Clearly, since the center's focusing action must depend on the variation of its waves, the moment-by-moment amount of medium, and that variation is as shown in the above figure, then a significant inverse square effect would be expected. (The figure shows the inverse-square effect as much less than it actually is. For example, the inverse-square envelope at $1/1000$ of the first full cycle of oscillation out from the singularity is $1,000,000$ times greater than that at the end of that first cycle).

However, that effect is directly cancelled by two other effects illustrated in Figure 16-11, below. Two rays, #1 and #2, of incoming wave are shown. Each is deflected by the same focusing power, that is each is deflected through the same angle, α. But, the focusing of ray #2 at twice the distance out from the encountered center as for ray #1 enables the focusing of #2 to overcome twice as much lateral displacement, d_2, as ray #1's d_1.

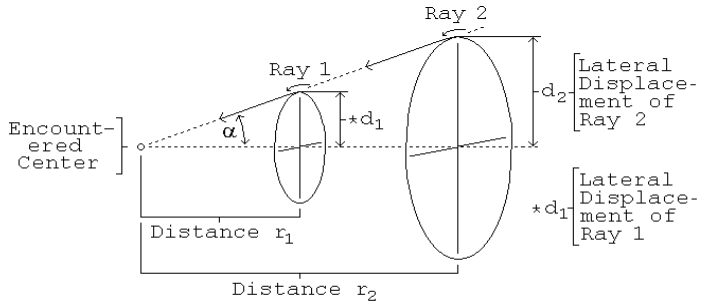


Figure 16-11

But, in addition and still referring to Figure 16-11, an incoming ray of propagating medium that is focused at distance r_2 out from the encountered center will experience on-going focusing action over twice the travel, for twice the time as will a ray that does not experience focusing until arriving at distance r_1 out from the center. The remaining time or travel distance over which further focusing can take place is directly proportional to the current radial distance outward from the encountered center, r, being discussed.

In other words, the effectiveness of a given focusing power at a given radial distance out from the target center depends directly on that radial distance squared, one factor of r for the effect on incoming ray lateral displacement that can be overcome and one factor of r for the amount of remaining application of focusing power depending on the amount of ray travel to the encountered center yet remaining over which further focusing can act. Therefore, the overall amplitude function must be multiplied by r^2 to properly represent the way it effects focusing as r varies. With the amplitude divided by r^2 for the inverse square effect and multiplied by r^2 for the relative focusing effects both may be dropped from further consideration with regard to analysis of the Coulomb focusing action.

For there to be focusing action there must be a gradient, a variation of U-wave amplitude in space (such as the inverse square gradient outward from a galactic mass that deflects passing rays of light). With the inverse square effect now eliminated from Coulomb focusing what produces the gradient ? The pure center oscillation (even without the inverse square effect) produces the necessary gradient in space.

Figure 16-10 shows that the oscillation's gradient can be positive or negative. In half the wave form, every other half cycle, the momentary amplitude increases as radial distance increases (positive gradient). The rest of the wave form exhibits decreasing amplitude as radial distance increases (negative gradient). It is such negative gradient that tends to deflect incoming U-waves toward the encountered center, tends to focus the incoming waves, just as the inverse square gravitational field of a galactic body focusing passing light rays is a negative gradient. By "negative" is meant negative gradient in $+U$ and positive gradient in $-U$; that is, a region of decreasing <u>absolute value</u> of the wave form with radial distance from the encountered center. Increasing such value tends to disperse or de-focus the waves.

Consequently, only the first region outward from the encountered center before the sign of the gradient changes has other than negligible effect on the focusing, because that region is the last portion of the encountered center's waves that acts upon the incoming waves before they reach or pass the encountered center itself. It is that region which has the "final say". Because the encountered center continuously oscillates the gradient in the region immediately next to it continuously alternates between focusing and de-focusing.

If that region is one of positive gradient the overall net effect on incoming U-waves is to de-focus them. If it is a region of negative gradient it tends to properly focus the incoming waves. Such a region, one having a negative gradient of the wave form, will be termed the *favorable region*.

Alternate focusing and de-focusing go on continuously from the moment a ray leaves its source center. Since the focusing power is independent of the radial distance from the encountered center as just shown above, the alternate focusing and de-focusing cancel. If they did not the focusing and, consequently, the mass of the encountered center would depend on the separation distance, which is not the case, of course. (Detail notes *DN 10 - Further Analysis of Coulomb Focusing* at the end of section *19* elaborate this.)

In the *favorable region*, that is when the gradient of the encountered center wave form is negative in the region adjacent to the encountered center, focusing takes place as indicated in Figure 16-12, below and continued on the following page.

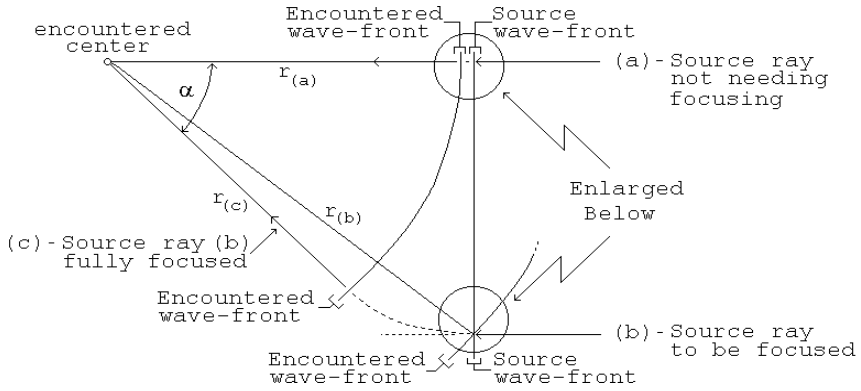


Figure 16-12(a)
Focusing Action of Encountered Center's Wave Gradient

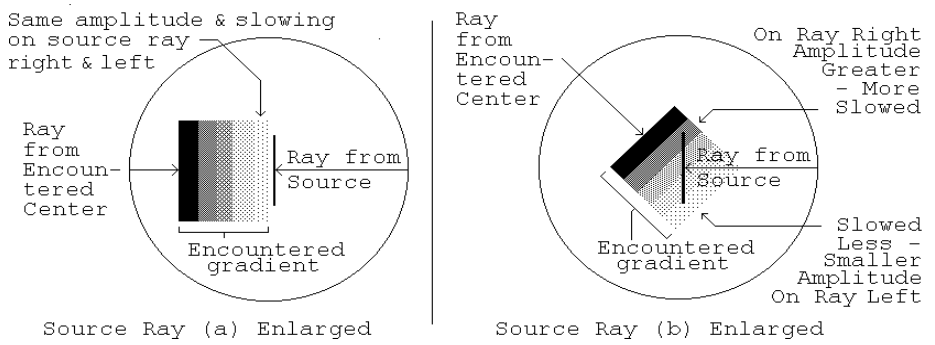


Figure 16-12(b)
Enlargement of Focusing Details

The wave front of waves propagating outward from the encountered center is curved. The wave front of waves from the source center, which is at a great distance from the encountered center, is effectively flat. (By "wave front" is meant the locus in the waves at a particular radial distance, r, from the center.) Incoming ray (a) is traveling perpendicular to the wave front of the encountered center. The wave form amplitude of the encountered waves is the same on both sides of the ray. Any slowing along the incoming wave front is the same on each side of ray (a) so that no deflection of ray (a) occurs.

But, before its path is bent incoming ray (b) encounters different wave form amplitude to its right than to its left. The negative gradient means that the wave form amplitude is in its half cycle where it decreases as r increases. Thus the amplitude to the right of ray (b) along the ray (b) incoming wave front is slightly greater than the amplitude to the left of ray (b). That is, the amplitude to the right is at a slightly smaller r and that to the left at a slightly greater r. The greater medium amplitude to the right of ray (b) slows the incoming waves to the right of ray (b) slightly more than the lesser amplitude to the left slows the waves on the left. That causes the wave front to bend to the right; ray (b) is bent through angle α, a focusing action.

The overall focusing behavior produces focusing of the U-waves onto an encountered center as illustrated in Figure 16-13, below.

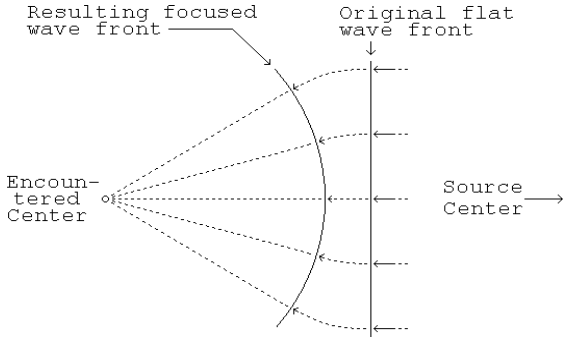


Figure 16-13
Coulomb Focusing

When a ray of the incoming wave becomes fully focused, that is becomes aimed directly at the center of the encountered center, that ray will remain so focused

for the rest of its travel to the encountered center (if the encountered center does not move) because it has become like ray (a) of Figure 16-12; it experiences no (further) focusing nor de-focusing.

The favorable region appears gradually as a cycle of the oscillation progresses. This is illustrated in Figure 16-14, below.

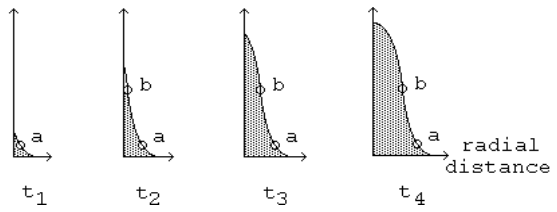


Figure 16-14
Progressive Appearing of the Favorable Region

Because of the progressive appearance of the favorable region point *a*, for example, appears earlier than point *b*. Furthermore, because of that earlier appearance, point *a* is present and has an affect on the overall amount of focusing for a greater portion of the time than does point *b*.

While shown in four static positions in Figure 16-14, above, the waves from the encountered center move outward at, essentially, the speed of light while the arriving waves pass through them to be focused or not as they pass. The situation is complex and in continuous flux. The magnitude of the focusing gradient at each radial distance from the encountered center is continuously changing as is the part of a cycle of the source wave form on which it is acting.

Clearly, the overall action that focuses incoming wave medium onto the encountered center, and produces the effects that we refer to as force, mass, acceleration and Coulomb's and Newton's laws, is quite complicated. So much so that to model and calculate it exactly would be quite difficult and perhaps not possible. The result is already subsumed in Equation 16-15, above. The purpose of the present discussion has been to show how the overall process is able to occur.

Rather than seeking to calculate the absolute mass of a particle from the above behavior, the more reasonable approach for the calculation of mass is a comparative one: choose a specific type center-of-oscillation as a standard and then determine the mass of other centers relative to it based upon their differences, the differences in their wave forms. This type of comparing is ultimately necessary in any case because a conversion to atomic mass units of any result calculated in terms of wave effects is also needed. That can only be done by comparison to a selected standard.

In 20th Century physics the chosen standard for the definition of the atomic mass unit (amu) has been $1/12$ the mass of a ${}_6C^{12}$ carbon atom for many years. That is, the ${}_6C^{12}$ atom is defined as having a mass of exactly $12.000,000,000,000$ amu. That choice came about as a decision affected by the needs and point of view of chemistry as well as those of physics. Carbon is one of the most important elements in chemistry. For the purposes of pure physics a better choice is the proton, a simple, fundamental type center-of-

oscillation, the nucleus of Hydrogen which is the most abundant element, and a basic building block of the atomic nuclei.

It has already been found that for centers of the same peak amplitude and of the simple *[1 - Cosine]* form, such as the proton and the electron, the masses are directly in the same ratio as the ratio of the oscillation frequencies of the two centers. Therefore, the comparison of the wave forms, alone, is sufficient to compare the focusing action and consequent mass of two different such centers.

The procedure, then, will be to take the proton as a standard and to develop the mass of any other such simple center relative to that of the proton by appropriate comparison of the wave forms. The calculation procedure for the cases of the more complex centers must effectively reduce / correspond to that for the proton. The basic linearity of the model of the neutron and the tendency of nature to be simple and linear would indicate that the mass calculation for combination particles such as the neutron should be a simple linear combination of the procedure for each of the particle's components as separate, independent particles.

The preceding analysis of the variation in factors affecting focusing as radial distance, *r*, outward from the encountered center varies was for no particular type particle / center-of-oscillation. It was merely analysis of the geometrical effects of the configuration and was an absolute result, not a relative comparison. Now, in comparing different particles / centers-of-oscillation the significant factor is the relative amount of the various focusing effects that different centers-of-oscillation exhibit.

The center-of-oscillation factors that can be different in comparing the proton against the electron and that can affect the relative magnitude of their focusing actions are all related to the only significant difference between the two particles, their frequencies and their wavelengths. Those factors are as follows.

- The average gradient of the oscillation wave form.

  This determines the magnitude of the focusing power as illustrated in the Figure 16-12(b) enlargement. The greater the frequency of the center the greater is its wave form gradient and relative focusing power.

- The maximum incoming ray lateral displacement that can be overcome.

  This is as described relative to Figure 16-11. Its relative effect depends on the radial extension of the favorable region, which is proportional to the wavelength.

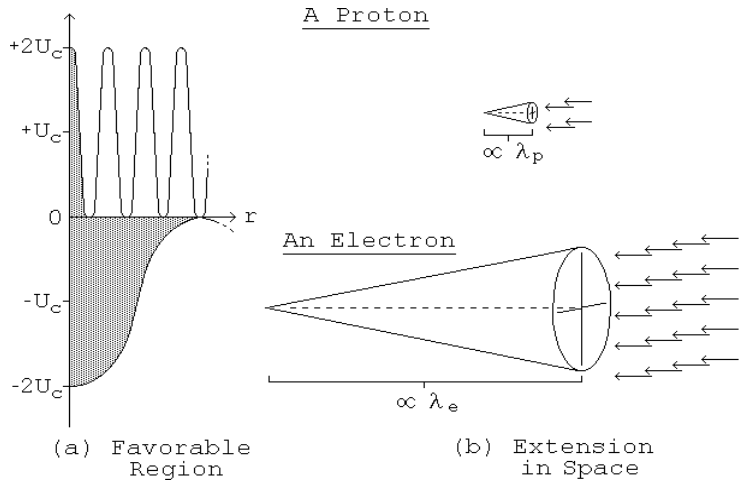
- The maximum incoming ray travel time / distance over which focusing takes place.

  This also functions as described relative to Figure 16-11 and its relative effect also depends on the wavelength of the center's oscillation.

- The repetition rate of the encountered center's favorable region.

This is discussed below in conjunction with Figure 16-15 and depends on the frequency of the encountered center-of-oscillation.

Figure 16-15, below, displays a proton and an electron encountered center wave form at the particular moment when the favorable region of each is at its maximum. The figure illustrates the differences between the focusing related aspects of the proton and electron wave forms.



The $electron/proton$ wavelength ratio is shown far from actual scale $\lambda_e/\lambda_p = 1836.152701$.

Figure 16-15
Comparison of Proton and Electron Focusing Dimensions

The proton has a relatively larger gradient, that is its amplitude changes more rapidly with radial distance from the encountered center than does the electron amplitude. The gradient is proportional to the relative frequency of the center's oscillation. The greater the gradient the greater is the center's power to bend rays, to focus incoming rays onto itself. Therefore, the proton's relatively greater gradient gives it a relative focusing advantage as an encountered center, an advantage proportional to its frequency.

This means that at whatever location within the favorable region that its gradient is acting the higher frequency / greater gradient center will more effectively bend incoming rays in direct proportion to its frequency. That is the relative amount of focusing power available to act if and where it has an opportunity to act. The actual locations where it can so act, the favorable region that determines the amount of such action that the encountered center is able to apply to an incoming ray, is the balance of the focusing process.

The electron's favorable region, compared to that of the proton, extends a greater distance out in space away from the encountered center and toward the incoming waves from the source center. The relative length of the favorable regions is proportional to the relative wavelength of the oscillations. That greater favorable region enables the electron's focusing to overcome proportionally

greater lateral displacement of incoming rays. It also means that the incoming ray experiences focusing over a proportionality greater travel distance through the proportionally greater favorable region. Thus the encountered center having the greater wavelength has an advantage in bending incoming rays because of the greater lateral displacement that can be overcome and again an advantage proportional to its wavelength because of the greater overall distance over which the focusing action has the opportunity to act.

As indicated in Figures 16-11 and 16-15, a greater overall ability to bend an incoming ray corresponds to a greater radius of a larger circular area within which all incoming rays are successfully collected and focused. Thus the relative overall *focusing power* of two centers is proportional to the square of their relative individual *ray bending power* just developed.

Finally, however, while the electron of Figure 16-15 is performing its focusing for a greater time as the incoming rays travel the greater distance through its favorable region, the proton of the figure is performing its less strong focusing action a number of times in repetition. That is, the relative overall amount of collection and focusing of incoming rays is proportional to the repetition rate of the favorable region, which is the oscillation frequency of the center.

The combined effect of all of these factors is developed in equation 16-37, below.

(16-37)

$$\frac{\text{Proton Focus Power}}{\text{Electron Focus Power}} \propto \left[\frac{\text{Proton Circular Collection Area}}{\text{Electron Circular Collection Area}}\right] \times \left[\frac{\text{Proton Repetition Rate}}{\text{Electron Repetition Rate}}\right]$$

$$\propto \left[\frac{\text{Proton Ray Bending Power}}{\text{Electron Ray Bending Power}}\right]^2 \times \left[\frac{f_p}{f_e}\right]$$

$$\propto \left[\left[\frac{\text{Proton Gradient}}{\text{Electron Gradient}}\right] \cdot \left[\frac{\text{Proton Extension in Space}}{\text{Electron Extension in Space}}\right]^2\right] \times \left[\frac{f_p}{f_e}\right]$$

$$\propto \left[\left[\frac{f_p}{f_e}\right] \cdot \left[\frac{\lambda_p}{\lambda_e}\right]^2\right]^2 \times \left[\frac{f_p}{f_e}\right] = \frac{f_p{}^3 \cdot \lambda_p{}^4}{f_e{}^3 \cdot \lambda_e{}^4} = \frac{c^3 \cdot \lambda_p}{c^3 \cdot \lambda_e}$$

$$\propto \frac{\lambda_p}{\lambda_e} \quad \text{or} \quad \frac{f_e}{f_p}$$

The net effect is that the relative Coulomb focusing power of a simple center-of-oscillation is inversely proportional to its frequency. That result is to be expected because it is consistent with the behavior of mass as already developed. Mass is inversely proportional to Coulomb focusing power which power is inversely proportional to frequency. Therefore mass is directly proportional to frequency, $mass = h \cdot f$, as has already been found to be the case.

THE MASS OF THE NEUTRON

This behavior of the focusing of a center-of-oscillation being a result of the center wave form's gradient and of the extension in space of its favorable region must apply to the neutron wave form in essentially the same way that it operates in the case of a simple center-of-oscillation's wave form, that of a proton or an electron. This develops as follows.

The neutron is the sum or, better, the combination of a proton and an electron. In any such combination of sinusoidal wave forms even though the action appears as the combination, the sum, the individual components are still, nevertheless, there. They still act effectively individually as well as in combination and must be so treated. (As was pointed out earlier, the overall sound of a symphony orchestra is a combination of many waves at many frequencies but we distinctly and separately hear each of the different instruments and different notes in spite of the combination.

Figure 16-16 below and continued on the following page shows, to the same scale, the wave form of a proton and that of a theoretical neutron. (The neutron wave form is that of a real neutron, not theoretical, except that the $^{proton}/_{electron}$ frequency ratio, which really is $^{1836.152701}/_{1}$, is depicted as only $^{10}/_{1}$ to exaggerate the combination wave form for purposes of more effectively illustrating the behavior.)

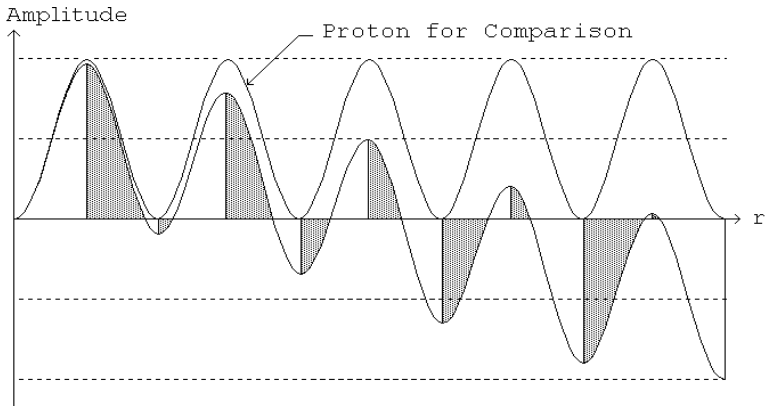


Figure 16-16(a) 1st Half
Typical Neutron Oscillation Favorable Regions
and Comparison to Proton

The figure presents samples of typical neutron favorable regions (shaded in the figure) over the range of form variation inherent in the wave form. The favorable region is that part of the wave form where the absolute amplitude decreases, becomes less positive in $+U$ and less negative in $-U$.

It can be seen that the gradient of the neutron wave form is increased over that of the proton in some parts of the neutron's favorable regions and is decreased in others. For example the descent of the neutron wave form curve from the middle peak of the five peaks shown in the "(a) 1st Half" figure, above, clearly exhibits a steepened gradient. Similarly, the descent of the neutron wave form from the corresponding middle peak of the "(b) 2nd Half" part of the figure, below, shows a markedly reduced gradient.

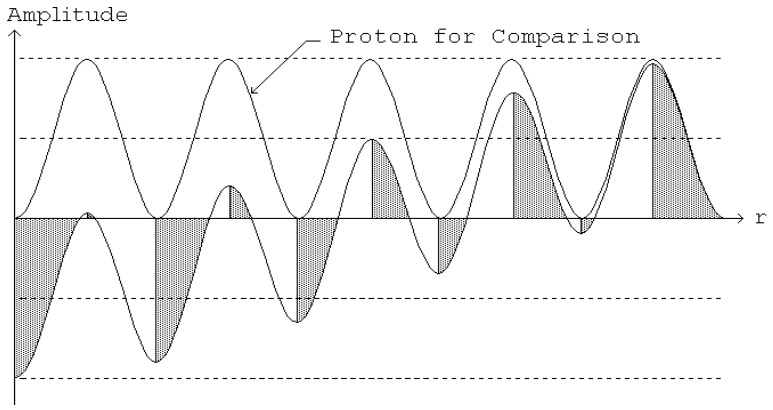


Figure 16-16(b) 2nd Half
Typical Neutron Oscillation Favorable Regions (continued)
and Comparison to Proton

The alternately increased and decreased neutron gradient behavior is to be expected. During the ten proton cycles depicted in the figure the wave form must not only move through those ten proton cycles but also through the simultaneously occurring one electron cycle during the same time. The neutron wave form must descend and ascend one peak-to-peak amplitude (for the proton cycle) plus (on the average) one-tenth of one peak-to-peak amplitude (for the electron cycle) during each proton period.

The gradient of the neutron wave form is the slope of the curve, the first derivative of the expression for the wave form. (See detail notes *DN 1 - Differential Calculus, Derivatives*). For the neutron (per equation 16-3) that gradient function is

$$\textit{(16-38)} \quad \text{Gradient}\left[U_{(1}n^{0})\right] = \cdots$$

$$\cdots = U_c \cdot \left[-2\pi \cdot f_e \cdot \text{Sin}(2\pi \cdot f_e \cdot t) + 2\pi \cdot f_p \cdot \text{Sin}(2\pi \cdot f_p \cdot t)\right]$$

The proton gradient (that is the term in f_p) is slowly (at the f_e rate) alternately (sinusoidally) increased and decreased. Those increases and decreases are in an amount only a small fraction (f_e/f_p) of the proton gradient. The neutron wave form peaks (not those of the pure proton) are also slightly changed. If R (for Ratio) is defined as f_p/f_e then it can be shown that the neutron peaks shift approximately, but quite closely to, as $1/R \cdot Sin[2\pi \cdot f_e \cdot t]$.

The extension in space of the neutron's favorable region is similarly complicated. The preceding Figure 16-16 shows that the simple one-identical-favorable-region-per-cycle behavior of the proton becomes fragmented into a variety of complex favorable regions in the various neutron cycles corresponding to full proton cycles. The neutron favorable regions occur on the overall average equally in $+U$ and $-U$. They would appear to more or less approximately average to the equivalent of a proton favorable region per cycle.

Figure 16-16 shows that the average gradient in (during, applicable to) each individual favorable region is unique to that favorable region; it differs from favorable region to favorable region. Since each of the favorable regions is

different and has a different focusing effect, the overall focusing effect for the neutron is the average of the focusing effect in each of its variety of different favorable regions.

In any particular such favorable region the *ray bending power* is proportional to the combined effect of that region's particular average gradient and its extension in space squared. That is, per equation 16-37 the relative focusing effect of any particular favorable region is as equation 16-39, below.

$$\text{(16-39)} \quad \text{Relative Ray Bending Power} = \left[\text{Average Gradient}\right] \times \left[\text{Extension In Space}\right]^2$$

To calculate that relative *ray bending power* for a particular favorable region the procedure would be as follows.

(A) Find the average gradient for the favorable region.

(1) Take the derivative of the wave form to get the expression for the gradient.

(2) A favorable region runs from just past the proton component's peak (the earliest that both wave form gradients are negative) to the wave form zero.

(3) Obtain the total gradient by integrating the gradient expression between the favorable region's beginning and end. (See Detail Notes *DN 5 - Integral Calculus (Mathematics of Summing Infinitesimals)*.)

The expression to be integrated is called the *integrand*. The integration process requires taking its anti-derivative. The integrand in this case is the gradient, the derivative of the wave form. The result of taking the anti-derivative of the derivative is, therefore, the returning to the original wave form as it was before taking its derivative to get the gradient.

The evaluation of the integral between its limits, which are the favorable region beginning and end, then reduces to just the value of the wave form expression at the wave form peak because the other limit is the wave form zero.

(4) Divide that valuation of the integral by the extension in space to obtain the average gradient within that favorable region.

(B) Multiply the above average gradient by the square of the extension in space as follows.

(1) Since the valuation of the integral of step (A)(3), above was divided by the extension in space at step (A)(4) to obtain the average gradient, and now that result must be multiplied by the extension in space, squared then ...

(2) ... simply multiply the valuation of the integral (before dividing by the extension in space) by the extension in space not squared.

(3) But that is simply multiplying the wave form peak value at the beginning of the favorable region by its associated extension in space -- a simple multiplication without calculus.

Thus the effective focusing action graphically corresponds to the area of a rectangle having as its sides the favorable region's peak amplitude and its extension in space. Figures 16-16(c) and (d) below illustrate that *focusing area* for the neutron and its comparison to the proton.

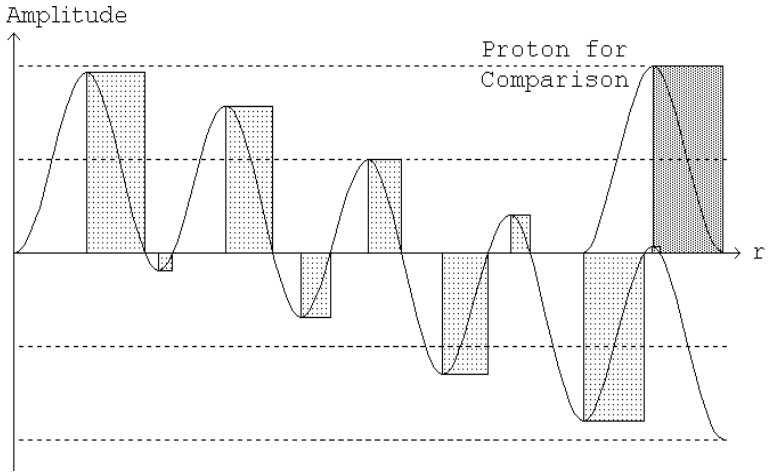


Figure 16-16(c) 1st Half
Neutron Focusing Areas Compared to Proton

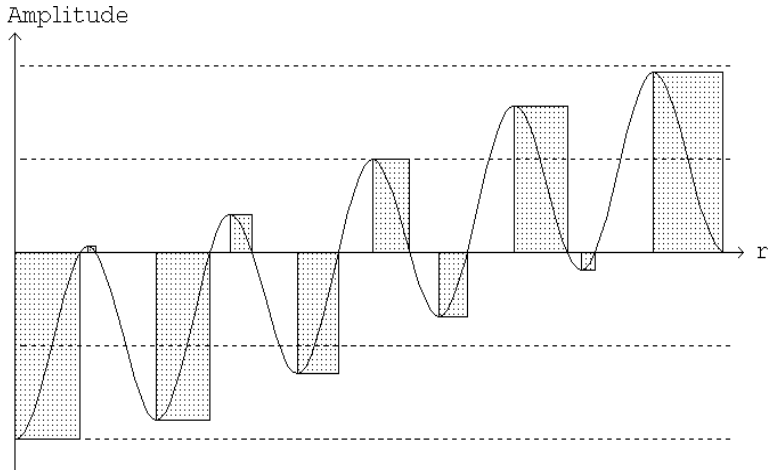


Figure 16-16(d) 2nd Half
Neutron Focusing Areas Compared to Proton

This dependence only on the peak value of the oscillatory portion of the wave form means that the average value of the oscillatory wave form, the Atomic Number, Z, has no effect on mass as, of course, is the case in reality.

The illustration in Figures 16-16(c) and (d) is quite crude because of the use of an exaggerated $R = f_p/f_e$ ratio and because of the precision limitations of the graphs. However, from the graphs it can be seen that:

- The neutron's focusing areas in $+U$ and $-U$ each appear to average approximately one-half the proton's focusing area, and
- Within the limitations of the depiction in the figure the overall average neutron focusing area, its *ray bending power*, appears to approximate that of the proton.

The problem in performing a precise calculation is that the calculation must be done for all of the possible different neutron favorable regions summed and then averaged. The same calculation must be performed for the proton's sole form of favorable region. Then the two results can be compared.

The actual extension in space is a wavelength related quantity, that is involving the parameter $[2\pi \cdot r/\lambda]$ where r is radial distance outward from the encountered center. It is more convenient to use p to stand for generalized proton oscillation angle in order to avoid confusing the development with $[2\pi \cdot r/\lambda]$ sprinkled throughout and to focus on the wave form's effect. In terms of p the proton oscillation is

$$(16\text{-}39) \qquad U(_1p^1) = U_c \cdot \left[1 - \cos[p]\right]$$

Thus the proton's favorable region peak amplitude is $2 \cdot U_c$ and its extension in space is π. Therefore the proton's *focusing area* is $2\pi \cdot U_c$.

The procedure for the neutron is to use an expression that expresses all possible forms of the neutron cycle in the neutron wave form. This is done by expressing the neutron wave form in terms of a single cycle of proton oscillation wave form, fixed in phase, combined with a single cycle of electron oscillation wave form in which the phase can be smoothly shifted over a range of one full electron oscillation cycle. Figure 16-17, below and not to scale, and continued on the following page illustrates this.

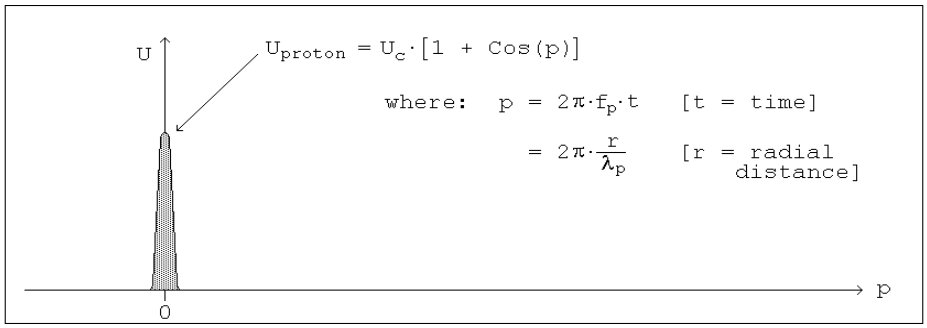


Figure 16-17(a)
A proton cycle phased with its peak at angle zero.

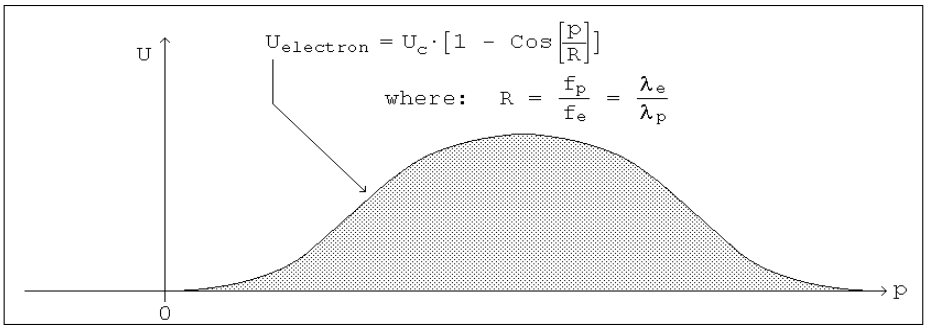


Figure 16-17(b)
An electron cycle phased with its zero at angle zero, depicted positive so as to be subtracted.

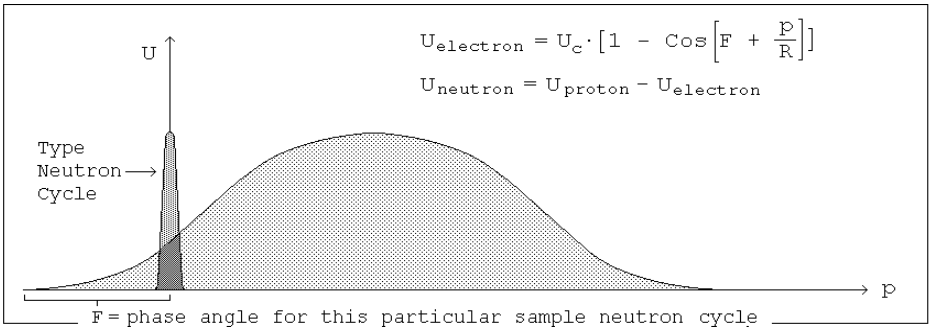


Figure 16-17(c)
For the neutron the electron phase is shifted by phase angle F over a 2π range producing all forms of proton cycle as F is varied.

As shown in the above Figure 16-17 the electron phase shifting parameter, F, makes it possible to represent all of the possible "type neutron cycles" in a neutron wave form by letting F vary over a 2π range. Figure 16-18, below, is an enlargement of the "type neutron cycle" part of Figure 16-17. The neutron cycle corresponding to these figures is approximately that of the second cycle of Figure 16-16(a).

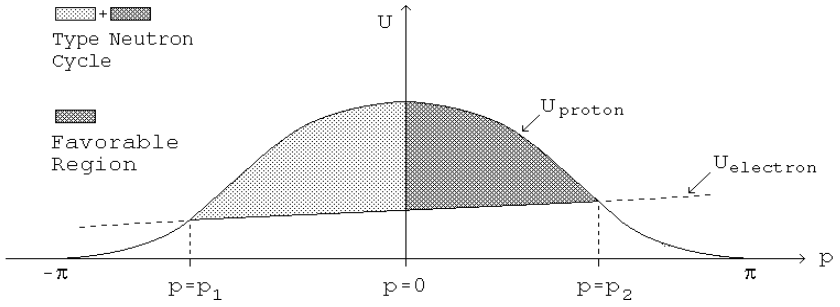


Figure 16-18

The figure illustrates that, when the electron wave form has an upward slope in the figure, then the magnitude of p_2 is somewhat less than the magnitude of p_1 because the rising electron wave form intercepts the proton wave form somewhat earlier for p_2 or, looked at in reverse, the descending electron wave form intercepts the proton wave form somewhat later for p_1. When the electron slope is downward the reverse is true. (This phenomenon can be seen by close examination of Figure 16-16, also.)

To find the value of p_2, the end of the extension in space, (the extension in space runs from $p = 0$ to $p = p_2$) the expression for the neutron must be set equal to zero. Then the equation is solved for p.

(16-40) $U_{neutron} = U_{proton} - U_{electron} = 0$

[Per Figure 16-17(c)]

$$U_c \cdot \left[Cos(p) - Cos\left[F + \frac{p}{R}\right]\right] = 0$$

(16-40, continued)

$$p = \pm\left[F + \frac{p}{R}\right] \pm n\cdot 2\pi \qquad [n = \text{integer}]$$

By varying F over the range [-π to +π] instead of [0 to 2π] only the n = 0 case need be pursued.

For ± = +	For ± = -
$p = \frac{R\cdot F}{R - 1}$	$p = \frac{-R\cdot F}{R + 1}$

which can be verified by substitution into equation 16-40.

Of these two solutions the latter, having *R+1* in its denominator rather than *R-1*, has the smaller magnitude, as does p_2 in Figure 16-18 and Figure 16-17(c). That latter solution is p_2, the other one being p_1, for the *F* range from $-\pi$ to *0*, the half cycle in which conditions are as in those two figures.

The neutron extension in space in that range is, then,

(16-41) $$\text{Extension in Space} = \frac{-R\cdot F}{R + 1} \qquad \text{For } F = -\pi \text{ to } 0$$

The favorable region peak amplitude is the expression for the neutron, per equation 16-40, with *0* substituted for *p* (the favorable region starts when the proton component gradient just starts to become negative).

(16-42)
$$U_{neutron} = U_{proton} - U_{electron}$$
$$= U_c\cdot\left[\text{Cos}[p] - \text{Cos}\left[F + \frac{p}{R}\right]\right]$$
$$\text{Peak Amplitude} =$$
$$= U_c\cdot\left[\text{Cos}[0] - \text{Cos}\left[F + \frac{0}{R}\right]\right]$$
$$= U_c\cdot\left[1 - \text{Cos}[F]\right]$$

The product of the peak amplitude and the extension in space, which is identical to the product of the average gradient in the favorable region and its extension in space squared, and which is the effective focusing action of the particular favorable region, its *focusing area*, is the product of the above two quantities. That is

(16-43)
$$\text{Focusing Area} = \text{Extension in space} \times \text{Peak Amplitude}$$
$$= \frac{-R\cdot F}{R + 1}\cdot U_c\cdot\left[1 - \text{Cos}[F]\right]$$
$$\text{For } F = -\pi \text{ to } 0$$

The above is a general expression for any particular value of *F* in the range, any particular type neutron cycle of the neutron wave form. To obtain the average effective focusing action of these various different favorable regions of the neutron wave form the above expression must be averaged over the range of the proton favorable region. That is, averaging over the proton range so as to validly compare the neutron focusing against that of the proton.

The range of the proton's favorable region is π. The averaging consists of summing the various type neutron cycle focusing areas and dividing by the range. The summing is done by integrating equation 16-43 (see detail notes *DN 5 - Integral Calculus (Mathematics of Summing Infinitesimals*). The summing must be over the range over which equation 16-43 applies, $-\pi$ to 0.

(16-44)

$$\text{Neutron Average Focusing Area} = \frac{1}{\pi}\cdot\int_{-\pi}^{0} \frac{-R\cdot F}{R+1}\cdot U_c\cdot\left[1 - \text{Cos}[F]\right]\cdot dF$$

$$= \frac{R\cdot U_c}{\pi\cdot(R+1)}\cdot\left[\frac{F^2}{2} - \text{Cos}[F] - F\cdot\text{Sin}[F]\right]_{-\pi}^{0}$$

$$= \frac{\pi\cdot U_c\cdot R}{2\cdot(R+1)}$$

The above summed the neutron over only the range $-\pi$ to 0, omitting the range 0 to $+\pi$. Furthermore, only the $+U$ half of the wave form was treated. Because of the symmetry both multiplying by 2 for the missing portion of range and again multiplying by 2 to include the $-U$ half will obtain the full result. The overall neutron effective focusing action is thus the result in the above equation 16-44 multiplied by 4.

(16-45)

$$\text{Neutron Average Focusing Area} = 2\pi\cdot U_c\cdot\frac{R}{R+1}$$

The comparison of the neutron focusing area to that of the proton is then

(16-46)

$$\frac{\text{Neutron Focusing Area}}{\text{Proton Focusing Area}} = \frac{1}{2\pi\cdot U_c}\cdot\left[2\pi\cdot U_c\cdot\frac{R}{R+1}\right]$$

$$= \frac{R}{R+1}$$

Per equation 16-37, the relative *focusing power* is the ratio of the square of the relative *ray bending power* times the ratio of the relative repetition rates. The $^{\text{neutron}}/_{\text{proton}}$ relative ray bending power is equal to the relative focusing areas as in equation 16-46, above. During one full cycle of its electron component the neutron oscillation goes through the same number of cycles as does its proton component plus the one electron cycle. That is, the neutron wave form repetition rate is equal to $[1 + {}^{1}/_{R}]$ times the proton repetition rate. Consequently, the focusing power of the neutron relative to that of the proton is as follows.

(16-47)

$$\frac{\text{Neutron Focus Power}}{\text{Proton Focus Power}} \propto \left[\frac{\text{Neutron Ray Bending Power}}{\text{Proton Ray Bending Power}}\right]^2 \times \left[\frac{\text{Neutron Repetition rate}}{\text{Proton Repetition Rate}}\right]$$

$$= \left[\frac{R}{R+1}\right]^2 \times \left[1 + \frac{1}{R}\right] = \frac{R}{R+1}$$

Since the mass varies inversely as the focusing it can then be said that

(16-48)
$$\frac{m_n}{m_p} = \frac{R + 1}{R} = 1 + \frac{1}{R}$$

$$m_n = m_p \cdot \left[1 + \frac{f_e}{f_p} \right] \qquad \text{[Definition of R]}$$

$$m_n = m_p \cdot \left[1 + \frac{m_e}{m_p} \right] \qquad \text{[Mass} \propto \text{frequency]}$$

$$= m_p + m_e$$

Thus the neutron mass is a simple sum of the masses of its component particles, the proton and the electron. It acts, focuses and in general behaves as that sum just as its wave form is that simple sum. Yet the neutron rest mass is significantly larger than the sum of a proton and an electron rest mass. How can that be ?

The masses of the proton and electron the linear combination of which particles is the neutron are not the proton and electron rest masses even though their combination in the neutron yields the neutron's rest mass. The component masses are the particles' relativistic masses at high velocity. This comes about as follows.

Since a neutron naturally decays into a proton and an electron those decay particles must be emitted at a velocity equal to or greater than their escape velocity. That is, because the proton and electron strongly mutually attract each other electrically, unless they separate at their mutual escape velocities they will immediately re-combine into a neutron.

Put another way, for a neutron to be formed from a proton and an electron the two must come together from the state of being mutually independent of each other. That means that they must mutually accelerate toward each other. In so doing they will each be at escape velocity and have the kinetic energy of that escape velocity at the moment of their combining into the new center-of-oscillation, the neutron.

The oscillation of that neutron must reflect all of the mass / energy that went into it in order for energy to be conserved. That requires that the neutron mass be equal to the sum of the rest masses of its component proton and electron plus any additional mass equivalent to their escape velocity kinetic energies.

The portion of the neutron's overall rest mass that corresponds to the component proton and electron's escape velocity kinetic energy is the neutron rest mass less the sum of the proton and the electron rest masses. Using the values for the masses of neutron, proton and electron from the previously referenced CODATA bulletin:

(16-49)
$$\text{mass}_{n,\Delta} = \text{mass}_{n,\text{rest}} - [\text{mass}_{p,\text{rest}} + \text{mass}_{e,\text{rest}}]$$

$$= 1.008,664,904 \cdots$$
$$\cdots - [1.007,276,470 + 0.000,548,579,903]$$

$$= 0.000,839,854 \text{ amu}$$

In the "classical" sense escape velocity refers to an object of some mass that is gravitationally bound to some other mass, for example a rocket to be launched from Earth. The force attracting the two objects, the rocket and the Earth, to each other acts on them equally in magnitude and opposite in direction. Consequently, momentums that are equal in magnitude and opposite in direction are imparted to them. Since momentum is the product of mass and velocity, when one object (Earth) is much more massive than the other (the rocket) it may be assumed with negligible error that it (the Earth) is not accelerated and its velocity is negligible. Then all of the kinetic energy is attributable solely to the rocket. That kinetic energy must be equal to the gravitational potential energy binding the rocket to the Earth (the two to each other) for the rocket to escape the Earth's gravitational pull.

However, in the case of a proton and an electron the assumption that only the particle of lesser mass is accelerated and that the other particle's kinetic energy is negligible is not valid. It is not that the electron escapes from the proton; they escape from each other. Or, it is not that the electron falls toward the proton; they fall toward each other. The kinetic energy of each is involved and it is the sum of their kinetic energies that must equal or exceed their binding potential energy (PE) for their velocities to be at or in excess of escape velocity.

The analysis (in SI units) is as follows (where r is the closest separation between the escaping objects or particles).

(16-51)

Gravitational	Electrostatic
rocket (R) escapes from Earth (E)	proton (p) and electron (e) escape from each other
(1) PE = (Force)·(r)	
$PE = \left[G \cdot \frac{m_R \cdot m_E}{r^2}\right] \cdot r$	$PE = \left[\frac{1}{4 \cdot \pi \cdot \varepsilon_0} \cdot \frac{q_p \cdot q_e}{r^2}\right] \cdot r$
(2) Final (escape) Kinetic Energy (KE) = Initial Potential Energy (PE)	
$KE_R = PE_{total}$	$KE_p + KE_e = PE_{total}$
$\frac{1}{2} \cdot m_R \cdot v_R^2 = G \cdot \frac{m_R \cdot m_E}{r}$	No direct solution. A 2nd relationship is:
	$P_p = -P_e$ [P is momentum]
$v_{R,esc} = \left[\frac{2 \cdot G \cdot m_E}{r}\right]^{\frac{1}{2}}$	The two relationships above must be simultaneously solved for the velocities.

For the gravitational case the escape velocity formulation does not involve the mass of the escaping object. In that sense it is independent of the relativistic mass increase with velocity. Furthermore, in the usual cases treating escape velocity of objects (rocketry and astronautics) the velocity never approaches magnitudes at which significant relativistic effects occur.

However, for the electrostatic case the escape velocity formulation must include the masses of the particles, which masses themselves can vary with their velocity. And, in the case of particles, velocities large enough to involve relativistic effects are likely to occur. Therefore, the electrostatic case must be

treated relativistically. The simultaneous solution of the two equations, kinetic energy and momentum, is as follows.

(16-52(a)) Momentum

$$\text{Relativistic Momentum}_{proton} = \text{Relativistic Momentum}_{electron}$$

$$\frac{m_p}{\left[1 - \frac{v_p^2}{c^2}\right]^{\frac{1}{2}}}.v_p = \frac{m_e}{\left[1 - \frac{v_e^2}{c^2}\right]^{\frac{1}{2}}}.v_e$$

[m_p and m_e are rest values.]

[From which, by solving for v_p the following is obtained.]

$$v_p = \frac{m_e \cdot v_e}{m_p \cdot \left[1 - \frac{v_e^2}{c^2}\right]^{\frac{1}{2}}} \cdot \frac{1}{\left[1 + \frac{m_e^2 \cdot v_e^2}{c^2 \cdot m_p^2 \cdot \left[1 - \frac{v_e^2}{c^2}\right]}\right]^{\frac{1}{2}}}$$

(16-52(b)) Energy

$$\text{Relativistic Energy (as Mass) is Conserved}$$

$$\left[\frac{KE_p}{c^2} + \frac{KE_e}{c^2}\right]_{gained} = \left[\frac{PE_{total}}{c^2}\right]_{lost}$$

$$(m_{p,v} - m_{p,rest}) + (m_{e,v} - m_{e,rest}) = m_{n,\Delta}$$

$$\left[\frac{m_p}{\left[1 - \left[\frac{v_p}{c}\right]^2\right]^{\frac{1}{2}}} - m_p\right] + \left[\frac{m_e}{\left[1 - \left[\frac{v_e}{c}\right]^2\right]^{\frac{1}{2}}} - m_e\right] = m_{n,\Delta}$$

(16-52(c)) Simultaneous Solution

The expression for v_p obtained in equation 16-52(a) is substituted for v_p in the denominator of the first term of the expression obtained in equation 16-52(b). The resulting expression has only v_e unknown and is solved for that value. (Rather than manipulating the expression a computer aided design program is used to calculate selected trial values of v_e until the correct result for $m_{n,\Delta}$, is obtained.)

The results of the simultaneous solution above are as follows.

(16-53) v_e = 275,370,263. meters per second
= 0.918,536,33 · c

v_p = 379,350.6975 meters per second
= 0.001,265,378 · c

At the above velocities the proton and the electron have total (relativistic) masses of

$$(16\text{-}54)\quad m_{e,total} = \frac{m_{e,rest}}{\left[1 - \left[\frac{v_e}{c}\right]^2\right]^{½}} = 2.529,490,15 \cdot m_{e,rest}$$

$$= 0.001,387,627,46 \text{ amu}$$

$$m_{p,total} = \frac{m_{p,rest}}{\left[1 - \left[\frac{v_p}{c}\right]^2\right]^{½}} = 1.000,000,80 \cdot m_{p,rest}$$

$$= 1.007,277,276 \text{ amu}$$

and their sum is the neutron mass.

$$(16\text{-}55)\quad m_{neutron} = m_{p,total} + m_{e,total}$$

$$= 1.007,276,596 + 0.001,388,308,25$$

$$= 1.008,664,904 \text{ amu}$$

The neutron oscillation wave form (equation 16-3) is now

$$(16\text{-}56)\quad U({}_1n^0) = U_c \cdot \left[\cos[2\pi \cdot f_{e\text{-}in\text{-}n} \cdot t] - \cos[2\pi \cdot f_{p\text{-}in\text{-}n} \cdot t]\right]$$

With the component electron and proton frequency and wavelength being as follows (calculating with mass in *kg*, not *amu*):

$$f_{e\text{-}n} = \frac{m_{e,total} \cdot c^2}{h} = 3.125,412,2 \cdot 10^{20} \text{ Hz}$$

$$f_{p\text{-}n} = \frac{m_{p,total} \cdot c^2}{h} = 2.268,733,6 \cdot 10^{23} \text{ Hz}$$

$$\lambda_{e\text{-}n} = \frac{c}{f_{e\text{-}n}} = 9.592,093,4 \cdot 10^{-13} \text{ m}$$

$$\lambda_{p\text{-}n} = \frac{c}{f_{p\text{-}n}} = 1.321.409,0 \cdot 10^{-15} \text{ m}$$

(These calculations assume that the component proton and electron are in a state of zero momentum and zero kinetic energy before being mutually accelerated into each other. It likewise assumes that the resulting neutron has zero kinetic energy and zero momentum because all the components' kinetic energy goes entirely into the neutron's rest mass and the two component's momentums are equal and opposite in direction netting to zero in combination. To the extent that the components do have initial kinetic energy and momentum then either the resulting neutron will have kinetic energy equal to the sum of the components' initial kinetic energies and momentum equal to the net of the two components' initial momenta or some of those quantities may appear in the form of some type of neutrino given off at the time the particles combine.

(Likewise, in describing the decay of a neutron into a proton and an electron, it was assumed that the neutron initially had zero kinetic energy and zero momentum. To the extent that that is not the case then some form of neutrino will account for the kinetic energy and net momentum not accounted for by the decay product proton and electron.)

There is a problem yet remaining with these calculations, however. The correct neutron mass was obtained by forcing the sum of the relativistic mass increases of the component proton and electron to be precisely the amount needed to make up the mass of a neutron at rest when added to the rest masses of the proton and electron. If, in fact, that is the energy of the two particles at the moment of combining then the hypothesis is valid.

The issue here is: how far apart are the proton and electron in their collision paths toward each other when they have the above kinetic masses ? For the calculations to be correct, that is for the hypothesis to be correct, their separation distance at that moment must be such that the two colliding particles are exactly at the moment of combining into the single neutron center-of-oscillation.

An initial calculation of that separation distance, r, is as follows.

(16-57)
$$\left[\text{Potential Energy}_{\text{As Mass}}\right] = \frac{PE}{c^2}$$

$$\text{and must} = m_{n,\Delta}$$

$$= 0.000,839,854 \ \text{amu}$$

$$\frac{PE}{c^2} = \frac{q_{proton} \cdot q_{electron}}{4 \cdot \pi \cdot \varepsilon_0 \cdot r} \cdot \frac{1}{c^2} = 0.000,839,854 \cdot \left\{ {}^{kg}/_{amu} \right\}$$

$$r = \frac{q_{proton} \cdot q_{electron}}{4 \cdot \pi \cdot \varepsilon_0 \cdot c^2} \cdot \frac{1}{0.000,839,854 \cdot \left\{ {}^{kg}/_{amu} \right\}}$$

The values of all of the quantities except r in the above can be found in the already cited CODATA Bulletin. The result is that the above r, the separation distance, is

(16-58) $r_{separation} = 1.840,636,27 \cdot 10^{-15}$ meters

For comparison, the wavelength of the proton frequency part of the neutron's oscillation is (from equation 16-56, above)

(16-59) $\lambda_{p-n} = 1.321,408,96 \cdot 10^{-15}$ meters

Similarly, some years ago experiments involving measurement of the scattering of charged particles by atomic nuclei, yielded an empirical formula for the approximate value of the radius of an atomic nucleus to be

(16-60) $\text{Radius} = [1.2 \cdot 10^{-15}] \cdot [\text{Atomic Mass Number}]$ meters

which formula would indicate that the radius of the neutron (atomic mass number $A = 1$) is about $1.2 \cdot 10^{-15}$ meters.

Thus the initial calculation of the separation distance of the proton and electron when their kinetic masses are just correct for them to form a neutron, per

equations 16-57 and 16-58, above, results in a separation distance of about 1½ neutron-equivalent wavelengths. That uncorrected result is so close as to essentially validate the hypothesis as it stands.

However, there is more.

THE LAMB SHIFT

In section *12 - A Model for the Universe (2) - Mass and Matter* it was pointed out that the interaction of wave and center has so far been based on the assumption that the wave encountering a center is a plane wave. That assumption is that the portion of a center's propagated spherical wave that encounters another center is such a small part of the total sphere that it can be treated as if it is flat, not spherically curved. If the distance that the wave has traveled before encountering another center is large relative to the effective intercepting cross-section of the encountered center the assumption is valid.

But, what is such a sufficiently large distance, and does the plane wave assumption validly apply to atomic orbital electrons and to the above close approach of the electron and proton becoming a neutron ? Figure 16-19, below and on the following page, illustrates the issue.

When the source center is distant the rays of arriving medium flow are all essentially parallel to each other and to the center line joining the source and encountered centers as in Figure 16-19(a), below. The amount of focusing deflection required to collect, to focus, a certain amount of those rays is essentially unchanged as the two centers approach each other so long as they are still far apart. In the figure that maximum required deflection is α_{max}. (The symbol ρ, used in the figure and development to come, is the Greek letter *rho*.)

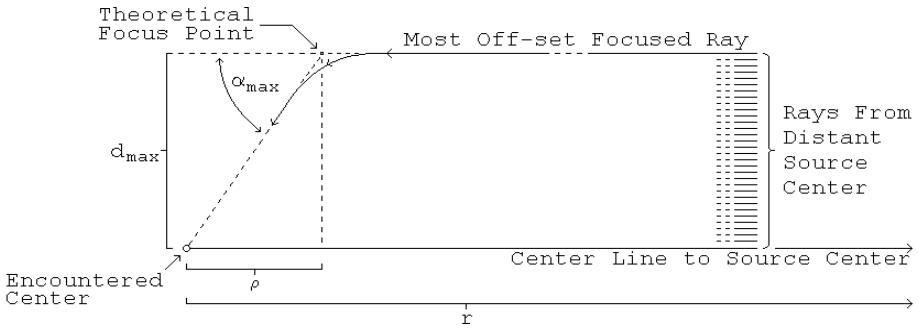


Figure 16-19(a)
Focusing of Rays from a Distant Source

When the two centers are relatively near to each other as in Figure 16-19(b), below, the rays arriving from the source center diverge from each other rather than running parallel to each other. A greater deflection is required to focus a particular ray: first the deflection to convert its course from diverging to parallel and second the same deflection as the distant case required to focus the ray from parallel to onto the encountered center. Since the focusing power of the encountered center is unchanged and part of that power is now diverted into correcting the divergence, only a part of its total power is available to accomplish the focusing action performed in the distant case.

As a result, when the two interacting centers are relatively near to each other less of the incoming medium is focused onto the encountered center than in the distant case. While in general less focusing by a center has the effect of appearing as greater mass of that center (the proton compared to the electron for example), the present situation is different. The encountered center is not changed. The effect is entirely due to the diverging angles of the incoming rays from the source center. It is not the encountered mass that is affected but, rather, the force delivered onto it by the source center. It is the magnitude of the Coulomb force that is reduced when the centers are near.

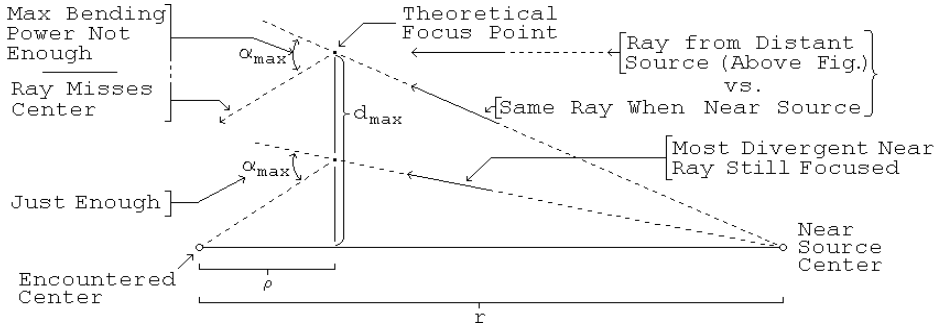


Figure 16-19(b)
Focusing of Rays from a Near Source

Before proceeding to the analysis of the effect of a near source, an observation relative to the preceding two figures should be made. Referring to the earlier equation 16-37, repeated in part below, the *Circular Collection Area*

(16-37)
$$\frac{\text{Proton Focus Power}}{\text{Electron Focus Power}} \propto \left[\frac{\text{Proton Circular Collection Area}}{\text{Electron Circular Collection Area}}\right] \times \left[\frac{\text{Proton Repetition Rate}}{\text{Electron Repetition Rate}}\right]$$

$$\propto \left[\frac{\text{Proton Ray Bending Power}}{\text{Electron Ray Bending Power}}\right]^2 \times \left[\frac{f_p}{f_e}\right]$$

(of incoming rays) is proportional to the *Focus Power*, inversely proportional to the mass. That area is proportional to the square of the d_{max} of Figure 16-19(a). That is, $[d_{max}]^2$ is inversely proportional to the encountered center's mass. Likewise, from equation 16-37, the *Ray Bending Power* squared is inversely proportional to the mass. That *Ray Bending Power* is proportional to α_{max} so that $[\alpha_{max}]^2$ is inversely proportional to mass. Therefore:

(16-61) Since: $d_{max}^2 \propto 1/m$ and $\alpha_{max}^2 \propto 1/m$

then: $d_{max} \propto \alpha_{max}$

$\rho \cdot \text{Tan}[\alpha_{max}] \propto \alpha_{max}$ [From Figure 16-19(a) $d_{max} = \rho \cdot \text{Tan}(\alpha_{max})$]

$$\rho \propto \frac{\alpha_{max}}{\text{Tan}[\alpha_{max}]}$$

For small angles the value of the tangent is the same as the value of the angle (when stated in natural measure, radians). Concerning α_{max}, the effective area for collecting and focusing incoming rays of medium flow from the source center onto the encountered center is as given in equation 16-8 repeated below.

(16-8) $$\text{Area} \propto \pi \cdot [\lambda_e \cdot U_e]^2$$

$$= K_{cs} \cdot \lambda_e^2 \cdot U_e^2 \qquad [\text{Per equation 12-26: } K_{cs} = c/h \quad U = Q \cdot c]$$

$$= \frac{c}{h} \cdot \lambda_e^2 \cdot [Q^2 \cdot c^2]$$

From this that area can be calculated in terms of λ_e, the other quantities all being fundamental constants of nature.

The calculation leads to an elaboration of the Coulomb focusing action that would logically and preferably be presented here. It must be deferred, however, until after further developments concerning the nature of the center-of-oscillation (and also related to the "problem of $r = 0$ in the denominator" partially treated earlier above), which developments evolve from the addressing of gravitation in section *19 - A Model for the Universe (9) - Gravitation.* The focusing and "Area" elaborations appear under the heading *Analysis of Coulomb Focusing Details* at the end of section *19*. One result is that d_{max} is approximately equal to $2 \cdot 10^{-33} \cdot [\lambda_e / r]$. Even with the source and encountered centers so close that $r = \lambda_e$, d_{max} and, therefore, α_{max} are quite minute. The present general conclusion, then, is that:

- $Tan[\alpha_{max}] = \alpha_{max}$ because α_{max} is so small, and
- ρ is therefore constant per equation 16-61.

In the near case there is less effect, less focusing of arriving medium flow, than for the distant case. Coulomb's law, expressed as potential energy as in equation 16-57, earlier above, in the near case now becomes

(16-62) $$\left[\text{(Adjusted) Potential Energy}_{\text{As Mass}}\right] =$$

$$= \frac{[\text{Reduction Factor}] \times PE}{c^2} = m_{n,\Delta} = 0.000,839,854 \ \text{amu}$$

$$\left[\begin{matrix}\text{Reduction} \\ \text{Factor}\end{matrix}\right] \cdot \frac{q_{proton} \cdot q_{electron}}{4 \cdot \pi \cdot \varepsilon_0 \cdot r} \cdot \frac{1}{c^2} = 0.000,839,854 \cdot \left\{{}^{kg}/_{amu}\right\}$$

but what is the formulation for the *Reduction Factor* ?

For the analysis of the effect of the source and encountered centers being so near to each other that the divergence of the source rays is significant the illustration and dimensions of Figure 16-19(c), on the following page, are used. In terms of that figure α_{max} must supply both β and α. The maximum ray bending power, all of which is available for focusing when the ray source is distant, must, when the ray source is near, be first applied to removing any ray divergence (β) with any remaining balance applied to focusing (α). Thus

(16-63) $$\alpha_{max} = \alpha + \beta$$

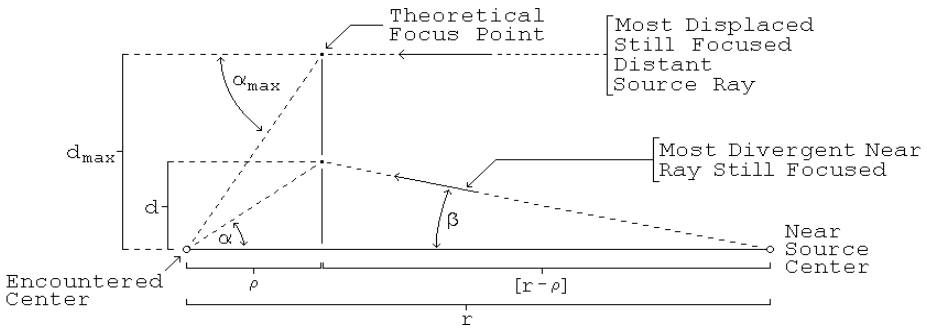


Figure 16-19(c)
Analysis of Near Source Case

The *Reduction Factor* depends upon the reduction of d relative to d_{max}, that is the ratio d/d_{max}, which quantity is developed as follows. Using that d_{max} and α_{max} are so small that $Tan\,[\alpha_{max}] = \alpha_{max}$, then from the above Figure 16-19(c) it can be said that

(16-64)
$$Tan[\alpha_{max}] = \alpha_{max} = \frac{d_{max}}{\rho} \qquad Tan[\beta_{max}] = \beta_{max} = \frac{d_{max}}{r - \rho}$$

$$Tan[\alpha] = \alpha = \frac{d}{\rho} \qquad Tan[\beta] = \beta = \frac{d}{r - \rho}$$

From which

$$a = \frac{d}{d_{max}} \cdot a_{max} \qquad b = \frac{d}{d_{max}} \cdot b_{max}$$

Then, substituting the above results into equation 16-63

(16-65)
$$\alpha_{max} = \alpha + \beta$$
$$= \frac{d}{d_{max}} \cdot \alpha_{max} + \frac{d}{d_{max}} \cdot \beta_{max}$$

From which

$$\frac{d}{d_{max}} = \frac{\alpha_{max}}{\alpha_{max} + \beta_{max}}$$

However, the available focusing power of the encountered center, however it is employed, is constant. Therefore

(16-66)
$$\alpha_{max} = [A\ Constant] \cdot d_{max} \equiv \chi \cdot d_{max}$$

where χ is the Greek letter *chi*. Then, substituting for α_{max} of equation 16-65 with equation 16-66 and for β_{max} of equation 16-65 with the β_{max} of equation 16-64

(16-67)
$$\frac{d}{d_{max}} = \frac{\chi \cdot d_{max}}{\chi \cdot d_{max} + \frac{d_{max}}{r - \rho}} = \frac{1}{1 + \frac{1}{\chi \cdot [r - \rho]}}$$

At this point another aspect of this extremely close approach of the two centers must be addressed: mutual favorable region incursion -- the approach is so close that each of the centers is advancing into the other's favorable region. Since the favorable region is where the actual final effective focusing action takes place there must be an effect of incursion into it on that focusing, an effect in addition to that treated in Figure 16-19, above. There are two such effects in favorable region incursion as follows.

- The amount of time, or of travel distance, within the favorable region, with focusing taking place, is reduced.

  That time or distance is proportional to the separation distance of the centers at that moment, r, and the size of the favorable region is proportional to the encountered center's wavelength, λ_e. Thus the reduction in the focusing or Coulomb action relative to that for distant centers is r/λ_e.

- The repetition rate of the encountered center becomes effectively greater.

  That effect equals the number of times that the separation distance of the centers at that moment, r, can repeat within the favorable region size, which is proportional to the encountered center's wavelength, λ_e. Thus the increase in the repetition rate or Coulomb action relative to that for distant centers is λ_e/r.

The two effects cancel. The mutual incursion into each other's favorable region does not, in itself, change the Coulomb action. This behavior also helps in understanding why ρ, the location of the theoretical focus point, is independent of the types of centers-of-oscillation involved, is in that sense a universal constant.

Such behavior is essential. For the situation of two different frequency centers-of-oscillation approaching each other, the two centers having different size favorable regions and different repetition rates, the change in the Coulomb action of one of the centers would be different than the simultaneous such change of the other center. The resulting behavior would not involve equal magnitude opposite direction Coulomb forces. That cannot be. Each must exert the same force as the other at all times. If that were not so the pair, as a system would self-accelerate according to the greater force.

In the analysis of focusing action it has been found again and again that effects that tend to reduce Focusing Power tend to be offset by other associated effects that correspondingly increase the repetition rate of that weakened power. The Focusing Power is proportional to the circular area having the Ray Bending Power as its radius. The net effect is that while the circular collection area of rays to be successfully focused corresponds to the square of the ray bending power, the concomitant repetition rate increase offsets the squaring. The net Focusing Power becomes just the Ray Bending Power, not squared.

That behavior applies to the reduction in the Coulomb action for the case of near centers. As the centers become closer to each other their Ray Bending Power decreases as has just been found in equation 16-67. At the same time their effective repetition rate increases. It increases because the focusing time or

travel distance decrease means that other rays can experience the corresponding same focusing action during the same time or distance as was the case for the focusing action on rays from a distant center. The curtailing as the centers become near produces simultaneously less ray bending, less time of focus and more time for other equivalent focusing. The net change in the Focusing Power, in the Coulomb effect action, is then just the Ray Bending Power.

The Reduction Factor sought for equation 16-62 is then the d/d_{max} of equation 16-67 as follows.

(16-68)

$$\text{Reduction Factor} = \frac{\text{Near Focus Power}}{\text{Distant Focus Power}} \equiv \frac{FP_n}{FP_d}$$

$$= \left[\frac{\text{Near Circular Collection Area}}{\text{Distant Circular Collection Area}}\right] \times \left[\frac{\text{Near Repetition Rate}}{\text{Distant Repetition Rate}}\right]$$

$$= \left[\frac{\text{Near Ray Bending Power}}{\text{Distant Ray Bending Power}}\right]^2 \times \left[\frac{\text{Distant Ray Bending Power}}{\text{Near Ray Bending Power}}\right]$$

$$= \frac{d}{d_{max}}$$

$$= \left[\frac{1}{1 + \frac{1}{\chi \cdot [r - \rho]}}\right]$$

The form of this effect is depicted graphically in Figure 16-20, below.

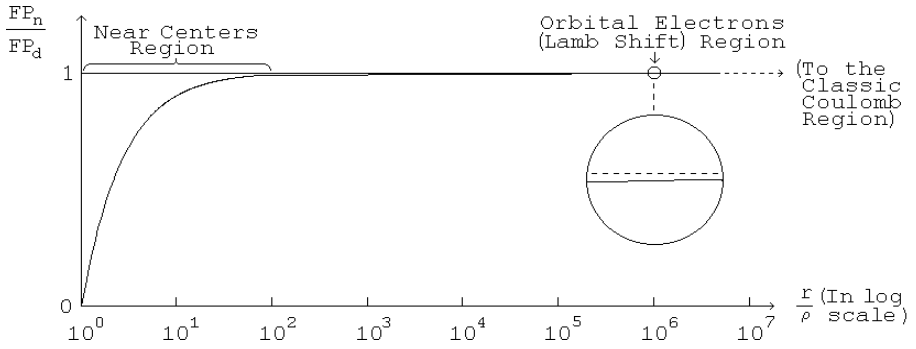


Figure 16-20
Coulomb Effect Reduction Factor When Source is Near

This effect is also the cause of the *Lamb Shift*. The Lamb Shift is an extremely fine or slight shifting to higher energy of some of the orbital energy

levels of Hydrogen. The Lamb Shift affects orbital electrons that are closer to the atomic nucleus more than those which are more distant; that is, the Lamb Shift is greater as r is smaller. For that reason, it produces a detectable affect principally on the electrons of the inner orbital shells ($n = 1$ or $n = 2$).

This effect, the Lamb Shift, is caused by the reduction in the negative potential energy due to the orbital electron being near enough to the nucleus that the full Coulomb effect, as when the incoming wave is plane, is slightly reduced. There being marginally less Coulomb attraction, the energy pit in which the electron resides is less deep, which means that its energy is somewhat more than would otherwise be the case. The amount of the effect decreases with increasing r because the Coulomb reduction due to the source wave front not being plane decreases as r increases.

The Lamb Shift occurs at much larger values of r (electron orbit radii that are on the order of $r = 10^{-10}$ *meters*) than the quite small value of r at which the neutron forms from the combining proton and electron (on the order of $r = 10^{-15}$ *meters*). Nevertheless, the Lamb Shift can be used for an approximate calibration of the above Reduction Factor.

The principal original Lamb Shift measurement was of the shift in the α line of the *Balmer series* in the optical spectrum of the Hydrogen atom. A brief review of atomic Hydrogen spectra is appropriate here in order to insure that the description is clear, as follows.

- Equations 15-2 through 15-5 summarize Bohr's original demonstration that those spectral lines are produced by electron transitions from outer to inner orbits, i corresponding to the orbit that the electron leaves (initial orbit) and f the one at which it arrives (final orbit).

- Equation 15-2, repeated below, describes the various lines in the spectra of Hydrogen. The lines occur in series named the *Lyman*, *Balmer*, *Paschen*, etc. series after the scientists who found and measured them. While the formula labels numerically the individual spectral lines, i, in each of the different spectral series, f, practice has been to refer to the first line as α, the second as β and so forth. Thus the Balmer α line is the line obtained with $f = 2$ and $i = 3$.

(15-2) $$\frac{1}{\lambda} = R \cdot \left[\frac{1}{f^2} - \frac{1}{i^2} \right]$$

[λ = wavelength of line
f = series nr: 1, 2, ...
i = f+1, f+2, ...
R = a constant called the Rydberg Constant]

- Most of the latter half of section *15 - A Model for the Universe (5) - Quanta and the Atom* develops the details of electron orbital and orbital transition behavior and its interrelationship with the photons of light emitted with the transitions.

The Lamb Shift is depicted in Figure 16-21 on the following page. Shift is shown in the figure only for the $l = 0$ orbit of the $n = 2$ shell. In general such shifts are found in detectable amounts only at $l = 0$ orbits. That is because the $l = 0$ orbits are circular so that the electron is near the nucleus throughout the orbit. The orbits for $l > 0$ are elliptical. The orbital path is mostly at greater radial distances from the atomic nucleus. Furthermore, in

elliptical orbits the electron speed is greatest at the low end of the orbit (nearer the nucleus) and is smaller as the path progresses farther out. Consequently, the electrons in $l > 0$ orbits spend relatively little time at the relatively small radial distance of the circular $l = 0$ orbits.

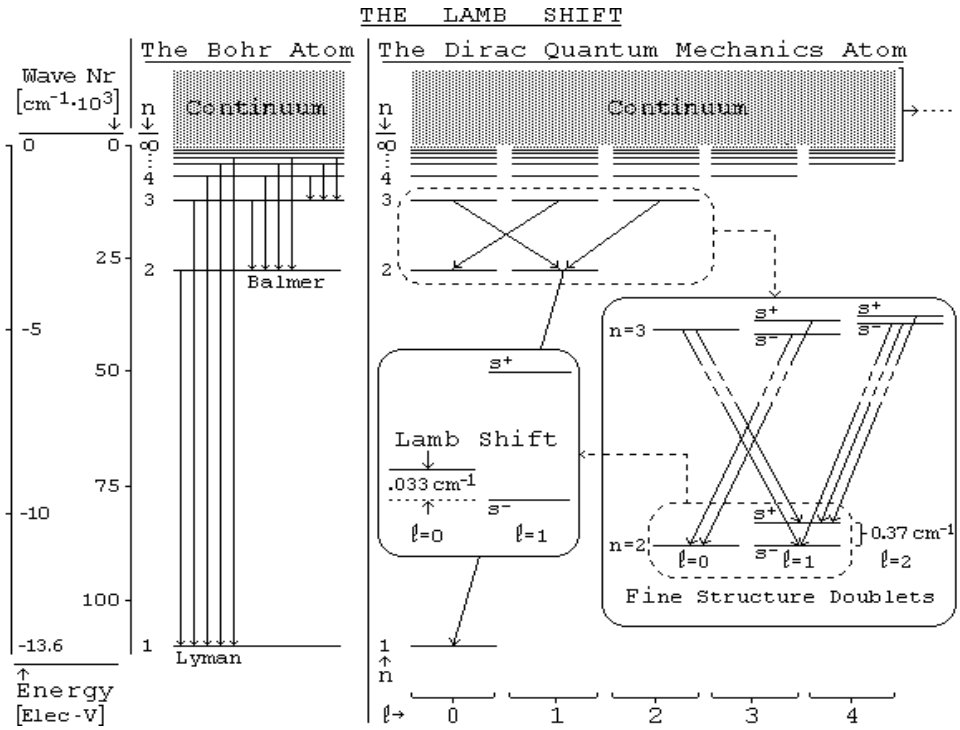


Figure 16-21
Hydrogen Spectra and The Lamb Shift

The original detection of the Lamb Shift was in the ($n = 2$) Balmer series where the lines are in the visible light range. A similar shift has been measured in the ($n = 1$) Lyman series, which is in the ultra-violet range, at higher frequencies, shorter wavelengths. The Paschen series ($n = 3$) is in the infra-red range but at radii such that the effect is minute.

The shift is stated in terms of the wave number (reciprocal wavelength) because the Rydberg expression, equation 15-2 above, is in terms of wave numbers. The amount of the *Balmer Â* shift is $0.033\ cm^{-1}$. That occurs at the $n = 2$ level where the overall level itself has the term value the Rydberg constant divided by n^2. The fractional shift is then as follows.

(16-69) $\Delta E = \text{Shift} = 0.033\ cm^{-1}$

$E = \text{Total Wave Number}$

$$= \frac{Ry}{n^2} = \frac{109,737.31534}{4} = 27,434.3\ cm^{-1}$$

$$\text{Fractional Shift} = \frac{\Delta E}{E} = \frac{0.033}{27,434.3}$$

$$= 1.2 \cdot 10^{-6} \quad \text{[dimensionless ratio]}$$

The above *Fractional Shift* is the fractional energy change due to the effect of the source and encountered centers being near to each other. The *Reduction Factor* as used in this analysis, equation 16-62, is the net energy after that change, *[1 - the above Fractional Shift]*. The *Reduction Factor* is, then,

$$\textit{(16-70)}\quad \text{Reduction Factor} = 1 - \frac{\Delta E}{E} = 1 - 1.2\cdot 10^{-6}$$

$$\left[\frac{1}{1 + \frac{1}{\chi\cdot[r - \rho]}}\right] = 0.999,998,8 \qquad \text{[Substituting for Reduction Factor equation 16-68]}$$

For the $n = 2$ orbit the radius, r, is $r_{n=2} = 2.1190152\cdot 10^{-10}$ m for Hydrogen. The ρ in the above formula is negligible in the case of the Lamb Shift where $r \approx 10^{5}\cdot\rho$ and the precision of the Lamb Shift datum being used is only two significant digits. Equation 16-70 can then be solved for the value of χ as follows.

$$\textit{(16-71)}\quad \chi = \frac{\text{Reduction Factor}}{r_{n=2}\cdot[1 - \text{Reduction Factor}]} \qquad \text{[Equation 16-70 solved for } \chi\text{]}$$

$$= 3.9\cdot 10^{15}$$

With regard to Figure 16-19(c) it has already been presented that the two centers must be acting in equal magnitudes with opposite directions. Consequently, the ρ of each of the centers is the same, a kind of universal constant. As the two centers approach closely the point where their theoretical focal points overlap is the end of focusing. At that point $\rho = r/2$.

The *Reduction Factor* is, then, the expression of equation 16-70 with the equation 16-71 value of χ substituted and $\rho = r/2$. The expression for the potential energy as the proton and the electron approach each other to form a neutron is then equation 16-62 with that *Reduction Factor* substituted. That expression can then be solved for r, the $r_{separation}$.

$$\textit{(16-72)}\quad 0.000,839,854\cdot\{kg/amu\} =$$

$$= \left[\text{Reduction Factor}\right]\cdot\frac{q_{proton}\cdot q_{electron}}{4\cdot\pi\cdot\varepsilon_0\cdot r}\cdot\frac{1}{c^2}$$

$$= \left[\frac{1}{1 + \frac{1}{\chi\cdot[r - \rho]}}\right]\cdot\frac{q_{proton}\cdot q_{electron}}{4\cdot\pi\cdot\varepsilon_0\cdot r}\cdot\frac{1}{c^2}$$

$$= \left[\frac{1}{1 + \frac{1}{\chi\cdot[r - r/2]}}\right]\cdot\frac{q_{proton}\cdot q_{electron}}{4\cdot\pi\cdot\varepsilon_0\cdot r}\cdot\frac{1}{c^2}$$

$$r_{separation} = 1.3\cdot 10^{-15}\ \text{m}$$

The precision of this result is limited to the two significant digits of the Lamb Shift datum. Nevertheless, it is quite close to the wavelength of the proton oscillation in the neutron, $\lambda_{p\text{-}n} = 1.321,408,96 \cdot 10^{-15}\ m$ per equation 16-59. If $r_{separation}$ is set at $\lambda_{p\text{-}n}$ then χ can be calculated and from that the value of ΔE, the Lamb Shift. That calculation gives a Lamb Shift of $.033,611,416\ cm^{-1}$ compared to the actual datum of $.033\ cm^{-1}$. That actual measured datum is depicted in Figure 16-21, below, which is a schematic reproduction of the original. Advances in experimental techniques and equipment have improved the precision of spectral measurements to about $0.000,001\ cm^{-1}$.

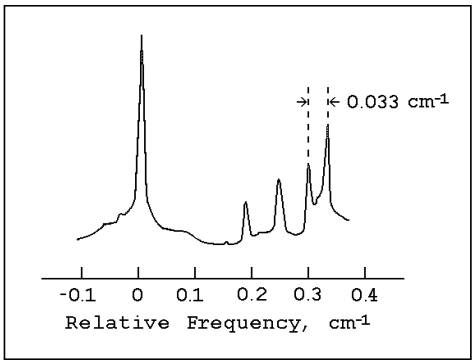


Figure 16-21
Schematic Depiction of The Original Lamb Shift Datum

The effect of the *Reduction Factor* on the potential energy is depicted in Figure 16-22, below. The figure shows the actual potential energy becoming unchanging where the separation distance, r, has fallen to just twice the theoretical focus distance, ρ. At that point the theoretical focus points of the two particles have overlapped and the Coulomb action ceases because no rays can be focused by either center onto itself at that close separation. The particles continue on toward each other at the terminal speed there obtained and merge to a neutron.

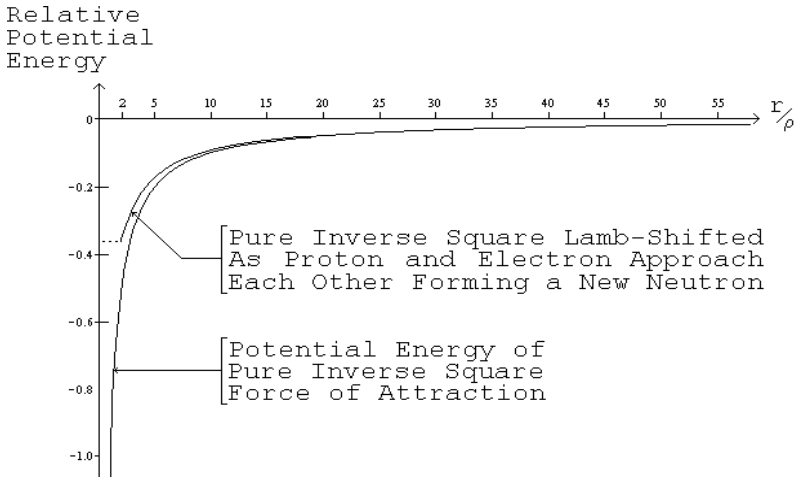


Figure 16-22
Proton - Electron Potential Energy in Forming a Neutron

SUMMARY

The above investigation and results demonstrate that:

(1) The neutron is a combination of a proton and an electron into a new particle, the neutron. The neutron mass is the sum of the escape velocity relativistic masses of the component proton and electron at their closest approach before merging.

(2) That closest approach is at one neutron wavelength, the wavelength of the proton-related oscillation within the electron-related envelope of the overall neutron wave form.

In addition:

(3) The separation distances at which the plane wave assumption with regard to Coulomb's law must yield to more complex treatment have been evaluated and the formulation of that treatment has been developed.

(4) The Lamb Shift has been incorporated into this Universal Physics with the somewhat erroneous original formulation of its cause being corrected.

(5) Newton's Laws of Motion have been derived from the fundamentals of Universal Physics. The nature and cause of motion has been clarified.