The geometry of the situation indicates that the orbital problem is more efficiently described using polar coordinates, however, rather than rectangular ones. That is, the coordinates to be used are r and θ, where r is radial distance from the center of rotation, and θ is the angular distance counter-clockwise from the zero-angle taken as horizontal to the right (at 3:00 o'clock).

The velocity, v, in the above equation 15-50 that determines the amount of radially inward acceleration that properly maintains the orbit, is velocity in the θ direction, v_θ, tangential to the circular orbit. In orbit the velocity in the r direction, radially, is $v_r = 0$. That is, even though there is a radial acceleration inward it produces no radial velocity. It merely curves the otherwise straight path into the circle.

Once the orbiting body becomes dislodged from its stable orbit for whatever reason (such reasons are discussed further below), it is orbital failure mechanics that is applicable. That situation is depicted in Figure 15-13b, below.

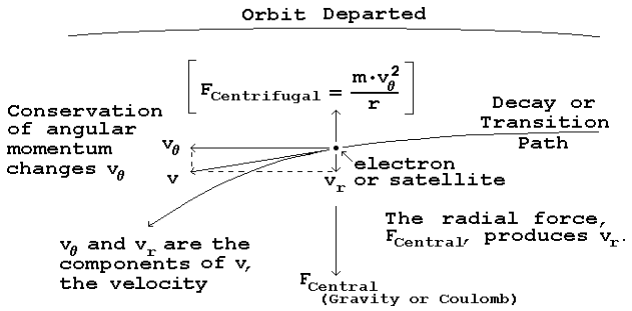


Figure 15-13b
Orbital Failure Mechanics

Such orbital failure involves a loss of potential energy. The potential energy is greater the higher the orbit, so the fall involves going to lower potential energy. Conservation of energy requires that for a satellite all of that lost potential energy (excepting losses to atmospheric friction) must appear in kinetic energy of the satellite, which requires an increase in its speed. The lost potential energy of the orbital electron likewise must be accounted for. In that case half goes to kinetic energy of the electron and half goes to the photon as demonstrated by equation 15-46.

There is a second conservation principle acting in these orbital failures, however: conservation of angular momentum. In every-day life a most familiar example of angular momentum conservation in action is a skater or dancer doing a spin. Usually the spin is initiated by the skater or dancer standing on one leg with the other leg well extended and swung in a circle to build up the motion of the spin. The spinning person then usually retracts the extended leg and immediately spins at a much greater speed. That increase in angular velocity is required in order to conserve the person's angular momentum. Usually when such a spin is to be ended a leg is extended again producing an immediate decrease in the speed of the spin and making a graceful stop possible.

In general, angular momentum, symbolized L, is analogous to linear momentum. Linear momentum is the product of the mass of a moving body and its velocity, that is

$$\begin{matrix}\text{Linear}\\ \text{Momentum}\end{matrix} = \left[\begin{matrix}\text{Linear}\\ \text{Inertial}\\ \text{Amount}\end{matrix} \equiv \text{Mass}\right] \times \left[\begin{matrix}\text{Linear}\\ \text{Velocity}\end{matrix}\right]$$

$$P = M \times v$$

For angular momentum the corresponding relationship is

$$\begin{matrix}\text{Angular}\\ \text{Momentum}\end{matrix} = \left[\begin{matrix}\text{Rotational}\\ \text{Inertial}\\ \text{Amount}\end{matrix} \equiv \begin{matrix}\text{Moment}\\ \text{of}\\ \text{Inertia}\end{matrix}\right] \times \left[\begin{matrix}\text{Angular}\\ \text{Velocity}\end{matrix}\right]$$

$$L = I \times \omega$$

The *moment of inertia*, symbolized I, is directly proportional to the square of the radius of the circle of rotation, $I \propto r^2$. (That radius, r, called the *radius of gyration*, is the radial distance from the center of rotation to the *center of mass* of the rotating mass. That center of mass is the location where the behavior is as if all of the body's mass were concentrated at that location.) Thus, for example, if the radius, r, were halved, the moment of inertia, I, would drop to one-fourth its prior value. If angular momentum is to be maintained then the angular velocity must increase by a factor of four to compensate for the moment of inertia decrease by that factor.

The linear velocity of the rotating body, which velocity is tangential to the circle of rotation, is equal to the product of the radius and the angular velocity: $v_\theta = r \cdot \omega$. Further pursuing the above example, with the angular velocity increased by a factor of four due to the radius being halved then the tangential linear velocity, v_θ, increases by a factor of one-half times four or two. Thus with conservation of angular momentum the decaying satellite or transitioning electron experiences linear velocity increase as its radial distance from the center decreases; that is, as the satellite falls or as the electron moves toward its inner orbital destination.

Referring to Figure 15-13b on the previous page, the magnitude and the direction of the moving body's speed, v, must be consistent with the two components of v: v_θ, and v_r. That is, from the triangular geometry,

(15-51) $$v^2 = v_r^2 + v_\theta^2$$

(15-52) $$\frac{v_\theta}{v_r} = \text{Tan}\left[\begin{matrix}\text{angle between}\\ \text{v and radial}\end{matrix}\right]$$

In the case of the decaying satellite, the magnitude of v_θ is controlled by conservation of angular momentum, there being no force acting in the θ direction to change that momentum. The magnitude of its v is controlled by conservation of energy because the lost potential energy must appear as kinetic energy. Then the magnitude of its v_r must become whatever is required to maintain those values of v_θ and v while also maintaining the relationships of equations 15-51 and 15-52. Except for the effect of the photon generated, those same statements of the required behavior of motion apply to the transitioning electron.

At this point the situation of the decaying satellite and that of the electron undergoing orbital transition diverge. The satellite, if disturbed out of its orbit, would accelerate and be increasingly directed away from the circumferential and toward the attracting Earth until it finally impacted. The electron in orbital

transition follows a less inwardly directed path as illustrated in Figure 15-14, below.

The less inward "Orbital Transition Path of Electron" in the figure requires the action of some other force, here designated F_{photon}, in addition to the always present Coulomb force, the additional force having the effect of changing the natural orbit decay behavior into the orbital transition behavior. This is an "apparent force" in that there is no additional object or charge introduced or involved when the orbital transition takes place. The participants during the transition are the same as those before and after: the orbital electron and the atomic nucleus. Yet, the effect of that "apparent force" is real. It not only changes the path of the electron from decay to orbital transition but it accounts for the energy that appears in the photon.

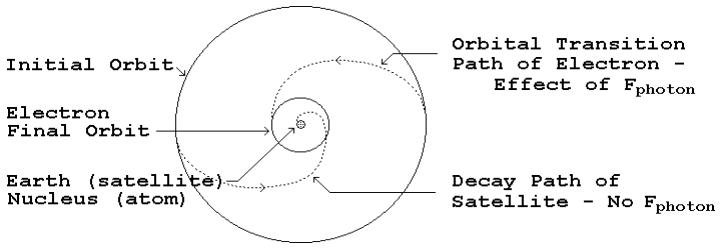


Figure 15-14
Electron Transition Mechanics -- Photon Equivalent Force
(F_{photon}, a force, should not be confused with f_{photon}, the photon frequency.)

Where does this effect as of an additional force come from ? What causes it ? The difference between the case of the decaying satellite and the electron orbital transition is that the decaying satellite is an electrically neutral object whereas the electron is a negative charge. The electron cannot change velocity without emitting E-M radiation because its velocity change produces a change in the shape of its U-wave propagation, a change which appears as a change in its magnetic and electric fields. And, all as described in section *14 - A Model for the Universe (4) - Magnetic and Electromagnetic Field*, changes in those fields mean that E-M energy is propagated. That propagation must be a photon as described in Table 15-11, Figure 15-12 and equation 15-49 as already discussed.

The effect as of an additional force is due to part of the energy that would otherwise go into the kinetic energy of the electron being diverted into the E-M energy of the photon, a diversion that happens automatically because of the changes in the electron's U-wave field as its velocity changes. Equation 15-46 shows that half of the total potential energy lost in the orbital transition goes to the photon and half goes to the increase in the electron's kinetic energy.

Then F_{photon} must be the effect as of a force acting on the transitioning electron and directed in the direction opposite to that electron's velocity at any and every moment during the transition. The opposite direction is required for the effect to be that of reducing the electron's otherwise resulting kinetic energy -- for F_{photon} to represent work being done by the electron, work that becomes the photon energy. Since F_{photon} accounts for half the lost potential energy going to the photon then the magnitude of F_{photon} might be expected to equal half that of the central Coulomb force of attraction, $F_{Coulomb}$. It actually must be less than half because it acts through a greater distance, the electron transition

path, than the purely radial inter-orbital distance through which $F_{Coulomb}$ acts. Figure 15-15 below depicts the situation.

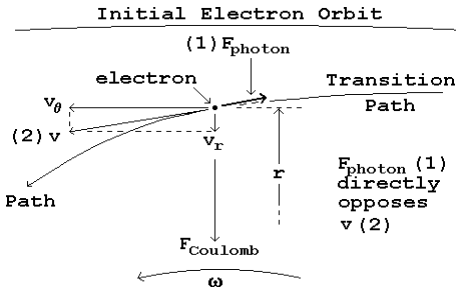


Figure 15-15
Forces in Electron Orbital Transition (Effect of F_{photon})

Being directed partly radially outward F_{photon} has a component that tends to oppose $F_{Coulomb}$ in the sense that it reduces the inward radial velocity, v_r, that would otherwise be acquired. Being directed partly tangential to the rotation and in the opposite direction to it F_{photon} tends to reduce the tangential linear velocity, v_θ, and in consequence tends to reduce the electron's angular momentum and angular velocity. That is F_{photon} diverts some of each of those, radial inward velocity and angular momentum, from the electron to the photon. As the transition progresses the electron velocity tends to increase because of the reduced radius and the resulting reduced moment of inertia making the angular velocity and the tangential linear velocity increase. At the same time F_{photon} tends to offset some of that acquired velocity. The net angular momentum lost by the electron appears in the photon.

It must be remembered that, while F_{photon} is described and depicted as a force, it really only symbolizes the natural effect, caused by the electron's electric charge, of the electron radiating when its speed changes. That is the effect that the total potential energy given up and available to the electron is allocated between the electron's kinetic energy and the photon's energy, with the electron's angular momentum behaving similarly. Except for that effect F_{photon} does not exist. It is not part of the overall system and external to the electron. It does not modify the change in potential energy nor the overall angular momentum (of the electron plus the photon) even though in the above figure it would appear to have components that would act so as to do so.

On the other hand, F_{photon} accurately represents the generating, the creation of the photon. The absolute orientation in space of F_{photon} rotates with the motion of the electron around the nucleus. That makes the photon reflect the rotational and angular momentum changes that take place during the transition and the associated generation of the photon. Representing the actions on the transitioning electron that cause and accompany its outer-to-inner orbital change, F_{photon} places into the photon, into the radiated E-M field of the transitioning electron, the inverse to that transition behavior.

That is, the photon carries, because the process places into it, the means to cause an encountered electron to perform the inverse of the outer-to-inner orbital change maneuver that was performed when the photon was generated. The photon carries in its U-wave field the exact means to cause an inner-to-outer

orbit change, the force, the angular momentum and the energy to enable the action to take place.

Solving equation 15-33 for the velocity,

$$(15\text{-}53) \qquad v_e = \frac{c \cdot k^2}{n \cdot \alpha^{-1}}$$

Then substituting that value of v into equation 15-29 and solving for R_e

$$(15\text{-}54) \qquad 2\pi \cdot R_e = n \cdot \lambda_{mw} \qquad \text{[Equation 15-29]}$$

$$= n \cdot \frac{h}{m_e \cdot v_e} = n \cdot \frac{h}{m_e \cdot \frac{c \cdot k^2}{n \cdot \alpha^{-1}}} \qquad \text{[Substituting equation 15-53]}$$

$$R_e = \frac{n^2 \cdot h \cdot \alpha^{-1}}{2\pi \cdot m_e \cdot c \cdot k^2}$$

$$= \frac{n^2}{m_e \cdot k^2} \cdot \frac{q^2 \cdot 10^{-7}}{\alpha^2}$$

The n is the orbit number (the stable orbits being numbered sequentially outward from the atomic nucleus) and is also the number of matter wavelengths in the orbit. (While orbits numbers *1, 2, ...* thus contain respectively *1, 2, ...* matter wavelengths in them, the matter wavelength at each orbit is different because the orbital velocity is different. The orbital path lengths are not in the ratio *1, 2, ...*.)

Thus from equation 15-53 the electron orbital velocity is inversely proportional to the orbit number,

$$(15\text{-}55) \qquad v_n \propto {}^1/_n$$

and from equation 15-54 the radius of the orbit is directly proportional to that number squared,

$$(15\text{-}56) \qquad r_n \ (\equiv R_e) \propto n^2$$

As a result the angular momentum is directly proportional to the orbit number, directly proportional to the square root of the radius.

$$(15\text{-}57) \qquad L = I \cdot \omega = [m \cdot r^2] \cdot [{}^v/_r] = m \cdot v \cdot r$$

$$L_n \propto [{}^1/_n] \cdot n^2 = n \propto r_n^{\frac{1}{2}}$$

An outer-to-inner orbit transition therefore involves a loss of electron angular momentum (as compared to the decaying satellite for which the angular momentum is constant). The lost angular momentum appears in the photon. Being the amount lost in an outer-to-inner transition it is the correct amount to restore for the inverse inner-to-outer transition.

One would somewhat instinctively tend to think of, to visualize, the inward orbital transition paths of an orbital electron from the *n=3* or higher orbit as being separate and distinctly different paths depending upon whether the

transition is to the next inner orbit or the inner orbit beyond that, or the third inner orbit, or whatever. It would seem natural that greater inward travel to the final orbit should involve a more inwardly directed transition path. That is indeed the case and comes about as follows.

The potential energy lost by an orbital electron as it transitions to an inner orbit is as given in equation 15-58 below.

(15-58)

$$PE = Force \times Distance \qquad [In\ general]$$

$$= F_{coulomb} \times Radius \qquad [Electron\ in\ atom]$$

$$= \frac{q^2}{4\pi \cdot \varepsilon_0 \cdot r^2} \times r$$

$$= \frac{q^2}{4\pi \cdot \varepsilon_0} \cdot \frac{1}{r}$$

$$\Delta PE = \frac{q^2}{4\pi \cdot \varepsilon_0} \cdot \left[\frac{1}{r} - \frac{1}{r_i} \right]$$

Conservation of energy requires that that ΔPE appear in the combination of the increased kinetic energy of the electron and in the generated photon. The electron and photon energies having been found to be equal, the electron velocity is determined by

(15-59)

$$\tfrac{1}{2} \cdot m \cdot v^2 = \tfrac{1}{2} \cdot \Delta PE$$

That is, there is only one value of the electron velocity, v, associated with each radial distance, r, as used in equation 15-58. (In this case the negative square root value for v has no physical significance.) That would tend to indicate that only one path of transition is possible because at any particular radial distance, r, there can be only one value of the electron velocity, v.

However, that analysis deals only with the scalar value of the total electron velocity. It does not address its direction as a vector because energy is a scalar, not vector, quantity. The other conservation principle involved in the transition, conservation of angular momentum, is a vector quantity. It is that quantity that results in different paths for different orbital transitions. That is, while the *magnitude* of the total electron velocity must obey equation 15-59, its *direction* must only be consistent with conservation of angular momentum, and the different possible orbital transitions have different amounts of change in the electron angular momentum from its initial to its final orbit.

Angular momentum is conserved by the angular momentum lost by the electron appearing in the photon. That action is mediated by F_{photon}, more precisely by its tangential or θ component.

The angular momentum is given by

(15-60)

$$L = m \cdot v_\theta \cdot r$$

The initial and final velocities of the electron consist of pure v_θ. That means that at the beginning and at the end of a transition the electron total velocity, v,

and its θ component, v_θ, are identical. There can only be one specific amount of change in the electron kinetic energy and its angular momentum for any particular transition. The initial angular momentum must go through a smooth transition to the final angular momentum.

But, during the transition the variation of the angular momentum is not precisely specified as is the overall velocity. While there can be only one value of v for each value of r there can be several alternative values of v_θ for each r because there can be different values of L.

The electron direction can be more or less inward with corresponding lesser or greater values of the v_θ component of the overall (energy determined) v. An orbital transition path that leaps more orbital intervals and therefore involves a greater loss of angular momentum to the photon has a more inwardly directed path that exhibits an initial greater rate of loss of angular momentum.

But the question remains: how are specific paths from orbit to orbit enforced ? What forces the transitioning electron to transition only between the allowed, the stable, orbits ? To understand that requires first a review of the stable behavior of the stable orbits themselves.

Assuming constant charge, q, the Coulomb force

$$\frac{q^2}{4\pi \cdot \varepsilon_0 \cdot r^2}$$

can vary only with the distance, r, between the charges. However, as was pointed out in the earlier discussion of the stable orbits, the Coulomb force is actually implemented by a series of pulses, the cyclic U-waves from the source charge / center of oscillation, and their interaction with the cyclic oscillation of the encountered charge / center-of-oscillation. The stable orbits are stable because the orbital path length is exactly an integer number of matter wavelengths so that the same amount of Coulomb action, the same number of source center U-wave pulses interacting with the same pattern of encountered center oscillation, occurs orbit-after-orbit.

If the path is not such then the amount per orbit of source center cyclic U-wave pulsing interacting with encountered center oscillation does not conform exactly to the value called for by Coulomb's law. The defining characteristic of the stable orbit, that the Coulomb force supply the required centripetal acceleration, is not *exactly* satisfied. The resulting quasi-Coulomb force amount may be somewhat smaller or somewhat larger than the amount called for by Coulomb's law.

To analyze and quantify the deviations in the variable quantities involved, the radius, r, and the electron orbital velocity, v, will be expressed in terms of the orbit number, n. That quantity, the orbit index, n, an integer, will here be deemed to be a continuous variable so that the r and v expressed in terms of n can be continuously variable not merely the discrete amounts at the stable orbits.

The centripetal force required for stability in a circular orbit is, per equation 15-50, repeated below,

(15-50)
$$F_{centripetal} = \frac{m \cdot v^2}{r}$$

The variables in that expression, v and r, vary with n per equations 15-55 and 15-56: $v \propto 1/n$ and $r \propto n^2$. Therefore the variation of the required centripetal force for a circular orbit as n varies is

(15-61) $$F_{centripetal} \propto \frac{[1/n]^2}{n^2} = 1/n^4$$

With constant charge the only variable in the expression for the Coulomb force is r. The r^2 in the Coulomb force expression denominator is proportional to n^4. Therefore

(15-62) $$F_{Coulomb} \propto 1/n^4$$

Thus the normal Coulomb force always provides the exact value of $F_{centripetal}$ required for a stable circular orbit.

The numerator of the Coulomb force expression is q^2, which is the effect of the source U-waves interacting with the encountered center responsiveness. The variation in that effect from as it is in the stable orbits depends on the ratio of the orbital path length to the matter wavelength. If that ratio is an integer then the behavior is the pure, normal Coulomb. If not then the behavior is quasi-Coulomb. The orbital path length is $2\pi \cdot r$. The matter wavelength is $h/m \cdot v$ per equation 15-10. Therefore,

(15-63) $$\text{Numerator } F_{Quasi\text{-}Coulomb} \propto \frac{\text{Orbit Length}}{\lambda_{mw}}$$

$$\propto \frac{2\pi \cdot r}{h/mv} = \frac{2\pi \cdot r \cdot m \cdot v}{h}$$

$$\propto n^2 \cdot [1/n] = n$$

and the overall quasi-Coulomb force then varies as

(15-64) $$F_{Quasi\text{-}Coulomb} = \frac{\text{Numerator}}{\text{Denominator}} \propto \frac{n}{n^4} = 1/n^3$$

The ratio of the quasi-Coulomb force to the normal Coulomb force then varies as

(15-65) $$\frac{F_{Quasi\text{-}Coulomb}}{F_{Normal\ Coulomb}} = \frac{1/n^3}{1/n^4} = n$$

For values of n somewhat above the stable orbit integer value the actual Coulomb force acting, $F_{Quasi\text{-}Coulomb}$, is too large. For values of n somewhat below the stable orbit integer value the actual Coulomb force acting, $F_{Quasi\text{-}Coulomb}$, is too small.

Those results mean that:

- *outside or above the stable orbit* integer value of n level the excessive values of $F_{Quasi\text{-}Coulomb}$ have the *net effect of moving the electron path inward.* The inward force produces an inward acceleration that is greater than the amount to

produce a circular orbit. The excess acceleration produces inward electron velocity. (The inward $F_{Quasi\text{-}Coulomb}$ is greater than the outward "centrifugal force".)

- *inside or below the stable orbit* integer value of n level the insufficient values of $F_{Quasi\text{-}Coulomb}$ have the *net effect of moving the electron path outward*. The inward force produces an inward acceleration that is less than the circular orbit amount. The deficiency produces less than circular motion, a net outward motion effect. (The inward $F_{Quasi\text{-}Coulomb}$ is less than the outward "centrifugal force".)

Figure 15-16a, below, illustrates the net overall effect. The behavior of the Coulomb force when the radius is such that the orbital path would not be an integral number of matter wavelengths is such as to tend to force the electron into such integer matter wavelength orbits. Those orbits are stable. The spaces in between the stable orbits are unstable and have natural restoring forces acting toward the stable orbits.

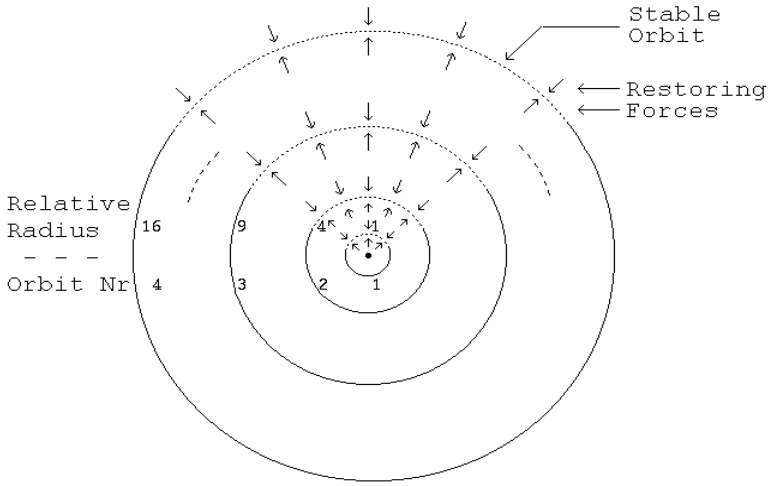


Figure 15-16a
Orbital Stability

Between the stable orbits there are stable transition paths. That is, from any point in an outer orbit there is one specific stable path to each of the inner orbits of that outer orbit. Such stable paths, which involve inward motion of the electron in transition between stable orbits of course, have at each point in their path the correct inward motion (velocity and acceleration) to compensate for the deviation of the value there of $F_{Quasi\text{-}Coulomb}$ from what the normal Coulomb force should be at that point. On either side of such a path there are restoring forces just as for the stable orbits. The restoring forces arise because there can only be one path that can correctly compensate between any particular pair of initial and final orbits. Any deviations from that path experience the same defects as do the unstable orbits.

An electron is, then, always in either a stable orbit or a stable transition path. If it should somehow be elsewhere the restoring forces immediately correct the situation. Figure 15-16b, below depicts typical examples of some of those stable transition paths.

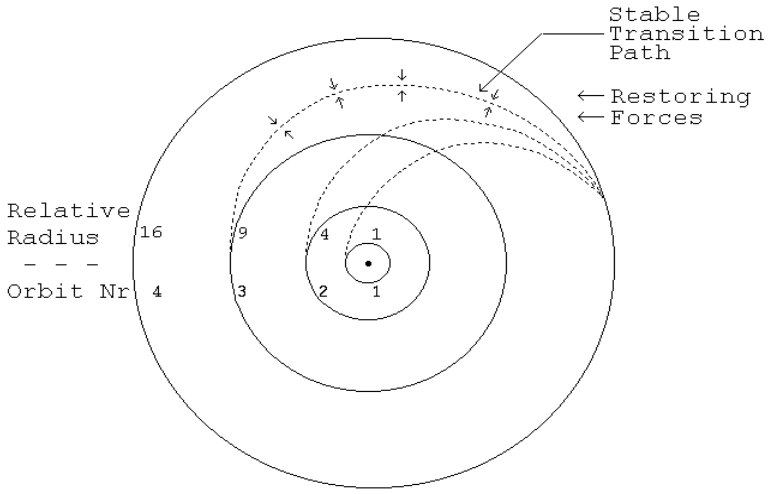


Figure 15-16b
Transition Path Stability

The inherent orbital and transition path stability are fortunate because there are bound to be numerous minor disturbances. First of all, the Coulomb attraction from the nucleus is actually the effect of repeated encounters of successive U-wave cycles from the nucleus impulsing the electron. The rate of these is on the order of 10^8 per orbit, which is large but not quite the same as a smooth continuous force.

Then, all of the other centers-of-oscillation in the surrounding matter are propagating U-waves. These waves come from and act in all directions and are both $+U$ and $-U$ so that they tend to cancel out overall, and they come from greater distances than the waves from the local nucleus so that they are weaker. But, they can have some net effect. They tend to disturb the orbit or to disturb a transition already in process. Finally, E-M radiation as "black body" radiation corresponding to the heat energy of the matter and its surroundings is present as minor U-wave / photon disturbances.

Inevitably, then, from time to time these effects will succeed in disturbing an electron residing in a stable orbit. Usually the disturbance cannot supply enough energy to move the electron to a higher stable orbit. Consequently, if the tendency of the disturbance is that of tending the electron away from the nucleus the electron will be moved to a slightly higher energy unstable orbit, radiate the excess energy as a relatively low frequency photon, and return to its original stable orbit. The radiation from the electron in this case is most likely in the heat energy range and part of the black body radiation of the substance as, most likely, was the original disturbance.

But a disturbance can free the electron from its stable orbit in a fashion such that the electron falls to another, inner stable orbit. This is the cause of the apparently prompt but random "decision" of an electron not in its innermost available orbit to fall inward toward it. It frequently can happen, however, that there are two or more alternative available orbits to which the electron could fall. What determines which is selected ? Certainly it cannot be counted on that the initial disturbance will direct the electron onto a specific correct transition path to any of the stable orbits, let alone a particular selected one.

What happens is that the disturbance places the electron in an unstable location where restoring forces immediately act. The resulting disposition of the electron will depend upon to where in the "no man's land" of unstable regions the electron was disturbed. The restoring forces will than place it in the most accessible stable configuration, orbit or transition path.

From the variation of v and r with variation of n per equations 15-55 and 15-56, the radially inward acceleration required in stable orbit varies inversely as the fourth power of n.

$$(15\text{-}66) \qquad a_{rad} = \frac{v^2}{r} \propto \frac{1/n^2}{n^2} = \frac{1}{n^4}$$

Thus, for example, a_{rad} is 16 times stronger in the $n=1$ orbit than in the $n=2$ orbit and 81 times stronger in the $n=1$ orbit than in the $n=3$ orbit. That is most likely the reason that an electron dropping out of the lowest orbit, the $n=1$ orbit, is a relatively rare event. The magnitude of the required initiating disturbance is 16 or more times greater than that required for the higher orbits. On the other hand, the progressively higher orbits are increasingly sensitive to minor disturbances launching the electron on an inward transition path.

ABSORBTIVE PHENOMENA

The problem of the atomic electron's stable orbits and the E-M radiation due to an electron falling from an outer to an inner stable orbit have now been resolved. It remains to clarify the absorbtive process, incoming E-M radiation exciting an electron to a higher orbit or to being entirely free of the atom.

First it is necessary to consider what it is that is absorbed, which is the radiation generated by the processes just discussed. The light or E-M radiation available for absorbtion by and excitation of an electron is that same E-M radiation given off by an electron falling to a lower energy orbit. It has already been shown that the radiation from any single outer-to-inner-orbit transition contains the energy, angular momentum and force that are exactly correct to cause an electron to execute the inverse transition -- *provided that <u>all</u> of that photon E-M wave encounters an electron that is oriented correctly to the capability of that photon.*

However, the E-M wave from a single transition clearly must radiate outward in all directions from the transitioning electron. The E-M radiation is merely an "imprint" on the radially outward U-wave propagation of the center-of-oscillation that is the transitioning electron. It is impossible for all of that radiation to encounter one other single electron.

Taking the macroscopic view rather than that of an individual electron, E-M radiation consists of a large number, almost a continuum, of waves propagating in the form of individual half-cycle sinusoids of radiation at a variety of frequencies. A light beam or other radiation is a plethora of such radiation bursts, a deluge of them that would have impressed even Noah: burst upon burst, side by side, in front, behind, overlapping, running together, and on and on. It is from among that immense number of very small parts of myriad inward electron transition radiations that an encountered electron may find that which it needs to perform an outward transition.

The wave front of a single such radiation burst, the output of a single electron's transition, disperses in space as it travels outward from its source. Only a quite small part of the total wave front of such an individual burst can encounter and interact with another particular electron. But, the radiation encountering a single particular electron is the sum of a very large number of such individual small parts of the radiation from individual electron inward transitions.

An absorbtive interaction is most readily understood by means of the principle of reciprocity. Radiative and absorbtive interactions are the inverse of each other. If one could make a motion picture of either type interaction and run it backwards the one type event should not be discernible from the other so far as the actual interaction is concerned. Put another way, the same laws apply to each:

- energy and momentum are conserved,
- the same change in U-wave and matter wave pattern must be present to correspond to the same radiation,
- the same F_{photon} must act in the same manner, etc.

An absorbtive interaction must involve the delivery to the electron of the same radiation as the inverse radiative interaction caused to be radiated.

Out of the plethora of arriving half-cycle sinusoids, more precisely the plethora of small portions of their individual total wave fronts, the electron responds to an instantaneous sum of arriving waves that may or may not have frequency, F_{photon}, etc. conforming to a transition to a particular higher orbit. The electron can only respond to whatever encounters it. If the electron responds to inappropriate arriving wave conditions (conditions that do not move it to another stable orbit, but rather leave it in "no man's land" where natural restoring forces will act on it) the mechanics already described above oppose and immediately cancel the inappropriate response.

In responding to an appropriate input, one that was generated by electron motion according to the correct orbital change mechanics, those same mechanics, embedded in the radiation's form, and the electron work together to produce a correct excitative transition. In effect, in transitioning from an inner to an outer stable orbit an electron "radiates" a "photon" that is the "negative" of the corresponding outer to inner orbit transition. The "negative" or inverse "radiation" is, of course, actually the absorbtion of that much, that portion, of the total plenum of arriving small parts of individual half-cycle sinusoid bursts.

For example, in a beam of light shined on a material, such as the white light passed through a gas to obtain the absorbtion spectrum, or the light shined on a substance to yield photoelectric effect, there is a very large number of radiative type interaction half-cycle sinusoid bursts propagating as waves. These constitute the beam of light. Some portion of them will coincide properly in frequency, F_{photon}, etc. *and have sufficient collective amplitude* at some electron so as to produce the observed absorbtive behavior.

"Sufficient collective amplitude" is the state in which the sum of the myriad minute parts of numerous transitions of the correct type adds up to being equal to or greater than the effect as if all of the radiation had passed intact from one such inward transitioning electron directly to the encountered electron. Of

course, most of the incident light passes on unaffected because of not having met that total set of requirements while encountering an electron, passes on because it is not cancelled out by the "negative" radiation of an absorbtion.

In a radiative type interaction the interaction energy is $W = h \cdot f$. That means that the interaction energy, W, is radiated as E-M radiation at frequency f; the nature of the event is such that the radiation is at frequency f. It is the frequency, not the amplitude or some other parameter, that characterizes the energy content of the radiation burst. In an absorbtive type interaction the interaction energy is, again, $W = h \cdot f$. That means that the interaction energy, W, is absorbed from radiation of frequency f; the nature of the event is such that absorbtion only occurs from radiation at frequency f. Again, it is the frequency, not the amplitude or some other parameter, that characterizes the energy absorbed from the incident radiation.

But, why is the energy magnitude dependent only on the frequency; how does wave amplitude enter into the process ? The waves are dispersing as U-waves do, so that the amplitude of each individual burst decreases steadily in inverse square manner from its value at the moment of the interaction that created it. The farther that an absorbtive interaction is from the source of incoming radiation the greater the number of individual bursts, each contributing a small portion of the requisite amplitude, that are required for an absorbtive interaction to be able to take place.

Amplitude is a factor in the amount of energy in the burst, $W = h \cdot f$. The amplitude is a universal constant and is related to Planck's Constant, h. In the derivation of Coulomb's Law and the subsequent discussion of charge, it was shown that while a center-of-oscillation's frequency and wavelength vary the Coulomb interaction depends on the product of the two and on center amplitude. Since the product of center frequency and wavelength is a constant, c, the speed of light, then if center amplitude is constant the fundamental unit of electric charge is constant. Of course, the fundamental unit of electric charge is a known constant, therefore all simple centers-of-oscillation such as the electron and the proton have the same amplitude, related to Planck's Constant, h. (Non-simple centers-of-oscillation will be discussed in later sections.)

The amount of energy naturally depends on frequency. The higher the frequency the more rapidly the E-M radiation oscillates. The E-M radiation carries the ability to cause corresponding change in motion in encountered charged particles. It requires more energy per time to make a rapid change than to make a gradual one. A shorter period (higher frequency) half-cycle sinusoid must contain directly proportional greater energy to produce the proportionally more rapid change.

RESOLUTION OF THE WAVE - PARTICLE DILEMMA

At this point it is apparent that E-M radiation from atomic orbital electrons or from any radiating charge relates in no way to a particle theory of radiation. Radiation being the changes in the U-wave field of a center-of-oscillation, which changes propagate outward in all directions as the U-wave field propagates, there is no way to accommodate a particle of radiation, nor a "wave packet" like a particle of radiation. There is no way that the behavior of E-M radiation can be compatible with a particle-like photon with its one specific direction of travel. The nature of E-M radiation, both classically and in terms of

this Universal Physics, requires omni- or at least symmetrical multi-directional radiation, not a photon-particle's mono-directivity.

But, if one examines the observational data that led to the particle theory of E-M radiation, it can be seen that the data do not really call for radiation particles. The evidence only requires that conservation always be maintained and that radiation related *energy exchanges* occur in discrete amounts of energy, $W = h \cdot f$. The quantization refers only to the energy of interaction at the point of the interaction.

- Planck's radiated energy bursts for black body radiation require that the black body lose energy in quanta of energy $h \cdot f$ rather than continuously. How the energy burst travels off, whether in one specific direction or as classical E-M radiation, has nothing to do with Planck's formulation.

- The photoelectric effect frequency dependency does not require a single particle having energy $h \cdot f$ to encounter the electron to be liberated. It only requires the delivery of that requisite amount of energy to that electron all at once.

- Likewise for the excitation of an electron from a lower to a higher orbit.

The quantization is only of the energy exchange at the point of the action, not of the associated E-M radiation. There is no evidence that a particle of E-M radiation exists in any sense. The data only require that the radiated energy initiate in "bursts" or whatever of magnitude $h \cdot f$, like the half-cycle sinusoid photon just developed.

For particles and objects having rest mass, the momentum, a quantity having both magnitude and direction (a vector quantity), acts always in the direction of the particle's velocity. But, the momentum carried by an E-M wave does not necessarily so act. E-M radiation, which results from changing speed motion of charge, tends to cause an encountered charge to move in the same manner as caused the motion change of the radiating charge, as shown in section 14 and as is essential for conservation of momentum. (If this were not the case radio and TV would not be possible because the received electrical behavior would not be a "copy" of that transmitted.)

The E-M wave traveling outward from a radiating charge carries momentum, that is the wave delivers momentum to an encountered charge, that is the encountered charge acquires a change in its velocity from the action of the E-M wave on it. The resulting change in motion of the encountered charge is not necessarily in the direction of motion of the E-M wave (which is radially outward in all directions from the source of the radiation), therefore the encountered charge's acquired momentum is not necessarily in that direction. The transmitted change of motion and momentum are in the same direction as those lost to the radiating charge. That is essential if momentum is to be conserved. The direction of propagation of the E-M wave may be at any angle to that, even perpendicular to it.

The particle hypothesis is an unjustified assumption derived from the data that led to it. The data requires a modification of the continuous E-M wave concept of Maxwell, but only the minimal necessary modification should be introduced to the generally valid and well established wave theory. The half-

cycle sinusoid wave burst as developed here is such a minimal modification. The photon hypothesis of traditional 20th Century physics goes much too far. One might say that it is a violation of Occam's Razor. The half-cycle sinusoid burst model is compatible with all of the data, that indicating Maxwellian waves and that which had seemed to indicate discrete particles. The photon model of traditional 20th Century physics created the dichotomy of two incompatible models each matching some of the data and seriously mis-matching the rest.

There is one set of data that is considered the *sine qua non* of the particle theory of radiation, however, and it must now be examined. That is the Compton Effect. The Compton Effect considers radiation to consist of particles and analyses a collision of a photon with an electron just as if two billiard balls were to collide in a glancing manner (Figure 15-17, below). The classical particle physics of the situation require that energy be conserved and that momentum be conserved independently in all directions.

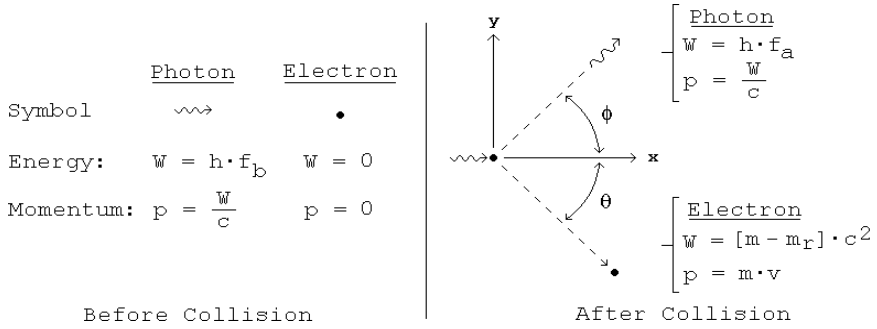


Figure 15-17
The Compton Effect

Thus:

(15-67) (1) Energy before = Energy after

$$h \cdot f_b = h \cdot f_a + (m - m_r) \cdot c^2$$

(2) The x-component of Momentum before
= The x-component of Momentum after

$$\frac{h \cdot f_b}{c} = \frac{h \cdot f_a}{c} \cdot \mathrm{Cos}[\phi] + m \cdot v \cdot \mathrm{Cos}[\theta]$$

(3) The y-component of Momentum before
= The y-component of Momentum after

$$0 = \frac{h \cdot f_a}{c} \cdot \mathrm{Sin}[\phi] + m \cdot v \cdot \mathrm{Sin}[\theta]$$

(4) Simultaneous solution of the above yields the Compton Effect equation

$$\frac{1}{f_a} = \frac{1}{f_b} + \frac{h}{m_r \cdot c^2} \cdot \left[1 - \mathrm{Cos}[\phi]\right]$$

which states that if photons are "scattered", that is deflected in various directions (ϕ) by collision with particles (of rest mass m_r), the scattered photons at direction ϕ will have a lower frequency after (f_a) than before the collision (f_b) according to the formula.

Experiment has verified that in fact the scattered radiation is at reduced frequency and in agreement with the formula. That has been taken as confirmation of the particle nature of the photon by traditional 20th Century physics, but it is not. It is only confirmation that (as would have been so in any case) energy and momentum must be conserved in such interactions. A particle form of radiation is not necessary to accomplish that.

In the Compton Effect E-M waves are absorbed by the electrons, which then radiate new E-M radiation. The absorbing of some of the incoming radiation produces one change in the electron's motion. The emitting of new radiation results from the change in the electron motion. The electron cannot avoid that re-emission for the same reason that an inwardly transitioning electron must radiate and cannot behave like a satellite. The electron has a charge and change in the speed of that charge results in radiation of E-M wave. Of course, energy and momentum are conserved. It could not be otherwise. The result is the observed effect. No photon is required to explain the Compton Effect. The photon of traditional 20th Century physics does not exist.

This destruction of the photon and the particle theory of radiation, for which Einstein received his Nobel Prize, is a major radical change to physics. But it should really not seem so. The wave-particle quandary has been there all along. Waves were so well established. A reconciliation of the two had to be made. The demise of the particle of radiation was inevitable.

This all may seem rather hard on Einstein who is now found to have been twice fundamentally in error (relativity vs. absolutivity and particles vs. waves), but it should not really so seem. Without Einstein progress to the present would have been more difficult. And the total unified field theory that Einstein sought is now realized. All of reality is field, the U-waves in their variety of effects and manifestations, more of which will be developed shortly. Matter appears as "densities" in the field as Einstein would have termed it -- actually the centers-of-oscillation, which propagate the field.

MULTI-ELECTRON ATOMS

The understanding of the nature and structure of matter, the substances of the material universe, was greatly advanced by the Bohr concept of the atom; however, that concept only worked truly successfully with Hydrogen. The development of an analogous understanding of all of the other atomic forms, the various other elements, remained to be worked out. At that time, the early 20th Century, the status of that development was as follows.

- The 19th century investigations of Boyle, Lavoisier, Dalton and others had produced the concept of *atoms* and *elements*. An atom was understood as the smallest, or unit, quantity of a substance that was such that it could not be chemically reduced to simpler components. An element was understood as an atom of a particular specific type (which we now identify in terms of its atomic number, Z, its number of orbital electrons). The atomic weights of the then some sixty-five known elements were

known and the concept of *compounds* as chemical combinations of elements had developed.

· Those advances then led to the discovery of the *Periodic Table of the Elements* in 1868. More precisely, its discoverer, Mendeleev, arranged the then known elements in increasing order of their atomic weights in tabular form according to their chemical properties, all elements having similar such properties being in the same column. He found that those properties vary periodically according to their atomic weights. Without enough information to develop the concept of atomic number, (Mendeleev used atomic weights to determine the order sequence of the elements according to what we now refer to as atomic number) let alone the concept of orbital electrons, he had nevertheless deduced their effect. See Figure 15-18 on the following page.

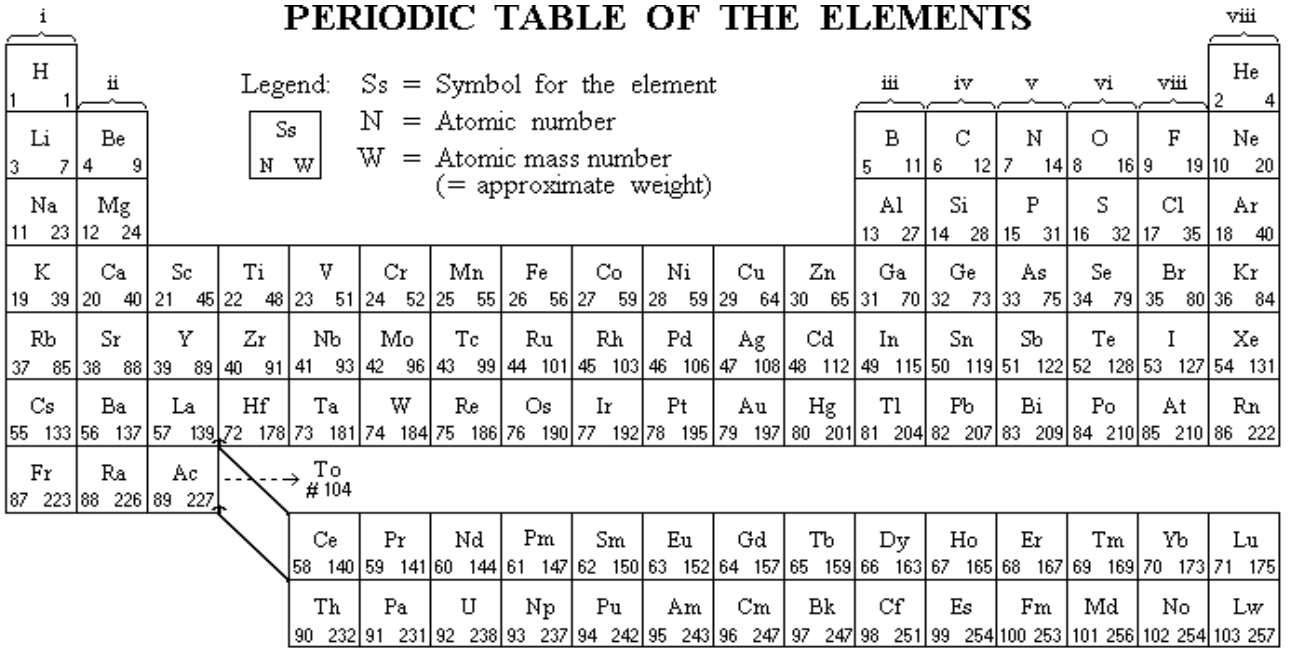
· While it was not then realized, the major significance of the form of the Periodic Table is that the *periods* correspond to the atomic orbital electron structure. The first period in the table has *2* elements, the second period has *8* and the third period has *18* in the form of an initial or primary *8* and an additional *10*, the table continuing in analogous fashion.

· At that point the internal structure of the atom was essentially completely unknown. Then Rutherford showed that the atom is, in fact, almost completely empty space: that it has a quite minute *nucleus* which is positively charged and, therefore, that it must have an equal amount of negative charge somewhere somehow in the rest of the empty space since the atom is overall electrically neutral. It was the problem of how that negative charge can exist in the presence of the positive nucleus without electrostatic attraction combining them that led Bohr to his development of the orbital electron "planetary" model.

Because of the spectacular success (for Hydrogen) of the Bohr hypothesis and its dependence on atomic spectra, spectral investigations became the major scientific activity in the search for further understanding of atomic structure. Those researches included the developing of better spectroscopes and techniques with a concomitant increase in the resolving power available. That lead to two complications: the problem of interpreting the greater complexity of the spectra of the elements higher than Hydrogen (as would be expected in any case) and the discovery of *fine structure* in the Hydrogen spectra.

Developments in traditional 20th Century physics beyond the Bohr model involved extending the principle of quantization of angular momentum that was used in the original Bohr model. The treatment of atomic orbital electrons by Sommerfeld was in the vein of such a direct extension. That approach was quickly superseded by the development of Wave Mechanics by Schroedinger and that by the Quantum Mechanics of Dirac and others in 1928. The data driving those developments was primarily atomic spectra. Spectral data was the principle data to be explained by theories of atomic structure, the principle pattern in nature which theories sought to explain, to which theories had to conform. From this developed 20th Century physics' theory of the multi-electron atom as follows.

PERIODIC TABLE OF THE ELEMENTS



Left "Anchor"

[i]·Most Chemically Active Metals

Mendeleev liked to think of his table as a "law of octaves", but in fact he lacked 6 elements in the 1st "octave" and had to cram an extra 10 into the 4th and thereafter. Later discoveries required an additional cramming of 14 into the 6th and thereafter.

Right "Anchor"

The Inert gases ·[viii]

Most Chemically·[vii] Active Metal – Salt Formers

Table 15-18

- The electron orbits are located in "shells", a shell conceptually being a spherical surface with the atomic nucleus located at the center of the sphere. The locations available for electron orbits are in a series of concentric shells corresponding to the orbit number, n, as used in the preceding development of the Bohr model of the atom, n taking the integer values $1, 2, 3, \ldots$. 20th Century physics calls that number the principal quantum number. Per equations 15-54 and 15-56 the radius of each such shell is proportional to its n^2.

- Each shell may have a set of "sub-shells". An additional quantum number, l, an integer and referred to as the azimuthal quantum number, is defined. It may have each of the integer values in the range 0 to $n-1$, each value corresponding to a separate sub-shell.

- The electron's orbital angular momentum is "spatially quantized". This refers to permitted relative tilts among the electron orbits of a shell. The convention for representing angular momentum is a vector perpendicular to the plane of the orbit using a right hand rule for its direction (if the fingers of the right hand point in the direction of motion of the electron then the thumb points in the direction of the vector). The spatial quantization hypothesis is that the projection of the angular momentum vector on an axis of measurement can only be certain integral multiples of $[h/2\pi]$. The orbital angular momentum in a shell is $l \cdot [h/2\pi]$. A third quantum number, m_l, an integer and called the orbital magnetic quantum number, is defined so that m_l may take the integer values from $+l$ through 0 to $-l$, a total of $[2 \cdot l + 1]$ values. The allowed projections of the angular momentum on a selected axis of measurement are each of the allowed values of $m_l \cdot [h/2\pi]$, where the various projections differ because of different tilting of the various orbits.

- A characteristic "spin" is attributed to the orbital electron. Its angular momentum may only have the value $\frac{1}{2} \cdot [h/2\pi]$. Depending upon whether the spin angular momentum vector is in the same or the opposite direction as the orbital angular momentum vector a fourth "spin" quantum number, m_s, has the value $\pm$ that angular momentum.

- The Pauli Exclusion Principle operates; that is: no two electrons in the same atom may have identical values for all four of the above quantum numbers, n, l, m_l, and m_s.

Included in this conception of the orbital electrons are that the orbits may be elliptical as well as circular and that the orbital electron is conceived of as not so much an object in a specific location as an effect "smeared out" over a substantial portion of the orbit. Generally, the above shells concept of the orbital structure of multi-electron atoms is validated in its agreement with the spectral data, the chemical behavior characteristics and the Periodic Table of the Elements.

Application of this set of rules results in the set of available locations for electrons in an atom listed in Table 15-19, on the following two pages.

"Quantum Number" Description of Orbital Electrons Arrangements

Element		Electron	Quantum Numbers			
Name	Z	Number	n	l	m_l	m_s
Hydrogen						
	1	1	1	0	0	-½
Helium						
	2	1	1	0	0	-½
		2	1	0	0	+½
Lithium						
	3	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
Beryllium						
	4	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
		4	2	0	0	+½
Boron						
	5	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
		4	2	0	0	+½
		5	2	1	-1	-½
Carbon						
	6	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
		4	2	0	0	+½
		5	2	1	-1	-½
		6	2	1	-1	+½
Nitrogen						
	7	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
		4	2	0	0	+½
		5	2	1	-1	-½
		6	2	1	-1	+½
		7	2	1	0	-½
Oxygen						
	8	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
		4	2	0	0	+½
		5	2	1	-1	-½
		6	2	1	-1	+½
		7	2	1	0	-½
		8	2	1	0	+½

Element		Electron	Quantum Numbers			
Name	Z	Number	n	l	m_l	m_s
Fluorine						
	9	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
		4	2	0	0	+½
		5	2	1	-1	-½
		6	2	1	-1	+½
		7	2	1	0	-½
		8	2	1	0	+½
		9	2	1	1	-½
Neon						
	10	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
		4	2	0	0	+½
		5	2	1	-1	-½
		6	2	1	-1	+½
		7	2	1	0	-½
		8	2	1	0	+½
		9	2	1	1	-½
		10	2	1	1	+½
Sodium						
	11	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
		4	2	0	0	+½
		5	2	1	-1	-½
		6	2	1	-1	+½
		7	2	1	0	-½
		8	2	1	0	+½
		9	2	1	1	-½
		10	2	1	1	+½
		11	3	0	0	-½
Magnesium						
	12	1	1	0	0	-½
		2	1	0	0	+½
		3	2	0	0	-½
		4	2	0	0	+½
		5	2	1	-1	-½
		6	2	1	-1	+½
		7	2	1	0	-½
		8	2	1	0	+½
		9	2	1	1	-½
		10	2	1	1	+½
		11	3	0	0	-½
		12	3	0	0	+½
(and so forth)						

Table 15-19
"Quantum Number" Description of Orbital Electrons Arrangements

The problems with this 20th Century physics conception of the orbital electrons are that the hypothesis does not really address the question of what, when, where, how, why the electrons are behaving and that it depends strongly on the concept of the quantization of angular momentum in various forms.

It has already been shown that the Bohr hypothesis was actually that the length of each orbital path must be an integral number of orbital electron matter wavelengths, not the quantization of angular momentum, even though it was not so recognized at the time. A reason is apparent for the matter wavelength restriction. There is no reason given nor available for angular momentum to be quantized. In 20th Century physics it must be, and is, accepted on faith. The question is therefore presented: what impels the orbital electrons into their structure in multi-electron atoms and just what is that structure ?

There are essentially three constraints that govern the behavior of the orbital electrons. But, before addressing them it is necessary to review and further develop an aspect of the behavior of electrons (or any particle of matter) in motion. Earlier in this section the matter wave of a particle in motion was derived as the beat frequency of the forward and rearward oscillations of a center-of-oscillation in motion. The equations are repeated below along with the graphical depiction of the result.

(15-15A) $\text{Wave \#1} = U_c \cdot [1 + \sin(2\pi f_f t)]$ [forward wave]

$\text{Wave \#2} = U_c \cdot [1 + \sin(2\pi f_r t)]$ [rearward wave]

(15-16A) $\text{Wave Sum} = U_c \cdot \left[2 + \sin(2\pi f_f t) + \sin(2\pi f_r t)\right]$

(15-17A) $= 2U_c + 2U_c \cdot \sin\left[2\pi\left[\frac{f_f + f_r}{2}\right]t\right] \cdot \cos\left[2\pi\left[\frac{f_f - f_r}{2}\right]t\right]$

(15-18A) $= 2U_c \cdot \left[1 + \cos\left[2\pi\left[\frac{f_f - f_r}{2}\right]t\right]\right] \cdot \sin\left[2\pi\left[\frac{f_f + f_r}{2}\right]t\right]$

$= 2U_c \cdot \left[\begin{array}{c}[1 + \text{Cosine}] \\ \text{Form of Varying} \\ \text{Amplitude}\end{array}\right] \cdot \sin\left[2\pi\left[\frac{f_f + f_r}{2}\right]t\right]$

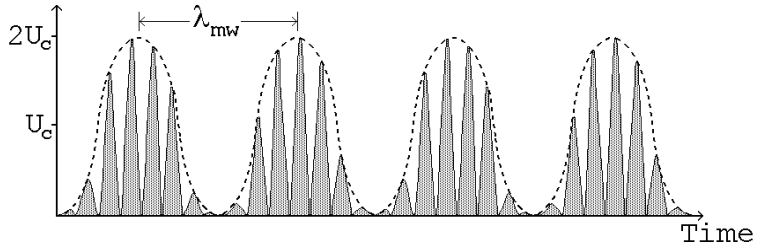


Figure 15-7
The Forward-Rearward Pulsation of a Center in Motion, Which is the Matter Wave

The above depicts the oscillation as a function of time. As was shown in the earlier discussion of matter waves, the matter wave must and does travel at

the velocity of the particle. The matter wave is a standing wave relative to the particle and in that sense appears as in Figure 15-20, below.

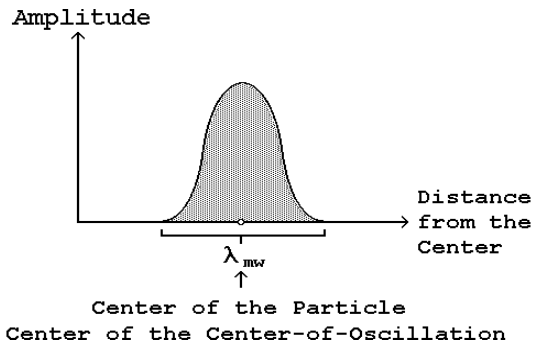


Figure 15-20
The Matter Wave of a Center in Motion Relative to the Center

(This is the electron "smeared out" over a substantial portion of the orbit as traditional 20th Century physics would have it. Nevertheless, the electron has a specific locus of its action, its center, as indicated in the figure.)

In its oscillatory behavior the electron extends a distance of $\frac{1}{2} \cdot \lambda_{mw}$ forward and rearward of its instantaneous center location. In effect it occupies that much space. To the side it still extends only the $\lambda_{sideward}$ of the center-of-oscillation's oscillation at the center's velocity, that is the center's rest wavelength adjusted for motion per equation 13-6. For an orbital electron the matter wavelength is on the order of $3 \cdot 10^{-10}$ meters and $\lambda_{sideward}$ is on the order of $2 \cdot 10^{-12}$ meters, less than $1/100$ the matter wavelength. The space that that matter wave occupies resembles the form of a very long thin tube, rather like an extremely long pencil or sausage.

The three constraints on the orbital electrons are:

(1) The orbital path length must be an integral number of matter wavelengths, as already developed.

(2) The electrons being all of the same charge magnitude and polarity, must tend to repel each other to a spacing equally apart subject to the common central attraction of the oppositely charged nucleus.

(3) The electron spacing along the orbital path must be such that the $\frac{1}{2} \cdot \lambda_{mw}$ extension of the electron center-of-oscillation in space forward and rearward of its current position does not impinge on or interfere with the space correspondingly occupied by any of the other electrons.

Of course, in addition there are the obvious constraints that the number of electrons in orbit must be the same as the number of equivalent positive charges in the nucleus because the atom is overall electrically neutral and that the electron orbits and the electron positions in the orbits must be such that the electrons do not collide nor interfere with each other.

The orbital electron arrangements of the above Table 15-19 result in there being space for a maximum of: *2* electrons in the *n=1* orbit, *8* electrons in the *n=2* orbit, *18* electrons in the *n=3* orbit, and so on. Those dispositions are correct; but that is not because of "quantum numbers" nor angular momentum nor a "Pauli exclusion principle" propounded because it appears to make the quantum number system work not because of an underlying scientific reason. That orbital electron arrangement is enforced by the requirement of accommodating the space that each orbiting electron's matter wave occupies.

Applying the constraints to the innermost *n=1* orbit where the orbital path length is λ_{mw}, there is only space for two electrons sharing an orbital plane, as shown in Figure 15-21, below. In the figure the second electron is located as close to the first electron as possible without their matter wave extensions in space interfering with each other. Introduction of a third electron into that orbit in that plane would involve spacing that would disrupt the particles and the orbit. Since there can only be two electrons in the orbit and they repel each other they will space *180°* apart.

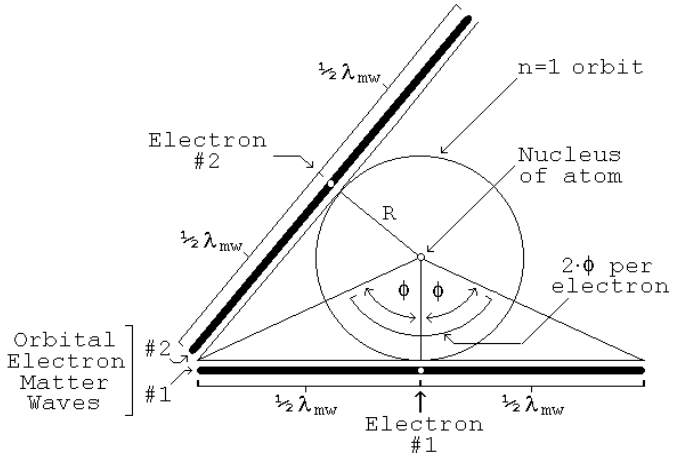


Figure 15-21
Electrons in n=1 Shell

(15-68) For the n=1 orbit or "shell" the orbital path length, the circular path circumference, is one matter wavelength: $\lambda_{mw} = 2\pi R$.

$$\text{Tan}[\phi] = \frac{\frac{1}{2}\cdot\lambda mw}{R} = \frac{\frac{1}{2}\cdot 2\pi\cdot R}{R} = \pi$$

$$\therefore \phi = 72.34°$$

$$\text{Electron space} = \frac{360°}{2\cdot\phi} = 2.49 \Rightarrow 2 \text{ electrons}$$

Now considering adding a third electron in a second *n=1* orbit with its orbital plane tilted relative to the orbit of the (above) first two electrons, the situation is somewhat like that of a sword dance where a number of dancers whirl and turn, each flashing a pair of swords, one in each hand, while avoiding any casualties among the dancers. The dancers' spacing, paths and timing must be

such that while their swords slash at each others' paths they do so when the dancer in that path (with his extended swords) is at another location on the path.

If a second two-electron orbit is introduced in a plane tilted relative to the above first $n=1$ orbital plane the third electron will interfere with the first two regardless of the tilt of its orbital plane relative to the other. This is readily seen by imagining in Figure 15-21, above, that the paper is folded along the line from the nucleus to where the two matter waves are shown just meeting. The fold tilts one electron's orbit relative to the other's but does not change the interference of the two. Thus, in terms of the angles in the above Figure 15-21, a second orbital plane tilted at an angle of $\phi = 72.34°$ or more would seem to fit.

However, the electron in that second orbital plane, starting at $\phi = 72.34°$ above one of the points of intersection with the first plane could travel only $[180°-2\cdot\phi] = 35.32°$ before being within $\phi = 72.34°$ of the other side of the orbit, the other point of intersection of the planes. During that $35.32°$ the pair of electrons in the original plane have not had the necessary travel, $\phi = 72.34°$, to clear their matter wave extensions in space from the common points of intersection of the two orbital planes.

The $n=1$ shell can only contain one orbital plane with only one orbit having two equally spaced electrons. Any additional content would involve the matter waves of the electrons interfering with each other -- the "dancers slashing swords" would at least clash if not injure the dancers.

For the $n=2$ orbit the sword dance becomes more complex. Clearly, from the above, the first two $n=2$ electrons can readily share an orbit as in the $n=1$ case. In fact, performing the calculation of equation 15-68 for the $n=2$ case shows that

(15-69) For the n=2 orbit or "shell" the orbital path length, the circular path circumference, is two matter wavelengths: $2\cdot\lambda_{mw} = 2\pi\cdot R$.

$$\lambda_{mw} = \pi\cdot R$$

$$Tan[\phi] = \frac{½\cdot\lambda mw}{R} = \frac{½\cdot\pi\cdot R}{R} = \pi/2$$

$$\therefore \phi = 57.52°$$

$$\text{Electron space} = \frac{360°}{2\cdot\phi} = 3.13 \Rightarrow 3 \text{ electrons}$$

Three electrons could fit in one $n=2$ orbital plane. However, the fit is close and more overall equidistant spacing of the electrons is achieved with the third electron occupying a new orbital plane tilted to the first.

How many such tilted planes can be accommodated at the $n=2$ level in total ? The shell can accommodate three such planes at $\theta = 60°$ relative tilts. This limit is set by $\phi_{n=2} = 57.52°$. Four planes at $\theta = 45°$ would be too close. The three planes have a common axis of intersection on which are the two points that all three of the orbits have in common (Figure 15-22, below). The six electrons (two per each of three orbital planes tilted at $60°$ relative to each other) pass through those two common points at $\delta = 360°/6 = 60°$ intervals (equidistant spacing). With $\phi = 57.52°$ there is just enough travel $(180°-2\cdot\delta) = (180°-2\cdot60°) = 60° > \phi = 57.52°$ between successive electrons for each electron to clear the area before the next one starts arriving.

Now the reason for only two electrons in each of the orbital planes here, even though three could fit in any one such plane, becomes clear. With three electrons per plane the electrons (all evenly spaced) would pass through the two common points of the three orbital planes every $\delta = 360°/9 = 40°$. That is closer than the minimum $\phi_{n=2} = 57.52°$ spacing required in this $n=2$ shell of orbits.

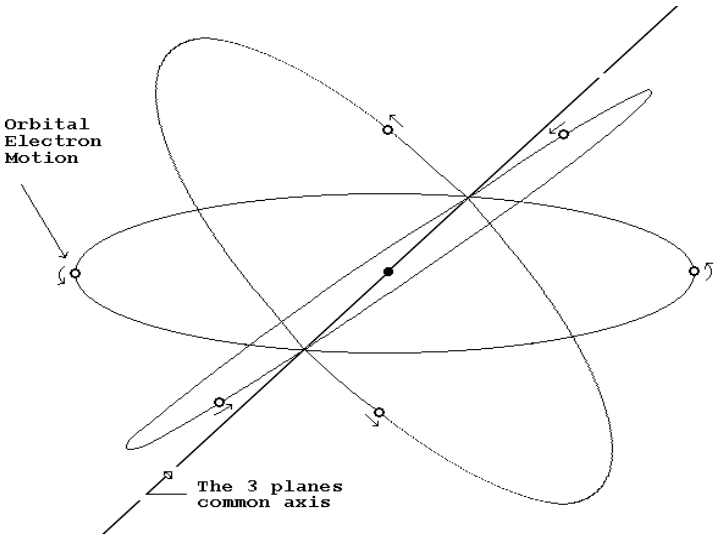


Figure 15-22
Three Orbital Planes and Relative Tilts, $n=2$ Shell

Can any more electrons fit in this shell ? Yes, two more in another orbital plane perpendicular to the common axis of the other three orbital planes. This new orbit intersects each of the other three successively at $\theta=60°$ intervals. The two electrons in each such intersected plane are spaced $180°$ apart. An electron passing such an intersection with one of the first three planes $60°$ after one of that plane's two electron's has passed and taking $60°$ to clear the intersection would have cleared the requisite $60°$ ahead of the other electron of that plane. Two such electrons $180°$ apart can be accommodated. Overall, therefore the number of orbital electrons that can fit in the $n=2$ shell is eight: two in each of the three planes depicted in Figure 15-22, above, plus two more in the plane perpendicular to the axis of those first three planes.

For $n=3$ the situation becomes considerably more complex. Now $\phi_{n=3} = 46.32°$. The reasoning as for $n=2$, above, indicates that the shell can still accommodate only three orbital planes intersecting on a common axis, each plane having two electrons in orbit $180°$ apart with the one more plane perpendicular to the common axis of the other three planes. In other words, for $n=3$ the shell appears able to only accommodate the same orbital structure as does the $n=2$ shell. This is in fact the case.

More precisely, the $n=3$ shell so functions until full in that form. Additional electrons for higher Z atoms then start filling the $n=4$ shell. Then, the electric field of those outer $n=4$ electrons becomes sufficient to modify the orbital structure situation and possibilities of the inner $n=3$ shell. The $n=3$ shell then can accommodate the expected five orbital planes on a common axis, each with two electrons, in addition to the already filled $n=2$ type structure. For

higher n the same kind of effect of outer on inner shell modifies the structure, the $n=5$ shell filling partly before the $n=4$ shell is completely filled and that partial outer shell's field then modifying the inner shell's structure.

How does an outer shell's partial filling increase the ability of the next inner shell to accommodate electrons without interference where, before that partial filling of the outer shell, the inner shell was as full as it could then be ? What determines the matter wavelength is the momentum of the electron per equation 15-10. That momentum varies as the square root of the energy in kinetic form because that energy is $m \cdot v^2$ and the momentum is $m \cdot v$. But the energy in kinetic form from orbit to orbit depends on the amount the potential energy changes. The partial filling of the outer shell with negative charges, electrons, changes the inner orbit potential energy.

It is the complex fitting of the space occupied by the orbital electron matter waves into the available integer-matter-wavelength orbital shells that determines the orbital electrons' arrangement structure. That structure is summarized in Table 15-23, below. The table, arranged so as to directly correspond to the "quantum number" system of 20th Century physics, shows what those data of Table 15-19 actually represent and why they produce correct results even though they are based upon the significantly incorrect theories of 20th Century physics.

Quantum Number	Orbital Structure
n	- The "index number" of the "shell". The shell's orbital path length is "n" matter wavelengths long. $n = 1, 2, 3, \ldots$
ℓ	- The "index number" of the particular "set" of orbital planes in the "shell". $\ell = 0, 1, \ldots n-1$ A "set" consists of orbital planes of orbits of the same length, tilted at equal angles relative to each other, and sharing the same common axis about which tilted. The number of "sets" in a "shell" is $[\ell + 1]$.
m_ℓ	- The "index number" of any particular orbital plane in any particular "set" of planes. $m_\ell = +[\ell], +[\ell - 1], \ldots 0, -1, \ldots -[\ell]$ The total of orbital planes in the "set" is $[2\ell + 1]$, always odd.
m_S	- Each individual orbital plane can fit 2 electrons equally spaced. [While for n > 1 more than 2 could fit, for the planes of the set taken together only 2 electrons per plane can be accommodated.] $m_S = -\frac{1}{2}$ and $+\frac{1}{2}$ [for the 1^{st} and 2^{nd} electrons of the plane].

Table 15-23

Figure 15-24 on the following page correlates this behavior with the structural implications of the Periodic Table of the Elements.

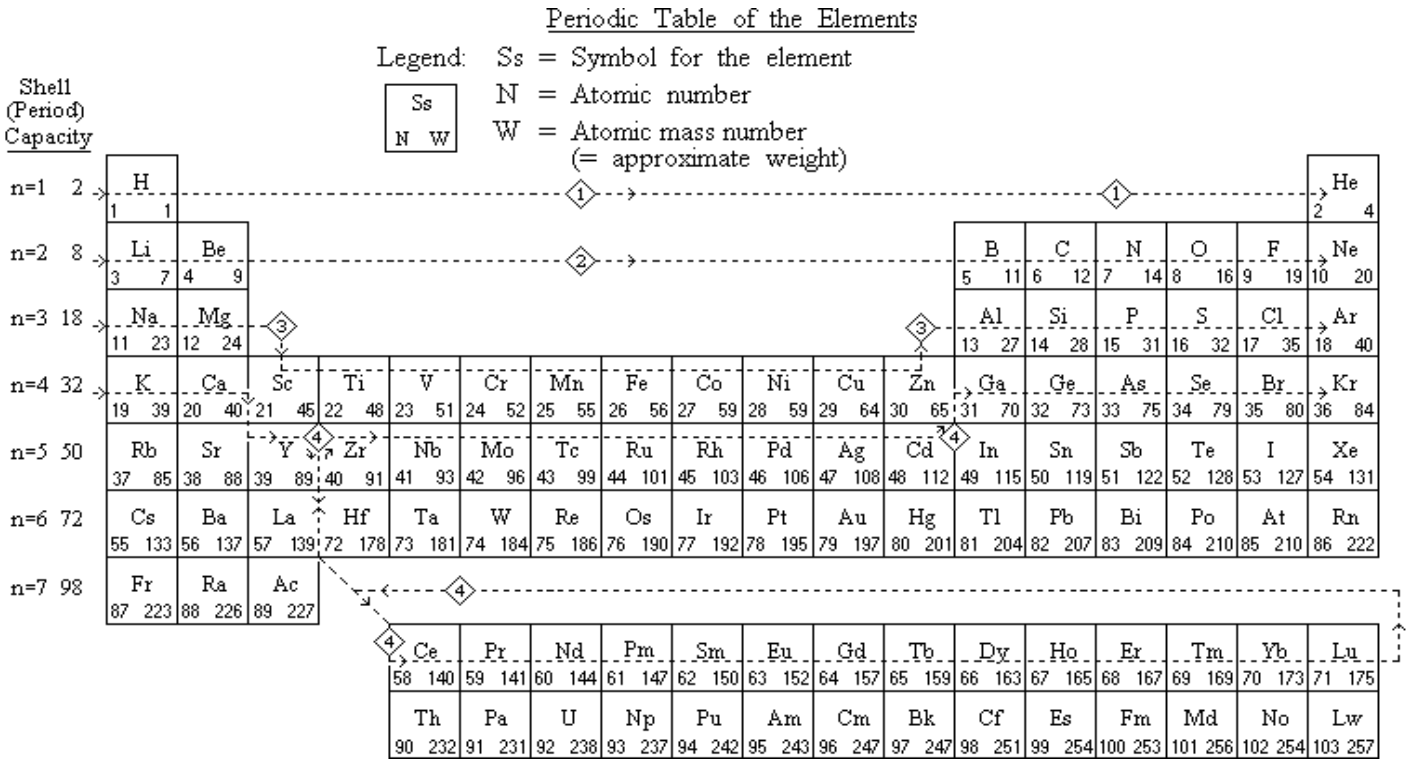


Figure 15-24
Correlation of Orbital Electron Shells & The Periodic Table of the Element

Referring back to Table 15-18, The Periodic Table of the Elements, the left most column, column *i*, contains only atoms having one single electron in the outer shell. That is why they are so chemically active. Compounds, combinations of elements, are formed by the component elements' atoms sharing outermost orbital electrons. A single such outermost electron can more easily find an accommodating space into which to fit in another atom than could two or more such outermost electrons.

Likewise, column *vii*, the next to the far right column, contains only atoms whose outermost shell is completely filled except for the final electron. That is why they are so chemically active. Such a single vacancy in the outermost shell can more easily find an accommodating electron to fill it than could two or more such empty electron positions.

The rightmost column, column *viii*, contains only atoms having a completely filled outermost shell. That is why they are inert, unable to form compounds. They have neither outer shell electrons nor vacancies to share. Thus, a row across the table corresponds in some sense to an orbital electron shell. The row starts with one outer electron and progresses through an increasing number up to a completely filled shell.

But as electrons and their associated negative electric charge accumulate in inner shells they tend to repel additional electrons that are too close. As a result the shells, after the first two, do not simply fill in shell vacancy order. Rather, at some points additional electrons can only be accommodated in shells further out than the current partially filled shell.

That behavior results in the shells filling in the manner indicated in Figure 15-24 on the previous page. And that behavior, combined with the structure of the Periodic Table, results in the shell capacities from the innermost, $n = 1$, shell outward being $2, 8, 18, 32, \ldots$ as the traditional 20th Century formulation of Table 15-19 or the more-correct-in-its-relation-to-reality formulation of Table 15-23 or the shell-filling paths in the Periodic Table per Figure 15-24 all yield and agree.

The Pauli Exclusion Principle, an empirical pragmatic acknowledgment of observed behavior with no underlying reasons for its validity, now has become the obvious and necessary condition that no atomic orbital electron may have its path such that its matter wave interferes with (occupies the same space as part of) the matter wave of any other orbital electron. This happens, of course, not because orbital electrons are "well behaved and obey the principle", but because an orbital electron path / position that does not so conform results in a clash of the two electrons involved preventing the interfering action, the interfering electron locations, from continuing.

In other words, the entire structural effect is the result of the matter waves of the orbital electrons and the restrictions that their space requirements impose on the system. While the appearance of quantization of angular momentum is there in some forms and with various modifications and adjustments (such as projections on an axis), that is only because of the relationship between angular momentum and matter wave length; that is, that a statement of quantized angular momentum is actually a statement of integer values of matter wavelength.

A direct and simple behavior and cause-effect relationship results from recognizing the role of the matter wave in atomic structure. Quantum Mechanics

appears rather arcane, certainly only distantly related to a model of reality. But why did the significance of the matter wave get essentially so completely overlooked by traditional 20th Century physics ? DeBroglie introduced the matter wave well before the advent of Quantum Mechanics.

The reason is that traditional 20th Century physics could not "trust" the matter wave. While the matter wave *wavelength* worked well in the relationships of things the matter wave *frequency* was a considerable problem. It could not be made to fit in with the rest of theory and consequently doubt was cast on the entire subject of matter waves. The problem was that traditional 20th Century physics did not know of energy and mass in kinetic form and in rest form, developments of this Universal Physics. They only knew of traditional kinetic and rest mass and energy, which are not applicable in the case of matter wave frequency and, consequently, matter wave velocity. It requires this Universal Physics to obtain a correct understanding and treatment of the matter wave only after which can its significance in atomic structure be developed.

FINE STRUCTURE AND SPIN

When the line spectrum of Hydrogen is obtained with a spectrometer of high resolving power it is found that the lines that appear as simple single lines at low resolving power are in fact pairs of lines. This phenomenon is referred to as the *fine structure*. The splitting of the (low resolution) single line into (high resolution) two lines is on the order of about 1 part in 10^4. Sommerfeld addressed this problem showing that if the orbital electrons had elliptical orbits, in which the electron velocity would be relatively slow far from the nucleus and faster than for the circular orbit case near the nucleus, the relativistic mass increase at the higher velocity provided a minute energy increase that was on the order of the correct amount to account for the line splitting. That is, the elliptical orbit's energy would be slightly different from a circular orbit's energy.

Sommerfeld's model for how the fine structure arises, a model based upon the conceived direct motion and action of the electrons, was soon superseded by Quantum Mechanics, a model that seeks not to directly represent electron motion but rather to express the electron behavior and its effects. However, in spite of the wide spread acceptance of Quantum Mechanics, the concept of elliptical electron orbits has been retained.

Quantum Mechanics overthrew the Bohr-Sommerfeld theory shortly after its development. In Quantum Mechanics the fine structure is attributed to the interaction of the magnetic field due to the electron's spin on its own axis with the magnetic field due to the electron's orbit around the nucleus. This is referred to as spin-orbit coupling. The two cases that are contended to account for the two lines close together in the Hydrogen spectrum are for the electron's spin angular momentum vector in the same direction as the orbital motion angular momentum vector and in the opposite direction.

In multi-electron atoms the fine structure becomes various multiplet structures depending on the number of electrons, rather than the doublet structure of Hydrogen with only one electron. For multi-electron atoms the coupling possibilities are spin-orbit, orbit-orbit, and spin-spin.

In a sense the conception that traditional 20th Century physics has of the electron is of a powder of negatively charged minute specks compressed into a

little ball. (One of the concerns of traditional 20th Century physics is that of what holds the electron together; with all of that charge packed so closely why does it not explode ?) In that sense, the electron is conceived of as spinning on its axis. It is conceived that the consequent circular motion of the specks of charge that are rotating about the electron's spin axis constitute a small current and generate a small magnetic field.

Actually, traditional 20th Century physics does not know, and has no way of knowing, whether the electron spins or not and if so then how rapidly, how (in traditional 20th Century physic's terms) the charge is distributed throughout the electron and what the electron diameter is, and so forth, all data necessary to calculation of its spin magnetic field. The contention of electron spin and its associated magnetic field depends entirely on that the concept is used to explain a fine characteristic in atomic line spectra. The amount of spin and the amount of consequent magnetic field is set by 20th Century physics at the value that explains the spectral fine structure.

In Universal Physics there can be no such concept, of course. Whether a center-of-oscillation can or does spin or not might conceivably be open to question but would seem to be inconsequential and irrelevant. The Coulomb effect of an electron center-of-oscillation is an effect external to the internal structure of the center. There is no way that such an electron can have a magnetic field due to spin.

Fine structure is the result of each orbital electron's having one or the other of two possible slightly different energy states in its orbit. In traditional 20th Century physics the two energy states result from the electron spin angular momentum (and magnetic) vector being in the same or opposite direction relative to the orbital motion angular momentum (and magnetic) vector. Spin in fact not being the cause because there is no spin, there must be some other cause that produces the same effect.

There is such another cause. That other cause is *absolute motion*, the effects of which have been neglected until now in the treatment of the behavior of the atomic orbital electrons. Paraphrasing a portion of the earlier *Section 13 - A Model for the Universe (3) - Motion and Relativity*:

> "There exists throughout the universe a background radiation which is the residual radiation from the immense energy of the "big bang", the start of the universe. ... This radiation is, of course, relative to the beginning, relative to the U-wave medium. Measurements of Doppler frequency shift of this radiation due to the motion of the Earth give an absolute velocity for the Earth relative to the medium of about $370\ km/sec$. The direction of the Earth's motion as indicated by those measurements is off in the direction from Earth of the constellation Leo."

The speed of the Earth in its orbit around the Sun is only about $31,000\ m/sec$ so most of Earth's absolute speed is due to its motion relative to its galaxy, the Milky Way, and the absolute motion of that galaxy through space. Generally speaking it is likely that most if not all of the universe has a comparable magnitude of absolute velocity directed radially outward from the location of the original "big bang". (This is treated further in section *21 - The Probable End*.) But, whether or not, this *absolute* velocity of our Earth and our

entire planetary-solar-galactic system of about $3.70 \cdot 10^5$ m/sec = 0.0012·c must be taken into account in considering the behavior of the orbital electrons.

The most important factor in the stability of an atomic orbital electron is that it must not radiate energy. That requires that it experience no changes in the shape of its U-wave pattern of propagation forward, rearward and sideward. And, that requires that its speed remain constant. But, the speed of an orbital electron has two components: its orbital speed relative to the nucleus, which has been extensively treated in the preceding analyses, and its absolute linear speed because it is part of our overall solar system.

In order for the electron to avoid radiating, it is its net speed, the resultant of those two components, which must remain constant. The way in which those two components combine to produce a net electron speed at any moment depends upon the orientation of the electron's orbital plane relative to the absolute velocity component of the electron, its atom and its solar-galactic system. The effect is illustrated in Figure 15-25, below.

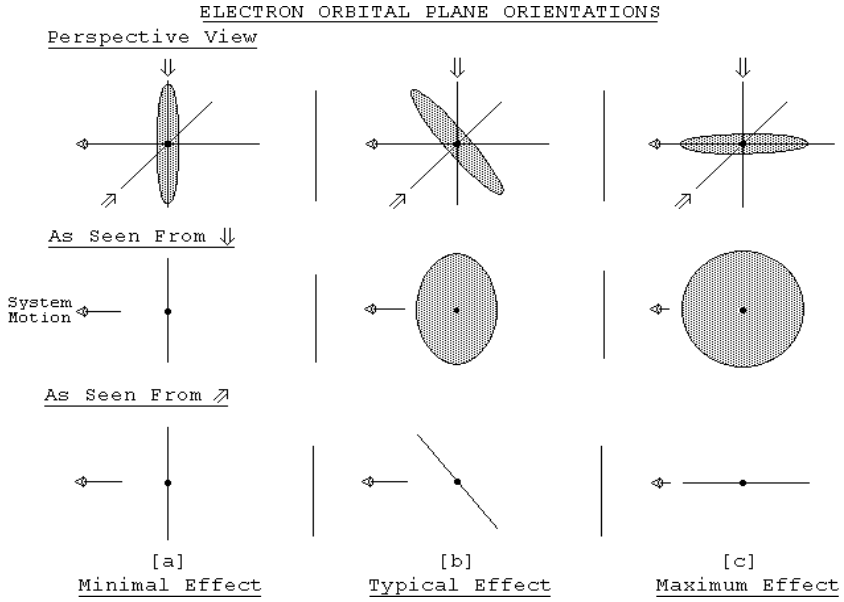


Figure 15-25
Relative Effect of Absolute Motion on Various Orbital Electrons

The figure illustrates different ways that the plane of an orbital electron's orbit can be oriented relative to the absolute motion of the atom's nucleus. If the orbital plane is oriented at right angles to the direction of absolute motion, as in the *[a] Minimal Effect* column of the figure, then the absolute motion produces the same change in the overall electron resultant speed everywhere in the orbit. The electron's total speed is that resultant. Its orbital speed relative to the nucleus is the circular orbit speed for that orbital shell as already analyzed and presented.

On the other hand, if the orbital plane is oriented parallel to the direction of absolute motion, as in the *[c] Maximum Effect* column of the figure, then the overall resultant speed of the electron varies between the sum of its circular orbital speed and the absolute motion speed and the difference of the two speeds

(see Figure 15-26, below). In general, orbital planes are frequently oriented between those two extremes as illustrated in the *[b] Typical Effect* column of the figure. For such cases the absolute motion can itself be resolved into two components: one at right angles to the particular orbital plan (Case *[a]*) and one parallel to it (Case *[c]*) and the resulting overall effect analyzed in terms of a combination of those two extreme cases.

Figure 25-26, below illustrates the analysis of the Case *[c] Maximum Effect* circumstances.

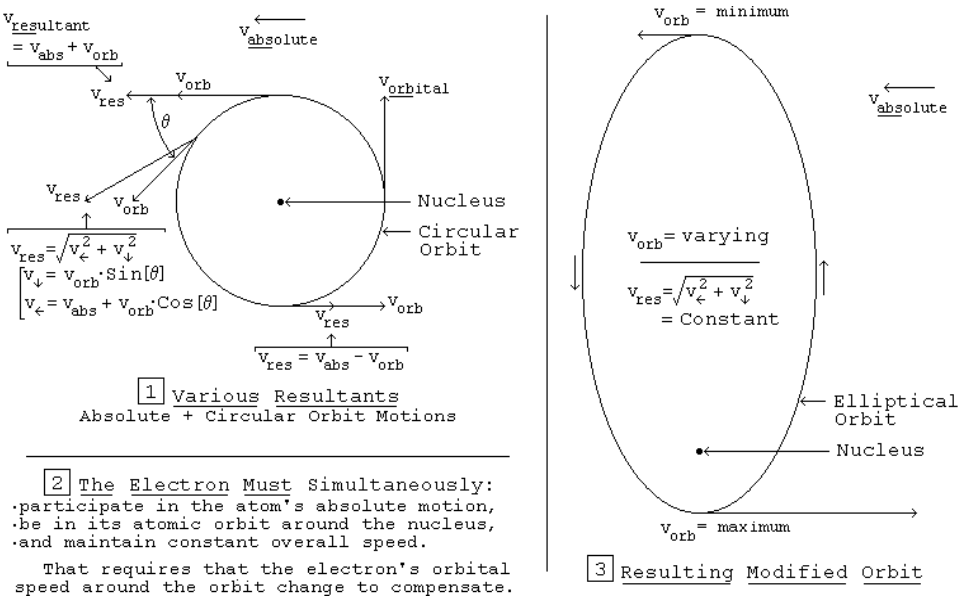


Figure 25-26

The figure is largely self-explanatory. If the electron is in a circular orbit (with consequent constant orbital speed) then the effect of the atom's absolute motion is to vary the electron's absolute speed, which is not acceptable. The only solution, the only *modus operandi*, is for the electron orbital speed to vary so as to compensate for the absolute motion and maintain constant absolute electron speed as shown in box 3 of the figure. The result is elliptical orbits for those orbits in which the orbital plane is not perpendicular to the direction of absolute system motion, that is for those orbits of Cases *[b]* or *[c]* or Figure 15-25.

The circular orbit speed in the $n = 1$ orbit of Hydrogen is about $2.2 \cdot 10^6$ m/sec. Our absolute speed is about $3.7 \cdot 10^5$ m/sec. The successive orbit speeds for $n = 2, 3, \ldots$ are $1/n$ times the $n = 1$ value. Thus the effect of absolute speed and the variations in orbital speeds are quite significant.

It is interesting to recall that the system of orbital quantum numbers developed by 20th Century physics and particularly elaborated by Dirac, described on the page before Table 15-19, used the convention of the projection of an orbital angular momentum vector on a reference axis to define the various orbital tilts. It has now here been found that the tilts are the direct result of the space required for the matter wave of each orbital electron and the tendency of the electrons to space themselves as equidistant from each other as the circumstances permit. And it has now here been found that the "reference axis",

an imaginary and missing element in traditional 20th Century physics terms, is actually the orbital plane orientation relative to the atom's absolute motion in space. The $l = 0$ value corresponds to the electron orbital plane being at right angles to the absolute motion, Case *[a]* of Figure 15-25. The $l = 1$ value produces a Case *[b]* situation. The horizontal orbit of Figure 15-22 is at right angles to the absolute motion and is circular. The other two orbits of the figure are now found to be elliptical, a pair tilted at equal but opposite angles relative to the absolute motion of the atom.

Figure 15-27 below gives a general summary of the orbital electron structure, which is the same in quantum mechanics and in this Universal Physics; and of the causes of that structure, in which quantum mechanics has some errors which are corrected in this Universal Physics.

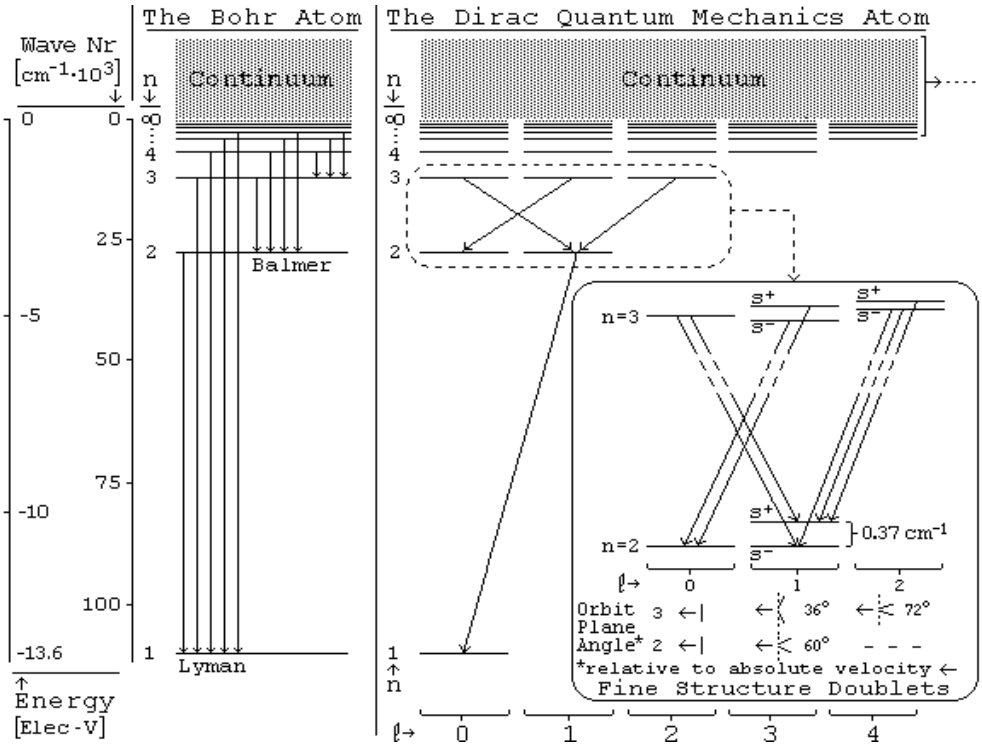


Figure 15-27
Hydrogen Atomic Spectra

Returning to the problem of the cause of the *fine structure* in atomic spectra, there is a second consequence of the orbital electrons' absolute motion. Each electron has a component of magnetic field due to its straight line motion in space in addition to its orbital motion magnetic field. The electron's orbital magnetic field, which is perpendicular to the plane of the orbit, tends to align with the linear motion magnetic field that is due to the atom's absolute motion, which field is circumferential to the electron's direction of absolute motion. There are two possible alignment orientations, that is two orientations when there is no force acting that tends to change the orientation to one of the two. One is orbital motion in the same direction as the absolute motion magnetic field and the other is the opposite. The two differ slightly in energy. It is not "spin-orbit"

coupling but "absolute motion - orbit" coupling that operates to produce the fine structure.

The electron's absolute motion magnetic field may seem to be rather weak for the purpose (just as would the magnetic field of a spinning electron so seem), but just as in the hypothesized spin-orbit coupling, both of the actions actually are acting at the same location, that of the electron.

High resolution spectral techniques, including the use of tunable lasers, disclose an even more closely spaced splitting of spectral lines which is called *hyperfine structure*. Analogous to the quantum mechanical explanation of fine structure in terms of hypothesized orbital electron spin, the hyperfine structure is attributed to nuclear spin, its consequent magnetic field, and its interaction with the electrons. But, the nucleus can no more have a spin magnetic field than can an orbital electron. In this Universal Physics that is clear for the case of Hydrogen where the nucleus is a proton, a simple center-of-oscillation. As will be developed in a later section it is also true of all atomic nuclei.

The hyperfine structure stems from electron orbital magnetic field interaction with the magnetic field due to the nucleus' absolute motion in space. Of course, overall the nuclear and orbital electron absolute motion magnetic fields cancel out since the direction of absolute motion is the same but the polarity of the moving charges are opposite. However locally, within the atom there is not general cancellation.

The final kind of minute structural variation in atomic spectra is that called the Lamb Shift. The Lamb Shift is a slight displacement of some, but not all, of the spectral lines from their otherwise expected locations the amount of shift being greatest for low orbits ($n = 1$) and falling off in amount progressively for the higher orbits. The shift, to slightly higher energy (slightly larger radius orbit), is due to the distance of the orbital electron from the nucleus being only marginally sufficient for the U-waves arriving from the nucleus and encountering the electron to act as pure plane waves. The arriving wave front at the orbital radii distances from the nucleus, especially for the shorter radii lower orbits, is not effectively a pure plane wave. The slight curvature of the wave front reduces the Coulomb attraction minutely.

This effect is discussed in detail at the end of the next section, section *16 - A Model for the Universe (6) - The Neutron, Newton's Laws*.

CONCLUSION

Up to this point the atomic nucleus, essential to the discussion, has been taken to be a body of undefined structure having the two characteristics necessary to the analysis, mass and positive charge, each in the amount appropriate to the type atom being analyzed. Of course, there is much more to the nucleus than that, and the point has now come to investigate the atomic nucleus.

The first step in that process is to investigate the neutron, the other nuclear component in addition to the proton.

DETAIL NOTES - 8

Analysis of Some Minor Effects on Orbital Electron Motion

1. U-WAVE TRANSIT TIME

This is the effect that the U-waves require a small but yet appreciable time to travel from the nucleus to the orbiting electron (and vice versa), and during that time the particles move a small distance along their paths. The effect is only of concern in the case of the Hydrogen atom, which has only one orbital electron. Because of its lack of symmetry the center of mass is not located at the center of the nucleus. The motions of the two bodies, the nucleus and the orbital electron must be and are about their common center of mass, which is located between them.

Each of the other atoms, for $Z > 1$ can have a symmetrical (or almost symmetrical) arrangement of its orbital electrons relative to its atomic nucleus so that the center of mass of the system of particles making up the atom is located at or near the center of the nucleus. Their symmetrical arrangement is the result of the mutual electrostatic repulsion among the electrons. The mutual repulsion causes the electrons to take relative spacings equidistant from each other within each shell of orbits. Only the Hydrogen atom has too few electrons to achieve any near symmetry.

Figure DN8-1 below illustrates the effect in the Hydrogen atom. The two component particles are shown in their positions, first at time t_1 and then at a slightly later time t_2, as they revolve around their common center of mass.

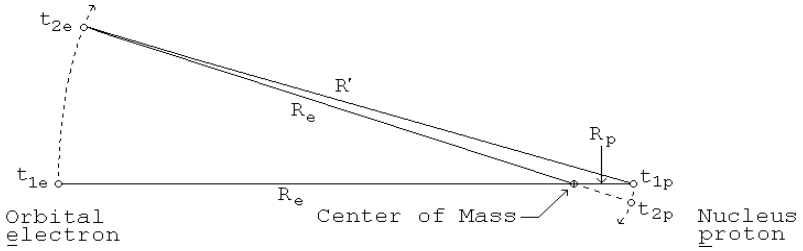


Figure DN8-1
Hydrogen Atom Particle Motion Effect on Encountered Wave (Not to scale)

The waves that the electron encounters at t_{2e} are those propagated by the nucleus at t_{1p} and which traveled the straight line path from t_{1p} to t_{2e},

which is of length R'. R' is shorter than the radial distance $R_e + R_p = R$ between the two particles.

The location of the common center of mass is determined as follows.

(DN8-1) $R_e \cdot m_e = R_p \cdot m_p$ [Definition of common center of mass]

$$R_e = R_p \cdot \frac{m_p}{m_e} = [R-R_e] \cdot \frac{m_p}{m_e} \qquad [R = R_e + R_p]$$

$$= R \cdot \frac{m_p}{m_p + m_e} = R \cdot \frac{m_{p/m_e}}{m_{p/m_e} + 1}$$

From the CODATA bulletin referenced in the main text the proton/electron mass ratio, m_{p/m_e}, is 1836.152701 so that

(DN8-2)
$$R_e = R \cdot \frac{1836.152701}{1836.152701 + 1} = 0.9994556794 \cdot R$$

Let

$$k = \frac{R_e}{R} = 0.9994556794$$

$$R_e = k \cdot R \qquad \text{and} \qquad R_p = [1-k] \cdot R$$

From the trigonometric law of cosines applied to the triangle $[t_{2e} - CoM - t_{1p}]$, where CoM is the Center of Mass, and then substituting from the above equation DN8-2 and solving, the following is obtained.

(DN8-3)
$$R'^2 = R_e^2 + R_p^2 - 2 \cdot R_e \cdot R_p \cdot \cos\left[\angle[t_{2e}\text{-}CoM\text{-}t_{1p}]\right]$$

$$R'^2 = k^2 \cdot R^2 + [1-k]^2 \cdot R^2 - \cdots$$

$$\cdots - 2 \cdot k \cdot [1-k] \cdot R^2 \cdot \cos\left[\angle[t_{2e}\text{-}CoM\text{-}t_{1p}]\right]$$

$$\frac{R'^2}{R^2} = k^2 + [1-k]^2 - \cdots$$

$$\cdots - 2 \cdot k \cdot [1-k] \cdot \cos\left[\angle[t_{2e}\text{-}CoM\text{-}t_{1p}]\right]$$

$$= 1 - 2 \cdot k \cdot [1-k] \cdot \left[1 + \cos\left[\angle[t_{2e}\text{-}CoM\text{-}t_{1p}]\right]\right]$$

The travel time of the ray of U-wave that follows the path R' from t_{1p} to t_{2e} is $\Delta t = (t_2\text{-}t_1)$. The electron path distance from t_{1e} to t_{2e} is that time multiplied by the velocity of the electron, v. The distance R' is the same time multiplied by the velocity of light, c. The ratio of the two distances is, therefore v/c. The greatest electron velocity in orbit is about $0.007 \cdot c$ ($n=1$ orbit) so that $v/c \le 0.007$. Thus the electron moves along its path a distance less than 1% of the orbit radius during the propagation time of a wave from the nucleus to the electron.

The angle $\angle[t_{1e} - CoM - t_{2e}]$ is therefore quite small. For such small angles the sine of the angle and the angle are numerically equal, which also means that the sine of the angle is the arc length divided by the radius. From

equation DN8-2 R_e and R' are almost equal. The sine of the angle, and therefore the angle itself, is then the ratio of the electron travel along its path to R', which was found just above to be less than 0.007. That is $\angle[t_{1e}$ - CoM - $t_{2e}] \leq 0.007$ *(radians)*.

From the figure, because the sum of the two angles is a straight line,

(DN8-4) $\text{Cos}\left[\angle[t_{2e}\text{-CoM-}t_{1p}]\right] = -\text{Cos}\left[\angle[t_{1e}\text{-CoM-}t_{2e}]\right]$

$= \text{-Cos}[0.007]$

$= \text{-0.9999755001}$

Substituting that result and the value of k from equation DN8-2 into equation DN8-3 and performing the calculation gives the result:

(DN8-5) $1 + \text{Cos}\left[\angle[t_{2e}\text{-CoM-}t_{1p}]\right] = 1 - 0.9999755001$

$= 0.0000244999$

$$\frac{R'^2}{R^2} = 1 - 2\cdot k\cdot(1-k)\cdot\left[1 + \text{Cos}\left[\angle[t_{2e}\text{-CoM-}t_{1p}]\right]\right]$$

$= 0.999,999,973,3$

$$\frac{R'}{R} = 0.999,999,986,65$$

The actual distance the U-waves travel, R', is almost identical to the theoretical distance, R. Thus, while the U-wave transit time effect exists, its magnitude is too small to be significant in this case, the $n=1$ orbit.

Equations 15-53 through 15-56 show that the orbital electron velocity is inversely proportional to the orbit number and the orbital radius is directly proportional to that number squared, that is $v \propto 1/n$ *and* $r \propto n^2$. For the $n=2$ orbit compared to the $n=1$ orbit all of the dimensions are 4 times greater, that is the diagram is identical to Figure DN8-1, above, except that all lengths are 4 times greater. That is except for the distance the electron travels. For an identical diagram the electron speed would have to be 4 times greater, also. The orbital electron, however, travels $1/2$ as fast along its path. The result is that the angle $\angle[t_{1e}\text{-}CoM\text{-}t_{2e}]$ is therefore $1/8$ the $n=1$ value and the U-wave transit time effect is that much less. The effect is inversely proportional to n^3.

Overall, then, the U-wave transit time effect is so small as to be essentially negligible.

2. NUCLEAR MOTION

The above Figure DN8-1 points out that the nucleus is also in motion for this configuration. In fact, since the electron and nucleus both move on paths around the common center of mass, then both of them are "in orbit" and everything said of the orbital electron applies also to the nucleus except that the amounts are different. The nucleus changes orbit when the electron does. That is, an electron orbit change shifts the location of the center of mass, but that

location cannot shift due to the electron's orbit change as such. It is the location of the overall atom. The nuclear orbit must correspondingly shift.

It turns out that nuclear motion is essentially negligible in its effects and all but undetectable in its radiation. This develops as follows.

(DN8-6) $$\frac{m_p \cdot v_p^2}{R_p} = \frac{q^2}{4\pi \cdot \varepsilon_0 \cdot R^2} = \frac{m_e \cdot v_e^2}{R_e}$$ [Centripetal force = Coulomb attraction for proton as for electron]

$$m_p \cdot v_p^2 = \frac{R_p}{R_e} \cdot m_e \cdot v_e^2$$ [Rearranging]

$$k' \equiv \frac{R_p}{R_e} = \frac{1-k}{k}$$ [Per equation DN8-2]

$$= 0.00054461704$$

Therefore

(DN8-7) $$f_{mw,p} = \frac{m_p \cdot v_p^2}{h} = k' \cdot \frac{m_e \cdot v_e^2}{h} = k' \cdot f_{mw,e}$$

$$\frac{f_{mw,p}}{f_{mw,e}} = k' = 0.00054461704$$

That is, the nuclear matter wave frequency is on the order of $1/10,000$ the electron matter wave frequency. That means that the frequency of the radiation caused by nuclear orbit changes is on the order of $1/10,000$ the frequency of radiation due to electron orbit changes. The frequency of orbital electron radiation is in the light range, on the order of 10^{14} *Hz* (cycles per second). Therefore the frequency of nuclear radiation due to orbit changes is on the order of 10^{10} *Hz*, somewhat above the higher commercial TV signals.

The energy, $h \cdot f$ is likewise $1/10,000$ that of the energy in electron radiation, the energy of visible light.

These calculations apply to the Hydrogen atom. In general the heavier atoms have much less asymmetry than Hydrogen and, therefore, much less consequent nuclear motion than Hydrogen.

Orbital Electron Energy Analysis

ASYMMETRICAL ENERGY ALLOCATION IN THE HYDROGEN ATOM

Referring to Figure 15-8, repeated below,

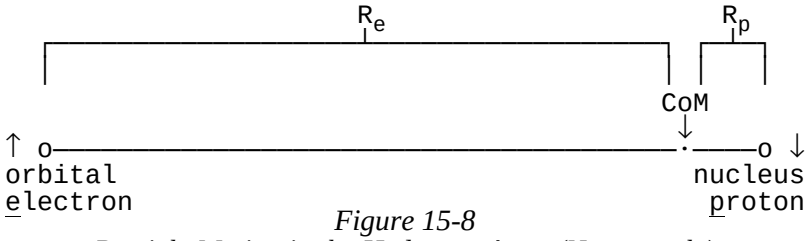


Figure 15-8
Particle Motion in the Hydrogen Atom (Not to scale)

the orbital electron and the nuclear proton each have potential energy because of the Coulomb attraction between them. If they could freely fall toward each other, converting their potential energy into kinetic energy, they would meet at their common center of mass and have shared the potential energy as follows.

(DN9-1)

force: $f = \frac{q^2}{4\pi \cdot \varepsilon_0 \cdot r^2}$

acceleration: $a = \frac{f}{m}$

velocity: $v = \int a \cdot dt = a \cdot t = \frac{f \cdot t}{m}$

distance: $s = \int v \cdot dt = \frac{1}{2} \cdot a \cdot t^2 = \frac{f \cdot t^2}{2 \cdot m}$

nucleus travels: $\frac{f \cdot t^2}{2 \cdot m_p}$

electron travels: $\frac{f \cdot t^2}{2 \cdot m_e}$

total travel: $\frac{f \cdot t^2}{2} \cdot \left[\frac{1}{m_p} + \frac{1}{m_e} \right]$

electron share of travel: $$\frac{1/m_e}{1/m_p + 1/m_e} = \frac{m_p}{m_p + m_e} = k$$

[They meet at the CoM.]

nucleus KE: $$\tfrac{1}{2}\cdot m_p \cdot v_p 2 = \tfrac{1}{2}\cdot m_p \cdot \left[\frac{f\cdot t}{m_p}\right]^2 = \frac{f^2 \cdot t^2}{2\cdot m_p}$$

electron KE: $$\tfrac{1}{2}\cdot m_e \cdot v_e 2 = \tfrac{1}{2}\cdot m_e \cdot \left[\frac{f\cdot t}{m_e}\right]^2 = \frac{f^2 \cdot t^2}{2\cdot m_e}$$

total KE: $$\frac{f^2 \cdot t^2}{2}\cdot\left[\frac{1}{m_p} + \frac{1}{m_e}\right]$$

electron share of KE: $$\frac{1/m_e}{1/m_p + 1/m_e} = \frac{m_p}{m_p + m_e} = k$$

The electron share of the Kinetic Energy is k and that is also the electron's share of the lost potential energy since its gained KE and lost PE are identical.

POTENTIAL ENERGY

Energy is a force acting through a distance. Potential energy is the energy that would be involved if the force did act through the distance (although it has not yet done so). In most common cases that calculation becomes simply taking the product of the force acting between two particles or objects and the distance between them.

In the case of atomic orbital electrons the situation can be confusing. Their potential energy is measured relative to the electron being entirely free of the atom (and entirely free of everything else, at least theoretically). In such a state the electron is in a neutral state. It has zero potential energy. From that zero potential energy state it would "fall" toward a positive charge, if it became involved with one, losing energy in the process. Thus the orbital electrons have negative potential energy. The nearer the negative orbital electron is to the positive atomic nucleus the less is its potential energy; that is, the greater is the negative value of its potential energy, the greater is the amount of energy it has lost since being attracted from its neutral state.

The calculation of that process for an electron falling toward a proton, where δ is the distance between them, is as follows. The electron falls from entirely free of the proton, at distance ∞ from it, to within distance r of it.

(DN9-2) $$\text{Potential Energy} = \int \text{Coulomb Force} \times \text{Distance}$$

$$PE = \int_{\infty}^{r} \frac{q_p \cdot q_e}{4\cdot\pi\cdot\varepsilon_0\cdot\delta^2}\cdot d\delta = \frac{q_p \cdot q_e}{4\cdot\pi\cdot\varepsilon_0}\cdot\left[\frac{-1}{r} - \frac{-1}{\infty}\right]$$

$$= -\frac{q_p \cdot q_e}{4\cdot\pi\cdot\varepsilon_0\cdot r}$$

This same magnitude of potential energy, but of positive sign, would result from the analogous calculation with like charges. Two like charges, initially located at separation distance r, will fall away from each other to infinite separation and neutral state. Their potential energy before falling is

(DN9-3)

$$\text{Potential Energy} = \int \text{Coulomb Force} \times \text{Distance}$$

$$PE = \int_{r}^{\infty} \frac{q_p \cdot q_e}{4 \cdot \pi \cdot \varepsilon_0 \cdot \delta^2} \cdot d\delta = \frac{q_p \cdot q_e}{4 \cdot \pi \cdot \varepsilon_0} \cdot \left[\frac{-1}{\infty} - \frac{-1}{r} \right]$$

$$= + \frac{q_p \cdot q_e}{4 \cdot \pi \cdot \varepsilon_0 \cdot r}$$

The entire difference between the two cases is the inversion of the starting and ending points, the direction of integration. (The charges enter into Coulomb's Law as absolute values, without sign, there being no absolute direction.)

These two cases appear graphically as in Figure DN9-1, below

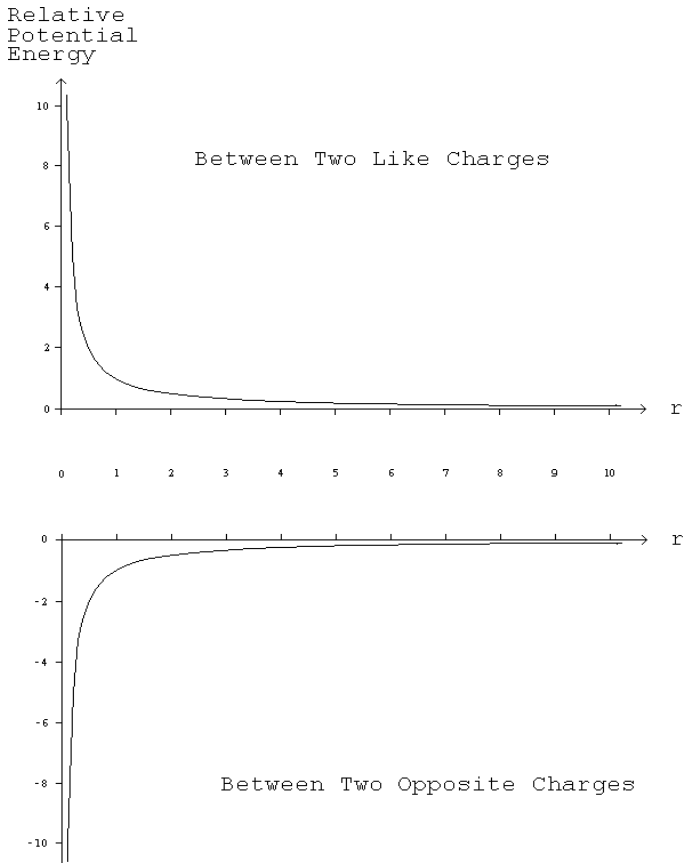


Figure DN9-1
Potential Energy of Two Electric Charges

Conceptually these diagrams can be thought of as hills. That is, the direction of decreasing potential energy is the direction in which a ball would roll down the curves if they were hills in a gravity field. This will all be of significance when the problem of the affect on the Coulomb force of the centers-of-oscillation being near to each other is addressed toward the end of the next section.