies even though dozens of billion dollars have been invested and despite the fact that the brightest physicists were involved (e.g. in Russia since 1944: Tamm, Kapitza and Sacharov, all receiving the Nobel price) with the triumph of Edward Teller having the solution first in much shorter time and against the frustration by colleagues and superiors. For the basic theory of the cross sections, indeed, there are a number of engineering type adjustments of formulas to explain the measured nuclear reaction cross section for fusion e.g. by fitting five parameters [7] or using larger numbers of parameters. Contrary to this it was *the first time that Li could calculate* the DT fusion cross section by applying a potential with imaginary part into the SchrÖdinger equation, not to be played down as an optical model only. In this way he arrived at DT cross sections that are in excellent agreement with the measurements with an *input for the calculation by clear physics only* using the resonance energy and the resonance width [8-10]. This model also explains why the DD reaction for very large distance as at LENR favors the tritium emission branch but has a low probability for the neutron emission branch.

Li reported about a continuation of his work including the S(E) factor in astrophysics and cold neutron experiments in a lattice. This all may be favored by the concept of "super absorption" with some enhancement in the nuclear reaction in terms of a constructive interference with the crystal lattice. The jump in the tritium branch of DD fusion at 1.62-keV energy was explained in terms of a strong electron screening effect. This also provides a connection to the muon-catalyzed fusion experiment of TRIUMP in Canada with an energy resonance at 0.3 eV. Special reference was given to the Arata-Zhang experiments where 0.511 MeV gamma radiation was never detected.

Li's model of selective resonant tunneling was applied by Si Chen et al. to study the Arata-Zhang experiment. The DD reaction cross sections were compared with the 5 parameter and the 7 parameter adjustment formulas. This calculation also supports the result by Clarke, McKubre et al. on the tritium production in the Arata –Zhang experiments.

The tunneling barrier problem was treated by J.Q. Li using a technique similar to that of the theory by X.Z. Li. Presentations included an application by Z-Q. Zhang who discussed a case where the electron is closer to the nucleus for treating K-capture.

Interesting electronic shell or band calculations were used for explaining measurements. Kirkinskii claimed that this is an unusual approach compared with standard quantum mechanical calculations. A very straight-forward application of E-k electron band calculations was presented (N. Luo et al.) to explain the measurements of the increase of the conductivity of a palladium wire up 10% when loading with hydrogen or deuterium.

The reviewer mentioned the rather settled result derived before [11] semi-empirically about the reaction time dependence on the distance between the nuclei. Comparing with the few reliable measurements, it was found that the reactions occur at a distance of around 1 to 3 pm and at a times of kilo-to mega- seconds for the reaction probability. This has a similarity to the K-shell electron capture and was reproduced by the above mentioned Li-theory. It was calculated that such a pm reaction distance between protons or deuterons to each other or to other nuclei can be achieved by Coulomb screening by a factor 13. Since screening by a factor 5 is possible in plasmas (Ichimaru), a higher screening is related to the swimming electron layer at the metal surface or at interfaces between layers of metals with different Fermi energy. A new result is the treatment for cases with a stretched double layer as known from laser produced plasmas. An alternative possibility of bringing the protons or deuterons to pm distance is the application of dielectric properties of plasma for shrinking of the atoms to the mentioned size. The then necessary reduced Bohr radius implies an enormous increase of the ionization energy. The plasma properties however can provide a strong decrease by the Inglis-Teller effect. Applying the only successful model for reproducing the change of spectral lines [12] by plasma polarization, some reasonable relations were derived for the dielectric shrinking of the hydrogen atom in the solid-state plasma with a favoring at the surface due to the reduced energy of surface plasmons. This model includes, however, more open questions than the swimming electron layer model such that more attention has to be given in due course to further LENR experiments for clarification.

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