Cold Fusion Phenomenon

and Solid State-Nuclear Physics

Cold Fusion Research Laboratory

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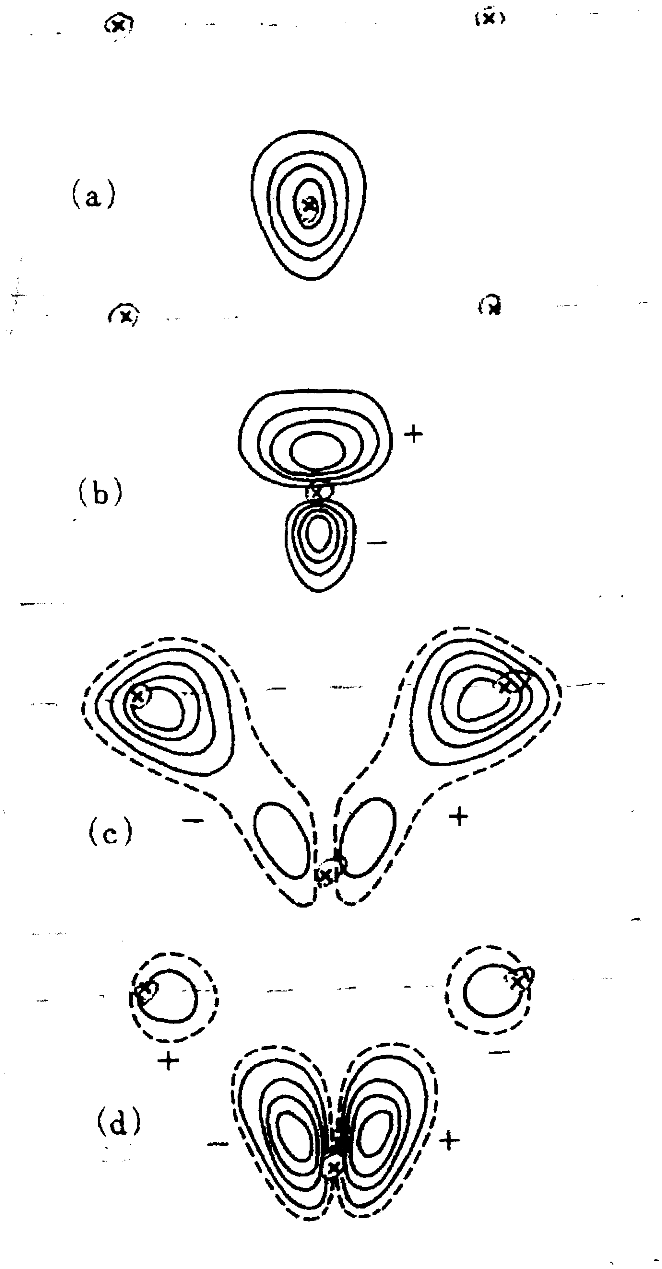
Abstract

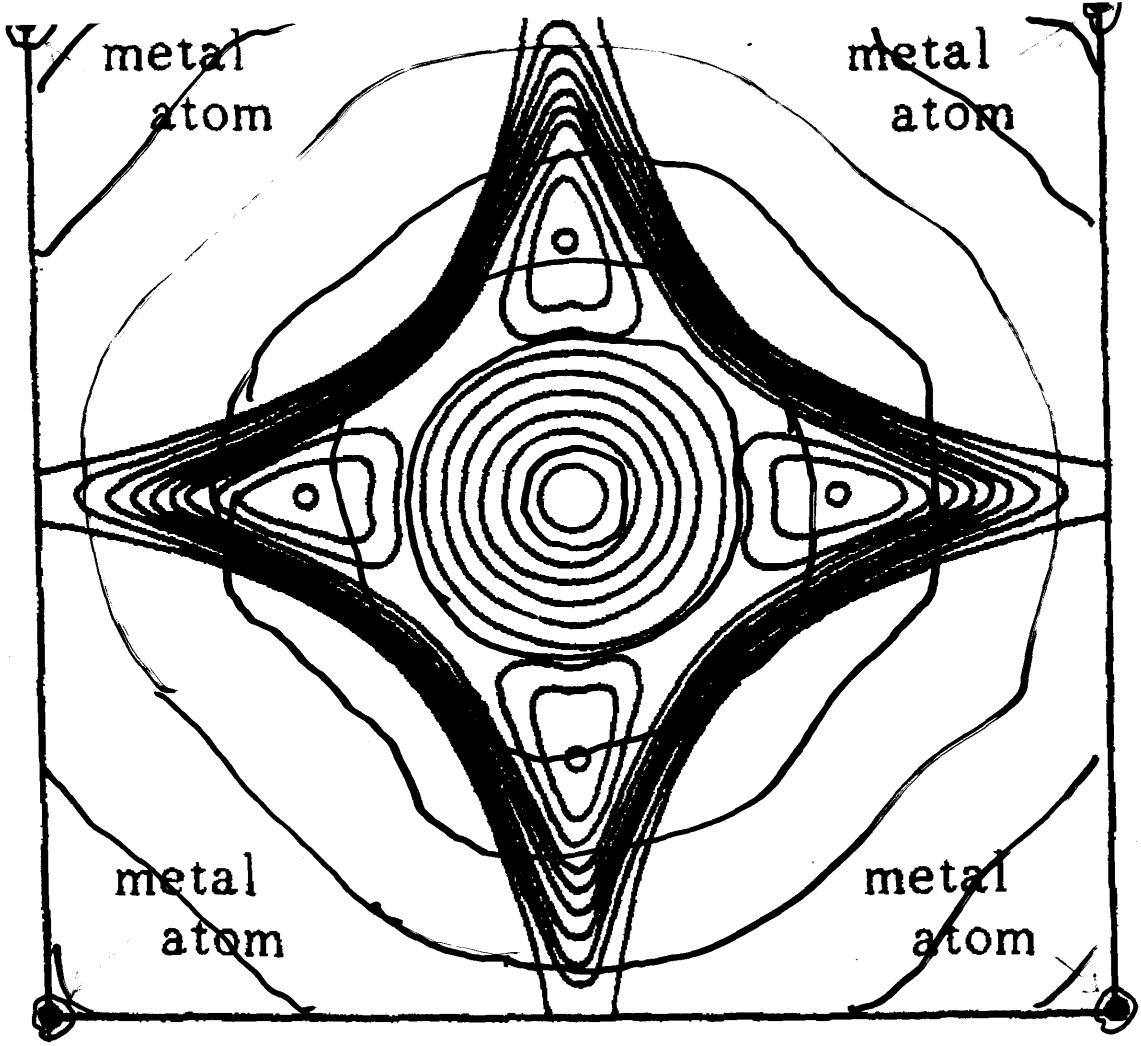
Since the discovery of the cold fusion phenomenon (CFP) in 1989, it has been steadily developed researches of science of CFP experimentally and theoretically revealing its complex nature; sporadic occurrence of various events including nuclear transmutations (NT) of elements with large mass numbers in compound systems under ambient radiations with qualitative reproducibility. Such typical characteristics of CFP as occurrence of CFP only in *fcc* (and *hcp*) transition metal alloys with hydrogen isotopes but not in *bcc* alloys, the stability effect in NT (H. Kozima, *Proc. ICCF10*), helium production only in electrolytic systems with lithium electrolyte in heavy water, optimum combinations of [cathode-electrolyte-hydrogen isotope], etc. are investigated quantum mechanically in this work.

It is shown that quantum mechanical states of hydrogen isotopes in transition metals worked out in the physics of transition-metal hydrides have a close relation with appearance of CFP; H in Ni and D in Pd in favor of CFP are related with wave functions of protons (deuterons) in these metals. Quantum-mechanical calculation of the interaction between occluded protons (deuterons) at interstitial sites and neutrons in nuclei at lattice points (lattice nuclei) [1] has shown that neutrons in different lattice nuclei interact strongly each other through the "super-nuclear interaction" mediated by occluded protons (deuterons). Neutrons in excited states with rather extended wave functions are favorable for this interaction. This super-nuclear interaction between neutrons in different lattice nuclei makes possible appearance of neutron bands at around zero-level of energy (the neutron evaporation energy of the lattice nuclei), which induces accumulation of neutrons at surface/boundary layers and formation of <u>cf-matter</u> there. Neutron drops in the so-realized cf-matter induce nuclear reactions in the region observed as CFP very different from those reactions in free space investigated in nuclear physics, hitherto.

[1] H. Kozima, "Quantum Physics of Cold Fusion Phenomenon" *Developments in Quantum Physics Researches* pp. 167-196, ed. V. Krasnoholovets, Nova Science Publishers, Inc., New York, 2004.



Illustrative Change of Topography of Wave Functions of a Proton Self-trapped in Ta according to the Quantum State; Ground State at (a) E = 0, Excited State at (b) E = 109 meV, (c) E = 158 meV, (d) E = 168 meV.



Black lines: An example of potential profile around an interstitial site. Potential profile on a (001) surface around a T-site of bcc β-V_2H.

Red lines: Illustrative probability density profile of a proton in an excited state trapped at the interstitial site.

In this paper, we investigate various experimental data obtained not only in the cold fusion phenomenon (CFP) but also in solid state physics, altogether. The key point of conceptual understanding of CFP is the wave function of protons/deuterons in transition-metal hydrides and deuterides.

Known knowledge of quantum mechanical states of hydrogen isotopes (proton/deuteron) in transition metals is used to estimate an illustrative interaction between a neutron in a lattice nucleus and a proton (or deuteron) occluded in the lattice.

Formalism of the cf-matter mechanism for CFP, developed in our previous papers, facilitates evaluation of unknown proton/deuteron densities at lattice nuclei and also of the neutron density of excited states in a lattice nucleus in CFP materials.

The necessary and sufficient conditions for CFP give us information about quantum mechanical states of CFP materials.

Following facts of CFP are consistently explained by our theory.

1) Qualitative reproducibility of CFP.
2) Sporadic occurrence of events in CFP.
3) Surface/boundary nature of events in CFP.
4) Effects of thermal neutrons on CFP.
5) Quantitative relations between simultaneous products of CFP, e.g. the numbers of reactions N_Q producing excess heat Q and N_t producing tritium atom;

$$N_Q \sim N_t.$$

6) Stability effect of the nuclear transmutation in CFP.
7) Production of tritium only in deuterium system.
8) Production of ^{4}He only in systems with Li.
9) Favorable combination of [metals–hydrogen isotopes–electrolytes];

e.g. Pd-D-Li, Ni-H-K.

Thus, the cold fusion phenomenon is fundamentally explained in consistency with knowledge of solid state physics of transition-metal hydrides/deuterides that has been obtained over more than hundreds years.

Knowledge of quantum mechanical states of hydrogen isotopes (proton and deuteron) in transition-metals is used to estimate interaction of a neutron in a lattice nucleus with a proton (or deuteron) occluded in the lattice.

Formalism of the <u>cf-matter</u> mechanism of the cold fusion phenomenon (CFP) developed in our previous papers facilitates evaluation of proton (or deuteron) density around lattice nuclei and also of density of a neutron in an excited state in a lattice nucleus where CFP realized.

It is necessary to have several conditions to attain necessary and sufficient conditions for CFP.

1) Occluded protons/deuterons are in states with widespread wave functions extending to lattice points, where they interact with neutrons in lattice nuclei.

2) Neutrons in lattice nuclei are in excited states with wave functions extended outside of lattice nuclei to interact with protons/deuterons occluded in the lattice.

3) Interaction of the proton/deuteron with a neutron in a lattice nucleus should be multi-lateral to mediate interaction between two neutrons in different adjacent lattice nuclei.

4) <u>The super-nuclear interaction</u> (neutron-neutron interaction mediated by occluded protons/deuterons) realize a new neutron state in solids. <u>a neutron band state</u> where neutrons are in a stable state itinerating in the lattice.

5) In the boundary/surface regions of solids with the neutron band, there appears <u>neutron drops</u> with a high-density neutron including protons and electrons.

6) Interaction of the neutron drops with lattice nuclei and exotic nuclei results in CFP.

7) Conditions for stable existence of the neutron band give conditions for optimal densities of proton/deuteron and neutron in lattice nuclei necessary for CFP.

8) Because of lack of experimental data on the proton/deuteron wave functions in cold fusion materials, we have to assume possible types of the wave functions and give necessary densities.

The Stability Effect of Nuclear Transmutation in CFP

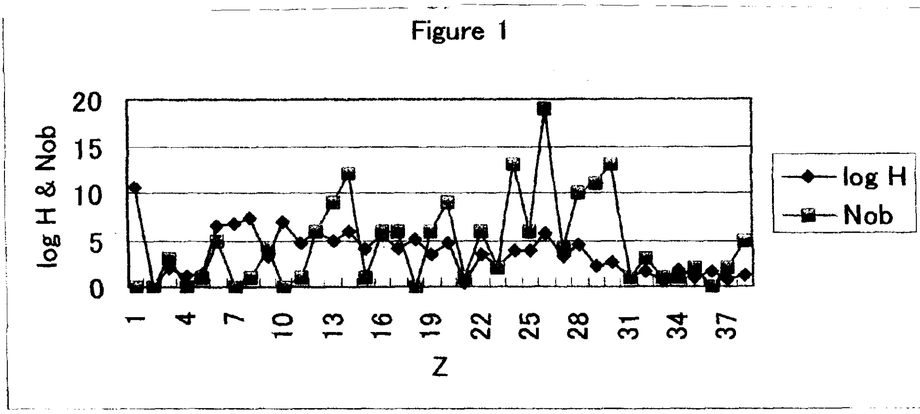


Fig. 1 Correspondence between the frequency N_{ob} observing elements in CFP and the relative abundances $\log_{10}H$ of elements in the universe (Z = 3 −38).

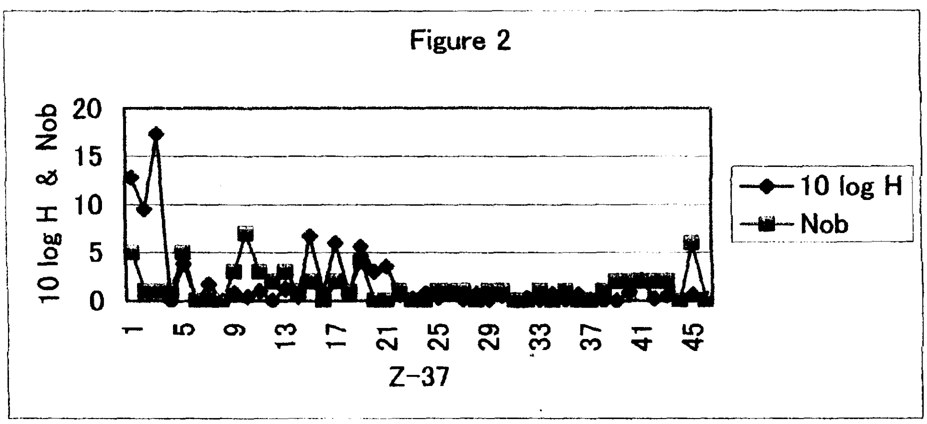


Fig. 2 Correspondence between the frequency N_{ob} observing elements in CFP and the relative abundances $\log_{10}H$ of elements in the universe (Z = 38 −84).

Figs. 1 and 2 show the stability effect of nuclear transmutation in CFP. Frequency of observation for new elements in cold fusion experiments shows good qualitative coincidence with the relative abundance log10H of elements in the universe. (cf. H. Kozima, "CF-Matter and the Cold Fusion Phenomenon" Proc. ICCF10 (to be published)