THE NATURE OF ELECTRICITY

WORK IN PROGRESS, SEE ALSO ARTICLES ON METALLIC BONDING, HEAT CAPACITIES AND SOLID LATTICE BARS OF METALS CONDUCT ELECTRICITY

NO CONDUCTION ELECTRONS!

ELECTRICITY IS THE PROPAGATION OF A POLARIZATION WAVE

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Einstein: … free electrons do not exist in metals at all.

Heisenberg:… electrons in metals were one proving ground for quantum mechanics.

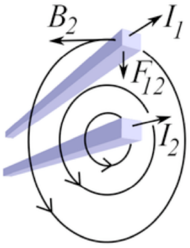
Abstract

Einstein was a quantum mechanics skeptic. [ei]
Heisenberg and the elite of physicists of the first half of the 20th century dissipated their time with non-existing conduction electrons of metals. [HBE]
But the electronic gas according to Drude, Bloch, Fermi, Pauli and others simply does not exist. Therefore the explanation of electrical conductivity in terms of the electron gas is lacking the necessary foundation. The fictitious electron gas theory cannot explain the speed of electricity, which is roughly c, the velocity of light. The phase velocity of an electron gas *sound wave* can never be the *rationale* for the speed of electricity. Obviously, flowing electrons cannot push each other through the wire like gaseous atoms can do. Recall that there are ions in the wire that slow electrons down... Therefore there is no analogy between sound speed and speed of electricity!

The speed of electricity is that of a polarization *wave*.
Like in a capacitor, a voltage polarizes the metallic dipoles of the wire. The propagation speed of the polarization depends on the dielectricity constant ε of the material. ε depends essentially on crystal structure.
For carbon nano tubes polarization depends on diameter and chirality. Diameter and chirality determine eigenfrequencies. Eigenfrequencies are determined also by atomic mass A. Critical temperature of superconductivity depends on atomic mass (isotope effect).
Electrical conduction depends on crystal structure. Because metallic bonding in terms of electron gas and atomic ions is untenable, stability of metallic lattice is only possible when there are solid lattice bars. These solid connection links consist of hydrogen (single, double parallel or in series).
Not only lattice types (bcc, fcc, …) must be distinguished, but also the (isotope) mass, the constitution of the lattice bars and the occurrence of unpaired hydrogen are in the lattice nodes
The model of this electrical polarization wave is a torsion wave that is not only localized in the wire but has its place also around the wire. Two electricity-carrying wires interact. Action at a distance in a vacuum cannot do that.

There is no vacuum but a dielectric and diamagnetic medium that is the carrier of electricity and magnetism around the wire.
In the wire the dielectric crystal lattice in company with the dielectric and diamagnetic medium conducts electricity.

Wikipedia describes the figure: *The top wire with current* I_1 *experiences a Lorentz force* F_{12} *due to magnetic field* B_2 *created by the bottom wire. (Not shown is the simultaneous process where the bottom wire* I_2 *experiences a magnetic force* F_{21} *due to magnetic field* B_1 *created by the top wire.*
(See also the article on the Hall effect. The Hall "current" cannot be conceived as a flux of charge carriers…)



Introduction

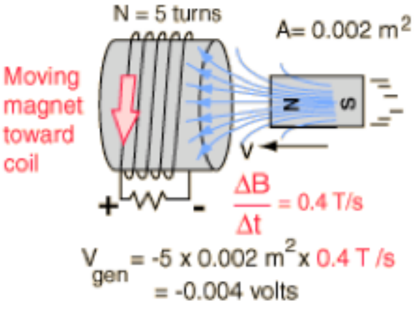
Oersted discovered in 1819 the deflection of a compass needle due to an electrical "current". This was the discovery of the fundamental connection between electricity and magnetism. Therefore an electrical current produces magnetism that generates a force on the compass needle. Assume that between the current carrying wire and the compass needle is nothing — a vacuum. Then if something in the wire exerts a force on the compass needle this force must leap over the vacuum gap. This is the concept of action at a distance or distant force.

In order to avoid the impossibilities with distant forces the concept of *magnetic field* was invented. When you switch on electricity the wire is accompanied by a magnetic field. Electricity switches on magnetism. Switching on magnetism is only possible when there are numerous elementary magnets that are aligned along magnetic field lines. Therefore a magnetic field requires a carrier that is a discretely structured electromagnetic medium. Switching on a magnetic field results in alignments of the elementary magnets. The magnetic field exerts a force on the needle. The carrier for all electromagnetic phenomena was formerly called a*ether*.

The alternative would be that the magnetic field is an emanation out of the wire. This is untenable. In other articles I argued that the so-called inertial forces are only explainable when there is an electromagnetic medium and not a vacuum.

Induction of electricity by a moving magnet

In 1831 Faraday discovered that a moving magnet toward a coil of wire induces a voltage. *Hyperphysics* (/hyperphysics.phy-astr.gsu.edu/hbase/electrical/farlaw.html) shows cause and effect. When the essence of electricity (or the voltage) means the propagation of a wave of polarization then we have to explain how the changing magnetic field induces a resonance in the polarization state of the metallic lattice of the wire. This is only possible when the magnetic field can act on molecular magnets that have charges +, —, too!



The magnet aligns molecular magnets in the metallic lattice. These molecular magnets are not electrons of the (non existing) electron gas but partly unpaired hydrogen atoms that are located at the lattice nodes. They are elasto-magnetically bound and can oscillate. For details see below. Because a hydrogen atom consists of + and — charges, the alignment of the molecular hydrogen magnets is at the same time also a polarization of charges. And the propagation of a state of polarization is nothing else than electricity.

But not only unpaired molecular hydrogen's serve for polarization and magnetic alignment. Because it is assumed that the *lattice bars of the metal consist of hydrogen's that can oscillate*, these molecular magnetic and +,—, charged bars can be magnetically aligned and polarized together. This is also the explanation how a magnet is capable to induce a voltage.

Magnetoresistance works the same way as magnetically induced electrical voltage does: when a magnetic field is applied to a wire, the electrical resistance of it changes. Molecular magnets and the charges of them changed positions….

There is also an electrical field due to an electrical current. The picture [BS] shows the experimental mapping of the field.

The argument is that we cannot comprehend the nature of electrical conduction in a wire when we restrict considerations only to the wire.

What does the electrical conductivity of the elements depends from?

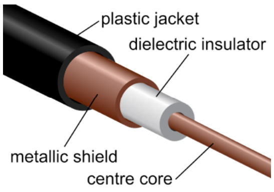
There is no *rationale* for the delivering of valence electrons in order to achieve metallic bonding and electrical conduction by valence electrons…
On no conditions the electron gas constitutes the electrical *current*, namely a stream or *flux* of charged particles. Electrical conduction is not a transport of something along the wire.

The electron gas cannot be ***The Servant of Two Masters:***
Bind together atomic ions and conduct electricity!
See Shenoy [she] for the complexity of electron conduction theory!

Nature has chosen the wave as a means of propagating states with a minimum transport of masses and charges.
In a metallic wire charges vibrate and elementary magnets are aligned due to a magnetic field. Imagine the metal as a 3D-mattress. In the lattice points are the cores of the atom, the linkage between cores are made up of hydrogen atoms as bonds.
Conjecture:
The hydrogen is composed of 4 elementary ring magnets with charges +—+— and is a magnetic bar. The state of vibrating charges and aligning magnetic moments is propagating. The propagating state is also a tension-state. A voltage sets up tension.
(In the kilo-Ampere range short "current" pulses generate a tension strong enough to break the wire into pieces.)

The origin of the misconception of electricity as a current of electrons was Daniell's DC element. There are (slowly) migrating electrons in a wire. But there is also a propagating polarization wave of electricity that phase velocity is roughly c.
Below we show that the electric current is not a current of something but a polarization wave. electrical conductivity depends on crystal structure of conductors and not on the alleged elecron gas.

Simple refutation of *conduction electrons* by measurement of the speed of electricity in coaxial cables



Speed of electricity in a coaxial cable is about (2/3) c, according to conduction electron theory, it should be equal to the speed of electricity in ordinary ● wires, namely ~ c
The dielectric of coaxial cables is mostly polyethylene. It slows down the electrical polarization phase velocity, which is the speed of electricity. The alleged electron gas in the copper cannot explain this fact... According to the theory of conduction electrons, both, the centre core and the metallic shield of the coax cable should conduct electricity with the same speed ~ c *irrespective* of the polyethylene filling! Also, when the speed od electricity is explained due to a wave at the surface of the metal, it should be c for both a coax and a non coax cable.
In fact, the filling reduces the speed of electricity!
This fact alone refutes conduction electron theory! According to current theory of electrical „current", the dielectric insulator has nothing to do with conduction... False!

Graph from *wikipedia*; *wikipedia* on coax cable: *One advantage of coax over other types of radio transmission line is that in an ideal coaxial cable the electromagnetic field carrying the signal exists only in the space between the inner and outer conductors.* (No field around the cable?)

Electrical conduction is not a flux of charges but a propagating state of (dipole) polarization and its frequency (AC)

An electrical "current" in a loop causes a magnetic field and the loop acts like a bar magnet with North and South Pole. This is a fact but the underlying definition of conduction current $I = dq/dt$ of electrons is untenable. The claim is that in a wire free electrons ("electron gas cloud") move and that moving charges define the current.
Electricity is a wave. The wave is the propagation of polarization. There is no electron current.
Polarization is due to the electrical field. Polarization propagates through the lattice of the wire. The lattice consists of positive and negative charges as building blocks. The speed of electricity is the phase velocity of a polarization wave that propagates through the wire and around the wire. This polarization speed depends upon the relative dielectric constants of the metal: $c_P{}^2 = 1/\varepsilon_0\mu_0$
where c_P = phase velocity of polarization, ε_r = electrical permittivity of the metal, μ_r = magnetic permeability of metal.

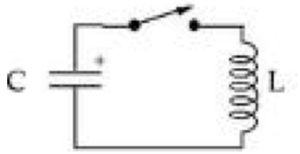
Electromagnetic waves cannot propagate through a vacuum
Of course a real vacuum cannot have qualities like electrical permittivity ε_0 and magnetic permeability μ_0. These qualities are qualities of something, namely of a *dielectric aether!*
Recall that the phase velocity squared of electromagnetic waves in the aether is:
$c^2 = 1/\varepsilon_0\mu_0$
$\mu_0 = 4\pi\ 10^{-7}$ H/m = $1.256\ 10^{-6}$ Vs/Am
$\varepsilon_0 = 1/\mu_0\ c^2 = 8{,}854...10^{-12}$ As/Vm
Recall that the **wave impedance** is

$Z_0 = \sqrt{\mu_0 / \varepsilon_0} = \mu_0\, c = 4\pi 10^{-7}$ N/A 2.99792458 10^8 m/s = **376,730 Ω**
Wave impedance cannot be caused by vacuity or by space itself that is a relation and not a thing.
Below is an explanation of the impedance of the propagating polarization wave of a conductor of electricity.
For the electromagnetic wave of light in the dielectric aether we have $(c)^2 = 1/\varepsilon_0\mu_0$.
Where $1/\varepsilon_0 = 8{,}98755\ 10^9\ [m^3 kg/q_2 s_2]$ and $\mathbf{1/\mu_0 = 1{,}0000031\ 10^7}\ [q^2/kgm]$.
Therefore we obtain $c^2 \approx 10^7/\varepsilon_0 \approx 9\times10^{16}\ [m^2/s^2]$

According to wikipedia:
the speed of electricity in an unshielded copper conductor range 95 to 97% that of the speed of light.
Numerical example: We assume for the phase velocity of electricity in copper wires
$c_P = 0.97\ c \longrightarrow$
$(c_P)^2 = 0.9409\ c^2 = 8{,}468\ 10^{16}\ [m^2/s^2]$
This is the case when the permittivity of the metal (copper) = $\varepsilon_r = 1{,}0628\ \varepsilon_0$:
$c^2 \approx 10^7/\varepsilon_r \quad \approx 9\ 10^{16}/1{,}0628\ [m^2/s^2] \approx 8{,}468\ 10^{16}\ [m^2/s^2]$
where ε_0 = permittivity of "vacuum" = 1, which is a relative magnitude.
A capacitor works as a part of an AC circuit, therefore it conducts electricity.
It works also if there is no dielectric material with $\varepsilon_r > 1$ between the capacitor plates.

But: Vacuity cannot be bypassed by electricity. In reality the erroneously so-called vacuum is a dielectric that consists of electrons and positrons and its permittivity $\varepsilon_0 = 1$. The electrical field polarizes the dielectric; the polarization wave propagates in the gap. If the capacitor works with a material dielectric inside ($BaTiO_3$ for example) the permittivity means permittivity of dielectric material **and** electron/positron dielectric (aether) combined! One cannot "evacuate" the space between the plates of the capacitor!
For barium titanate $BaTiO_3$ that serves as capacitor material $\varepsilon_r \approx 10^4$, $c_P \approx c/100$.

Capacitors conduct AC without a current of electrons



Conductivity depends on molecular structure. Metals are good conductors, ceramics are poor conductors. Ceramics serve for some purposes as insulators but in the true sense of the word they are poor conductors.
Empirical evidence that ceramics are conductors is the industrial application of *ceramic dielectrics* for capacitors. Take for example an electrical circuit with a barium titanate ($BaTiO_3$) capacitor. The alternating "current" (AC) goes through the capacitor!
Otherwise there would not be an elecric circuit, electricity passes the capacitor…
Dipoles of dielectrics in a capacitor undergo polarization.
There is a propagation „wave" of polarization states in the ongoing direction of the alternating "current" (AC). Therefore dielectrics are conductors for AC. The current is not a flux of „drifting" electrons but a propagation of a polarization state along the wire and the capacitor dielectric.

Electricity is not localized in the wire alone. As we know, a magnetic field is around the wire… The polarization wave of electricity is thought of to be a torsion (screw) wave, like light waves.

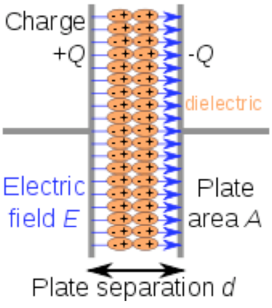
A textbook explains:

Effect of structure on the dielectric constant
... the more available polarisation mechanisms a material possesses, the larger its dielectric constant will be. .... materials with permanent dipoles have larger dielectric constants than similar, non-polar materials.
,... among polymers, the more mobile the chains are (i.e. the lower the degree of crystallinity) the higher the dielectric constant will be.
For polar structures, the magnitude of the dipole also affects the magnitude of polarisation achievable, and hence the dielectric constant. Crystals with non-centrosymmetric structures such as barium titanate have especially large spontaneous polarisations and so correspondingly large dielectric constants.
DoITPoMS, Department of Materials Science and Metallurgy, University of Cambridge

And: **The $BaTiO_3$ molecules don't possess free (drifting) electrons which could constitute an electrical current. But AC passes $BaTiO_3$!**
Recall that textbooks claim that free metallic electrons are the carrier of the electrical current. By the way, there are no free electrons in a metallic wire and they are not necessary to conduct electricity, see barium titanate, which conducts AC without free electrons!
Now You are prepared to understand the fallacies of textbooks concerning the function of capacitors: http://en.wikipedia.org/wiki/Capacitor explains:

The non-conductive region is called the dielectric or sometimes the dielectric medium.
In simpler terms, the dielectric is just an electrical insulator.
Nonsense! Every LC (figure: feynman.bgsu.edu) circuit can only oscillate if the capacitor is a conductor of AC. Obviously, that conductor part with area A is a bad conductor. But it functions in the same way as the conductive metal wires of the circuit: The alternating current in the wire changes the orientation of the +, - dipoles. That means that the "current" is a propagation of a polarization state and not a flux of charges. The same goes on in the dielectric when an alternating voltage polarizes the dipoles. Therefore, in the wires and in the dielectric of the capacitor we have a periodic propagation of polarization states and not a flux of electrons.
Note that "current" theory distinguishes between the conductor current of electrons in the wire and the displacement current in the capacitor. Here it was explained that there is no difference: In the wire and in the capacitor a polarisation wave propagates, this is the nature of electricity

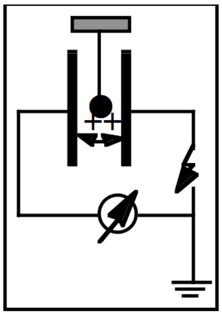
Wiki further explains: ...
When there is a potential difference (voltage) across the conductors, a static electrical field develops across the dielectric, causing positi charge to collect on one plate and negative charge on the other plate
The plates of the capacitor are part of the circuit. There are not sees of + (positron) or – (electron) charges at their facing surfaces.
The molecules of the metallic wire contain no free positrons, from where they should appear?
Like in the wire there are alternating polarization states of the molecular structure due to a potential difference. The cause for the electrical field between the capacitor plates are not the Q+ or Q- seas of the plates but the potential difference between the plates. The resulting voltage polarizes dipoles inside of the dielectric.



Direct “current” (DC) in a capacitor

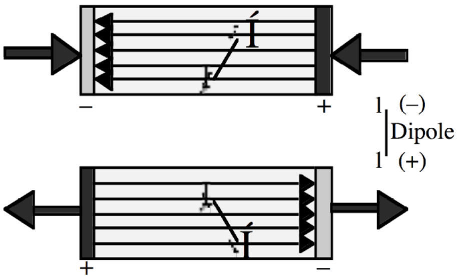
Charging a capacitor with DC means polarization of plus and minus charges. When the maximum possible displacement of the plus and and minus charges is completed, electrical conductivity stops. Now discharge begins. Displacemant of charges goes back, a depolarization wave is the result.
When completely charged, dielectrics block direct current (DC). But the dielectric breakdown of air or “vacuum” = 3 MV/m.

Repetition: Because the capacitor works as well within a „vacuum“, **there is no vacuum between the plates but a dielectric!** This dielectric *aether* consists of positive and negative charges. Therefore we assume that the carrier of all electromagnetic phenomena is a dielectric that consists of electrons and positrons.



Next capacitor example, see the graph: Oscillating *charges in a capacitor produce an electrical “current”. [paus]*
It seems to be that the oscillating charge represents the current of charges! But the speed of electricity would then be << c! The oscillating charge causes polarization waves (AC) of the dielectric electron positron aether between the plates and these waves have phase velocity ~ c.
By the way, the accelerated charge produce the polarization waves, these waves are accompanying waves of the electron. This phenomenon has nothing to o with the irrational duality of electron and electron wave!

Piezo-effect: no current
Dipoles in the lattice due to forces –> E-field



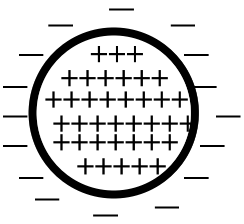
Both the **piezo electrical effect** and the reverse piezo electrical effect show a relationship between electrical tension and mechanical tension. A compressive stress on a quartz crystal produces a voltage. On the other side the electrical field between the plates of a capacitor causes a deformation of a quartz crystal.
Deformations of the crystal result in displacements of atoms and charges. The charges form dipoles. When forces compress the crystal like in the sketch, the dipoles become twisted (not completely aligned) this way:
–>(+)(–)(+)(–)(+)(–)<–, and in the case of stretching this way: <–(–)(+)(–)(+)(–)(+)–>.

The result of the displacements <u>and twists</u> of charges is an electrical field, whose direction depends on the sequence of the charge signs. The piezo effect is a disproof of the concept of moving electrons, which allegedly constitutes the electrical current.
The magnitude of the piezo effect depends on the crystal structure. For example for NaCl the piezo effect is small, for Zinkblende it is big because the charge distribution is capable to swing out.
The heat producing electron cloud by electron bangs into the crystal structure is incompatible with the Wiedemann-Franz law which states the proportionality of temperature to the ratio of thermal and electrical conductibility: $3(k/e)^2\, T = K/\gamma$, where k is Boltzmann’s constant.
Also the Joule-Lenz law shows that there must be a non-mechanical relationship between heat and electricity: $\delta Q = I^2 R\, dt = IU\, dt = U^2/R\, dt$, where δQ is the amount of heat that is produced within dt. Recall also the thermoelectrical effect.

Around electricity carrying wires there must be an electromagnetic medium

The magnetic field of the solenoid is around the wire; therefore there must be a medium that exerts the magnetic effects. The alternative would be a vacuum and some *actio in distans*. Therefore we cannot explain electrical current without an electromagnetic medium, formerly called *aether*. In fact, today "current" mainstream physics has no *rationale* for the explanation of the conduction current.
The most important requirement for scientific electrodynamics is a theory that explains the conduction current as an interaction of conduction wire and the surrounding electromagnetic ether.
Vacuum physics is in a dead end. Recall that the unity Ampere is defined in terms of the attractive force that acts between two wires conducting electricity. This force is explainable only with the knowledge of the structure of the carrier of the electromagnetic field between the wires. Otherwise only the unintelligible *actio in distans* can explain the effect.

According to the prevailing quantum theory metallic bonding is an interplay of the free valence electrons that constitute the so-called electron cloud and the ion cores of the lattice atoms. The electrons allegedly drift in a random manner through the lattice of ion cores. The bonding model explains metals as a lattice of ionic cores held together by a gas of free electrons! This is an untenable explanation.



The electron gas cannot hold together the ionic cores that are repelling each other! (According to a recent theory the electrons travel on the surface of the wire!)

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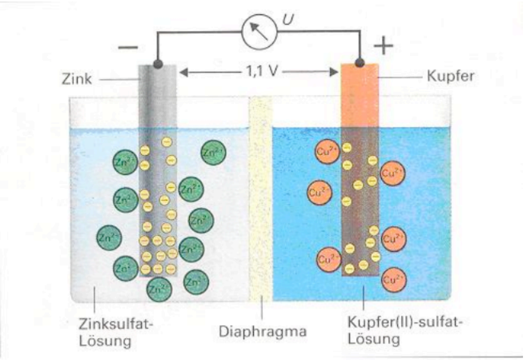
Don't misunderstand drifting electrons in Daniell's element as "electrical current"!



Voltage in Daniell's element wire causes a polarization wave with speed ~ c.
Don't misunderstand the current of slow drifting electrons in the wire as electricity. This electron flux exists besides of the polarization wave.
Considering a compact cylindrical wire, the electrons can be distributed along the surface of the wire, maintained by the batteries. Or are these also distributed inside the wire? …
It is not the topic of this article, where the electrons are flowing. By no means can the speed of electricity (~ c) be related to this electron flux. Considering electricity it is from the electrical power station, it is not due to *valence* conduction electrons… the voltage could release metalic surface electrons, but they are irrelelevant for the electrical wave that propagates with ~c. In any case these electrons would be an effect of electricity and not the nature of electricity. See [assis], graph from:
http://www.ps-chemieunterricht.de/jg12/ec/loesungst.htm

* * *

Electrical conductivity of metals

Free electron gas and energy band theory are per se untenable.
Free electrons do not exist in metals at all!

Both models, the *free electrons gas theory* of Drudge-Lorentz and the *band model* of Bloch ET. al. uses the basically wrong shell model of the atom which is the bed of Procrustes of QM.
Both models suppose for the conduction mechanism

(a) That electrical conduction is identical with electronic conduction which therefore can be localized only in the conducting metal wire and
(b) That a vacuum surrounds and penetrates this wire that therefore cannot be an interactive player with the metal wire.

Any modeling of a conduction mechanism by conduction electrons in a vacuum is necessarily a failure because the electrical conduction takes place not only in the wire but also around the wire and inside of the wire where current theory suppose a vacuum between electrons and atomic ions.
In 1820 Oersted observed that an electrical current changed the direction of a compass needle. Biot and Savart expressed this effect by a law. The real cause of the effect is an electromagnetic field. This field is surrounding the wire and is part of the *nature* of an electrical current.
Also in 1820 Ampère showed that two parallel wires carrying electrical currents attract or repel each other if the currents are in the same or in the opposite direction, respectively.

Because an explanation by an *actio in distans* is unintelligible, the electromagnetic field is a real one and not a mathematical auxiliary device. The effects observed by Oersted and Ampère are crucial experiments for the existence of a medium formerly called the ether.

Remember that for Hertz [hertz] the *main question* was to clear the essence and the attributes of the space filling medium, the aether. According to Hertz the knowledge of the aether is the key for the comprehension of gravitation, inertia and *electromagnetism*!
Again, the electrical current is neither the (slow) flux of the alleged electron gas of the metal wire nor the (velocity of light)-flux of charges (which ones?) nor the superconductivity-flux of the hypothetical Cooper pairs.

Conclusion:
There is no current or flux of something.
Instead of a current we should think at a changing polarization state of a crystal lattice that's interacts with the surrounding electromagnetic medium (aether). Think for example at electromagnetic longitudinal and/or torsion waves, the wire may be their conductor.
Till now we don't know the true nature of electricity in its entirety.

Refutation of conduction electrons:

Ir and Pt show identical or only minutely differing data concerning crystal structure, atomic weigth, number of protons, density, valency, electron density and lattice constant. According to electron conduction theory the electrical conductivities of Ir and Pt should differ also only minutely. But Ir conducts electricity 2.2 times better than Pt does!
Explanation: There are solid lattice rods. Ir possesses double bonds **II**, whereas Pt has only **I**.
So the Ir lattice possesses mor conductors! for details see below.

	Crystal	Atomic weight	Pro-ton #	density $\rho = g/cm^3$	Valency z	$n = z \times \rho / A$ # eletrons	lattice a [Å]	El. conduct. 10^6 S/m
Ir	**fcc**	**192.2**	**77**	**22.5**	**z = 6**	**0.7**	**3.84**	**21.**
Pt	**fcc**	**195.1**	**78**	**21.5**	**z = 6**	**0.66**	**3.92**	**9.4**
Ir/Pt	**1**	**0.98**	**0.99**	**1.05**	**1**	**1.06**	**0.98**	**2.2** ●

Electromagnetic properties of bcc metals

Explanation: 2 H’s in series (— —) for K, Rb, Cs represent slack (trembling) bonds. So the more the mass increases the more energy is consumed by thermal vibration of the kernels and electrical conductivity must decrease.
The poor conductivity of Mn is explainable due to its huge unit cell dimensions: its lattice constant is 891 pm. Therefore lattice bars consist at least of 2 H’s in series. Temperature let them tremble and this trembling disturbs electrical conduction.
An exception is Mo that is diamagnetic. Lattice spacing’s are in the same range.
Note that Molybdenum is a broad mix of isotopes with mass numbers 92, 94, 95, 96, 97, 98. It is possible that some isotopes are diamagnetic and some are paramagnetic….

The graph below shows that for example the bcc elements Li, Na, K, Rb, Cs and Ba have approximately the same magnetic susceptibility.

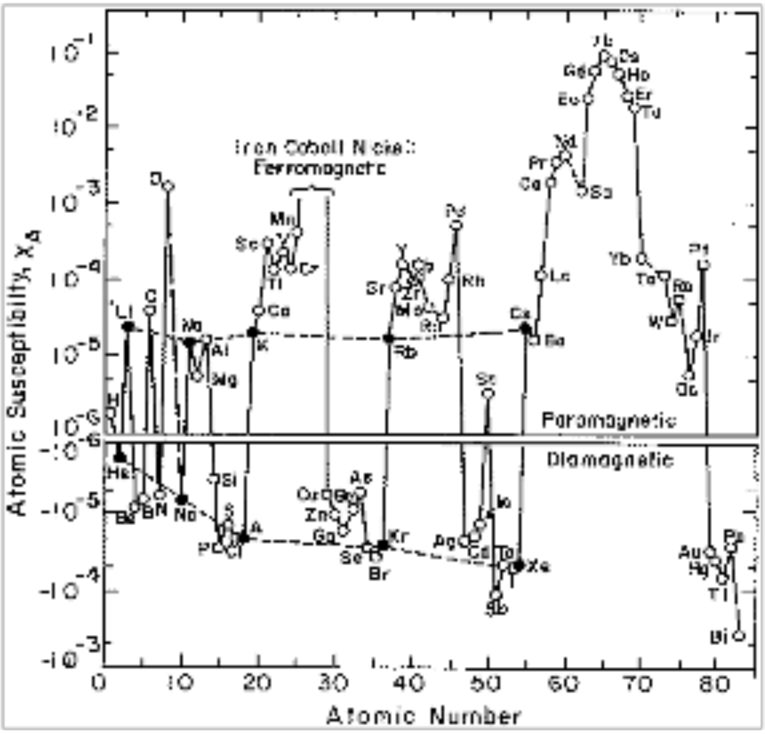
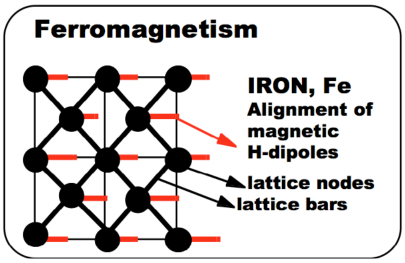


Bild 2.6: Atomare magnetische Suszeptibilitäten der Elemente.

aus: Robert O’Handley, *Modern Magnetic Materials*, Wiley, New York (2000) [Nach Bozorth, Copyright IEEE Press (1993)]

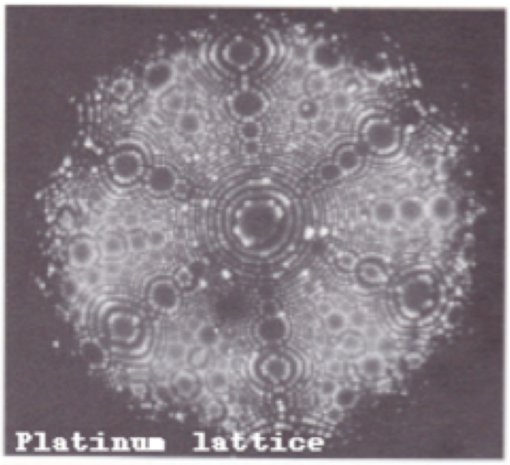
Considering susceptibilities of paramagnetic elements there is a striking big difference between the alkali elements and Fe, Ni, Co and Cr. What is the difference in terms of crystal structure? For Li-7 the nodes contain 3 H’s ((2×7 —8)/2 = 3), therefore one H is unpaired and can react in magnetic fields. For Na-23 we obtain (2×23 —16)/2 = 15H, again one H is unpaired.
For bcc Fe-57 we obtain (2×57 —8)/2 = 53.
For fcc elements with one H as bond the formula for the number of H’s in the nodes (see below) is A - 6. So we obtain for Ni-61 55 H’s, for Co-59 53 H’s and for Cr-53 47 H’s in the nodes. Therefore Fe, Ni, Co and Cr have unpaired magnetic dipoles.

Remarkable is that number of H’s in the nodes of Fe, Ni, Co and Cr shows the same order of magnitude (53, 55, 53, 47, respectively). It is a conjecture that in this case the unpaired



magnetic dipoles can easily be turned. But experiments show *ferromagnetic anisotropy*, i. e., the magnetic direction dependence. Probably this magnetic dipole directions are magnetic and electrostatic equilibrium states that coincide with the cubic lattice directions. This behaviour is referred to as cubic ferromagnetic anisotropy.
The rationale in terms of magnetic equilibrium is very simple, whereas current QM explanation is laborious. See Phys. Rev, 52, 1178 (1937)
http://prola.aps.org/abstract/PR/v52/i11/p1178_1
J. H. van Vleck:
It is shown that the dependence of the intensity of magnetization on direction in cubic single crystals probably results from the interplay between orbital valence and spin-orbit interaction. Because of the spin-orbit coupling, ...
The different behavior of iron and nickel can easily explained in terms of crystal structure: Iron has bbc, whereas Ni has fcc structure. Temperature and the different nodes of lattices influence the equlibrium too.
Stainless steel is an alloy of 90% Fe (ferromagnetic) + 10% Cr (anti-ferromagnetic). But this alloy is not ferromagnetic! Both, Fe and Cr have bcc structure, but their nodes are different. The node structure is still not understood.

A *surface* emmision picture of the Forschungsinstitut für Elektronenmikroskopie at Graz Technical University can be interpreted as follows: Obviously the surface cannot deliver a 3D picture of the lattice.
But the regular crosssing lines can be interpreted as the connection lines between the atoms. They can be either a representation of the electrostatic forces or bonds (bars) that consist of hydrogen.
We assume that these hydrogens are parts of the atoms that serve for bonding. (We don't assume that these hydrogens are products of the dielectric medium...)
But these bonds are not thougth of as Hydrogen bridges as in current theory but as real bars of hydrogen atoms. Therefore the lattice possesses real (massive) bars.



The table shows the supposed metallic structures of some fcc-metals.

Fcc metals												
H-bonds	‖	‖	|	|	|	|	|	|	|	— —		
	^{103}*Rh*	Ir193	^{27}*Al*	Ni	Pd100	200Pt	Cu	Ag	^{197}*Au*	Pb	$_{\alpha}$Ca	$_{\alpha}$Sr
R_H	—	+	—	—	—		—	—	—	+	—	—
F, P, D10^{-7} cm^3/mol	P10	P2,5	P1,65	F	P54,6	P19,3	D0,55	D1,95	D 2,8	D 2,3	P 0,55	P9,2
el. cond.10^7 S/m	**2,3**	**2,1**	**3,8**	**1,4**	**1.**	**0,94**	**6,0**	**6.3**	**4.5**	**0.5**	**2,9**	**0.76**
th. cond.W/mK	150	150	235	91	72	72	400	430	320	35	200	35
a [Å]	**3.8**	**3.84**	**4.05**	**3.52**	**3.89**	**3.9**	**3.61**	**4.08**	**4.08**	**5.0**	**5.6**	**6.1**
rigidity/Gpa	150	210	26	76	44	61	48	30	27	5,6	7,4	6,1
density g/cm^3	12,46	22,65	2,7	8,91	12	21,1	8,92	10,5	19,3	11,34	1,55	2,63
spec heat J/(kgK)	137	131	904	445	240	133	384	235	129	127	631	300

Comment:
Comparing **Rh and Ir**, Ir is more rigid, the electrical conduction is lower than for Rh. Ir is a mix of isotopes, so that here the rule is violatete that the decrease of rigidity is accompanyied by a decrease of electrical conductivity.

Comparison **Pd and Ag**: all properties (lattice constant, rigidities, specific heat) are only marginally different but electrical and thermal conduction are remarkable different. **Electrical conduction of Ag is 6.6 fold!** Then: Pd is paramagnetic, Ag is diamagnetic. What are the causes for the differences? Isotope impurities are significant: Ag is a 50:50% mix of Ag-107 and Ag-109 but Pd is a broad mix of: ^{102}Pd 1.02%,^{104}Pd 11.14%, ^{105}Pd 22.33%, ^{106}Pd 7.33%, ^{108}Pd 26.46% ,^{110}Pd 11.72%. This broad isotope mix may be the cause for the obstruction of conduction! Moreover, Pd is an isotope hybrid with only one isotope with an odd mass number A: Pd-105 with 22% abundance. Probably only this isotope is a good conductor. Both Ag isotopes have odd mass numbers…, Ag conducts electricity about 6 times better than Pd! For QM the key factor for conductivity is the number of conducting electrons. According to the electron conduction theory Ag has two valence electron whereas for Pd valence is 4.

Fermi energies determine **electrical conductivity** according to the QM formula
$\mathbf{E_F = K_N}\, \boldsymbol{n}^{2/3}$, where K_N is a constant, ***n*** is the number of free electrons.
There are allegedly $\boldsymbol{n} = \mathbf{z}$ (# of valence electrons) $\times\ \boldsymbol{\rho/A}$ free electrons
that can flow through the assembly of atomic core ions (ρ… density, A… mass number).
Ag: $n = z \times \rho = 2\times10.49 = 20.98$ Pd: $n = z \times \rho = 4\times12.02 = 48.08$
The Ag/Pd ratio for ***n*** is 0.436; and
$(0.436)^{2/3} = 0.58$, this does not correspond to the electrical conduction ratio for Ag/Pt 6.6!
Imagine the **lattice of Ag or Au** as an elastic 3D-mattress. Both lattice spacing and lattice structure of Ag and Au are the same. The sole difference between Ag- and Au mattress concerns the lattice points. The nodal points of silver Ag-107 has: (107 – 6) = 101 H.
For ^{197}Au: = 191 H.
The atomic cores in the lattice points and the hydrogen linkages are connected by magnetic coupling. Obviously the elasticity of this coupling depends on the configuration of the cores and their quantity of hydrogen constituents.
Regarding **Pt and Pd**, roughly all values don't differ significantly, except mass A, rigidity and specific heat. Due to the greater mass of of Pt (200 vs. 100), the effective bar length of the Pt lattice is shorter than for the Pd lattice. This bar length difference explains that the Pt lattice is stiffer. Because the Pt effective bar length is smaller than for Pd, specific heat is also smaller. Why electrical conductivities don't differ more? Notice that P and Pt, both consist of a brad mix of isotopes, thisis their main impurity…
Compare Pd with Ag: mass number A, density and unit cell dimensions, are roughly the same, but Ag conducts electricity 6.3 times better? The key factor for conductivity is the number of conducting electrons. According to the electron conduction theory Ag has only one valence electron whereas for Pd valence is 4. For Pd the number of free conduction electrons is therefore 4-fold greater.

The rationale for the poor conductivity of Pd it is because Pd is an isotope hybrid with only one isotope with an odd mass number A: Pd-105 with 22% abundance. Only this isotope is a good conductor because it possesses an unpaired hydrogen that serves for conduction. The isotopes with even mass numbers are poor conductors. This can be seen comparing the conductivity of Ag . Both Ag isotopes have odd mass numbers…So Ag conducts electricity about 6 times better than Pd!

Regarding the metals **Ni and Cu**, the failure of the model of conduction electrons is obvious: Both, Ni and Cu, have fcc structure and two valence electrons.
(*hyperphysics* textbook does not use the two valence electrons of Cu:
copper that have one free electron per atom..., which means the $4s^1$ electron;
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/ohmmic.html)

If one applies band theory (see later) and let work the two valence electrons for the conducting job, then the conducting electrons have roughly the same environnement iside of Ni and Cu, except slightly different mass numbers and electron shells:
Ni versus Cu,
Fcc unit cells dimensions are roughly the same for Ni and Cu.
Mass numbers A are in the same range: A = 58,7 for Ni, A = 63,6 for Cu. For both, Ni and Cu, densities are nearly equal: n = 8,91 and 8, 92 g/cm^3, respectively. This tiny difference cannot be the cause for the big difference concerning conductivity: Ni = 1.4; Cu = 5.9! Recall the QM formula for conductivity: $\sigma = n e^2 \tau/m$. Because of the equality of densities, conductivities could differ only due to τ, the mean flying time of electrons. Because of the rougly equal environment for electrons inside Ni and Cu, the relation for the mean flying time (or free path) cannot be 1:4.

What is the essential difference between Ni and Cu? Look at the stable isotopes (periodic table.com):

^{58}Ni	68.1%	**^{63}**Cu	69.2%
^{60}Ni	26.2%	**^{65}**Cu	30.8%
^{61}Ni	1.1%		
^{62}Ni	3.6%		
^{64}Ni	0.9%		

The two Cu isotopes possess odd mass numbers. According to our theory (see below) in this case there is an unpaired hydrogen per unit cell that is responsible for good electrical conductivity because it is polarizable and electricity is thought of as a polarization wave in the wire.
Ni contrasts with Cu because it possesses only a tiny isotope fraction with odd mass number (1,14% for ^{61}Ni). All other Ni isotopes possess even mass numbers. Fcc structures with even mass numbers are relatively poor conductors because they don't possess unpaired hydrogens per unit cell. Electron conductivity theory ignores crystal structure as well as isotope composition

Now we compare Al with Au: crystal structure and lattice spacing are the same, melting point and rigidity of Au are greater. The ratio of masses is 27/ 197. Electrical conductivity of Au is greater than that of Al. Due to its greater mass, the effective bar lengths of Au are smaller than of Al, therefore the Au lattice is stiffer and electrical conductivity is better. Au is diamagnetic whereas Al is paramagnetic.

What is the cause of diamagnetism of Cu, Ag, and Au and Pb?
A diamagnetic element shows a weak repulsion in a magnetic field. Recall that the smallest repulsion is observed for ^{209}Bi.
Bi has a basic centered monoclinic crystal structure. Probably the elementary magnets are blocked by the structure and by the huge dimensions of atomic kernels.
Note that superconductivity shows always diamagnetism.
Above we concluded that for bcc metals the conductivity decreases with increasing mass number A (or density). So the value for the electrical conductivity of Ba (bcc!) is only 30. But for the "heavier" fcc-structured Au it is 450! For Au the 12 bonds prevent the atomic cores

from excessive thermal vibrations

Then compare ^{39}K with ^{40}Ca. All parameters are in the same range but Ca is a significantly better electrical conductor than K. Why? α-Ca has an fcc structure whereas K (its structure is bcc. Electrical conduction obviously depends on the number of connecting H's. The propagation of the polarization state
(= electrical conduction) has a better efficiency.

The **big difference between Au and Pb regarding the conductivity** is unexplainable in terms of current "current" theory.
Explanation in terms of crystal structure: Both, Au and Pb have fcc structure. But there is a big difference: the bars of the Au structure consist of one single hydrogen atom, |, whereas the bars of the Pb lattice consist of two hydrogen atoms in series, — — !
Bond lengths of Pb are significantly greater than bond lengths of Au. The result is a significant greater rigidity of Au that causes a greater electrical conductivity.
Smaller density of Pb cannot compensate this, so Au is the better conductor!
The cause for the poor conductivity of Pb is probably also the broad mix of isotopes: ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{204}Pb. The unalloyed Pb isotopes are possibly better conductors than the isotope-alloy.
According to quantum physics the atoms of the Pb isotopes do not differ from one another regarding their physical properties because the number of neutrons that characterize the isotopes is irrelevant for the physics of the atoms except that the "inert" mass is different.

Even not all isotopes of Pb must have necessarily the same crystal structure. Lattice structure, type of H bonds (||, —, — —) mass number A and probably the structure of the atomic kernel and the magnetic couplings between the kernels and the linking H's exercise an influence on conductivity. Regarding Ca and Sr, bot, Sr and Ca are a mixture of different isotopes. Remarkable are the small rigidties of Ca and Sr. their bonds consist of two H's in series that respond to magnetization. Therefore Ca that cosnsists of 97% of Ca-40 is paramagnetic although it has no unpaired H. (40 -12 = 28 H's in the lattice nodes.) Ca is therefore also a god electrical conductor: the vibrating bonds can be polarized.

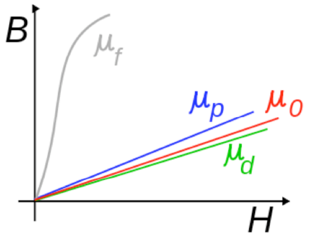
Special casse **Th-232**. The unique isotope of thorium is Th-232, it has fcc structure. Because 232 is an even number, according to the rule for the number of hydrogen's in the lattice nodes there are 232 – 6 = 226 H's. Obviously, there is no unpaired hydrogen for the purpose of conducting electricity. But Th-232 is a conductor. The cause is that the lattice bars consist of two H's in series (— —). This is the case because the lattice constant is 508 pm.

Diamagnetism vs. paramagnetism

Regarding the fcc metals Al, Ag, and Au in hinsight of its magnetic susceptibility, Al is paramagnetic whereas Ag and Au are diamagnetic. So the unpaired hydrogen of Ag and Au was not able to make the metals paramagnetic. Let's compare the magnetic susceptibilities:

	χ (mol SI): m^3/mol: Wikipedia
Al - 27	Paramagnetic + 2,1 10 $^{-10}$
Cu - 63, 65	Diamagnetic - 0,7 10 $^{-10}$
Ag -107, 109	Diamagnetic - 2,5 10 $^{-10}$
Au -197	Diamagnetic - 3,5 10 $^{-10}$

The jump from paramagnetic-Al to diamagnetic-Cu susceptibility happens in a very small range. So one can conjecture that the cause



was ignored. We must take into consideration that the measurment is not an operation *in vacuo* but in the *dielectric and diamagnetic medium.*
Helmholtz, a disciple of Faraday, propagated this dielectric and diamagnetic medium on the continent. [berk]
The relative magnetic permeabilities of the materials differ in magnitudes only minimal from the relative magnetic permeability $\mu_0 = 1$ of the alleged vacuum that is in reality a dielectric medium of electrons and positrons. (Obviously, nothingness or vacuum, could not have qualities like μ_0 and ε_0 !)
Magnetic susceptibility is defined: $\chi = \mu_r - \mu_0$ or $\chi = \mu_r - 1$
Therefore, the relative magnetic susceptibility of diamagnetic material is $\mu_r < 1$, that of a paramagnetic material $\mu_r > 1$.

Wikipedia (*Permeability (electromagnetism)* shows simplified comparison of permeabilities. (graph)
Considering Al and Cu, the nodes of Cu occupy more space than the nodes of Al do, so the mobility of the unpaired hydrogen is reduced. Cu cannot produce the paramagentic effect.
The table shows that diamagnetism increases with atomic number A for fcc structures

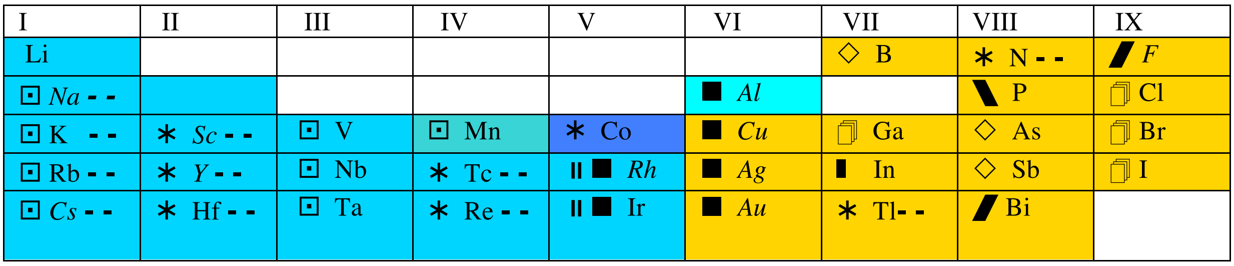
Paramagnetism vs. diamagnetism due to crystal structures

Note the distinction between magnetism in the gaseous state of an element and in its magnetism in the crystalline state. Example silver, Ag: since the Stern-Gerlach experiment it is known that Ag is (para) magnetic as a single atom. But a piece (volume) of silver metal is diamagnetic! It is reasonable to determine the magnetic susceptibilities per mole.
Regarding Na, K, Rb and Cs, they possess the same structural design. All are paramagnetic and their magnetic susceptibilities are in the same range. In the nodes is one unpaired hydrogen atom that acts as a tiny magnet.

Elements with trigonal, triclinic and monoclinic structure show exclusively diamagnetism. Trigonal structure have: B, Hg, As, Sb, Te. P is triclinic. Monoclinic structures have F and Bi. Bi is the element with maximum diamagnetism. Exactly, Bi has base centred monoclinic structure.
The common structural feature of triclinic, trigonal and monoclinic structures is that all three are *"oblique types"!* The other structures "stand straight". Most paramagnetic elements possess bcc, fcc of hcp structures.

Molecular properties • Magnetic type, crystal structure

⊡:bcc	**◇:trigonal**	**✱:hexagonal**	**⧹:triclinic**	**p paramagnetic**	**f ferromagn.**
■: fcc		**▮: tetragonal**	**⧸:monoclinic**	**d diamagnetic**	**af anti-f.**
🗍: base centered orthorhombic; ⊠ : face centered orthorhombic; D: diamond					



I	II	III	IV	V	VI	VII	VIII	IX
Li						◇ B	✱ N - -	⧸ *F*
⊡ *Na* - -					■ *Al*		⧹ P	🗍 Cl
⊡ K - -	✱ *Sc* - -	⊡ V	⊡ Mn	✱ Co	■ *Cu*	🗍 Ga	◇ As	🗍 Br
⊡ Rb - -	✱ *Y* - -	⊡ Nb	✱ Tc - -	ıı■ *Rh*	■ *Ag*	▮ In	◇ Sb	🗍 I
⊡ *Cs* - -	✱ Hf - -	⊡ Ta	✱ Re - -	ıı■ Ir	■ *Au*	✱ Tl- -	⧸ Bi	

✱ Be						D C	⧸ O	■ Ne
✱ Mg- -						D Si	☒ S	■ Ar
■ Ca - -		⊡ Cr ‖	⊡ Fe	■ Ni	✱ Zn - -	D Ge	⧸ Se	■ Kr
■ Sr - -		⊡ Mo ‖	✱ Ru	■ Pd	✱ Cd - -	D $_{\alpha}$Sn	◇ Te	■ Xe
⊡ ~~Ba~~ - -		⊡ W ‖	✱ Os	■ Pt	◇ Hg	■ Pb- -		
Remarks: $_{\alpha}$Sn: diamond structure, diamagnetic. $_{\beta}$Sn: tetragonal, paramagnetic								

- **Electrical conductivity 10^6 S/m**

structure	**bonds**			
⊡ **bcc**	| , ‖ double bonds, - - 2 H’s in series	▮ **tetragonal**	❐ **bc orthorh**	**D diamond**
■ **fcc**	|, ‖ , - -	☒ **fc orthorh**	◇ **trigonal**	
✱ **hcp**	|, ‖ , - - 2 H’s in series	⧹ **triclinic**	⧸ **monoclinic**	

I	II	III	IV	V	VI	VII	VIII	IX
⊡ Li 11						◇ B		
- - Na 21					■ Al 38		⧹ P 10	❐ Cl
- - K 14	- - Sc 2	⊡ V 5	⊡ Mn 1	✱ Co 17	■ Cu 59	❐ Ga 7	◇ As 3	❐ Br
- - Rb 8	- - Y 2	⊡ Nb 7	- - Tc 5	‖ ■Rh23	■ Ag 62	▮ In 12	◇ Sb 3	❐ I
- - Cs 5	- - La 1,6	⊡ Ta 8	- - Re 6	‖ ■ Ir 21	■ Au 45	- - Tl 7	⧸ Bi 1	
✱ Be 25						D C		
✱ Mg23						D Si	☒ S	
- - Ca 29	- - Ti 3	‖ ⊡ Cr 8	⊡ Fe 10	■ Ni 14	- - Zn 17	D Ge	⧸ Se	
- - Sr 8	- - Zr 2	‖ ⊡Mo20	✱ Ru 14	■ Pd 10	- - Cd 14	▮ Sn 9	◇ Te	
- - Ba 3	- - Hf 3,3	‖ ⊡W 20	✱ Os 12	■ Pt 9	◇ Hg 1	- - Pb 5		