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The Cold Fusion Phenomenon as a Complexity (3) – Characteristics of the Complexity in the CFP –

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Abstract

Complexity in the cold fusion phenomenon is investigated using several experimental data sets and its characteristics are determined. It is shown that the density *n* of the trapped neutrons (quasi-free neutrons in CF materials) assumed in the TNCF model is used as the parameter of recursion relations in the nonlinear dynamics in which bifurcation and chaotic behavior are mathematically investigated very well. Thus, the CFP has to be investigated taking nonlinear dynamical point of view into consideration.

1. Introduction

In the previous paper [1], we have shown that the recursion relations in nonlinear dynamics [2] describe fundamental properties of events in the cold fusion phenomenon (CFP), giving mathematical foundation for previous treatments of the CFP as complexity [3 – 6].

The experimental data set of neutron emission obtained by De Ninno et al. [7] was analyzed as an example showing a recursion function $f(x)$ in the recursion relations

$$x_{n+1} = \lambda f(x_n) \qquad (n = 0, 1, 2, 3, \cdots) \tag{1}$$

and also showing a bifurcation depicted by a logistic difference equation (l.d.e.), a special type of the equation (1),

$$x_{n+1} = \lambda\, x_{n+1} (1 - x_n). \tag{2}$$

In that analysis, the parameter n_n (the suffix n in this notation specifies the neutron) assumed in the trapped neutron catalyzed fusion model (TNCF model) was identified as the variable x_n in Eq. (1) or Eq. (2).

In this paper, we give a unified explanation of typical experimental data sets obtained in the CFP on the basis of the investigation of complexity given in the previous works [1, 3 – 6].

2. Analysis of Typical Experimental Data Sets Showing Characteristics of Complexity

There are several data sets of the CFP showing dependences of observables (physical quantities) on such parameters as time τ, temperature T, the loading ratio η of hydrogen isotopes to host metals (η = D/Pd, H/Ni, etc.), density of neutrons in the material n_n, electrolytic or discharge current density i, and so forth. In this section, we list up typical experimental data sets exhibiting some features of the recursive equations (1) and the l.d.e. (2).

2.1. Data set by De Ninno et al. [7]

The experimental data set obtained by De Ninno et al. shows neutron emission from TiDx samples in dynamical processes of absorption/desorption when the sample temperature T varied between 77 K and the room temperature. As was explained in the previous paper [1], the variations of the neutron emission simulate the characteristics of the l.d.e. [2].

2.2 Data set by McKubre et al. [8]

The experimental data set of excess energy generation in Pd/D_2O + LiOD/Pt electrolytic systems by McKubre et al. [9] is one of the most extensive calorimetric result obtained in this field. The excess power P_{ex} (W/s) has been observed as functions of the loading ratio η (= D/Pd) and electrolytic current density i (A/cm^2) in addition to temporal variation of P_{ex}.

Based on our quantum mechanical investigation, we may assume that the number density n of trapped neutron increases with η which makes the super-nuclear interaction more effective to build up the neutron band below zero [4] when other conditions are kept constant.

We investigate the data by McKubre et al. [9] from this point of view. Then, Fig. 1 shows the temporal evolution of their data [9, Fig. 5] which is to be compared with the inserted figures of Fig. 2 of [1].

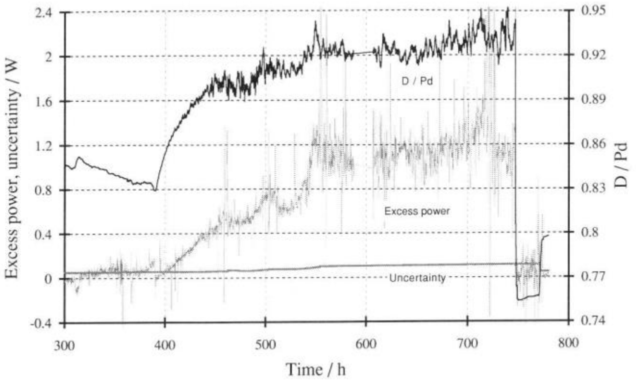

Fig. 1. Variation of Excess Power, Uncertainty and Loading ratio [9].

In the initial part from 400 to 550 h of Fig. 1, the loading ratio η increase from 0.8 to 0.92 and the excess power P_{ex} increases up to about 0.8 W while with a burst at around 460 – 470 h. This increase of P_{ex} with η (or n_n in our interpretation) reminds us the recursion function $f(\mathrm{x})$ shown in Fig. 1 of [1]; the excess power P_{ex}, which is proportional to n_n, increase with n_n until a point n_n where $f(n)$ becomes a maximum.

The bursts of P_{ex} appear while η does not change much as we see in Fig. 1. We may interpret these variations of P_{ex} as a presentation of bifurcation as appeared in inserted figures of Fig. 2 of [1] in the case of the l.d.e.

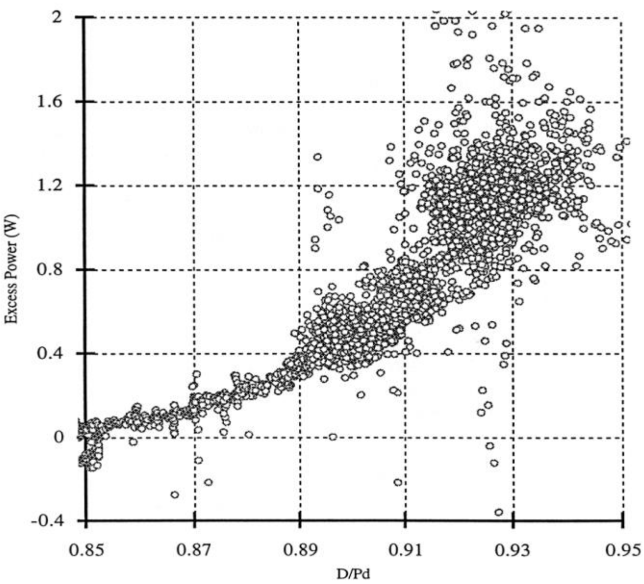

Fig. 2 Variation of Excess Power with Loading ratio [9]

Figure 2 shows the variation of the excess power P_{ex} as a function of the loading ratio [9, Fig. 7]. The excess power depicted in this figure shows such a chaotic behavior for $\eta > 0.89$ as appeared in "Chaotic region" of Fig. 2 of [1].

Furthermore, there appear several chaotic behavior at $I \simeq$ 0.1, 0.4, 3.9, 5.1 and 7.1 in Fig. 3 where are plotted P_{ex} vs. cell current I. As far as we know at present, there are no explicit relations between the cell current I and the parameter n (density of the trapped neutrons) we used to explain Fig. 1 and 2. The occurrence of the chaotic behavior in Fig. 3 may be accidental depending on other uncontrollable factors in the system.

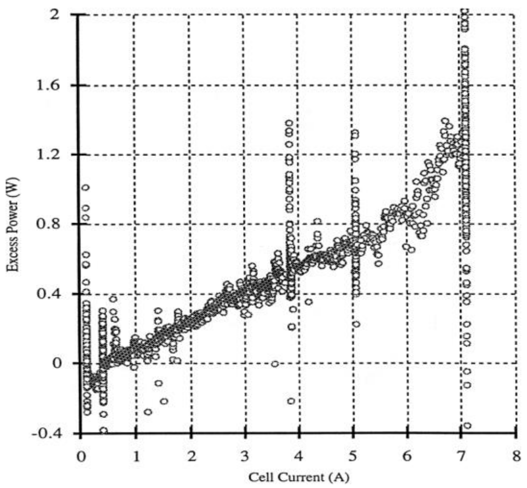

Fig. 3 Variation of Excess Power with Cell Current

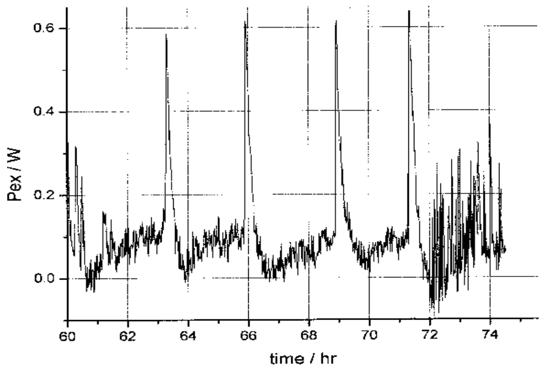

Fig. 4. Excess power pulses during a 14 hour period of an experiment (070108) which lasted 12 days as a whole.

2.3 Data set by Dash et al. [6]

Experimental data set of the excess energy in $Pd/D_2O + H_2SO_4/Pd$

electrolytic systems by Dash et al. [6] gives another illustration of complexity in the CFP. They observed temporal variations of P_{ex} with bursts up to 20 W as shown in Fig. 4 similar to those observed by McKubre as shown in Fig. 1.

These features of the excess power P_{ex} as a function remind us the behavior of the l.d.e. as shown in inserted figures of Fig. 2 of [1] as pointed out already in relation to Fig. 1 in Section 2.2.

With a statistical treatment of the data sets obtained by Dash et al., we could show bifurcation of the excess power generation in Fig. 5 [6]. To plot this figure, we assumed that the amount of excess power increases with temperature of the sample generalizing property of the system that P_{ex} is finite only if the temperature of the system is higher than a critical temperature $T_c \simeq 90$ degC.

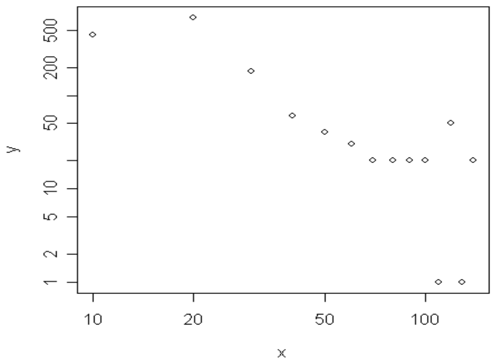

Fig. 5. Distribution of the frequency N_P (= y) producing excess power P_{ex} (= x). To depict log-log curve, values of N_P and P_{ex} were arbitrarily multiplied by 10^n. (x = 100 in this figure corresponds to P_{ex} = 1 W).

The behavior of P_{ex} depicted in Fig. 5 illustrates explicitly the bifurcation of the state in the l.d.e. appeared at 3 < b < 3.4 in Fig. 2 of [1].

2.4 Positive Feedback of Nuclear Reactions in the CFP

We have shown several examples of the bifurcation (or bifurcation-like behavior) of the CFP in experimental data sets in the above subsections. In these figures, the bursts of signals corresponding to the branch of Fig. 5 or Fig. 2 of [1] may be realized by upper more effective positive feedbacks to increase the population or density than the lower branch.

Even if the bursts of the excess power generation in Figs. 1 and 4 and of the neutron emission in Fig. 2 of [7] have finite heights, we may suppose cases where they increase without limit not restrained by any negative feedback thus resulting in explosions.

2.5 Explosions observed in the CFP

There are several reports of explosions in the CFP. The first group of the explosion is comparatively well analyzed [10, 11]. In these cases, the Pd cathodes were narrow cylinders similar to that used by Dash et al. [6].

The positive feedback observed in the excess power bursts appeared in Fig. 4 might be effective to raise the sample temperature especially due to the specific shape (cylinder) of the cathodes and finally to induce explosions in these cases [6].

The second group of the explosion is composed of the cases observed by Fleischmann et al. [12] and by Mizuno et al. [13]. These explosions occurred in experiments with cathodes with simple geometry in ordinary electrolytic system Pd/D_20 + LiOD/Pd and in plasma discharge system W/H_2O + K_2CO_3/Pt with a voltage of 350 V. These data may be explained by the similar mechanism to that sued in the first group while we do not have enough data to discuss them, further.

Another explosion observed in SRI reported by Smedley et al. [14] might be classified to the second group if it is related to nuclear reactions in the Pd cathode.

3, Conclusion

Several events of the CFP have explained by characteristics of complexity assuming that the parameter n of the TNCF model corresponds to the variable of the recursion relations (1).

The TNCF model has been effectively used to explain semi-quantitative relations between observables in the CFP. The investigation given in this paper has shown again ability of the idea contained in the model to explain some characteristics of the CFP as complexity. This result clearly shows that events in the CFP does not have quantitative reproducibility but qualitative or statistical one common to many-body systems.

The assumption of the parameter n_n as a variable in the recursion relations (1) will be investigated in following works.

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