Pd D-D Fusion and Jitterbug Structure

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Clusters of Palladium atoms (also clusters of atoms of Nickel and similar elements) have two basic structures:

Icosahedral and Cuboctahedral

1 - Icosahedon <-> Cuboctahedron Jitterbug Transformation

2 - Palladium clusters with absorbed Deuterium (PdDx) have two states:

Icosahedral with Tetrahedral absorption sites

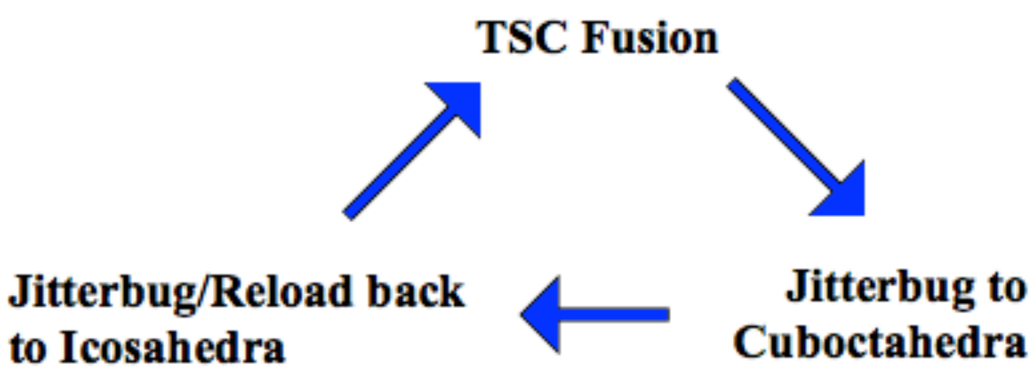
Cuboctahedral with Octahedral absorption sites

3 - Tetrahedral Symmetric Condensation (TSC) in PdDx produces Fusion.

4 - Icosahedra TSC Fusion Triggers Jitterbug to Cuboctahedra.

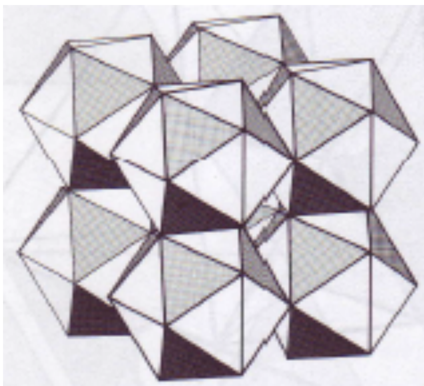
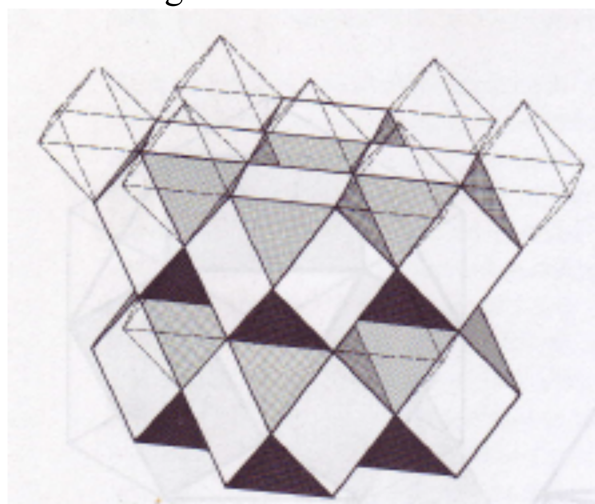
5 - Cuboctahedra Jitterbug back to Icosahedra and reload TSC sites.

6 - Repeat the Cycle:



1 - Icosahedon <-> Cuboctahedron Jitterbug Transformation

Icosaahedra and Cuboctahedra both have 12 vertices so that it is possible to transform them into each other. Buckminster Fuller called that transformation the Jitterbug

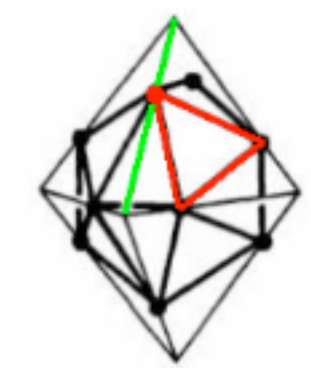
(images from Synergetics by Buckminster Fuller (Macmillan 1975, 1982))

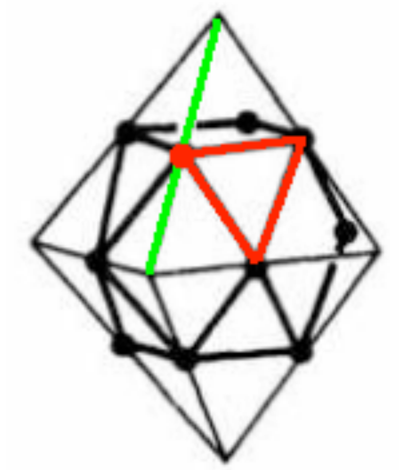
To make Cuboctahedra (unit edge length) from Icosahedra (unit edge length) choose 6 pairs of Icosahedra triangle faces (white in the above images) and lengthen the common edge of each pair by a factor of sqrt(2). That expansion flattens each of the triangle pairs to produce 6 square faces of the Cuboctahedron. The other Icosahedral 20 - 2x6 = 8 (shaded) triangle faces are rotated and become the other 14 - 6 = 8 triangle faces of the Cuboctahedron.
,
thus increasing the number of faces from 8+6 = 14 to 8+(6+6) = 20
while keeping the number of vertices constant at 12.

There are two ways to choose a diagonal of an Icosahedron triangle face pair in the construction, corresponding to the two possible orientations of an Icosahedron.

Choice of diagonal for one Icosahedra triangle face pair forces (by requiring consistency) the choices for all other face pairs of all Icosahedra.

The triangle faces of the Icosahedron/Cuboctahedron are rotated by a Golden Ratio





(images adapted from Geometrical Frustration by Sadoc and Mosseri (Cambridge 2006))

angle defined by
sliding Icosahedron vertices on the edges of a circumscribing Octahedron
from points dividing edges into Golden Ratio segments
to points dividing edges into two equal segments
so that the Octahedron then circumscribes a Cuboctahedron.
If the edge lengths of the Icosahedron/Cuboctahedron are kept the same
then the Octahedron surrounding the Cuboctahedron will be an expansion
of the Octahedron surrounding the Icosahedron.

Just as in the choice of a Cuboctahedron square diagonal to be compressed,
there are two ways in which the edge could be divided into Golden Ratio segments,
corresponding to the two possible orientations of an Icosahedron.

Choice of Golden Ratio segments for one edge forces (by requiring consistency)
the choices for all other edges.

The volume expansion of the Jitterbug Transformation
from Icosahedron (unit edge) to Cuboctahedron (unit edge) is:

Icosahedron volume = (5/12) (3 + sqrt(5)) = 2.18169499
Cuboctahedron volume = (5/3) sqrt(2) = 2.3570226

Icosahedron/Cuboctahedron volume ratio = 0.9256147947

Cuboctahedron/Icosahedron volume ratio = 1.0803630254

2 - Palladium clusters with absorbed Deuterium (PdDx) have two states:
Icosahedral with Tetrahedral absorption sites
Cuboctahedral with Octahedral absorption sites

In Structural transitions and stabilization of palladium nanoparticles upon hydrogenation (Nanotechnology 17 (2006) 1292–1299) F. Calvo and A. Carre say:
"... bulk palladium-hydrogen ... can absorb a large amount of hydrogen ...
Below the natural saturation concentration of about 70% ... the hydrogen atoms reside mostly in the octahedral sites of the fcc Pd lattice.
Palladium becomes stronger and less ductile at low hydrogen concentrations. ...
particularly interesting ... is the possibility of controlling the shape of the nanoparticles using the amount of hydrogen gas. ...
Unfortunately, electronic structure calculations are not practical for clusters containing more than about a hundred atoms, or when dynamical information is needed. ...
tight-binding calculations ... have shown that icosahedra and cuboctahedra could be very close in energy once the second shell is filled. ...
Cuboctahedra ...[and]... icosahedra ... contain exactly the same number of atoms. ...
we examine the simultaneous influences of hydrogen concentration and temperature on the stable structure of palladium nanoclusters ... to explore the relative stability of icosahedral and cubic structures containing an increasing amount of absorbed hydrogen, at zero temperature ... [and]... to account for temperature effects by calculating the relative free energies of the two phases. ...
In the case of ... the 147-atom Pd cluster ... the favoured structure in the pure metal is the three-layer icosahedron. ...

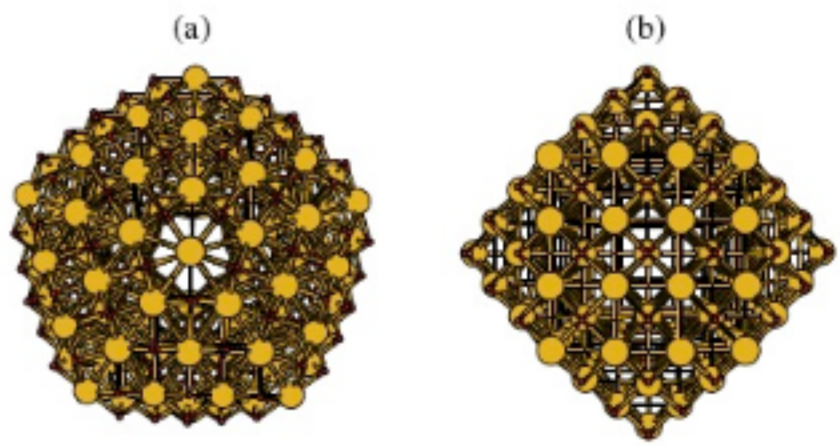


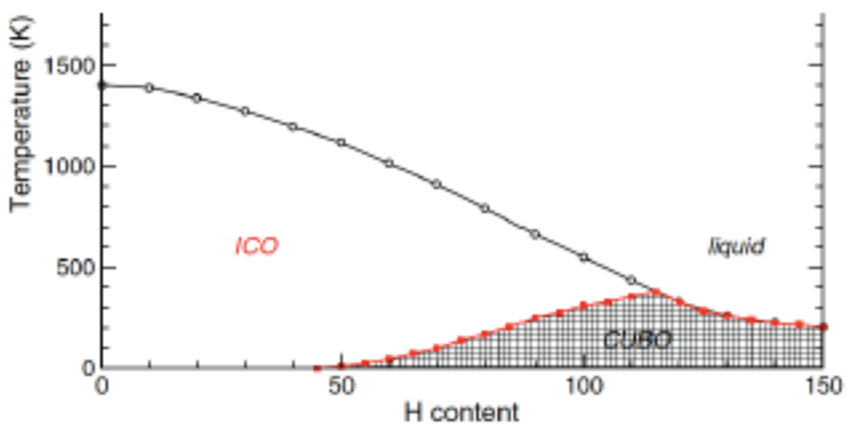
Figure 1. Palladium clusters fully loaded with hydrogen.
(a) $Pd_{147}H_{200}$, I_h symmetry; (b) $Pd_{147}H_{164}$, O_h symmetry.

The icosahedral cluster ... shows ... tetrahedral occupancy. ...
the cuboctahedral cluster ...[prefers]... absorption in the octahedral sites. ...

we could produce stable structures of Pd147Hx clusters based on the icosahedron and cuboctahedron, containing at most 200 hydrogen atoms and 164 [hydrogen atoms] respectively. These absorption rates are far above the bulk absorption capacity under normal conditions.

For a Pd147Hx cluster with a given Pd lattice structure ... at zero temperature ...
hydrogen absorption initially ... favors icosahedra,
but stabilizes cuboctahedra at zero temperature above 46 hydrogen atoms ...

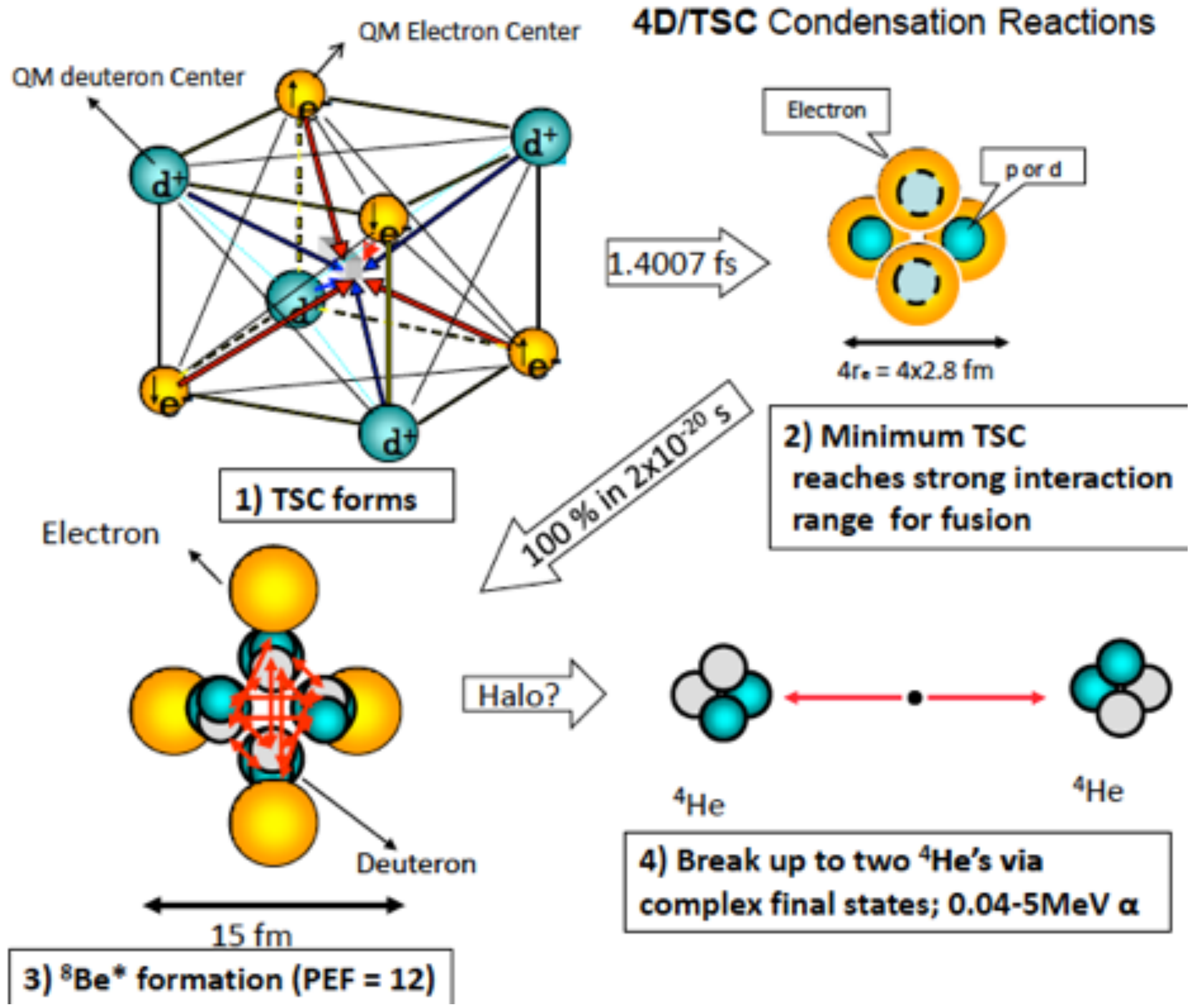
Figure 4 ... ...[is a]... Schematic structural diagram of the Pd147Hx cluster in the icosahedral, cuboctahedral and liquid phases ...[that shows]...



... effects of a finite temperature on the relative stability of Pd-H clusters ...".

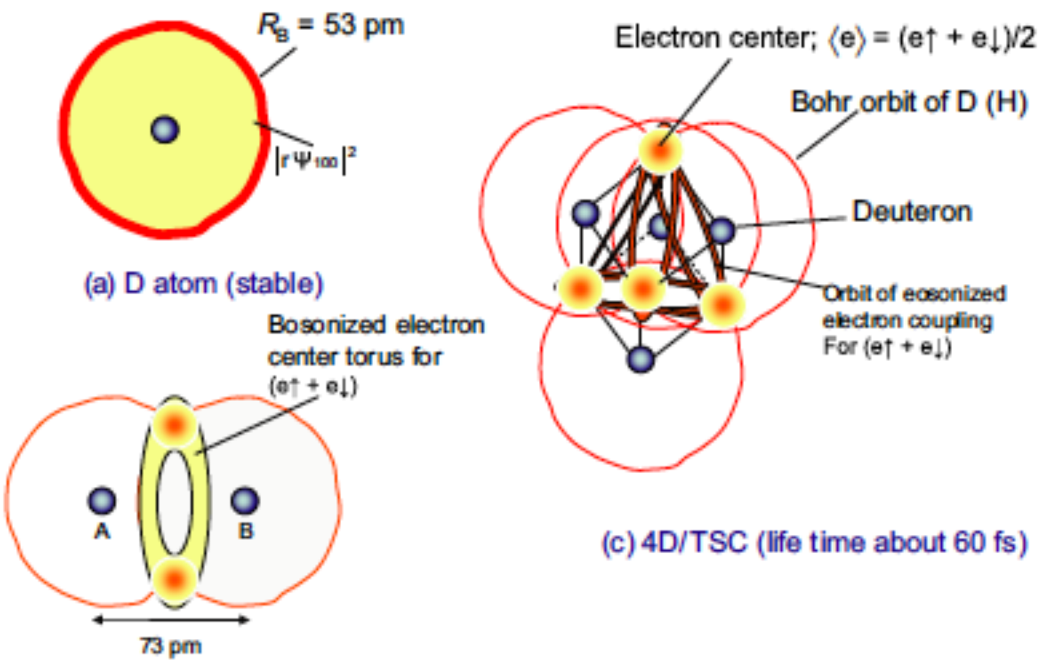
3 - Tetrahedral Symmetric Condensation (TSC) in PdDx produces Fusion.

Akito Takahashi in Physics of Cold Fusion by TSC Theory by Akito Takahashi ICCF17 12-17 August 2012 and J. Condensed Matter Nucl. Sci. 33 (2009) 33-44 and J. Condensed Matter Nucl. Sci. 1 (2007) 129-141 "... proposed ... **deuteron fusion process by ... Tetrahedral Symmetric Condensate (TSC)** ...
Every particle in TSC can make central squeezing motion with same velocity, to keep charge neutrality of total TSCsystem ... this squeezing motion can be treated as Newtonian mechanics until when four deuterons get into the range (about 5 fm) of strong nuclear interaction. ... TSC starts Newtonian squeezing motion to decrease linearly its size from about 100 pm radius size to ... the minimum size state ... as shown in ... Semi-classical view of squeezing motion of TSC,
<e> = (e↓ + e↑)/2 for QM view at four electron centers ...



... Classical squeezing motion ends when four deuterons get into the strong force range (5 fm) and/or when four electrons get to the Pauli's limit (about 5.6 fm for e-e distance). Here for Pauli's limit, we used the classical electron radius of 2.8 fm ... Since the range of strong interaction is comparable to the classical electron diameter (5.6 fm) ... the intermediate nuclear state 8Be* will be formed just after the minimum size state ...
Immediately at ... 8Be* formation ... 4d-cluster shrinks to much smaller size (about 2.4 fm radius) of 8Be* nucleus, and four electrons should go outside due to the Pauli's repulsion for fermions. Shortly in about few fs or less (note; Lifetime of 8Be at ground state is 0.67 fs), 8Be* will break up into two 4He particles, each of which carries 23.8 MeV kinetic energy ...

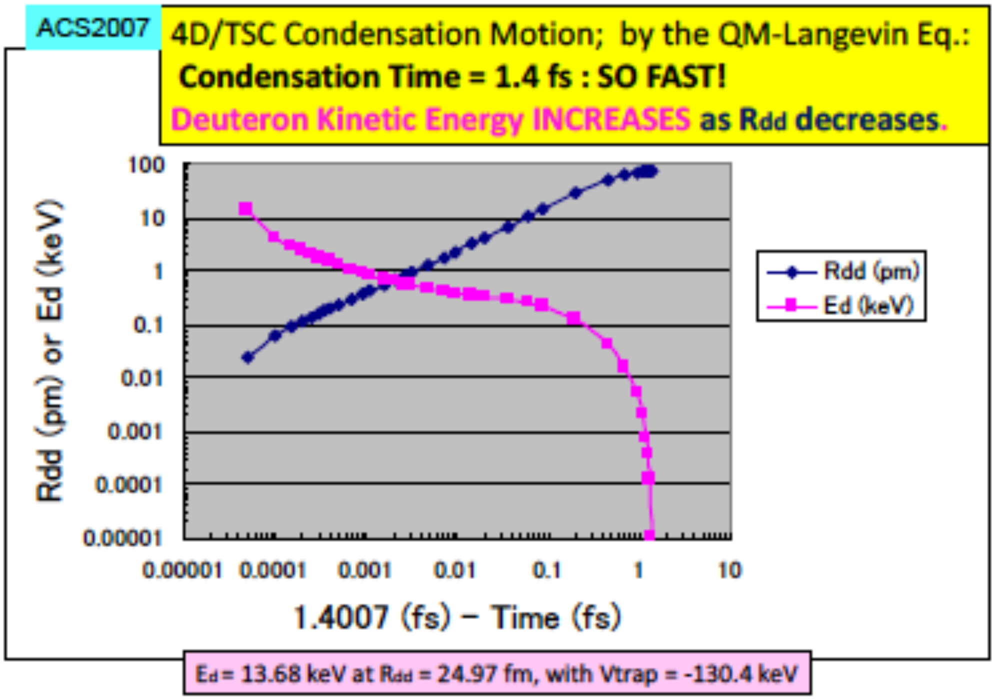
when TSC is just formed ... averaged electron position (electron center of <e> = (e↓ + e↑)/2, Bosonized electron pair ...) ... locates at vertexes of regular cube with tetrahedral combining orbits and outer dilute clouds ...



(b) D2 molecule (stable): $\Psi_{2D} = (2+2\Delta)^{-1/2}[\Psi_{100}(r_{A1})\Psi_{100}(r_{B2}) + \Psi_{100}(r_{A2})\Psi_{100}(r_{B1})] X_s(S1,S2)$

... At ... cube ... vertexes ... three Bohr wave functions superpose and electron density is about nine times larger than that of outer dilute cloud. Therefore, the semi-classical treatment of central squeezing motion by Newtonian is approximately fulfilled for "coherent"central averaged momentums for eight particles. ...

As soon as 4D/TSC(t=0) state with D2 molecule size (Rdd = 74 pm) is formed ... the QM-Langevin equation gives numerical solution for time-dependent Rdd and mean relative kinetic energy of d-d pair of a face of 6 TSC (d-e-e-d-type) faces, as copied from reference and shown in Fig.10. ...



... The 'adiabatic' size of 4D/TSC reaches at a few tens fm size in 1.4 fs, so fast. With adiabatic 4D/TSC size around 20 fm, 4D-fusion takes place by ...

D + D + D + D -> 8Be* (Ex= = 47.6 MeV: J*) ...

Fusion yield per 4D/TSC generation is calculated by integrating time-dependent fusion rate by the Fermi's first golden rule ... that was very close to 1.0, namely 100%, during the very small time interval of ca. 2 x 10^(-20) s in the final stage of condensation.

Mean relative kinetic energy of neighboring d-d pair of 4D/TSC-minimum is ca. 14 keV, which is accidental resembling value to the hot fusion experimental devices as ITER (DT plasma).

...

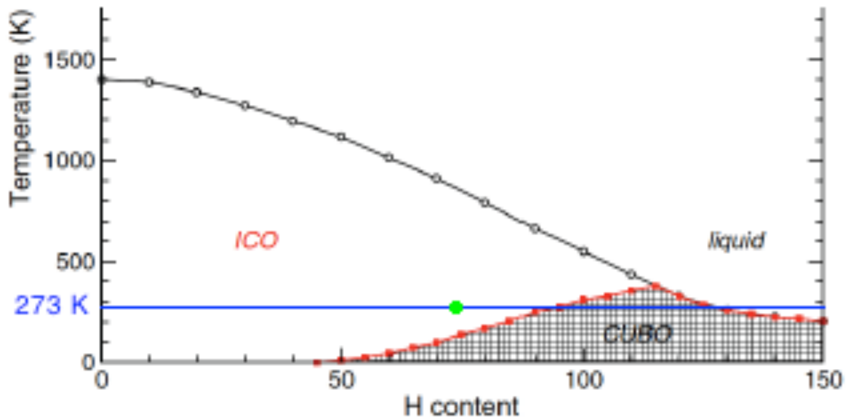
the quantitative study on the **TSC formation probability in D(H)-loaded metal systems is yet to be done** by solving many-body time-dependent problems under organization field of condensed matter. It is challenging work ...".

The answer to that challenge may be

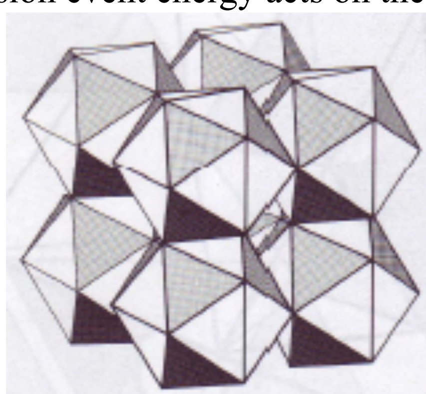
the Icosahedra <-> Cuboctahedra Jitterbug Transformation.

4 - Icosahedra TSC Fusion Triggers Jitterbug to Cuboctahedra.

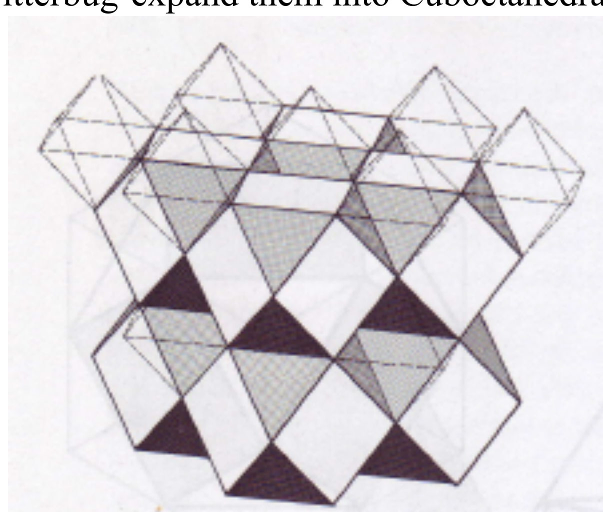
Consider a Pd-D cluster with 147 Pd atoms and 73 Deuterium atoms at 273 K



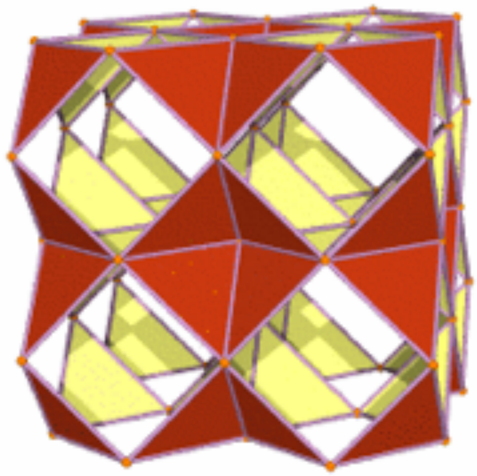
similar to the Icosahedral Pd-H state (green dot) on the Calvo-Carre diagram. Pd147D73(273K) is naturally initially Icosahedral with tetrahedral occupancy producing TSC Fusion events with two 4He each with 23.8 MeV kinetic energy. The 47.6 MeV per TSC Fusion event energy acts on the relatively closed structure



of the Icosahedra to Jitterbug-expand them into Cuboctahedra

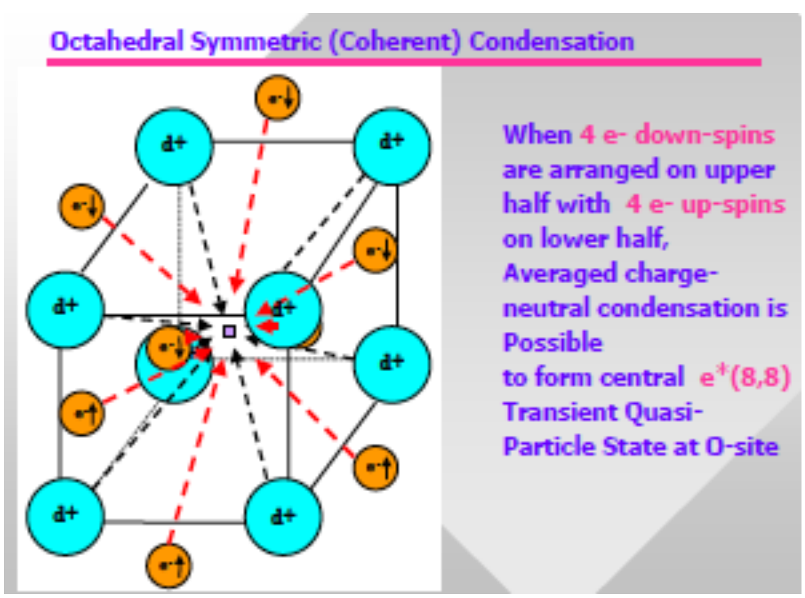


5 - Cuboctahedra Jitterbug back to Icosahedra and reload TSC sites.



The Cuboctahedera have relatively open structure facilitating release of energy as shown on the image above with 3 orthogonal square-cross-section pathways from www.antiprism.com .

Since the Cuboctahedra have only Octahedral absorption occupancy sites they have no TSC Fusion, but there is a possibility of OSC Fusion.
Akito Takahashi in Proceedings of the 5th Meeting of Japan CF Research Society Kobe 2003 www.jcfrs.org/file/jcf5/jcf5_16.pdf and in slides Clean Fusion and Fission Osaka 2004 said:
"... Clean Fusion by Tetrahedral and Octahedral Symmetric Condensations ...
For 8D fusion ...
8D -> 16O*(109.84 MeV) -> 8Be + 8 Be + 95.2 MeV -> 12C + 4He + 50.12 MeV
...

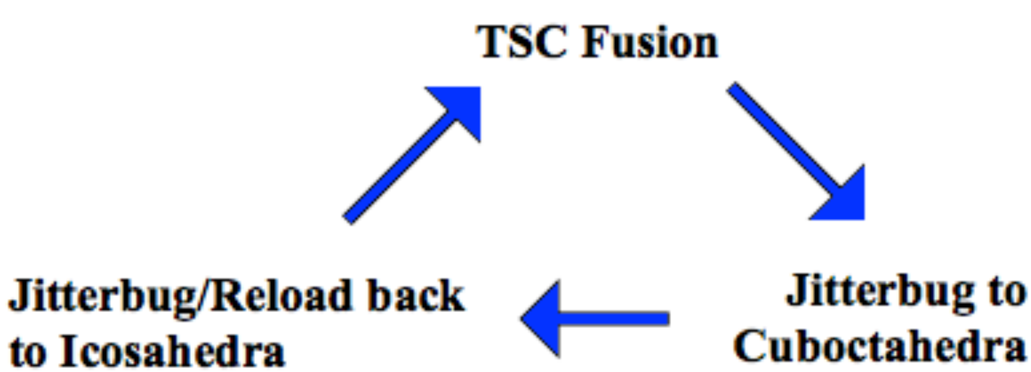


... OSC may happen much more difficultly ... The OSC condition requires local PdD2 lattice of overloaded conditions, so that we assume ... the OSC cluster density is very low as 10^16 clusters/cc ...
we have still surprisingly high power level as 78 W/cc (8x10^12 f/s/cc) ...[compared with 4D TSC Fusion for which]... we estimate ... the average TSC cluster density to be ... 10^22 clusters/cc ... we get power level ...
to be 3 W/cc (3x10^11 f/s/cc) ...".

My opinion is that:
even though 8D OSC Fusion in Cuboctahedra could produce a lot of power its 2-cube geometry is much less stable than the 2-mirror-tetrahedron structure of 4D TSC Fusion in Icosahedra
and
each large-open-Cuboctahedron is less compact and rigid than an Icosahedron
and
a Pd147D73 cluster at 273 K is in the phase region for Icosahedral structure
so
8D OSC Fusion is not likely to take place
but
a Jitterbug transformation back to Icosahedral structure is likely
and
the Cuboctahedral phase serves two purposes:

release of any 4He etc that may have been trapped in Icosahedra
and
reloading the tetrahedral sites in the new Icosahedral phase created by Jitterbug.

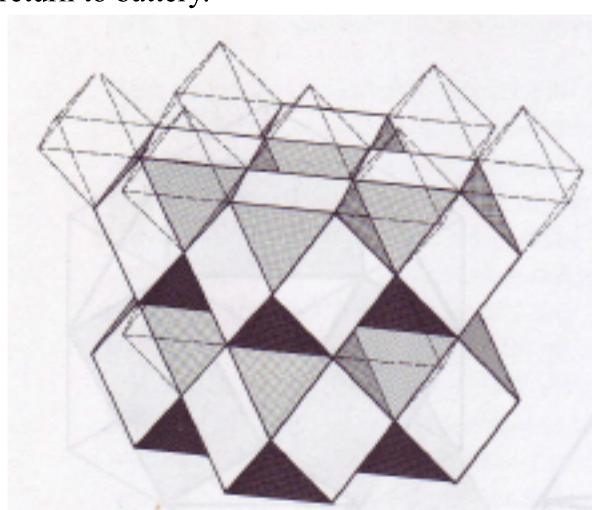
6 - Repeat the Cycle:



Pd D-D Jitterbug Fusion:
Mechanical Analogy

(with Colt Series 80 Government 10 mm Delta Elite version of Browning's M1911 semi-auto)

"... The M1911 ... use[s] ... the short recoil ... action ... Cycle ...
1. Ready to fire position. [Slide] is locked to barrel, both are fully forward.
[Icosahedral Pd with D atoms in TSC positions]
2. Upon firing, [slide] and barrel recoil backwards a short distance while locked together. Near the end of the barrel travel, the [slide] and barrel unlock.
[Firing = D-D Fusion]
3. The barrel stops, but the unlocked [slide] continues to move to the rear, ejecting the empty shell and compressing the recoil spring.
[Recoil Spring = Icosahedral Stability Phase induces transformation of Cuboctahedra]
4. The [slide] returns forward under spring force, loading a new round into the barrel.
[Loading New Round = Cuboctahedral D atoms moved to Icosahedral TSC positions]
5. [Slide] locks into barrel, and forces barrel to return to battery.



... The very first short-recoil-operated firearm was also the first machine gun, the Maxim gun.
... Vladimirov also used the short recoil principle in the Soviet KPV-14.5 heavy machine gun. ..."
(quote from Wikipedia entries on M1911 pistol and on Recoil operation)