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III. Bloch Nuclides, Iwamura Transmutations, and Oriani Showers

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ABSTRACT

The Iwamura et al. 2-alpha addition transmutations[1] and the Oriani-Fisher energetic particle showers[2] demand an explanation. They both depend on the same physics as responsible for cold fusion, namely the coherent partitioning of deuteron charge when the deuteron assumes a Bloch-like form and becomes distributed among a large number N_{well} of potential wells. As a result the work required to bring the 2 "nuclei" into contact is reduced by $1/N_{well}$. In cold fusion 2 spin-zero paired deuterons fuse as per $2\text{-}D^+_{Bloch} \rightarrow {}^4He^{++}_{Bloch}$ + 23.8 MeV. In the Iwamura process 2 ${}^4He^{++}_{Bloch}$ fuse as per $2\text{-}{}^4He^{++}_{Bloch} \rightarrow {}^8Be^{4+}_{Bloch} + E_{nuc}$, in a Bloch-sensitive reaction where reaction energy E_{nuc} is a function of N_{well}. Deuteron cold fusion is not Bloch sensitive because the reaction changes the coordinate exchange symmetry pairing. A Bloch-sensitive fusion product is mobilized to seek a larger number of hosting wells. This causes ${}^8Be^{4+}_{Bloch}$ migration to a surface where Cs^+ ions protruding above the surface are overlapped. They add the ${}^8Be^{4+}_{Bloch}$ product in an exothermic reaction. In an Oriani process the ${}^8Be^{4+}_{Bloch}$ detaches from its hosting surface, dissolves, forms clusters, and gets suspended in off-gases as a flake nucleus with 2-dimensional periodic symmetry. Its geometry and internal nuclear excitation spectrum cause a normally forbidden energy transfer from gas to flake, until the increasingly energized ${}^8Be^{4+}_{Bloch}$ fissions into a pair of MeV alpha particles.

IWAMURA TRANSMUTATIONS

We first model the Iwamura transmutation process. In the Iwamura transmutation process deuterium permeates a plate reactor containing 5 internal CaO diffusion-inhibiting layers. It produces a slow transmutation of a surface layer of Cs atoms into Pr atoms by a two-alpha addition reaction The process involves 4 steps. First is a fusion of 2 D^+ into ${}^4He^{++}$. It is followed by the fusion of two ${}^4He^{++}$ into ${}^8Be^{4+}$, the migration of the ${}^8Be^{4+}$ to the plate's surface, and the absorption of the ${}^8Be^{4+}$ by a surface-deposited Cs atom. The deuterons, ${}^4He^{++}$ and ${}^8Be^{4+}$ are all in Bloch form. The starting reaction is a 2-dimensional symmetry version of the Fleischmann-Pons (F-P) Bloch-function cold fusion reaction.

The final-state product of F-P fusion is ${}^4He^{++}$ in a coherently partitioned Bloch-wave form. ${}^4He^{++}$ is an alpha particle and has zero spin. If coherently partitioned ${}^4He^{++}$ is created from coherently partitioned D^+, it seems reasonable to assume that partitioned ${}^8Be^{4+}$ can be created from partitioned ${}^4He^{++}$. The ${}^8Be^{4+}_{Bloch}$ product is a Bloch-sensitive nucleus, since no change in coordinate exchange symmetry and no spin change accompanies its creation. The 2 alpha-fusion reaction requires that the partitioned ^{8}Be nucleus be stable. Non-partitioned ^{8}Be is unstable by about 0.09 MeV.[3] It is unstable because the work of bringing two ^{4}He nuclei together is greater that the energy release accompanying the merger of the two $^{4}He^{++}$, by a difference of 0.09 MeV. The charge repulsion work is about 1.5 MeV, which means that the nuclear energy made available by merging the two ^{4}He nuclei is about 1.4 MeV. However, double Bloch symmetry means that the charge repulsion work is reduced by having the $^{4}He^{++}$ partitioned. Therefore, at large N_{well} the partitioned nuclear product should be stable. Since Bloch $^{8}Be^{4+}$ is Bloch-sensitive, a decrease in free energy drives an expansion and migration, which delivers it to the metal surface. In contrast, the F-P fusion product $^{4}He^{++}{}_{Bloch}$ is not Bloch-sensitive, hence remains within the interface subsystem where it was created.

Transmutation occurs when the expanding $^{8}Be^{4+}{}_{Bloch}$ overflows an above-surface $^{133}Cs^{+}$ ion in its path. A suitably deposited sub-monolayer Cs atom loses its valence electron to the Pd metal and resides as an above-surface ion. The expanding $^{8}Be^{4+}{}_{Bloch}$ overlaps the Cs nucleus, encountering a deep nuclear potential well. Because of partitioning, there is only a small amount of positive charge within the single charge-density maximum of the $^{8}Be^{4+}{}_{Bloch}$ where it overlaps the Cs nucleus. The Coulomb repulsion between the Cs nucleus and this small amount of charge is insufficient to destroy the coherency of the $^{8}Be^{4+}$ Bloch state at large N_{well}. Minimization of system energy is the reason that overlap occurs. The $^{8}Be^{4+}{}_{Bloch}$ and the localized ^{133}Cs nucleus form a composite state, i.e., Bloch ^{8}Be + localized ^{133}Cs. After a first scattering interaction with the lattice at the $^{8}Be^{4+}{}_{Bloch}$ boundary, a mixed quantum state describes the composite state. The N_{well} fluctuation process transfers the exothermic reaction energy to the lattice, producing a ^{141}Pr stationary state nucleus. Spin considerations seem to suggest that the product state should be a spin 7/2 state, whereas the ^{141}Pr ground state nucleus is spin 5/2. It may be that the product state is ^{141}Pr spin 7/2, which is metastable by 145 keV.

ORIANI SHOWERS

We now model the Oriani showers. Oriani showers are characterized by the observation of MeV-energy decay particles recorded as tracks in CR-39 plastic. The showers are an occasional and anomalous result of F-P electrolysis. There have been repeated observations by Oriani of the MeV-energy particle showers. They demand explanation. The showers are a more challenging problem than the crude modeling of F-P cold fusion and the Iwamura transmutations. Like the Iwamura process, the phenomenon depends on coherent partitioning. But while the fusion and transmutation processes require only a clarification of the protocol used to mathematically describe the wave function of a coordinate-exchanged 2-body Bloch system at large N_{well} (double Bloch symmetry), modeling of the Oriani showers explores new physics in the interaction between a coherently-partitioned nucleus and a Maxwellian gas. The modeling questions the applicability of the Second Law of

Thermodynamics in an unusual sequential-scattering process that preserves micro-reversibility.

The Oriani observations are illustrated in the following quotes. Oriani and Fisher write, "Approximately 40,000 energetic charged particles were recorded in a pair of plastic detector chips suspended in vapor above an active electrolysis cell. .... Analysis of track orientations indicates that the shower originated in a compact source in the vapor between the chips. ... duration is estimated to have been a few seconds. Analysis of etch pit cone angles and angles indicates that the tracks were produced by 2 MeV alpha particles." Concerning other studies they wrote, "The detected particles carried energies in the range of a few MeV, indicating that they must have arisen in nuclear reactions. Evidence for such reactions was found in deuterium gas behind a palladium cathode that served as part of the cell enclosure, in air behind similarly disposed palladium and nickel cathodes, in air beyond the glass well of the electrolysis cell, and in oxygen gas above the anode when the anode and cathode were placed in separate arms of a U-tube cell." Regarding an earlier experiment they wrote, "We focus attention on one experiment with four detector chips suspended above the H_2O solution of Li_2SO_4 with Pd as cathode material. Two of these chips developed track densities considerably above levels in the range of controls, but the other two showed enormous numbers of tracks on the sides facing each other and much smaller numbers of tracks on their rear sides."

It is difficult to explain the shower observations without building on the modeling of the Iwamura transmutations. The key ingredient is the Bloch-sensitive nucleus with 2-dimensional Bloch symmetry. In the case of Oriani's D_2O experiments the Bloch-sensitive nucleus seems most likely to be the same partitioned ^8Be responsible for Iwamura's alpha-addition transmutations, i.e., $^8Be^{4+}{}_{Bloch}$. Each Bloch nucleus is in the form of a flake 1-nucleus thick and extending over maybe a 10-micron-square area. Electrolysis off-gas leaving the metal separates the flakes from the metal surface that had served as a template for their formation. Since water is a polarizable liquid, the flakes dissolve in the water and do not immediately transfer out of their Bloch form, with its multiple charge-density-maxima configuration. Groups of flakes get tangled up, forming clusters. The dissolved cluster gets embedded in the gas evolving from either the cathode or anode gas-evolving electrode. This set of behaviors seems required to create nuclearly unstable gas-borne clusters, as required to explain Oriani's observations.

Interestingly, Oriani also observes MeV showers in light water electrolysis studies. In this case, my view is that the Bloch-sensitive nucleus is likely Bloch ^2He, which is the coherently-partitioned form of the normally unstable spin-paired double proton. Like the ^8Be nucleus, the ^2He nucleus of impact nuclear physics is unstable. However, both $^8Be^{4+}{}_{Bloch}$ and $^2He^{++}{}_{Bloch}$ are Bloch-sensitive nuclei. In both $^8Be^{4+}{}_{Bloch}$ and $^2He^{++}{}_{Bloch}$, coherent partitioning reduces the Coulomb work needed to bring the precursor nuclides into contact. Therefore, it is probable that $^2He^{++}{}_{Bloch}$, like $^8Be^{4+}{}_{Bloch}$, becomes stable at large N_{well}.

ENERGIZING FLAKE NUCLEI

None of the above explains why a cluster of Oriani flakes decays into a shower of MeV particles. The challenge is that it seems difficult to see how Bloch nucleus flakes can be energized by the cold fusion process. It seems especially difficult for the light water case, since no exothermic proton fusion process has been identified. A different energizing process seems required.

Consider the case where the nuclear product is two ~3-MeV alpha particles produced by fission of a $^{8}Be^{4+}_{Bloch}$ flake. Neglecting the possibility of a resonance transition, a Bloch nucleus in the form of a flake starts out as a stable, well-ordered ground-state quantum system. At large N_{well}, it could be in a low energy nucleus state, which might be stable by as much as 1 MeV. Consider the internal structure of $^{8}Be^{4+}$. The energy level chart for $^{8}Be^{4+}$ is shown in Heyde[3] to contain 2 relatively low lying spin-zero states, first, the previously mentioned state that is endothermic relative to zero-velocity free alpha particles by 0.09 MeV, and second, a spin-zero state endothermic by about 6 MeV. See Fig. 1. The 6-MeV state is shown as being broadened to a width of 0.8 MeV by pre-dissociation into two alphas. This means that the flake has a very short life, of the order of 10^{-20} s, in accord with Planck uncertainty. It means that the state can be transiently occupied as a virtual state in violation of conservation of energy.

To explain the Oriani particles one is forced to consider a non-standard type of energy transfer from a Maxwellian gas to a flake nucleus. One must envision the flake acting as a Maxwell demon, presumably because of the wide spacing between internal energy levels and because of the flake's formal 2-dimensional symmetry structure. Single atoms are considered to collide elasticity with the flake, as if bouncing off a rigid wall. They have too little energy to excite the nucleus. Exceptionally energetic collisions are viewed as being able to transfer energy to and from the nucleus, exciting the nucleus to higher or lower energy states. On the balance, the transitions go to higher energy levels, since a higher density of such levels is available. The internal energy of the nucleus gradually rises. Since only the highest energy collisions can contribute energy to the flake, the flake acts as a Maxwell demon, cooling the flake in apparent violation of the Second Law of Thermodynamics, but not in violation of excitation,de-excitation micro-reversibility. It can be argued that none of the molecule-flake impacts have enough energy to excite any of the nuclear transitions indicated in Heyde. Such may be the case. However, the discontinuous motion of suspended fine particles undergoing Brownian motion suggests that abrupt, relatively large energy transfers can occur between gas and a suspended macroscopic object. Also, it may be that bending or other deformation of a flake can add a fine structure to the flake's set of energy levels that goes beyond the Heyde treatment, while still preventing the flake from being responsive to low energy molecule collisions. Clearly the Maxwell demon process is very speculative. However, one notes that the successful cooling of trapped atoms in the manufacture of atom Bose-Condensates is also a Maxwell demon type process, in that only the fastest moving atoms participate in energy transfer collisions during the laser cooling step.

If the Maxwell demon process operates, the flake nucleus rises in energy until it gets to a high enough energy that it can transition to the pre-dissociated 6-MeV state. The Bloch wave function collapses to single maximum form, and fissions, producing a pair of ~ 3-MeV alphas, each of which loses energy to the gas before hitting a CR-39 plate. If a $^{2}He^{++}_{Bloch}$ flake is energized by the same type process, energetic protons would be the Oriani-observed fission product. Proton tracks can be difficult to distinguish from alpha tracks of a different energy. Showers are the result of flake fissions within a cluster. A first fission energizes its companions, leading to a sequence of flake decays.

^{8}Be SYNTHESIS AND FISSION

The ^{8}Be nucleus teaches reaction phenomena responsible for low energy nuclear reactions. Properties of ^{8}Be nucleus are shown in Fig. 1.

Li-Feshbach RESONANCE

X-Z Li has shown that deuterons can tunnel through a Coulomb barrier to nuclear dimension if they are in energy resonance with a nuclear state for a sufficiently long time. Implicit is the presence of a very narrow resonance (width << 100 eV), i.e., a resonance not broadened by a strong coupling to dissipation modes.[4] The dissipation can be characterized by an imaginary term in the nuclear potential. In the Bloch-ion scenario, fusion of side-by-side ions play no role. With superposed ions, there no Coulomb barrier. Instead the 2-body wave function has an anti-correlation factor. Nonetheless, Li's sharp resonance picture provides a useful way of envisioning the interaction between two free-space alpha particles interacting with a coherently partitioned ^{8}Be nucleus, as shown in Fig. 1.

The Bloch Ion picture describes two types of nuclei, Bloch-insensitive nuclei and Bloch-sensitive nuclei. $^{4}He^{++}_{Bloch}$ is Bloch insensitive, because of the stability introduced by the exothermic formation of spin-paired protons and spin-paired neutrons. $^{8}Be^{4+}_{Bloch}$ is Bloch sensitive because no such strongly exothermic change in exchange symmetry takes place in its creation. The Bloch-insensitive nucleus has the same energy whether it is in single potential well form or is in a coherently partitioned form. Therefore, increasing the coherent partitioning of the $^{8}Be^{4+}_{Bloch}$ wave function shifts the energy states of the $^{8}Be^{4+}_{Bloch}$ relative to that of 2-$^{4}He^{++}_{Bloch}$, as shown in Fig. 1. By increasing N_{well} one causes $^{8}Be^{4+}_{Bloch}$ to scan a sequence of vibration excitation states into and out of resonance with identically partitioned, fixed-energy 2-$^{4}He^{++}_{Bloch.}$ The result is a sequence of Feshbach-resonance energy-balance crossings, allowing nuclear configuration changes to occur at nuclear-reaction time scale, without simultaneous energy transfer to the lattice.

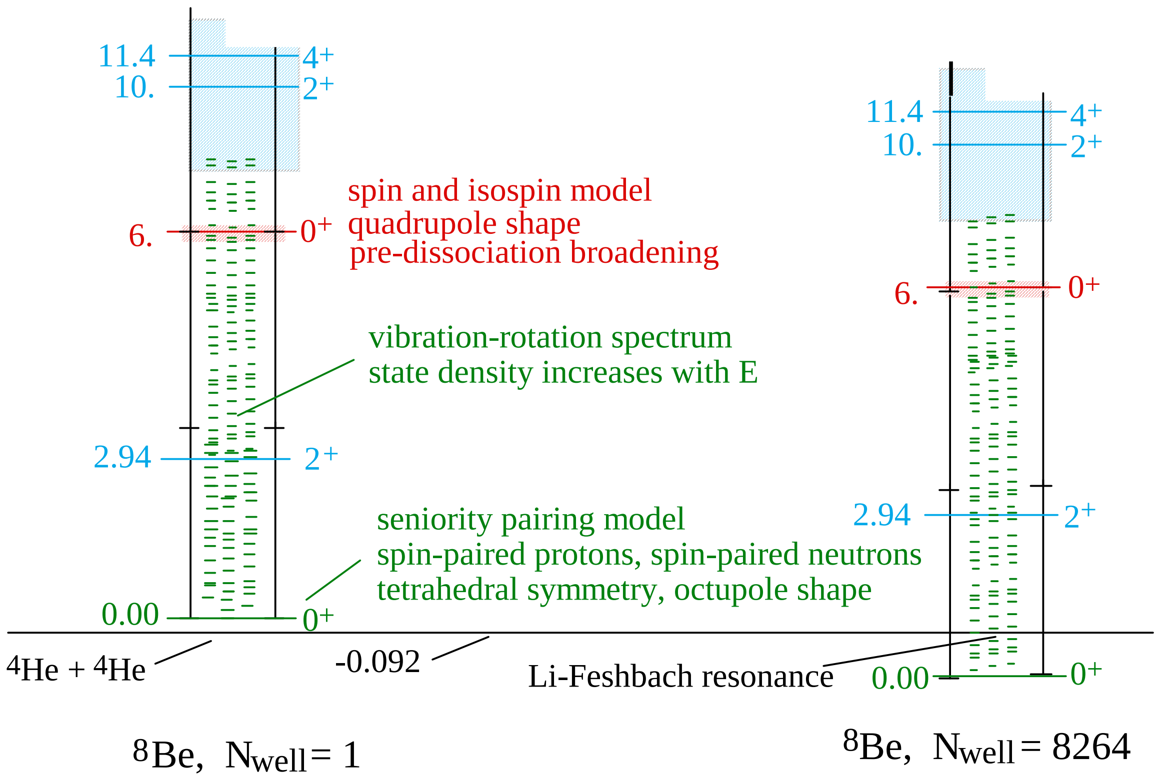

Fig. 1 **Energy level diagram** of ^{8}Be presented by Heyde (1994), and extended by interpretation and Bloch modeling. The downward shifted diagram on the right shows spin-zero ground states at 0.00 MeV and 6. MeV. The 6-MeV state is pre-dissociation broadened, and is interpreted as fitting a spin-isospin model with quadrupole symmetry (p302). The 0.00-MeV state is interpreted as fitting a seniority-pairing model (p322) with octupole symmetry(p302). An energy level fine structure is sketched as horizontal lines on the unshifted chart, but also applies to the downward shifted chart. It represents vibration,rotation excitations of the octupole configuration. A similar fine structure (not shown) exists for the quadrupole configuration (p316). The downward shifting of the diagram shows the effect of coherent partitioning, as applied to a Bloch-sensitive nucleus. The unshifted nucleus is endothermic with respect to two free alpha particles by 0.092 MeV (p54).

Synthesis of $^{8}Be^{4+}_{Bloch}$. The downward shifting of the energy diagram caused by coherent partitioning brings the level representing two free $^{4}He^{++}$ into resonance with an excited vibration level of $^{8}Be^{4+}_{Bloch}$. Lattice fluctuations move the $^{8}Be^{4+}_{Bloch}$ on and off a narrow width Li-Feshbach resonance, coupling the lattice to the nuclear state. Fluctuation in the degree of resonance induces scattering events in the lattice at the boundary of the ion coherence volume, transferring nuclear energy to the lattice.

Fission of $^{8}Be^{4+}$. Oriani's D_2O electrolysis leads to $^{8}Be^{4+}_{Bloch}$ nuclei with 2-dimensional periodic symmetry. These nuclei resemble flakes and are entrained in electrolysis off-gasses. Extreme-energy collision events within the gas cause excitations and de-excitations of the quadrupole nucleus. Because the density of states increases with increasing E, the excitation energy rises until it reaches 6 MeV, at which level $^{8}Be^{4+}_{Bloch}$ transitions to quadrupole $^{8}Be^{4+}$, which fissions into two 3-MeV alphas. The alphas strike Oriani's CR-39 detector plates after losing 1 MeV energy in the gas.

The Bloch Ion Hamiltonian $\boldsymbol{H_2}$, Eq.2 of Paper I, describes a coupling between the energy level of a Bloch-sensitive nucleus and its coherently-occupied volume. This coupling perturbs the lattice at the circumferential boundary of 2-dimensional symmetry Bloch sensitive nuceli. In reverse, lattice fluctuations, some of which are thermal and at the electromagnetic time scale, can move the 2-$^4He^{++}_{Bloch}$ vs. $^8Be^{4+}_{Bloch}$ (octupole shape) in and out of resonance. It would seem that these repeated Feshbach crossings would stimulate energy transfer to the lattice in the form of scattering events, and introduce irreversibility. The Li-Feshbach resonances may play a major role in LENR processes.

CONCLUSIONS

The essential physics underlying cold fusion is quantified in the Hamiltonian $\boldsymbol{H}_2$, which is Equation 2 of Paper I of this set of papers. It applies in its most simple form to the fusion of $^4He^{++}_{Bloch}$ into $^8Be^{4+}_{Bloch}$ in the reaction $2\ ^4He^{++}_{Bloch} \rightarrow {}^8Be^{4+}_{Bloch}$. The Hamiltonian shows that the work of forcing 2 indistinguishable Bloch-function feedstock ions into nucleus-nucleus contact varies with partitioning parameter N_{well}. The result is that the ground state energy level of the product nucleus is a "Bloch-sensitive" nucleus, i.e., a nucleus whose energy level is a function of $N_{well.}$ The Be-synthesis reaction becomes resonant at a particular value of N_{well}, which means that Xing-Zhong Li's hypothesized nuclear resonance condition can be realized in at least one condensed-matter fusion reaction.[4] It is hypothesized that a Bloch sensitive nucleus is an intermediate product in the F-P fusion reaction $2\ D^+_{Bloch} \rightarrow {}^4He^{++}_{Bloch}$. The Hamiltonian also identifies variations in N_{well} as the primary interaction perturbation that couples the nuclear and lattice components of the condensed matter system. This coupling enables dissipation of the nuclear energy by lattice scatterings.

One major process not yet addressed is a realistic modeling of the envisioned 2-step fusion reaction $2\ D^+_{Bloch} \leftrightarrow {}^4He^{++}_{dd\ Bloch} \leftrightarrow {}^4He^{++}_{Bloch} \equiv alpha_{Bloch}$, which is Equation 3 in Paper I.

The set of papers suggests deuteron fluxing may be playing a larger role in F-P heat generation than often assumed. The apparent importance of maintaining a temperature gradient across a catalyst bed in heat generation studies supports this view.[5] In another LENR area, the claims for electrolysis-associated remediation of neutron-rich fission products should be given more weight.[6] If research in this area is undertaken, it should use H_2O rather than D_2O, because the responsible nucleus-addition reactions likely involve the spin-paired double proton $^2He^{++}_{Bloch}$. Transmutation of a fission product nucleus towards the valley of stability is supported by $^2He^{++}_{Bloch}$, and not by $^8Be^{4+}_{Bloch}$. The spin-paired double proton Bloch nucleus is discussed in Paper III.

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