Listening to Metal Physics

The physics of metals is an extension of the chemistry of molecules as applied to very large molecules with a periodic arrangement of metal atoms. Metals have a somewhat higher density than the typical molecule. The abnormally high density of metal crystals means an abnormally high electron density. The abnormally high electron density in combination with periodic array order creates a special type of chemical orbital consisting of a many interconnecting lobes in a lattice array. When an electron fills this orbital, it is called a quasiparticle. A grouping of array orbitals sharing the same array structure is called a band, and the electron occupants are called band state electrons. These band state electrons are the electron quasiparticles. They are the charge carriers that flow through the metal when a wire carries an electric current.

The huge abundance of electron quasiparticles is what makes a metal different from other crystalline solids. A solid having a much smaller number of the electron quasiparticles is called a semiconductor. Non-conducting solids like ionic crystals, covalent solids, and plastics have no quasiparticles. The enormous collection of quasiparticles in a metal is called a fermi sea, named after Nobel Laureate Enrico Fermi. The fermi sea electrons populate a near continuum of energy levels up to a maximum energy level called the fermi level. The electron fermi sea neutralizes embedded metal ions. The metal atoms became positive ions when they donated their outer electrons to the common pool, i.e., the fermi sea.

The number of interconnecting lobes in an electron quasiparticle orbital is enormous. Whereas a *p*-orbital consists of 2 lobes (potential wells) on opposite sides of an atom's nucleus, a metal quasiparticle orbital can consist of 10^{15} communicating potential wells. This number is 100,000 times Earth's population. The Pauli exclusion principle that limits occupation of chemical orbitals to no more than 2 electrons per x, y, z state, also applies to quasiparticle orbitals. Pauli exclusion limits the electron density even at high pressure, preventing shrinkage that would otherwise occur. As in molecules, the relatively large volume required by the electrons in the solid is what determines the density of the solid. Among other things Pauli physics prevents the shrinkage of the Earth under the pull of its own gravity.

The type of orbital (chemical vs. quasiparticle) occupied by an electron depends on its environment. During battery operation, an electron belonging to an ion in a battery's electrolyte enters the battery's metal anode and converts from a chemical orbital form to an electron quasiparticle orbital form. It joins the electron fermi sea. Electron quasiparticles then flow through the wires of the electrical circuit, arrive at the battery's metal cathode, and convert back to molecular orbital form as they re-enter the electrolyte.

The job of the cold fusion reactor designer is to create a situation where deuterons initially in heavy water or deuterium gas enter a metal and convert to deuteron quasiparticle form. This conversion can be made to occur in small sub-volumes of a metal crystal, consisting of 10^3 potential wells. This spread-out orbital form creates a very low density type of deuteron matter in which each deuteron's charge is coherently partitioned into many small fractional pieces. The quasiparticle deuterons have their own multi-lobe orbital structure, which means that they occupy their own set of communicating potential wells. When two suitably paired quasiparticle deuterons are occupying the same set of potential wells, there is a pairing of fractional charges present in each well, but the amount of opposing charge present is too small to keep the fractions apart. Coherent partitioning means that the fractional pieces are "entangled", which means that one must sum over all the pieces to see what really happens. Even after summing over all the pieces, the deuterons have made contact. Having made contact, the paired quasiparticles fuse in response to the nuclear strong force.

A quasiparticle fusion event can be pictured as taking place in 2 steps. Prior to the first step, all the quasiparticle deuterons in a given volume were paired with all the other quasiparticle deuterons in what is called a many-body system. They formed their own multi-lobe swimming pool. The resulting density distribution of deuteron positive charge was neutralized by negatively charged electron matter borrowed from the electron fermi sea. The number of electrons borrowed from the fermi sea equals the number of quasiparticle deuterons in their many-body system. This process of neutralization is called dressing. Dressing means that a portion of the electron fermi sea coexists in the deuteron's potential-well volumes and limits the range of the dd-repulsion electric field that tries to keep the deuteron matter in separated-deuteron form. The mathematics uses a screening radius, designated r_{sc}, to measure the range-limiting effect on the dd repulsion force. This screening radius appears in the equation that quantifies the effectiveness of the fermi sea's ability to support the dressing process.

In the first reaction step, several things happen. A selected dd pair meeting "spin-zero" requirements, as specified in the next chapter, segregates itself from the deuteron many-body system and gets neutralized (dressed) by its own 2-electron portion of the electron fermi sea. The isolated dd pair then undergoes a change in its internal structure. The internal geometry of the 2-deuteron system shrinks to nuclear density, either spontaneously or in response to a momentum shock probably associated with a new deuteron changing from localized to quasiparticle geometry, or vice versa. In this stimulated reaction picture, the momentum shock is delivered to the many-body deuteron system and its dressing electron fermi sea matter. The shock momentarily creates a "resonance" condition in which the energy of the total system containing the initial deuteron pair state momentarily equals the total system energy of the collapsed state. The shock causes a transient relative motion between the deuteron pair and its hosting metal, which causes a so-called "momentum scan". The change in dd internal structure is accompanied by a small transfer of momentum to the hosting metal.

The second step is the transfer of 23.8 MeV of nuclear energy from the quasiparticle helium nucleus to the hosting metal. The shock transfer of momentum described above makes a potential fusion reaction irreversible. The new helium nucleus is born with its internal nuclear matter in a state of intense internal vibration. From the point of view of the nucleus, the helium-4 is in a highly excited internal state. It is born at a high energy level. After collapse, the internal structure of nuclear matter has the same dd form that it had before collapse. The protons and neutrons describing the internal nuclear structure have retained their paired deuteron form, designated (d,d). The deuterons have retained their proton-neutron bonds. This (d,d) nuclear structure can also be written (pn,pn). The most stable form of helium-4 nucleus has an internal structure which has mainly neutron-neutron plus proton-proton bondings. This lower energy, more stable configuration can be written (nn,pp). The de-excitation transfer of 23.8 MeV of nuclear energy to the outside world is thought to occur in a cascade of discrete steps. It is thought that these transfers are accompanied by momentum impulses given to the hosting metal lattice at the edge limits of the good interface area, where the interface encounters the larger enclosing metal. The electron screening (dressing) becomes impaired at the edge boundaries of the good crystallite interface area. It is thought that momentum impulses should also occur perpendicular to the interface.

Regardless of process details, reaction energy cannot be released in the form of energetic particles or gamma rays. These conventional emitted quanta have point-like geometries which do not match onto the lattice geometry of the partitioned nucleus form. The geometric mismatch guarantees that the cold fusion process is radiationless. (See Reifenschweiler disussion on p. 17)

Geometries Compared

Fig. 3.4,1 illustrates the deuteron quasiparticle orbital geometry that makes cold fusion possible. The top row shows calculated spatial distributions of adsorbed H atoms located on two different faces of Ni surface crystal. Since the H and D chemistries are the same, the Figure compares the chemical orbital of a deuteron confined within a potential well with that of a deuteron quasiparticle orbital. The right side picture applies to the deuterons that are responsible for cold fusion. The deuteron has adjusted to the 2–dimensional symmetry of the surface crystal. The bottom row drawings show the difference between 2 deuterons in adjacent chemical orbitals and 2 paired deuteron quasiparticles. The 2 adjacent chemical orbitals resemble a D_2 molecule, whereas the paired deuteron quasiparticles resemble spin-paired electrons. The paired deuteron quasiparticles share the same volume. In quantum language, they have "overlapping wave functions".

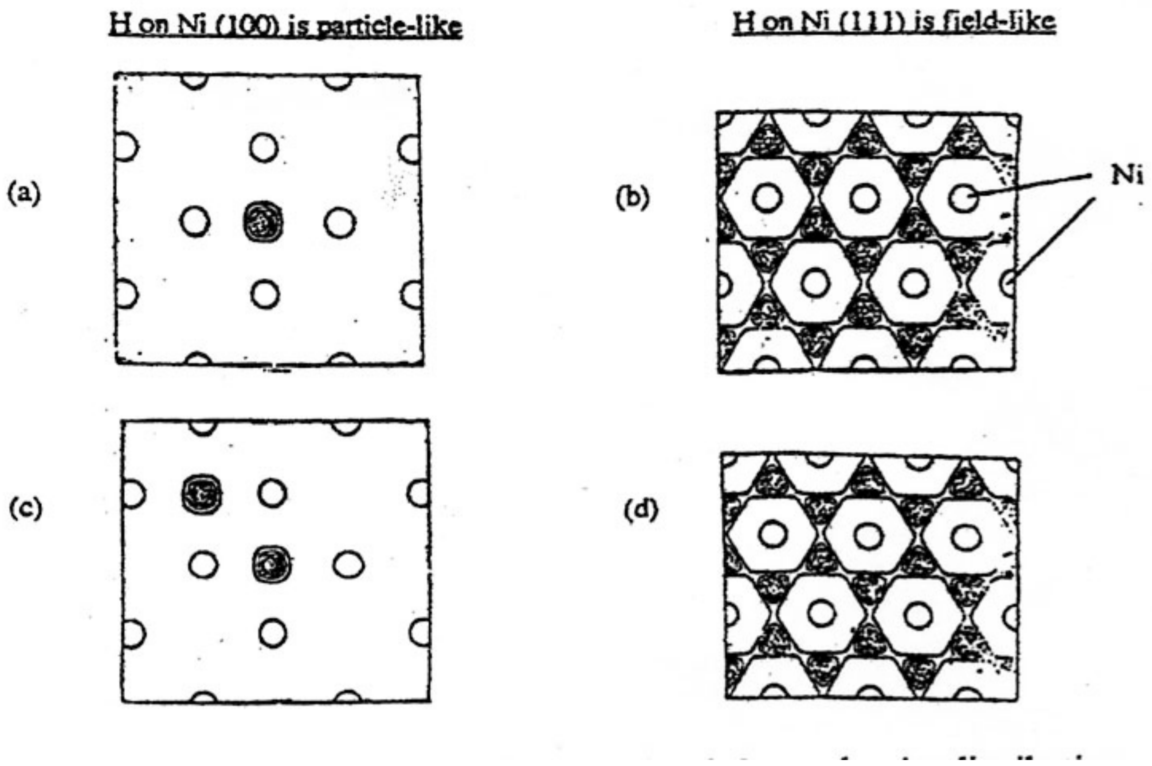

Fig. 3.4,1 The figure is based on calculated charge density distributions of H^+ on Ni surfaces by R. Nieminen. 1a shows the chemical orbital of a H^+ ion confined within a potential well on the Ni crystal surface designated (100). 1b shows the quasiparticle orbital of an excited state H^+ ion on the Ni crystal surface designated (111). The quasiparticle H^+ ion (proton) is coherently partitoned among a large number of potential wells. These calculations apply equally to deuterons. 1c illustrates the geometry of two deuterons confined within adjacent potential wells on Ni (100). 1d illustrates the geometry of two coherently partitoned quasiparticle deuterons confined within a large number of potential wells on Ni (111). The two coherently partitioned quasiparticles share the same volume, have wave function overlap, and are able to fuse their internal structures in response to the nuclear strong force attraction.