Interface Model of Cold Fusion

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Abstract

The interface theory of cold fusion is a variant of Ion Band State (IBS) Theory.[1] It models Bloch symmetry deuterons in a 2-dimensional metal lattice instead of the 3-dimensional metal lattice first used. Both IBS variants recognize that the required lattice symmetry has limited extent, with the reactive deuterons being bound inside a closed volume like a box. The reactive deuterons are confined within classical turning point boundaries, while within the box their density distributions are modulated by a lattice array potential. Strictly speaking, the IBS fusion theory is a many-body theory. Nuclear dd fusion is one of several LENR processes. Some LENR processes do not require many-body ions and support room temperature nuclear reactions using light ions in single-particle Bloch geometry. For example, the decay of metastable single-body Bloch-function ^{8}Be seems to be the source of MeV alphas in Oriani's light/heavy water electrolysis, and in several co-deposition electrolysis CR39 studies, as described in *ICCF14 Abstracts*.[2] The Oriani MeV alphas are side products of both light water and heavy water electrolysis, using either Pd or Ni cathodes, as shown in highly repeatable tests. Bloch ^{8}Be is likely the nuclearly reactive component in the final step of the Iwamura *et al.* transmutation studies.[3] Despite differences, all LENR systems seem to share some essential physics.

The essential feature that seems to be shared by all LENR processes is a need to produce coherently partitioned light "atoms", where coherent partitioning means the type of partitioning that occurs when a low density Bose condensate becomes partitioned in an optical lattice.[4] As applied to LENR, a coherently partitioned atom means a coherently partitioned ion neutralized by coherently partitioned electron(s). Superfluid behavior marks the presence of coherently partitioned atoms in Bose condensates in lattices. To behave as a superfluid, Bose condensate atoms must occupy a lattice that consists of a communicating network of shallow potential wells that are separated by potential barriers low enough to allow tunneling. Also, the number of Bose atoms in the lattice must be smaller than the number of potential wells, or must be a non-integer times the number of potential wells. The atoms must be indistinguishable in the Pauli sense, i.e., when 2 "indistinguishable" particles collide and move apart, neither of the receding particles can be identified as one of the incident particles. Indistinguishable particle interactions must be modeled using 2-particle wave functions that express coordinate exchange symmetry.

The challenge to LENR experimenters is to create a nuclear reactive environment. In practice, this means to create conditions involving a metal solid that causes coherent partitioning of a feedstock atom. This means that the configuration of the atom must become describable by a wave function with many equivalent centers. One must create "many-centers" nuclei neutralized by many-centers electrons. A particle is best thought of as a "quantum-of-mass". A quantum of electron mass, if localized, is called an electron; if delocalized in a Bloch configuration it can be called a quasiparticle electron. If 2 quasiparticles interact, their interaction cannot be modeled using an expansion of wave functions around a single center-of-mass. When the interaction is nuclear, the nuclear physics cannot be calculated using a sum over wave-function spherical harmonics about a center-of-mass. This means that quasiparticle-quasiparticle nuclear interactions cannot be modeled using the standard center-of-mass expansions of classical nuclear physics. This incompatibility is a major factor in the nuclear physics community's failure to understand cold fusion. It is also the reason that dd cold fusion reactions do not result in emission of energetic particles or γ-rays.

Providing a nuclearly active environment for reactive deuterons means the same as providing an environment that catalyzes a geometric change in a "D-atom" from a single-center geometry to a many-centers geometry. One strategy is to place deuterons inside a solid which has a very stable and regular lattice symmetry. The first geometry that seems to have catalyzed cold fusion is a 3-dimensional fcc Pd metal lattice with each of its octahedral sites occupied by an interstitial deuteron. In Fleischman-Pons cold fusion, overpotential electrolysis of a D_2O electrolyte deposits deuterons onto a Pd metal cathode to create this environment. Further added deuterons then occupy a communicating network of unit cells containing 2 shallow tetrahedral sites and the periphery of one octahedral site. This paper describes a second strategy. It argues that an interface between an ionic crystal and sputtered Pd metal can provide a 2-dimensional many-centers geometry using equilibrium chemistry. The ZrO_2,nanoPd catalyst developed at Tohoku U. seems to be of this type.[6]

This paper applies IBS theory to many-body interface deuterons located between a ZrO_2 crystal face and a Pd nanocrystal. Photomicrographs of ZrO_2,nanoPd catalyst show fragmented Pd nanocrystals embedded in larger ZrO_2 crystals. At some of the contact surfaces the Pd metal is assumed to have formed an epitaxy fit onto the ZrO_2 substrate.[7] Epitaxy makes an unusually stable, low energy first layer of Pd on the ionic crystal surface. Above the epitaxy Pd layer are transition layers containing interstitial deuterons and vacancies, and above the transition layers is fcc cubic Pd metal. The interface + transition layer constitutes an energy minimizing configuration, and incidentally provides a major reservoir for non-reactive absorbed deuterium.

The stability of the epitaxy Pd layer on a ZrO_2 crystal face is caused by the large negative Gibbs free energy of ZrO_2, and the relative malleability of nanoPd. The stability of the interface is not damaged by its hosting an extremely thin layer or sheet of D^+ quasiparticles (D^+_{Bloch} ions) between the metal oxide and the epitaxial metal layer. The D^+ quasiparticle sheet is extremely thin and resides harmlessly between the epitaxy Pd layer and the ZrO_2 crystal. Normal diffusing deuterons become D^+_{Bloch} ions when they encounter this strictly ordered environment. When a D^+_{Bloch} ion transitions to quasiparticle geometry, it becomes neutralized by an electron quasiparticle, which forces the epitaxy layer to move away from the ZrO_2, but only by about a 0.001 fraction of a metal layer. The resulting layering is: 1) ZrO_2 crystal, 2)

D^{+}_{Bloch} "atom" sublayer, 3) epitaxy Pd layer, 4) transitional Pd layers with interstitial D atoms, 5) fcc Pd nanocrystal.

IBS theory as applied to ZrO_2 + nanoPd interfaces preserves 2-dimensional periodic symmetry. The modeling uses stationary state quantum mechanics and many-body physics. The physics could be called “semi-classical” quantum orbital physics. In atom physics, the word "orbital" does not imply electrons in planetary orbits around a nucleus. Instead, it implies a set of negatively-charged electron wave functions pulled as densely as possible on top of a positively charged nucleus. It is a mistake to think of an atom as being mostly empty space. Instead, it is jam packed with electron charge-density matter. An atom appears as empty space only to a high energy impacting nucleus or γ-ray. Electron density is limited by Pauli exclusion. Atom structure is determined by system energy minimization.

Atom quantum mechanics teaches us about *s*, *p*, *d*, ….wave function states. Each wave function describes an electron density distribution. The distribution is a matter field, i.e., has a value at every point is space. The electrons in H, He, Li, and Be are all in *s*-states. Each *s*-electron has spherical symmetry. The boron atom adds a non-spherical *p*-electron. The *p*-electron is coherently partitioned between two equal volume potential wells. Half the *p*-electron’s density is in one potential well, half is in the other, with zero electron density centered on the boron nucleus where the 2 potential wells touch. One must sum over both potential wells to recover the electron. In other words, boron's *p*-electron displays coherent partitioning behavior.

Figure 1. Density distribution of p-electron orbital in boron. Calculation by D. T. Cromer.

In IBS fusion Bloch deuterons, like *p*-electrons, are coherently partitioned. The IBS Bloch deuterons must be coherently partitioned into 1000 or more potential wells to avoid a Coulomb barrier. Energy minimization calculations show that a deuteron many-body wave function with more than 1000 potential wells will have no Coulomb barrier. Instead, the wave function expresses coordinate exchange symmetry and wave function overlap.

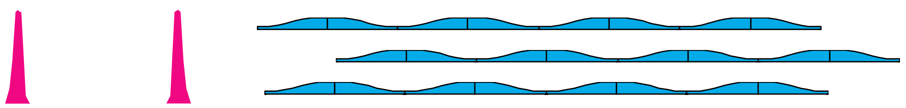

Figure 2. D_2 Molecule. D^{+}_{Bloch} Quasiparticle(s) inside an Interface

The reason that energetic particles and γ-rays do not occur in cold fusion is that they cannot exist as coherently partitioned entities at lattice spacing. Their deBroglie wavelengths are too small. Therefore they cannot be part of the initial and final state wave functions, as required for reaction. The dd-fusion transitions are restricted to transitions that preserve spin and nuclear angular momentum. Unlike hot fusion, the likely dd-fusion initial configuration is a spin-zero pair or pairing, which then undergoes a 0^+ to 0^+ density-distribution changing transition.

Quasiparticle ^4He can exist in either (pn,pn) or (pp,nn) nuclear geometry. The initial spin-zero D^+_{Bloch} pairing has (pn,pn) geometry, which is the same as (d,d) geometry. The first transition collapses the wave function from potential well dimensions to nucleus dimensions, creating a metastable excited $^4He^{++}_{Bloch}$ nucleus. A minimal transfer of energy occurs during this step. Transfer of the remaining 23.8 MeV to the metal lattice requires a cascade of transitions between sequential metastable states, with rates determined by the Fermi Golden Rule.

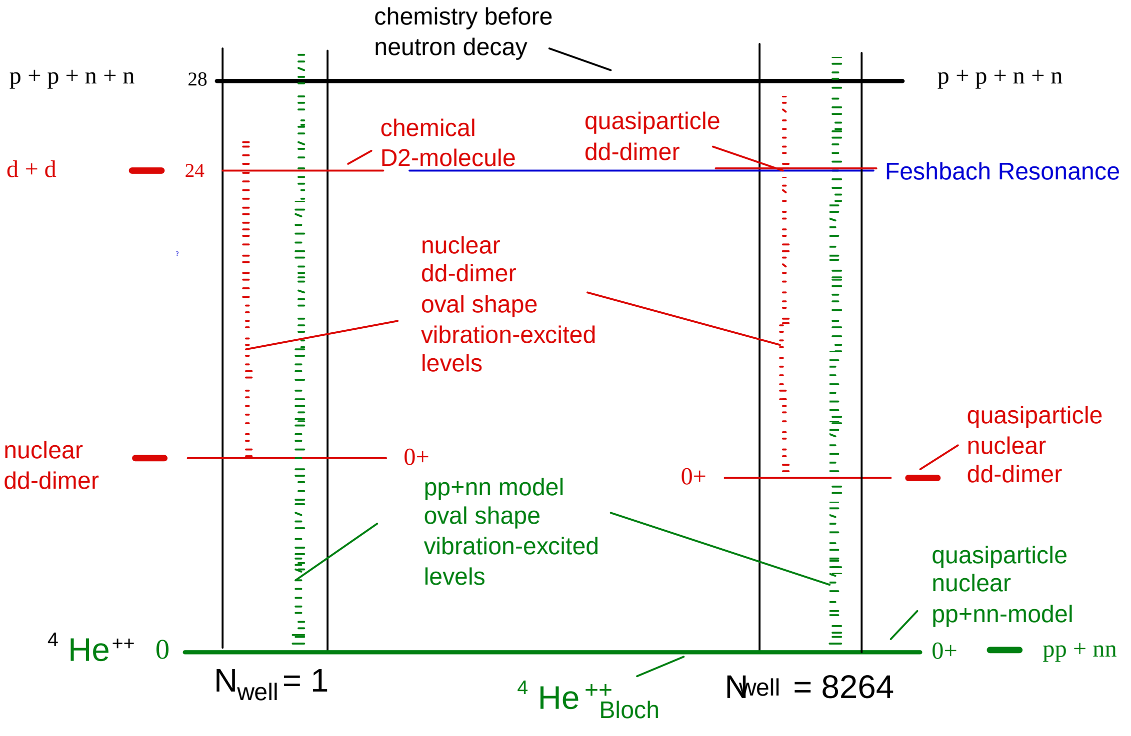

Figure 3. Energy level diagram for d+d and pp+nn ^4He in single-center and Bloch geometry.

When a diffusing deuteron transitions to Bloch geometry configuration within a ZrO_2 + nanoPd interface, energy minimization requires an accompanying Bloch electron. If N_{well} = 1000, Pauli exclusion requires the Pd epitaxy metal layer to jump back by 0.001 metal layer thickness. The jump is a momentum shock that pushes ZrO_2 and nanoPd crystallite apart, sometimes stimulating an irreversible energy transfer from an initial state Bloch deuteron many-body system to a hosting metal lattice. Even a small energy transfer makes the fusion reaction irreversible.

The partitioned electrostatic force between two quasiparticle deuterons decreases with N_{well}. Therefore work done to bring deuterons into contact decreases with N_{well}. [In each well $F_{12}=e^2/r_{12}^2 N_{well}^2$. Summing over potential wells gives $F_{12}=e^2/r_{12}^2 N_{well}$.] Therefore, a coherently partitioned $^4He_{Bloch}$ product is more stable at higher N_{well}. This lowering of nucleus ground state energy makes the flakelike nuclear product seek larger N_{well}.[2,3]

The wave function boundary within which a D^+ many-body system resides is subject to quantum fluctuations. Boundary fluctuations which change bound volume also change N_{well}. Fluctuations in N_{well} cause the energy of (pn,pn) $^4He^{++}{}_{Bloch}$ to fluctuate, which can "scan" the energy of a nuclear configuration wave function state across the energy of the dd pairing initial state. This phenomenon creates a transient Li-Feshbach energy-match resonance. Scanning across a Feshbach resonance causes geometric change accompanied by a small transfer of momentum + energy to the hosting lattice. A small energy transfer makes the reaction irreversible.

As shown in the energy level chart, quasiparticle ^4He exists in both (pn,pn) and (pp,nn) nuclear geometries. The initial spin-zero $D^+{}_{Bloch}$ pairing has (pn,pn) geometry. The first transition collapses the wave function from potential well dimensions to nucleus dimensions, creating a metastable excited $^4He^{++}{}_{Bloch}*$ nucleus. Transfer of 23.8 MeV to metal lattice requires a cascade of transitions between metastable states, with rates determined by the Fermi Golden Rule.

The interface model suggests that the following transitions are supported by 2-dimensional symmetry LENR. The asterisk designates a metastable excited nuclear state. Unbalanced charges reflect electron quasiparticle configuration changes.

1) $D^+{}_{Bloch} + D^+{}_{Bloch} \rightarrow {}^4He^{++}{}_{Bloch}*$ dd fusion reaction
2) $D^+{}_{Bloch} + {}^6Li^+ \rightarrow {}^8Be^{++}{}_{Bloch}*$ Oriani heavy water reaction
3) $H^+{}_{Bloch} + {}^7Li^+ \rightarrow {}^8Be^{++}{}_{Bloch}*$ Oriani light water reaction
4) $^8Be^{++}{}_{Bloch}* \rightarrow {}^8Be^{++*}$ degradation of lattice symmetry creates a preferred mass center
5) $^8Be^{++*} \rightarrow {}^4He^{++} + {}^4He^{++}$ fission creates 2 alphas in CR39
6) $^4He^{++}{}_{Bloch} + {}^4He^{++}{}_{Bloch} \rightarrow {}^8Be^{++}{}_{Bloch}*$ second step in Iwamura reactions
7) $^8Be^{++}{}_{Bloch} + {}^{133}Cs^+ \rightarrow {}^{141}Pr$ Iwamura alpha addition transmutation step

The synthesis reactions are promoted by scanned Li-Feshbach resonances. Reactions 1 and 6 occur in co-deposition experiments. Premature separation of $^8Be^{++}{}_{Bloch}*$ from its hosting interface leads to a flakelike neutral atom $^8Be_{Bloch}*$, which can diffuse through liquids and solids. Reaction 7 requires a cascade of energy transfers to a hosting lattice. Some of the available excited nuclear states of $^8Be*$ are shown in an energy level chart provided by Heyde.[8]

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