

**Neutron Drops and Production of
the Larger Mass-Number Nuclides
in Cold Fusion Phenomenon**

H. Kozima,
Physics Department, Portland State University
Portland, OR 97207-0751, USA
E-mail, cf-lab.kozima@pdx.edu

Synopsis

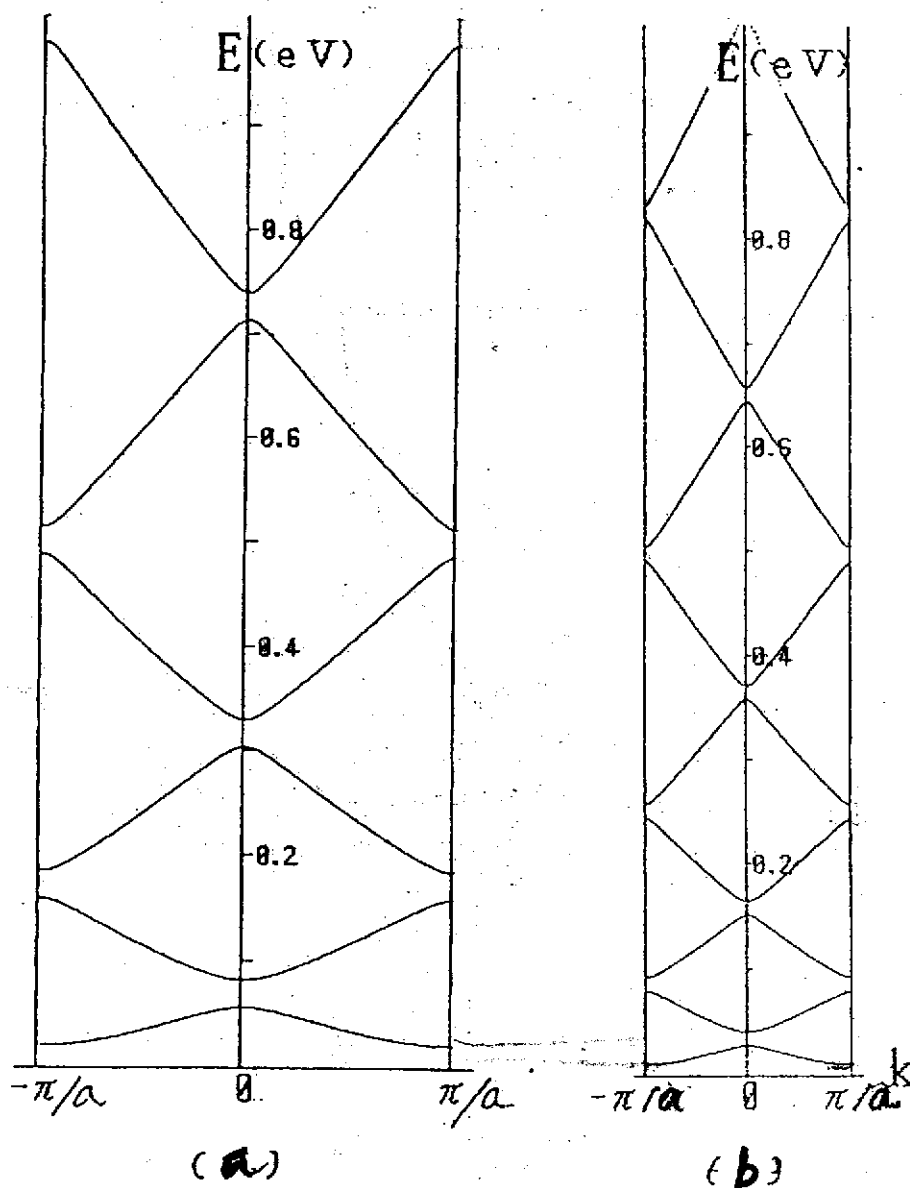
Production of the larger mass-number nuclides in the cold fusion phenomenon (CFP), i.e. nuclear reactions and accompanying events occurring in solids with high densities of hydrogen isotopes in ambient radiation, is investigated from a point of view based on the neutron drops formed in the boundary region of materials used in experiments where observed new nuclides with larger mass numbers than nuclides preexisted in the system.

The neutron drops are formed in the boundary region where neutron Bloch waves in the samples are reflected and where large density of neutrons are formed by the local coherence of neutron waves with similar energies but different wave-number vectors. The large density neutrons in the region result in a state with neutron drops including neutrons and a few protons imbedded in a thin background neutron gas as shown by numerical simulation in the neutron star matter problem worked out in the early 1970's.

Existence of lattice nuclei in the CF matter such as PdH or PdD that are absent in the neutron star matter makes difference in the two cases. Qualitative discussion on the effects of these lattice nuclei is given in favor of formation of neutron drops in CFP that makes appearance of CFP rather complex than the case of neutron star matter.

Neutron Conduction Bands in Transition-Metal Hydrides and Deuterides

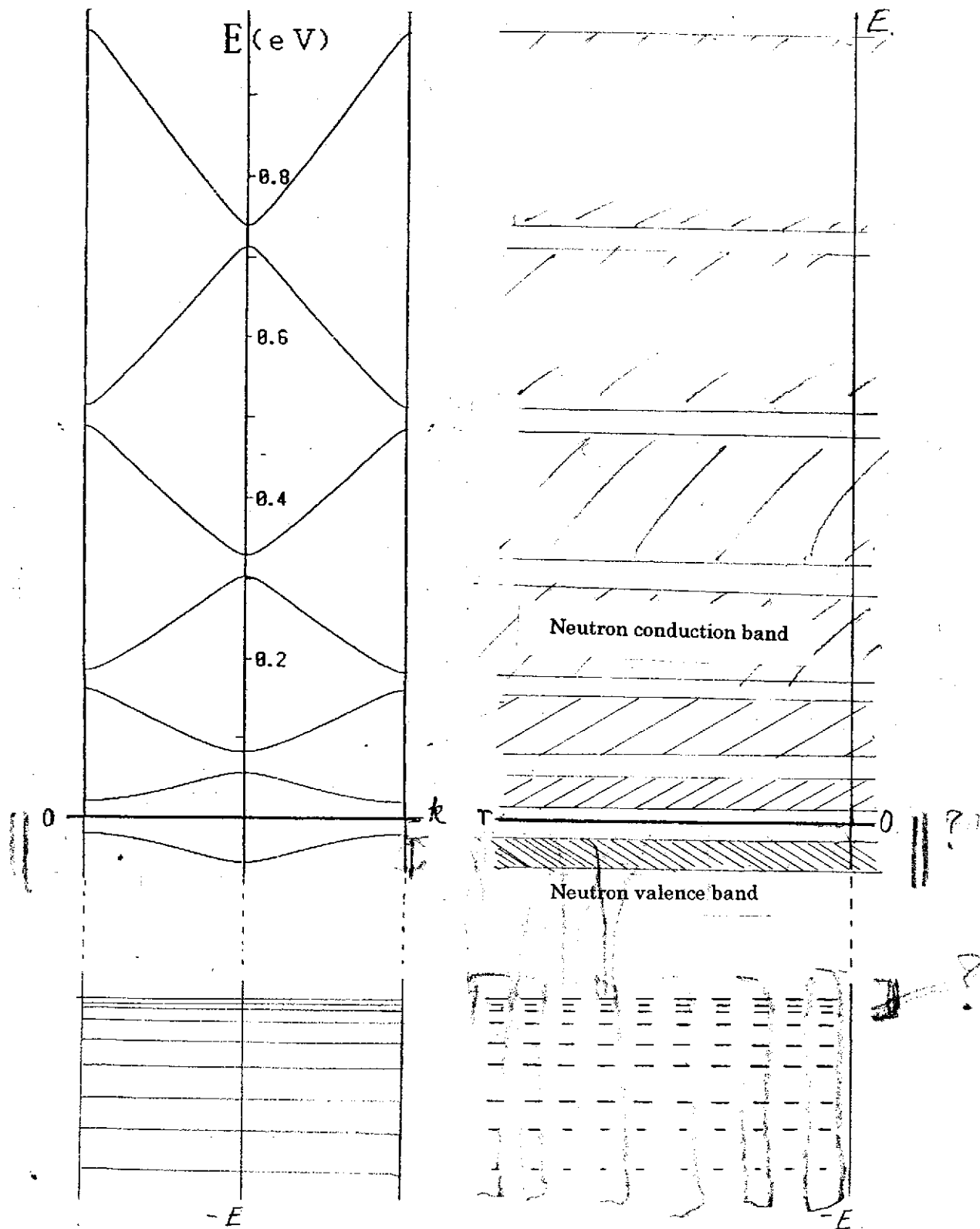
H. Kozima, "Neutron Band in Solids", *J. Phys. Soc. Japan* **67**, 3310 (1998).



Neutron Valence Bands in Transition-Metal Hydrides and Deuterides

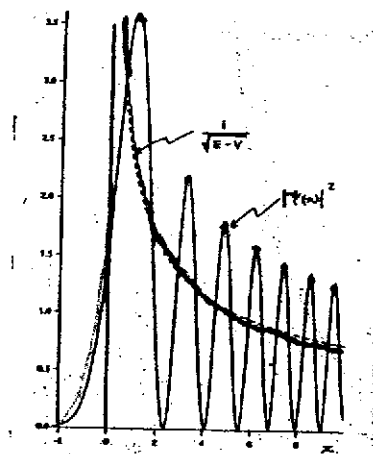
H. Kozima, "Excited States of Nucleons in a Nucleus and Cold Fusion Phenomenon in Transition-Metal Hydrides and Deuterides" *Proc. ICCF9* (to be published);

H. Kozima, "Anomalous Nuclear Reactions and Atomic Processes in Transition-Metal Hydrides and Deuterides" *J. New Energy* 6-3 (2002) (to be published).

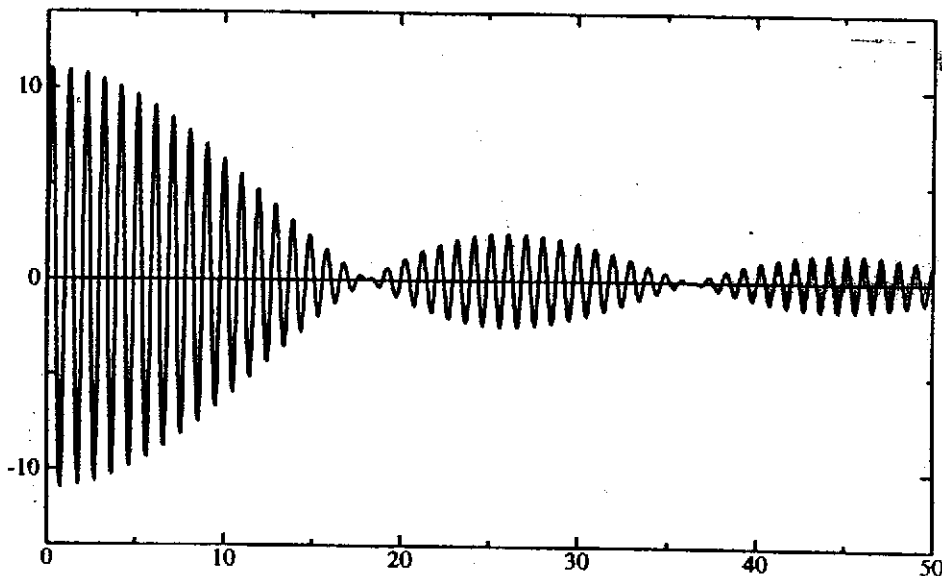


Local Coherence of Neutron Bloch Waves in the Boundary Layer

H. Kozima, K. Arai, M. Fujii, H. Kudoh, K. Yoshimoto and K. Kaki, "Nuclear Reactions in Surface Layers of Deuterium-Loaded Solids" *Fusion Technol.* **36**, 337 (1999).



$$y = a \sum \sin 2\pi(k_i x + \alpha_i) \quad (a = 1, \alpha_i = 0, k_i = 1.000, 1.005, \dots, 1.050)$$



Neutron Drops formed in the Boundary Layer

H. Kozima, "Neutron Drop: Condensation of Neutrons in Metal Hydrides and Deuterides", *Fusion Technol.* **37**, 253 (2000).

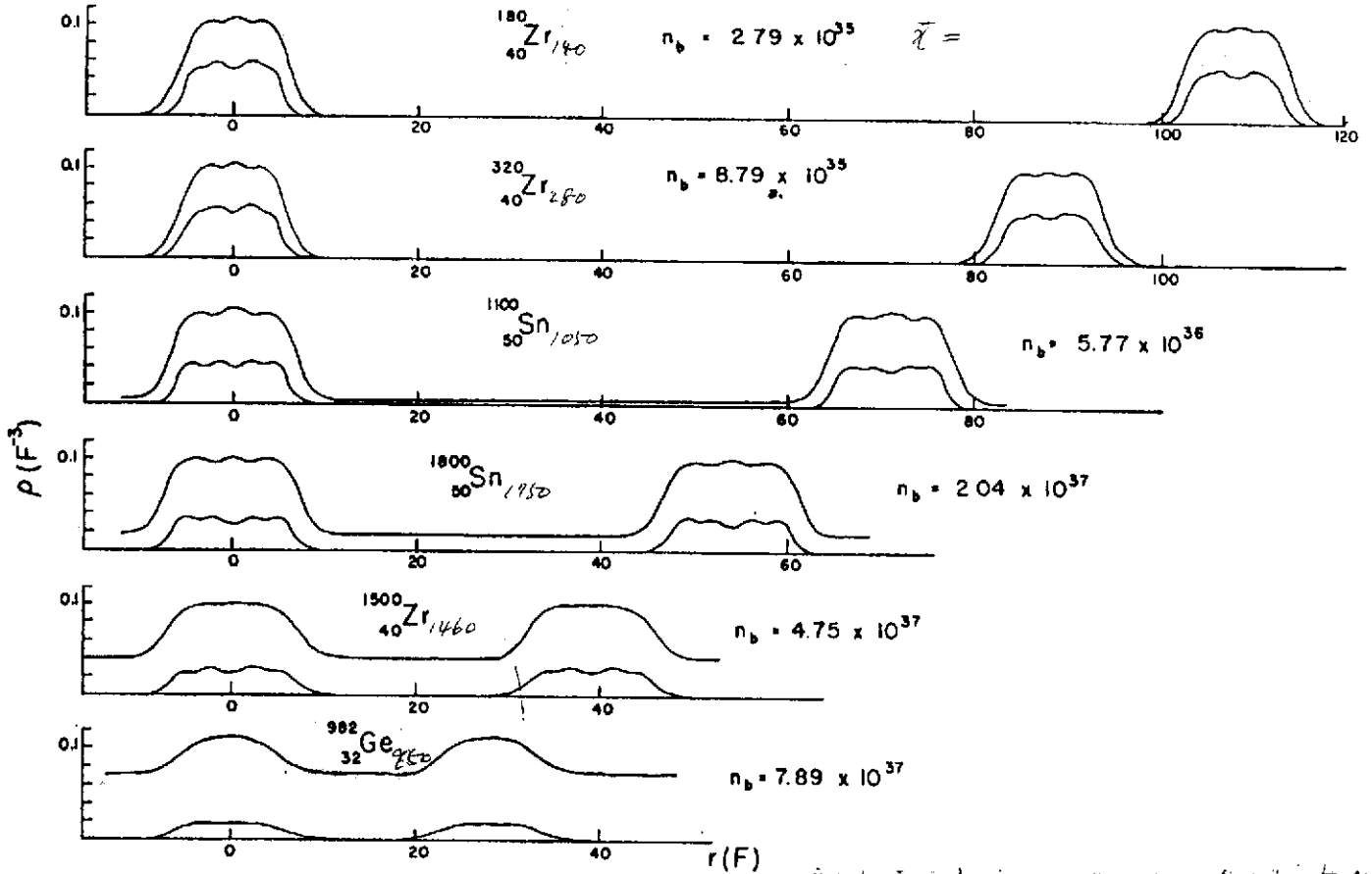


Fig. 3. Proton and neutron density distributions occurring in a neutron drop.

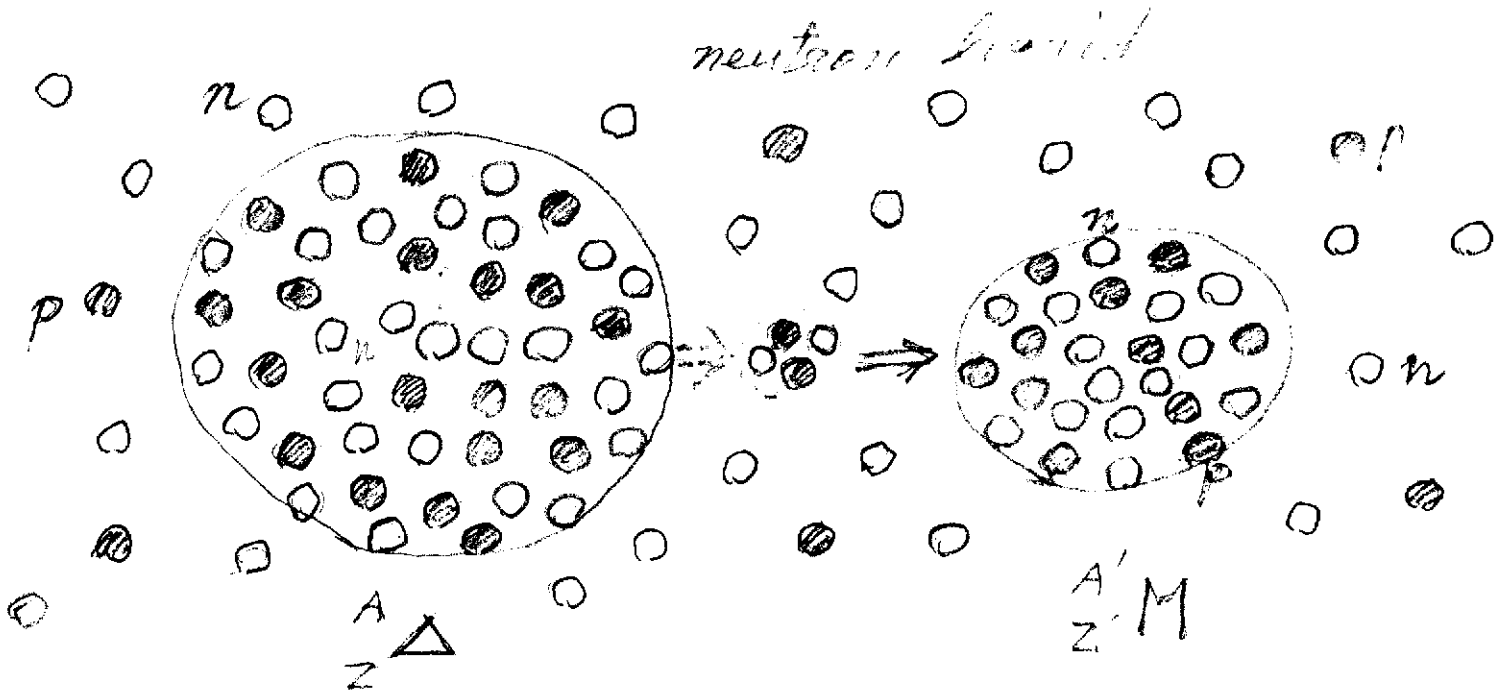
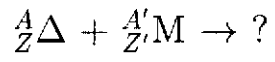
J.W. Negele and D. Vautherin, "Neutron Star Matter at Sub-nuclear Densities" *Nuclear Physics A* **207**, 298 (1973).

Table 1: The theoretical and extrapolated to $n_G = 1 \times 10^{30} \text{ cm}^{-3}$ values of the lattice constant a of Coulomb lattice and the proton-to-neutron ratio \bar{x} in the neutron drops $\frac{A}{2}\Delta(n-p \text{ clusters})$ as functions of n_G , where n_G is the density of the neutron gas surrounding the neutron drops in the Coulomb lattice. For reference, a and \bar{x} for the lattice of Pd metal (composed of $^{110}_{46}\text{Pd}$) is added.

Density $n_G(\text{cm}^{-3})$	5×10^{37}	5×10^{36}	5×10^{35}	4×10^{34}	1×10^{30}	(Pd metal)
Estimated a (Å)	4×10^{-1}	7×10^{-1}	8.7×10^{-1}	1.1×10^{-3}	2×10^{-3}	$a_{\text{Pd}} = 2.5$
Estimated \bar{x}	0.28	0.45	0.53	0.53	0.7	$\bar{x}_{\text{Pd}} = 0.72$

Simple extrapolation of the result obtained in neutron star matter problem to lower density situations gives an interesting feature of transition-metal hydrides and deuterides in boundary layers where lattice nuclei are distributed in the Coulomb lattice of the neutron drops.

Interaction of Neutron Drops and Nuclei in the Boundary Layer



Decay Time Shortening (DTS), Gammaless Reactions (GLR), Nuclear Transmutations NT_A , NT_D and NT_F , and Fission Barrier Decrease (FBD)

$$\frac{A}{Z}\Delta + \frac{A'}{Z'} M^* \rightarrow \frac{A}{Z}\Delta^* + \frac{A'}{Z'} M \quad (\text{GLR}), \quad (1)$$

$$\rightarrow \frac{A}{Z}\Delta^* + \frac{A'}{Z'+1} M' + e^- + \bar{\nu}, \quad (\text{DTS}, \beta) \quad (2)$$

$$\rightarrow \frac{A}{Z}\Delta^* + \frac{A'-4}{Z'-2} M' + \frac{4}{2} He, \quad (\text{DTS}, \alpha) \quad (3)$$

$$\frac{A}{Z}\Delta + \frac{A'}{Z'} M \rightarrow \frac{A''}{Z''}\Delta + \frac{A'+A-A''}{Z'+Z-Z''} M', \quad (\text{NT}_A) \quad (4)$$

$$\frac{A}{Z}\Delta + \frac{A'}{Z'} M \rightarrow \frac{A''}{Z''}\Delta + \frac{A'+A-A''}{Z'+A-A''} M^* \quad (5)$$

$$\rightarrow \frac{A''}{Z''}\Delta + \frac{A'''}{Z'''} M' + e^- + \bar{\nu}, \quad (\text{NT}_D, \beta) \quad (6)$$

$$\frac{A}{Z}\Delta + \frac{A'}{Z'} M \rightarrow \frac{A''}{Z''}\Delta + \frac{A'+A-A''}{Z'+Z-Z''} M'^* \quad (7)$$

$$\rightarrow \frac{A''}{Z''}\Delta + \frac{A'''}{Z'''} M'' + \frac{A''''}{Z''''} M''', \quad (\text{NT}_F \text{ by FBD}) \quad (8)$$

(1) Gammaless Reactions (GLR); [16]

(2) and (3) Decay-time shortening (DTS); [17], [18], [19], [20], [21].

(4) NT_A ; [16], [26], [27], [28], [29], [30].

(6) NT_D ; [17], [18].

(8) NT_F ; [22], [23], [24], [25], [26],

Acknowledgement

The author would like to express his thanks to John Dash for valuable discussions during this work. This work is supported by a grant from the New York Community Trust and Professional Development Fund for Part-time Faculty of Portland State University.

References

- (1) M. Fleischmann, S. Pons and M. Hawkins, "Electrochemically induced Nuclear Fusion of Deuterium", *J. Electroanal. Chem.* **261**, 301 (1989). (Q, n, t)
- (2) S.E. Jones, E.P. Palmer, J.B. Czirr, D.L. Decker, G.L. Jensen, J.M. Thorne and S.E. Tayler, "Observation of Cold Nuclear Fusion in Condensed Matter", *Nature* **338**, 737 (1989). ($n(\varepsilon)$)
- (3) A.J. Leggett and G. Baym, "Exact Upper Bound on Barrier Penetration Probabilities in Many-Body Systems: Application to 'Cold Fusion'", *Phys. Rev. Letters* **63**, 191 (1989).
- (4) S. Ichimaru, "Nuclear Fusion in Dense Plasmas", *Rev. Mod. Phys.* **65**, 255 (1993).
- (5) H. Kozima, *Discovery of the Cold Fusion Phenomenon - Evolution of the, Solid State-Nuclear Physics and the Energy Crisis in 21st Century*, Ohtake Shuppan KK., Tokyo, Japan, 1998.
- (6) H. Kozima, K. Kaki and M. Ohta, "Anomalous Phenomenon in Solids Described by the TNCF Model", *Fusion Technol.* **33**, 52 (1998).
- (7) G. Baym, H.A. Bethe and C.J. Pethick, "Neutron Star Matter," *Nuclear Physics* **A175**, 225 (1971).
- (8) J.W. Negele and D. Vautherin, "Neutron Star Matter at Sub-nuclear Densities" *Nuclear Physics* **A207**, 298 (1973).
- (9) H. Kozima, "Neutron Drop: Condensation of Neutrons in Metal Hydrides and Deuterides", *Fusion Technol.* **37**, 253 (2000).
- (10) H. Kozima, K. Arai, M. Fujii, H. Kudoh, K. Yoshimoto and K. Kaki, "Nuclear Reactions in Surface Layers of Deuterium-Loaded Solids" *Fusion Technol.* **36**, 337 (1999).
- (11) H. Kozima, M. Ohta, M. Fujii, K. Arai and H. Kudoh, "Possible Explanation of ^4He Production in a Pd/D₂ System by the TNCF Model" *Fusion Science and Technology* **40**, 86 (2001).
- (12) H. Kozima, "Neutron Band in Solids", *J. Phys. Soc. Japan* **67**, 3310 (1998).
- (13) H. Kozima, "Excited States of Nucleons in a Nucleus and Cold Fusion Phenomenon in Transition-Metal Hydrides and Deuterides" *Proc. ICCF9* (to be pub-

lished); *Abstracts of ICCF9*, p.91 (2002).

(14) H. Kozima, J. Warner and G. Goddard, "Cold Fusion Phenomenon and Atomic Processes in Transition-metal Hydrides and Deuterides" *J. New Energy* **6-2**, 126 (2001)

(15) H. Kozima, "Anomalous Nuclear Reactions and Atomic Processes in Transition-Metal Hydrides and Deuterides" *J. New Energy* **6-3** (2002). (to be published)

(16) N.J.C. Packham, K.L. Wolf, J.C. Wass, R.C. Kainthla and J.O'M. Bockris, "Production of Tritium from D₂O Electrolysis at a Palladium Cathode", *J. Electroanal. Chem.* **270**, 451 (1989). (³H detection. The first observation of convincing tritium production. An example of the "gammaless nuclear reactions" widely noticed in the cold fusion phenomenon (CFP). NT_A and GLR)

(17) R.T. Bush, "A Light Water Excess Heat Reaction suggests that 'Cold Fusion' may be 'Alkali-Hydrogen Fusion'" *Fusion Technol.* **22**, 301 (1992). (⁴⁰Ca detection, NT_D and DTS)

(18) I.B. Savvatimova, Y.R. Kucherov and A.B. Karabut, "Cathode Material Change after Deuterium Glow Discharge Experiment", *Trans. Fusion Technol. (Proc. ICCF4)* **26**, 389 (1994). (¹⁰⁷Ag detection, NT_D and DTS)

(19) J. Dash, I. Savvatimova, S. Frantz, E. Weis and H. Kozima, "Effects of Glow Discharge with Hydrogen Isotope Plasmas on Radioactivity of Uranium", *Proc. ICCF9* (2002) (to be published). (Decay-time shortening of ²³⁸U in electrolytic systems)

(20) I.V. Goryachev, "Abnormal Results of Experimenting with Excited Substances and Interpretation of the Discovered Effects within the Frames of the Model of Collective Interactions", *Proc. ICCF9* (2002) (to be published). (Decay-time shortening of radioactive nuclides)

(21) J. Dash, I. Savvatimova, G. Goddard, S. Frantz, E. Weis and H. Kozima, "Effects of Hydrogen Isotope on Radioactivity of Uranium" *Proc. ICENES2002* (to be published). (Decay-time shortening of ²³⁸U in a discharge system.)

(22) J.O'M. Bockris and Z. Minevski, "Two Zones of "Impurities" Observed after Prolonged Electrolysis of Deuterium on Palladium", *Infinite Energy* Nos. 5 & 6, 67 (1995-96). (NT_F)

(23) T. Mizuno, T. Akimoto, T. Ohmori and M. Enyo, "Confirmation of the Changes of Isotopic Distribution for the Elements on Palladium Cathode after Strong Electrolysis in D₂O Solution", *Int. J. Soc. of Materials Engin. for Resources* **6-1**, 45 (1998). (NT_F)

(24) T. Ohmori, M. Enyo, T. Mizuno, Y. Nodasaka and H. Minagawa, "Trans-

mutation in the Electrolysis of Light Water - Excess Energy and Iron Production in a Gold Electrode", *Fusion Technol.* **31**, 210 (1997). (NT_F)

(25) G.H. Miley, G. Narne, M.J. Williams, J.A. Patterson, J. Nix, D. Cravens and H. Hora, "Quantitative Observation of Transmutation Products Occurring in Thin-Film Coated Microspheres during Electrolysis", *Progress in New Hydrogen Energy (Proc. ICCF6)*, 629 (1996). (NT_F)

(26) H. Yamada, S. Narita, Y. Fujii, T. Sato, S. Sasaki and T. Omori, "Production of Ba and Several Anomalous Elements in Pd under Light Water Electrolysis" Proc. ICCF9 (to be published); Abstracts of ICCF9, p.123 (2002). (NT_F and NT_A; Pd → Ba, Pb)

(27) S. Miguet and J. Dash, "Microanalysis of Palladium after Electrolysis in Heavy Water", *Proceedings of 1st Low Energy Nuclear Reactions Conference*, College Station, Texas, p. 23 (1995) (NT_A; Pd → Cd).

(28) R. Kopecek and J. Dash, "Excess Heat and Unexpected Elements from Electrolysis of Heavy Water with Titanium Cathodes", *Proceedings of 2nd Low Energy Nuclear Reactions Conference*, College Station, Texas, p. 46 (1996) (NT_A; Ti → Cr).

(29) J. Warner and J. Dash, "Heat Production during the Electrolysis of D₂O with Titanium Cathodes", *Conference Proceedings 70 (Proceedings of 8th International Conference on Cold Fusion, Lerici, Italy)*, p.161 (2000) (NT_A; Ti → Cr).

(30) Y. Iwamura, M. Sakano and T. Itoh, "Elemental analysis of Pd Complexes: Effects of D₂ Gas Permeation" *Jpn. J. Appl. Phys.* **41**, 4642 (2002) (NT_A; Cs → Pr, Sr → Mo)