TSC Pd-D Fusion, Effective Electron Mass, Muon Fusion

Frank Dodd (Tony) Smith, Jr - 2015

Abstract

Muon fusion is a known process based on the high muon / electron mass ratio enabling a muon of a Deuterium atom to screen the positive charge of its Deuterium nucleus and allow two Deuterium nuclei to approach one another close enough for fusion D + D -> 4He + 23.8 MeV to take place.

Julian Schwinger, who said

"... in the very low energy cold fusion, one deals essentially with a single state, described by a single wave function, all parts of which are coherent ...",

encouraged Simons and Walling to propose that
Deuterium nuclei and electrons in Palladium could get increased effective mass through Palladium structure quantum processes to screen Deuterium nuclei enough for fusion D + D -> 4He + 23.8 MeV to take place
and for the "heavy electrons" to carry away most of the 23.8 MeV fusion energy into Palladium structure electron system
and for the entire process to be "... enhanced ... by high electron density contributed by ... Pd centers" located near the point of fusion.

Akito Takahashi proposed that the structure of Palladium would encourage a tetrahedral configuration of 4 Deuterium nuclei and 4 Deuterium electrons as a coherent quantum Tetrahedral Symmetric Condensate (TSC) that would collapse (with the 4 electrons screening the 4 D nuclei) and fuse
D + D + D + D -> 8Be + 47.6 MeV -> 4He + 4He + 47.6 MeV.

Palladium clusters of 147 atoms (about 1.5 nanometers) have
a ground state icosahedral configuration that encourages TSC fusion
and a metastable cuboctahedral configuration that allows reloading
of ambient Deuterium into the Palladium cluster by a Jitterbug transformation
with, for each TSC configuration, a central Palladium atom to enhance the process.

If each 147-atom Palladium cluster is embedded into a Zeolite cage
then the fusion energy can be carried from the Deuterium electrons
to the Palladium electrons to the Zeolite electrons, thus heating the Zeolite,
which heat can be released as needed by reacting with D20 to form steam.

“... Muon-catalyzed fusion ... is a process allowing nuclear fusion to take place at temperatures significantly lower than the temperatures required for thermonuclear fusion, even at room temperature or lower. It is one of the few known ways of catalyzing nuclear fusion reactions ...
The muon, 207 times more massive than the electron ... form[s] an electrically neutral muonic deuterium atom ... that acts somewhat like a "fat, heavy neutron" due both to its relatively small size ... about 207 times smaller than an electrically neutral electronic deuterium atom ... and to the very effective "shielding" by the muon of the positive charge of the proton in the deuteron ... reduc[ing] the electromagnetic repulsion between two nuclei and draw[ing] them much closer into a covalent bond than an electron can.
Because the nuclei are so close, the strong nuclear force is able to kick in and bind both nuclei together. They fuse ...” (Wikipedia - Muon-catalyzed fusion)

“... In muon-catalyzed fusion ... the internuclear distances are shortened, potential well depths increased, and turning points moved inward in much the same way as suggested here; the screening caused by the lattice electrons acts much as the muon does, although the fact that only one muon is present per 2H+ pair whereas the 2H+ are surrounded by many electrons may cause the "heavy electrons" and muons to behave differently as far as radiationless relaxation is concerned ...
in the Pd lattice ... enhanced rate of 2H + 2H fusion ... involves a tunneling phenomenon aided by screening of the Coulombic repulsion between the 2H+ ions ... by neighboring 'heavy electrons" with mass m* = 10 electron masses ...
:... two D+ nuclei in the presence of ... Pd lattice ... electrons experience an attractive interaction at long range analogous to chemical binding;
this attraction is balanced and eventually exceeded by the screened Coulombic repulsion at smaller bond lengths.
... screening moves the E = 0 turning point inward (this turning point occurs at approximately 0.5 A in D2+) but does not persist much beyond approximately 0.1 A; from this point inward,
the bare Coulombic barrier (plus any centrifugal barrier) pushes the D+ nuclei apart.
The E = 0 turning point shifts inward to approximately 0.5 A / m* in a model which attributes screening to "heavy electrons" of mass m* times the true electron mass.
Thus, the primary effect of the screening is the reduction of the width of the barrier through which tunneling must occur rather than the height of the barrier. ...

[[(0.5 A = 0.05 nm) / (m* = 10 me) = 0.005 nm = 5,000 fm]]

...
a radiationless relaxation (RR) path ...

22H * 4He* ... 4He* => 4He + heat (≤ 24 MeV)

... in which energy is transferred to the PdD... lattice, perhaps mediated through the lattice electrons, ... predicts that each fusion event could produce up to 24 MeV of heat, unaccompanied by a large, troublesome neutron flux or by 3H formation ...
For muon-catalyzed fusion, tunneling through the Coulombic-plus-centrifugal barrier is possible even at low temperature because binding by the muon **(m***= 207) moves the turning point inward to approximately 2.5 x 10^(-11) cm [= 2.5 x 10^(-13) m = 250 fm]
...

Once the 4He* is formed ... it must ... undergo relaxation to produce ground-state 4He ...[such as by]... internal conversion (IC) in which energy is transferred from the excited 4He* nucleus by coupling to neighboring electrons ... IC rates scale as the electron density near the nucleus from which they receive energy as do rates of most radiationless transitions that occur via energy transfer from the excited nucleus through the electrons to the lattice ... this density could be greatly enhanced by the proximity of either Pd electrons or lattice electrons having large "effective masses"
(perhaps m* = 10-12.5)
... we estimate the rate of IC for a process in which
a single electron carries away all 24 MeV of energy ...[of]... 4He* => 4He + heat
... It is known that IC can eject K-shell, L-shell, and other electrons ...
and that more than one electron may be ejected ..
It may therefore be possible for the excited nucleus to transfer its energy to several electrons, each of which subsequently undergoes thermalizing collisions ...
In the absence of a method for estimating the rate of such many-electron events,
we present here the lower bound estimate described above
...
it may be that RR is enhanced ...[also]... by high electron density contributed by the neighboring Pd centers (where the density of conventional electrons is even higher than that computed for heavy electrons near 4He* nuclei
and where the inner-shell electrons have bohr frequencies of the order of 10^19 s-1) .
It should be noted that these RR energy-transfer rates are in line with isomer shifts in Mossbauer spectroscopy (e.g., an isomer shift of 1 mm s-1 corresponds to a frequency shift of 4.8 x 10^11 s-1 for a 24-MeV photon).
Isomer shifts reflect the differential effects on the energies of the ground and excited nuclear states caused by the electron density near the nucleus
...
It should be stressed that RR rates need only be considerably faster than the rates of fragmentation to either 3He + n or 3H + 1H for this model to be consistent with the observations. We argue that formation of the odd-parity states of 4He* that fragment quickly is suppressed at low energies. Moreover, the even-parity (0+,0) state can not fragment to the odd-parity 3He + n or 3H + 1H products unless the fragments exit with one (or more) unit of collisional angular momentum. Doing so would require these fragments to tunnel outward through their repulsive centrifugal barriers which is certain to slow fragmentation. Clearly, if the 4He* fragmentation rates are much less than the RR rate, little neutron or tritium signal will be detected. The model put forth here, which attributes qualitative differences between low- and high-energy fusion to parity,
is consistent with ... observations
...
J.S. thanks Prof. Julian Schwinger for very stimulating and encouraging conversations. ...". (Cheves Walling and Jack Simons, J. Physical Chem. 93 (1989) 4693-4696)

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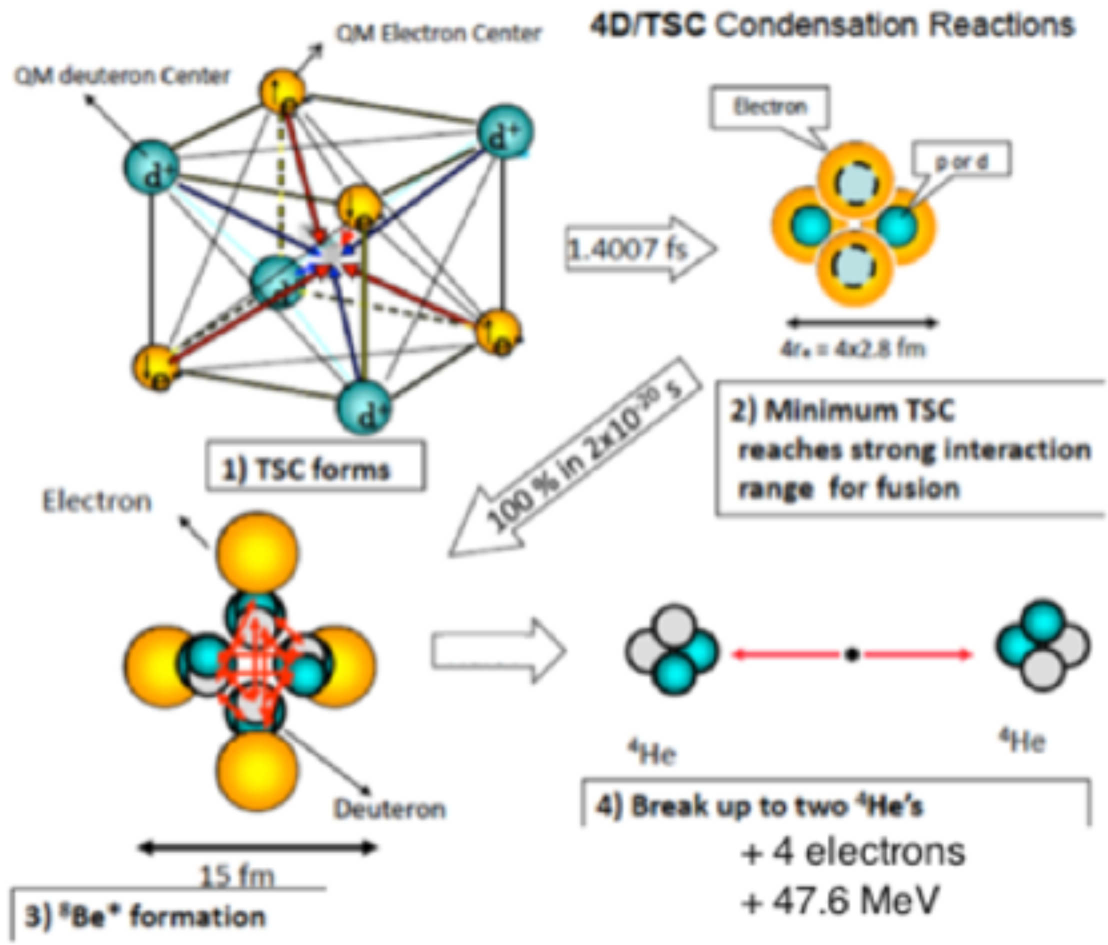


Palladium clusters of 147 atoms (about 1.5 nanometers) have a ground state icosahedral configuration that encourages TSC fusion and a metastable cuboctahedral configuration that allows reloading of ambient Deuterium into the Palladium cluster by a Jitterbug transformation with, for each TSC configuration, a central Palladium atom to enhance the process.

Exceptionality of the 147-atom Pd cluster size is supported by magnetic studies:

"... Bulk palladium has a large susceptibility, but nevertheless it is a paramagnetic material ...
Nevertheless, Pd is close to a ferromagnetic instability.

The magnetic properties of Pd clusters and nanoparticles have been studied a lot in both theoretical and experimental investigations. It was revealed that the low dimension and lower coordination number of these clusters and nanoparticles results in enhancement of their magnetism. ...

ferromagnetism existed in solid solutions of Co in Pd as dilute as 0.1% although the distance between Co atoms was about 10 A indicating a ferromagnetic interaction between the Co atoms at these long distances. The above mentioned experiments suggested that **the solute atom polarizes the surrounding Pd atoms to form a 'giant' magnetic moment**.

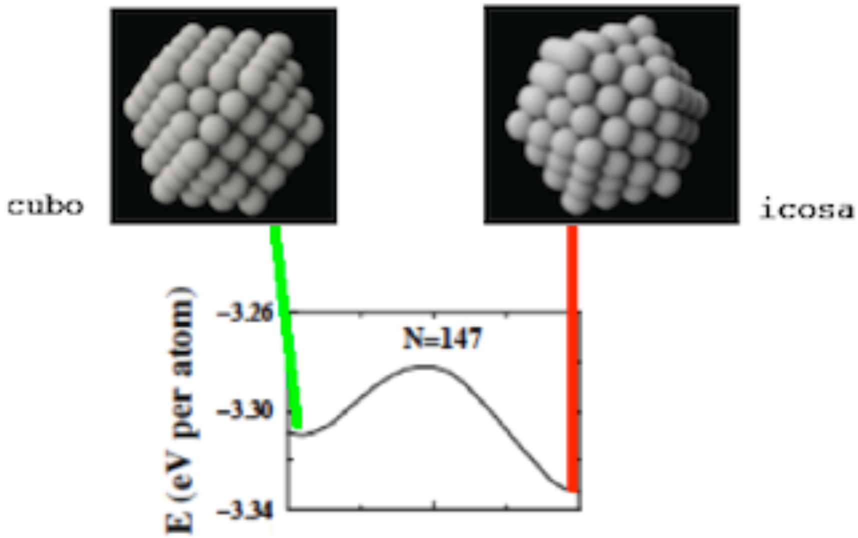
The total magnetic moment of a polarized cloud may be as much as 10 μ_B with average Pd moments of 0.05–0.4 μ_B .

Such a polarization cloud may consist of 200 host atoms.

The spatial extent of this cloud ranges from 10 to 50 A [= 1 to 5 nanometers]. ...".
(Stepanyuk, Ingnatiev, Negulyaev, Saletsky, and Hergert, J. Phys. Condens. Matter 24 (2012) 235301)

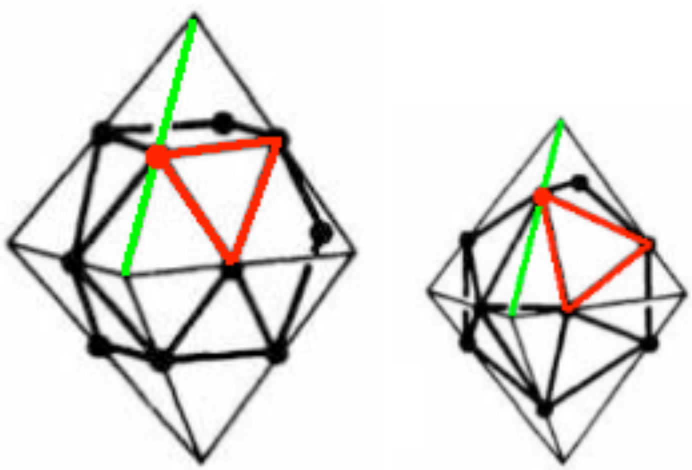
Geometry of Palladium 147 atom cluster

The 147 atom cluster of Palladium atoms has two geometric configurations:



a metastable Cuboctahedral state and an Icosahedral ground state
which can transform into each other by a Jitterbug transformation

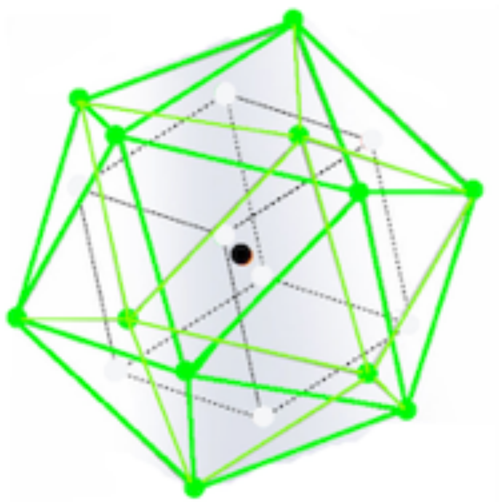
whereby the 6 cubo square faces correspond to 6 pairs = 12 icosa triangle faces
and the 4 - 6 = 8 cubo triangle faces correspond to 20 - 12 = 8 icosa triangle faces

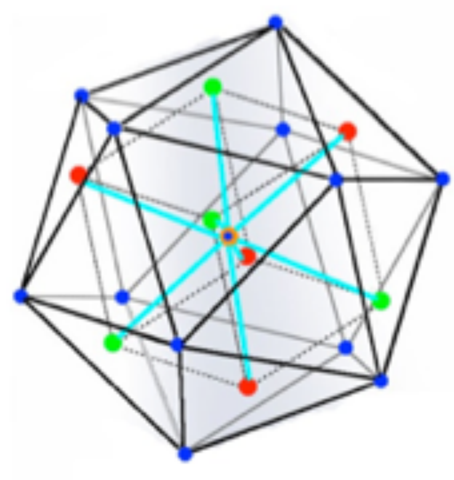


with vertices rotated from a mid-point of an edge of an enclosing Octahedron
to a Golden Ratio point on that edge.

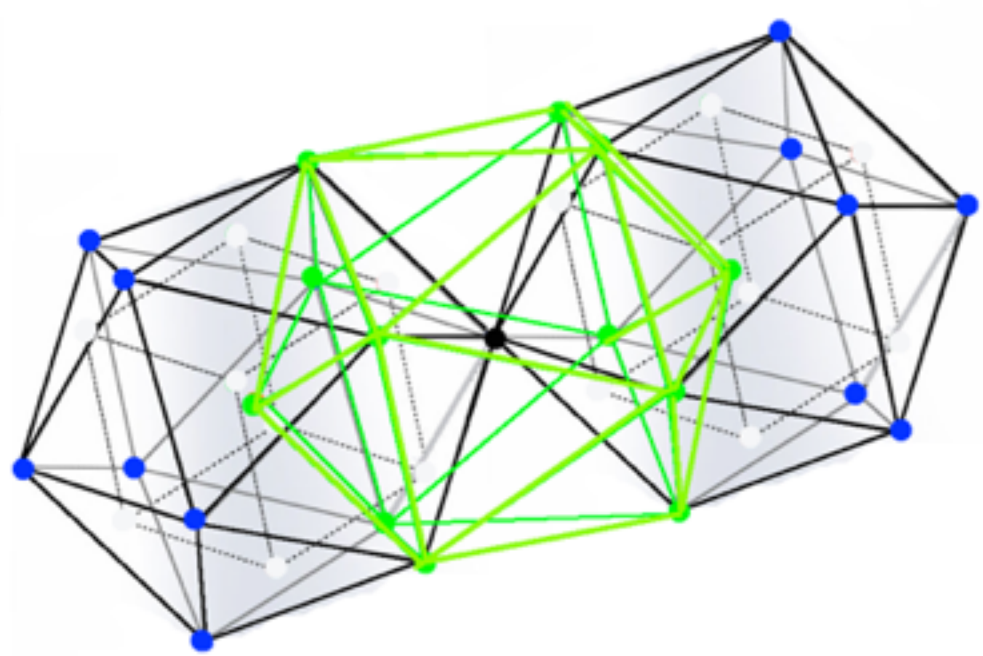
The 147-atom cluster is made up of a single central Palladium atom
surrounded by 3 layers of Pd atoms:

Layer 1 = central 1 (black) + 12 icosahedral (green) = 13 vertices
and 20 tetrahedral cells
It is a single icosahedron configuration that allows TSC fusion
of 4 Deuterium nuclei (red dots) screened by their 4 electrons (green dots)
condensing along symmetrical paths (cyan lines) to fusion at the center



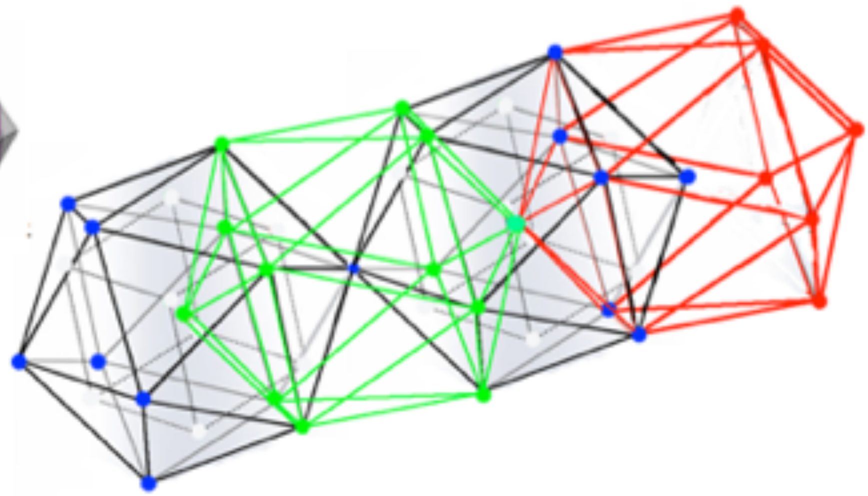


Layer 2 adds 32 vertices (blue) for total of 55
and 60 tetrahedral + 20 cuboctahedral cells for total 80 tetra + 20 cubo = 100

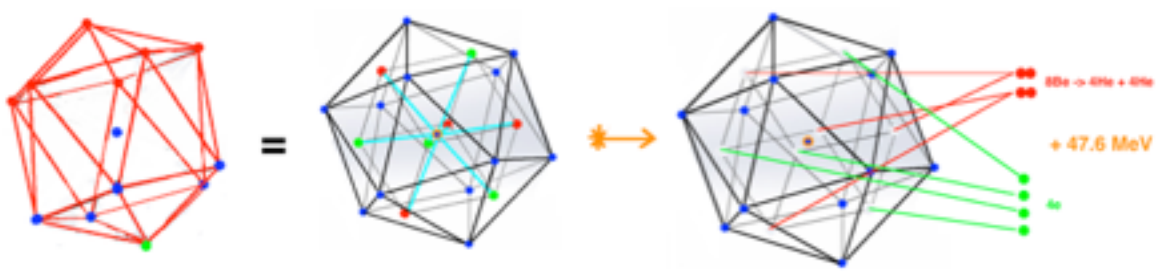


It is a configuration of 2 TSC fusion icosahedra sharing the central vertex
with the remaining 55 - (26-1) = 30 vertices in 3 10-vertex bands

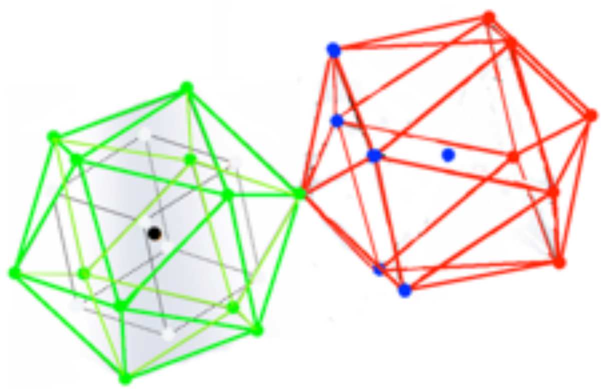
Layer 3 adds 92 vertices (red) for total of 147
and 120 tetrahedral + 60 cuboctahedral cells for total 200 tetra + 80 cubo = 280



It is a configuration of 12 TSC fusion icosahedra

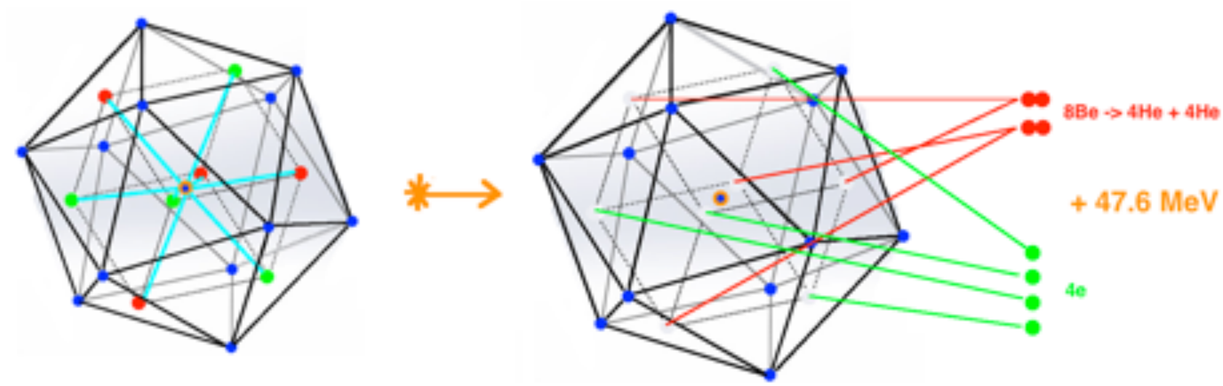


each of which shares a vertex with one of the 12 vertices of the Layer 1 icosahedron.

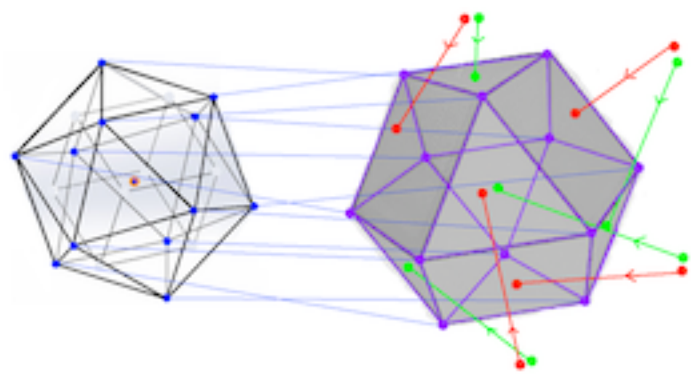


so that the entire 3-layer 147-atom configuration has 13 TSC fusion icosahedra:
12 outer icosahedra and 1 central icosahedron.
The 13 TSC configurations have 13x13 = 169 vertices but
24 vertices are shared between an outer and the central TSC
and 5x12 = 60 vertices are shared between two outer TSC
so 169 - 24/2 - 60/2 = 127 of the 147 vertices are in the 13 TSC
The remaining 147 - 127 = 20 vertices outside the 13 TSC are
at the centers of the triangle faces of the entire 147-atom icosahedron.

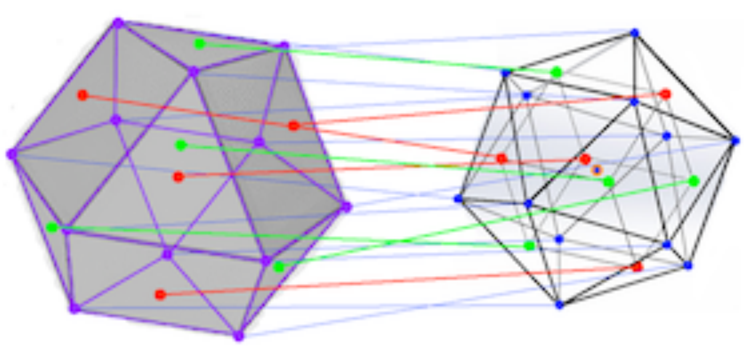
Each of the 13 TSC fusion icosahedra is capable of TSC fusion if it has absorbed 4 Deuterium nuclei + electrons:



The heated Palladium cluster expands by Jitterbug to Cubocta Metastable State
The Fused Deuterium nuclei can be replaced by ambient Deuterium.
Replacement is easier for the 12 outer TSC configurations than for the 1 central TSC configuration which is not directly exposed to ambient D gas

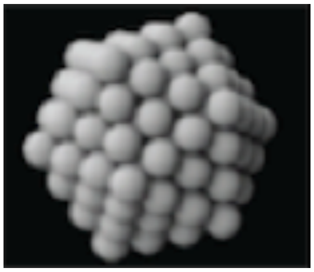
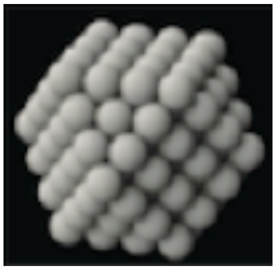


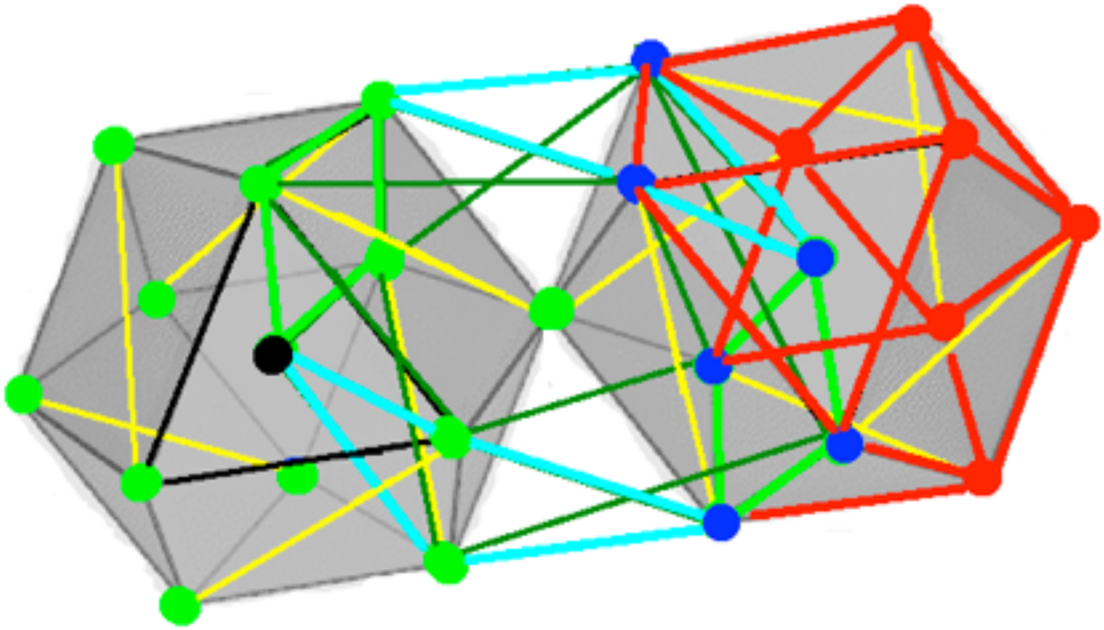
The Cubocta Metastable state, loaded with the new Deuterium, collapses by Jitterbug back to the Icosa Ground State



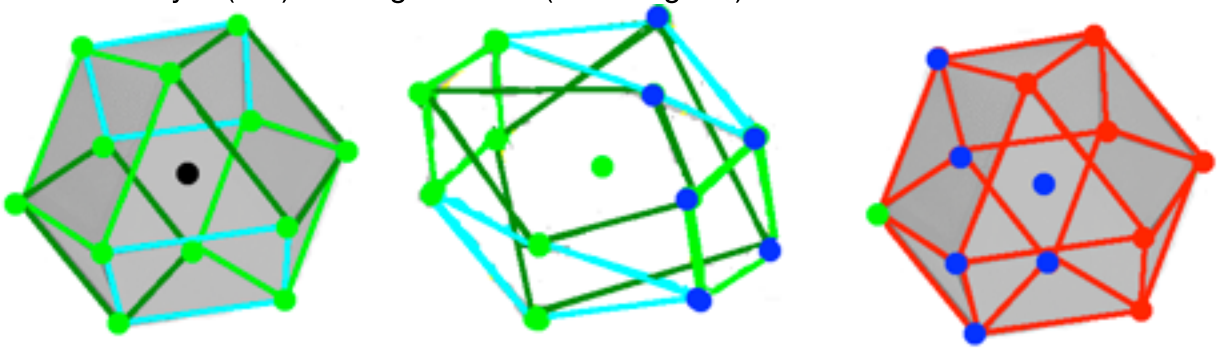
Then a new TSC Fusion occurs and the cycle repeats.

147-atom Cuboctahedral Geometry

The 147-atom 3-layer icosa structure  goes to 
a 3-layer cuboctahedral structure by Jitterbug transformation of all 147 atoms.

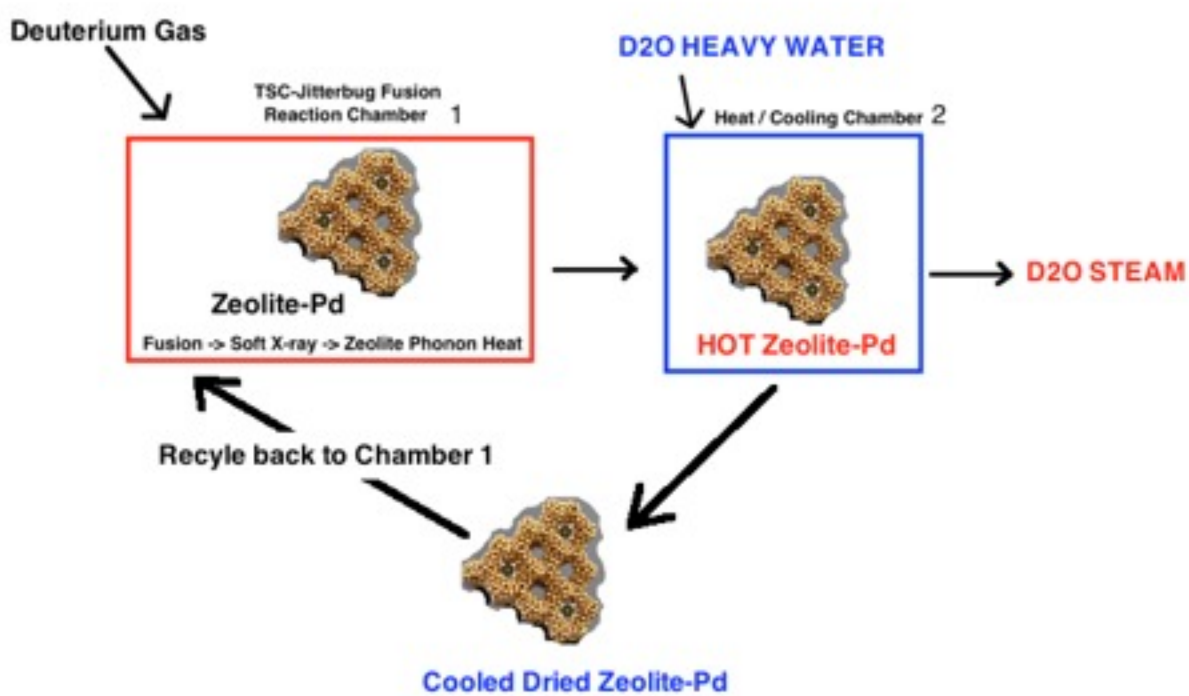


Like the icosa case, in the cubo case there is a central (black) vertex
surrounded by 12 (green) cubo-configured vertices
and a second layer (blue) forming an intermediate (distorted) cuboctahedron
and a third layer (red) forming an outer (more regular) cuboctahedron.



In the cubo case, there are also 12 outer TSC Jitterbug cuboctahedra
plus a single central TSC Jitterbug cuboctahedron, so Jitterbug transformation of the
entire 147-atom Pd cluster works consistently with individual JItterbug transformations
of the 13 TSC icosahedra and TSC Jitterbug cuboctahedra.

If each 147-atom Palladium cluster is embedded into a Zeolite cage then the fusion energy can be carried from the Deuterium electrons to the Palladium electrons to the Zeolite electrons, thus heating the Zeolite, which heat can be released as needed by reacting with D20 to form steam.



Further details are in my paper at

http://vixra.org/abs/1501.0234