SECTION 12

A Model for the Universe (2)
Mass and Matter

As the wave propagated by the center-of-oscillation is the field, so the center-of-oscillation itself is the charge, is the mass, is the matter of the "particle" involved.

- These are the only physical realities underlying our entire universe: the center-of-oscillation and the propagated wave. These alone are, cause, account for all of matter, mass, field, force, charge, energy, radiation, everything.

- As will be shown shortly, all field is one aspect or another of the waves propagated by centers-of-oscillation and all forces, all interactions of matter with matter or field, are interactions of those propagated waves with other centers.

- As will be shown shortly, every atomic or nuclear particle having a "rest mass" is some form of a center-of-oscillation. (See *Footnote 12-1, Rest Mass*, at the end of this section.)

- As will be shown shortly, all "particles" not having rest mass are an aspect of the propagated waves' behavior.

- As will be shown shortly, the primal oscillation that came into existence in the Beginning (*+U* and *-U*) inevitably "broke down" into myriad centers-of-oscillation (to us, matter), all propagating U-waves (to us, fields and radiation), and all interacting (to us, forces) with consequent changes in motion (to us, the behavior of our observable universe).

MASS

It has already been presented in the discussion of electrostatic field that the effect which is called "force" is the result of the waves propagated by a center- or centers-of-oscillation arriving at and interacting with an encountered center, the center upon which the force is exerted. (In the following discussion, centers will be referred to as the "source" center and the "encountered" center. Of course every center is continuously in both roles. The distinction here is only in order to clarify the discussion. For this purpose, subscript "$_e$" signifies encountered center and subscript "$_s$" signifies source center.)

The effect of an individual wave encountering a center is the delivery of an impulse, an amount of momentum change, to the center. The wave, then, as it is propagated by its source center, carries potential impulse, "potential" because it is not realized in an effect until an encounter with a center occurs. The amount of potential impulse in the wave is, of course, proportional to the amplitude of the wave. It is that amount, that amplitude, which decreases as the square of the distance from the source center because it becomes spread over a greater area. The overall stream of waves carries the potential impulse of one wave times the repetition rate, the frequency, of the waves. The potential status of the wave's impulse is exactly the same status as that of electric field (which it, in fact, is) where electric field is potential force and not realized as actual force until it interacts with an electric charge (a center-of-oscillation).

That unrealized, potential, effect of the incoming waves from a source center, the waves' magnitude multiplied by their repetition rate or frequency, then becomes realized as actual effect by the interaction with the encountered center.

Newton's Law,

(12-1) $$\text{Force} = \text{Mass} \times \text{Acceleration}$$

can be restated as

(12-2) $$\text{Acceleration Resulting} = \text{Force Applied} \times \frac{1}{\text{Mass}}$$

and in that form is a more natural statement since force is the cause and acceleration the effect. This translates in terms of waves and centers into

(12-3) $$\begin{bmatrix}\text{Acceleration}\\ \text{Resulting}\end{bmatrix} = \begin{bmatrix}\text{Wave}\\ \text{Potential}\\ \text{Impulse}\end{bmatrix} \times \begin{bmatrix}\text{Responsiveness}\\ \text{of the Center}\end{bmatrix}$$

or, more succinctly,

$$\text{Acceleration} = \text{Wave} \times \text{Responsiveness}.$$

[While the "acceleration" quantity of Newton's Law is retained in the revised formulation of equation 12-3, the other quantities are not directly analogous. That is, the division of the acceleration into the product of two components as in equation 12-3 involves a different pair of components than those of equation 12-2. Force and "wave potential impulse" are not the same and responsiveness is not identical to inverse mass. This distinction between the significance of the terms for the Newtonian and this Universal Physics description of the same overall action will be clarified shortly, below.]

[In actual events the resulting acceleration may also result in changes in the incoming wave (by motion of the center changing the separation distance with the consequent inverse square law effect on wave magnitude, for example) and it may result in changes in the encountered center's responsiveness (to be seen shortly and the equivalent of relativistic changes in mass with velocity).]

In this formulation *Responsiveness* appears in the role of $^1/_{Mass}$ so that it would appear that (using $\propto$ which means "proportional to")

$$\text{(12-4)}\qquad \text{Responsiveness} \propto \frac{1}{\text{Mass}} \quad \text{or} \quad \text{Mass} \propto \frac{1}{\text{Responsiveness}}$$

however, the connection is more subtle as will be seen shortly.

The responsiveness would seem to depend upon several factors. The first factor is encountered center cross-section, the effective "target" area that the encountered center has for intercepting incoming waves. Of the total wave traveling outward from the source center, the only part that interacts with another center is the part that encounters the center, that is intercepted by the encountered center. A center intercepting a "large" portion of wave would receive a greater impetus to change in motion from the arriving wave than would a center intercepting a "small" portion of the wave. All other things being the same, the center intercepting the larger portion of incoming wave would receive the greater impulse and consequently would experience the greater momentum change. Thus inverse inertial mass, or center responsiveness, must depend on the encountered center's cross-section for interception of U-waves as one factor.

[The discussion here assumes that the arriving wave comes from a sufficiently distant center that the wave is effectively a plane wave, that is, that the part of the wave intercepted by the encountered center is a flat wave front of which every part travels parallel to the center part. The non-plane wave case is treated in a later section and turns out to be of negligible effect even with the relatively non-distant separation of the orbital electrons of atoms from the nucleus except a slight effect, the "Lamb Shift", detectable at the closer orbits.]

A center of smaller cross-section is of greater mass (lesser responsiveness), all other effects being equal, and requires greater arriving wave amplitude to experience a specified change in motion than does a center of larger cross-section. Cross-section is a matter of size, that is it is proportional to the area of interception of the incoming wave front. The encountered center being a spherical oscillation the cross-section should be the area of a circle perpendicular to the direction of travel of the wave front as it encounters the center. That area should depend on the wavelength of the encountered center's oscillation; more precisely it should be proportional to the square of that center's wavelength since the area of the circle will be π *(pi)* times the square of the radius.

[The wavelength is the distance between successive peaks of the wave, the distance that the wave travels during one cycle of its oscillation, that is until it starts to repeat itself see Figure 12-1 on the following page. The spherical oscillation that is the center expands outward from being of zero size until it extends one wavelength in all directions from its center point; then it starts another cycle. The full wavelength just expanded out to continues moving outward as propagated wave.]

[One cannot make a statement as to the definite "size" of the center in space since it is continuously varying; however it is convenient to think of its "size" as a sphere of radius equal to the wavelength. Since for the moment the cross-section is being taken as <u>proportional</u> to the square of the wavelength, not <u>equal</u> to it, there is no problem that the "size" is not determinate.]

This yields the first factor in mass, or responsiveness,

$$\text{(12-5)}\qquad \text{Cross-section} \propto \pi\cdot\lambda_c^2 = K_{cs}\cdot\lambda_c^2$$

(12-6)

$$\begin{bmatrix}\text{Respon-}\\\text{siveness}\end{bmatrix} \propto [\text{Factor 1}]\cdot[\text{Factor 2}]\cdot[\text{Factor 3}]$$

$$= \left[\begin{matrix}\text{Cross-}\\\text{section}\end{matrix}\right]\cdot[\quad "\quad]\cdot[\quad "\quad]$$

$$= [\ K_{cs}\cdot\lambda_c^2\ ]\cdot[\quad "\quad]\cdot[\quad "\quad]$$

where: K_{cs} = a constant for the proportionality

λ_c = the wavelength of the encountered center oscillation (λ is the Greek letter lambda analogous to Roman "l")

In order to account for the action of waves on an encountered center relating only to that portion of the total wave front intercepted by the encountered center, the incoming wave must be expressed in terms of "Incoming Wave Potential Impulse per Unit Area". That is, the intercepted wave potential impulse, the "Wave" of equation 12-3, is

(12-7)

$$\text{Wave} = \frac{\text{Total Propagated Wave Potential Impulse of Source Center}}{\text{Total Spherical Area of Source Wave at Distance Encountered Center is from Source}}$$

$$= \text{Wave Potential Impulse per Unit Area}$$

so that upon being multiplied by the cross-sectional area at the encountered center the units of area are cancelled and the resulting quantity is wave impulse (as measured at and as intercepted by the encountered center). The division by the area of a sphere is the essence of the inverse square law, of course.

The second factor in responsiveness is the effective amplitude of the encountered center's oscillation during the interaction. As will shortly be seen, the frequency of a centers' oscillation varies and, therefore, the frequency of the waves varies. Recalling that the center oscillation is of a *[1-Cosine]* form as depicted in Figure 12-1, below, a range of possible interactions can occur because of various different source and encountered center frequencies. The extremes and mean of the range of possible encounters follow the figure.

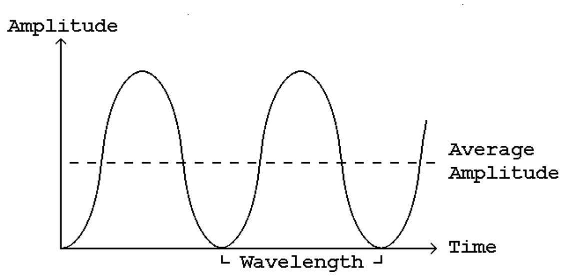

Figure 12-1
Oscillation of a Center

(1) $\text{Frequency}_{\text{wave}} << \text{Frequency}_{\text{center}}$

If the frequency of the arriving wave is much less than that of the encountered center then the encountered center goes through all of its amplitude values, as above, many times while one wave arrives. Clearly in this case the effective amplitude during the encounter with that one wave is the average amplitude of the encountered center's oscillation.

(2) $\text{Frequency}_{\text{wave}} >> \text{Frequency}_{\text{center}}$

If the frequency of the incoming wave is much greater than the frequency of the encountered center then one arriving wave encounters the center while the center is essentially at one value of its oscillation (wherever on the curve of Figure 12-1 that it happened to be). However, successive incoming waves will encounter the center at various other points on the curve and the average of a large number of such encounters will again be the average amplitude of the encountered center's oscillation.

Since the frequencies are very large this averaging is valid unless one frequency is very close to being a multiple of the other and the phases do not vary. However, the frequencies are constantly changing due to the effects that produce relativistic mass changes as discussed in the later section on Motion and Relativity and the phase is constantly changing because of relative motion of each center with regard to the other.

Furthermore, in real matter, not our idealized model of one source and one encountered center, every center is constantly "bombarded" by various waves from a variety of directions at a variety of frequencies due to the immense number of centers making up ordinary matter. As pointed out earlier, these can be analyzed individually in accordance with the Fourier principal; however, the total effect is such that it would be an extremely rare event for a center to maintain both phase and frequency-multiple relationships with a wave for even one cycle.

(3) $\text{Frequency}_{\text{wave}} = \text{Frequency}_{\text{center}}$

Finally, if the frequencies are the same then the interaction takes place over exactly one cycle and the effective amplitude is, again, the average.

Thus the relative frequency and the relative phase of the wave and the center that it encounters have no effect on the large scale result from the interaction. The *Factor 2* is not a variable quantity but merely the average amplitude of the encountered center, which is designated U_C.

However, the absolute frequency of the encountered center is very applicable and yields the third factor in the formula for responsiveness. Just as the incoming wave repetition rate affects the amount of force that the wave can deliver to the encountered center, as already presented, so the encountered center repetition rate affects that center's responsiveness to the wave. While the wave is encountering the center, each cycle of the encountered center's oscillation is affected by the wave. The encountered center is, by analogy, "bumped" by the incoming wave each time the center oscillation expands out from the zero point of its oscillation (Figure 12-1, above) and encounters the wave, which occurs at the frequency of the encountered center. (This is most easily visualized if the frequency of the encountered center is much larger than that of the wave, but it applies in any case.)

The *Factor 3*, then, is encountered center frequency and equation 12-6 becomes

$$\text{(12-8)} \quad \begin{bmatrix} \text{Respon-} \\ \text{siveness} \end{bmatrix} = \begin{bmatrix} \text{Cross} \\ \text{section} \end{bmatrix} \cdot [\text{Amplitude}] \cdot [\text{Frequency}]$$

$$= [\ K_{cs} \cdot \lambda_c{}^2\ ] \cdot [\ U_c\ ] \cdot [\ f_c\ ]$$

where: K_{cs} = a constant of the proportionality,
λ_c = the wavelength of the encountered center oscillation,
U_c = its amplitude, and
f_c = its frequency.

Since the wave propagates at the speed of light, a universal constant usually represented in equations by the symbol c, the frequency and the wavelength are related as in equation 12-9, below.

$$\text{(12-9)} \quad f_c = \frac{c}{\lambda_c}$$

Substituting this into equation 12-8

$$\text{(12-10)} \quad \text{Responsiveness} = K_{cs} \cdot \lambda_c{}^2 \cdot U_c \cdot \frac{c}{\lambda_c}$$

$$= K_{cs} \cdot \lambda_c \cdot U_c \cdot c$$

is obtained. Further, recognizing that K_{cs} is a constant for the proportionality (of unknown value), c is a constant (of known value) and U_c is a constant quantity about which little is known and which is yet to be specified, then the quantities are related proportionally as in equations 12-11a and 12-11b, below, (with making use of equation 12-4 and equation 12-9).

(12-11) (a) (b)

$$\text{Responsiveness} \propto \lambda_c \qquad\qquad \text{Mass} \propto {}^1/\lambda_c$$

$$\propto {}^1/f_c \qquad\qquad \propto f_c$$

Thus the responsiveness of a center to change in its motion due to a wave arriving and encountering it is directly proportional to the center's wavelength and inversely proportional to its frequency. The mass is directly proportional to the center frequency and inversely proportional to the wavelength.

This result is also given by traditional 20th Century physics (if a new, but reasonable assumption is introduced) as follows.

(1) From traditional 20th Century physics the energy equivalent of mass is

$$\text{(12-12)} \quad E = m \cdot c^2 \qquad \text{(E is energy, m is mass).}$$

(2) From traditional 20th Century physics the energy equivalent of an oscillation is

(12-13) $E = h \cdot f$ (f is frequency, and h is another universal constant about which see below).

(3) Applying these to a center-of-oscillation (that represents a particle of mass *m*, and is oscillating at frequency *f*), there can be only one total energy of the particle / center, therefore,

(12-14) $m \cdot c^2 = h \cdot f$ (setting (1) and (2) above equal to each other),

$m \cdot c \cdot (\lambda \cdot f) = h \cdot f$ (substituting $c = \lambda \cdot f$ for one of the two *c* factors on the left),

$m \cdot c \cdot \lambda = h$ (cancelling f on each side)

$$m = \frac{h/c}{\lambda}$$ (rearranging).

But, h/c is the ratio of two universal constants and, therefore, a constant itself. Thus mass is inversely proportional to center wavelength and directly proportional to center frequency -- the same result as obtained by analyzing the wave interaction with the encountered center.

The "reasonable new assumption" is that a constant, namely *h*, may be used with a center-of-oscillation's frequency to get the energy equivalent as in step (2), above, just as for a photon the energy is its frequency (electromagnetic wave frequency) multiplied by *h* (Planck's constant), which has been long established. That the result produces the same relationship between mass and frequency would appear to justify the assumption.

This constant, *h*, might not seem to be the same Planck's constant, *h*, for the center-of-oscillation case as for photons, however, because it is the factor for the conversion to energy of the frequency of a center-of-oscillation, which represents rest mass. In traditional 20th Century physics Planck's constant has not been shown to convert the frequency of a rest mass (the frequency of a rest mass is not a known concept in traditional 20th Century physics), only that of a kinetic mass (kinetic energy) as, for example, the case of photons. But, frequency is frequency and mass and energy are equivalent. Using Planck's constant yields frequencies and wavelengths corresponding to the rest mass of the electron (subscript "$_{e-}$", below) and proton (subscript "$_{p+}$") as follows.

Taking the values listed below for the quantities involved (the quantities are known to much greater accuracy but as below is sufficient for the moment),

$h = 6.63 \cdot 10^{-28}$ erg-sec $\qquad c = 3.00 \cdot 10^{10}$ cm/sec

$m_{e-} = 9.17 \cdot 10^{-28}$ gm $\qquad m_{p+} = 1.68 \cdot 10^{-24}$ gm

and using equations 12-9 and 12-14, the implied frequency and wavelength of the electron and the proton are as follows ("Hz" is cycles per second).

$f_{e-} = 1.24 \cdot 10^{20}$ Hz $\qquad f_{p+} = 2.27 \cdot 10^{23}$ Hz

$\lambda_{e-} = 2.41 \cdot 10^{-10}$ cm $\qquad \lambda_{p+} = 1.32 \cdot 10^{-13}$ cm.

Experiments involving scattering of charged particles by atomic nuclei have yielded an empirical formula for the approximate value of the radius of an atomic nucleus to be

(12-16) $\quad R = (1.2 \cdot 10^{-13}) \times (\text{Mass Number, A})$ cm

The proton is the nucleus of the Hydrogen atom with mass number $A=1$. For that value of A equation 12-16 gives a radius of $R=1.2 \cdot 10^{-13} cm$. That result is so close to the value of λ_p just obtained above (especially since the proton center-of-oscillation's "average" "radius" is likely somewhat smaller than the center's extent in space to a full one wavelength) that it would appear that this use of Planck's constant is correct and that the rest frequency and wavelength of the electron and the proton are as just given. [That this use of Planck's constant is correct is shown definitively in section *15 - Quanta and the Atom*.]

It is a curious result, but nevertheless the case, that whereas we tend to think of the electron as "small" and the proton as "large" (because the electron mass is much smaller than the proton mass), actually the electron appears "large" relative to the proton. The reason is that it requires larger cross-section, greater responsiveness, to have smaller mass. Thus the electron with a rest mass about $^1/_{1836}$ of the proton rest mass has a wavelength 1836 times that of the proton and an implied "radius" 1836 times that of the proton. Contrary to the traditional schematic diagram or animated illustration showing a hydrogen atom with a large proton nucleus and a small orbital electron, and contrary to the large sun and small planets analogy, the actual case would appear to be of a large electron orbiting a small nucleus.

Whether one could ever define or identify a "radius" for a center-of-oscillation is open to question. The concept of radius assists in thinking about centers-of-oscillation but is not otherwise applicable to the physics discussion. Cross-section, which is very applicable to the physics, need not at all be the same magnitude as the area of the circle of radius equal to the center's "radius". But, nevertheless, the relative cross-sections of different centers must be proportional to the square of their relative wavelengths.

Likewise, the question of the actual interaction of wave with center requires care. It is tempting to think in macroscopic physical terms of impulse, force, "bumping" and so on. The principle of equivalence would say, "These actions and events appear to be like the macroscopic Newtonian actions and events and they in fact are the actual "microscopic" actions and events that produce the macroscopic Newtonian ones, therefore they must be the same." The seeming defect in equivalence is in responsiveness versus mass and in waves and centers versus "hard" physical objects. On the other hand, that is the entire point of the principle of equivalence, and it is correctly applied here (and is more comfortable to our thinking) if the order of statements is reversed:

- not "Wave - center interactions are the same as Newtonian force, impulse, etc. type actions and events",

- but "Newtonian force, impulse, etc. type actions and events are really wave - center interactions,"

which is the case.

Consequently, it is clearer and more straight forward to use the Newtonian terms of force, impulse, etc. in describing wave - center behavior.

PRECISE FORMULATION AND COULOMB'S LAW

In the traditional formulation of Newton's Law as inverted (equation 12-2 repeated here)

(12-2)
$$\text{Acceleration Resulting} = \text{Force Applied} \times \frac{1}{\text{Mass}}$$

and for the case that is now being considered, that in which the force results from the electrostatic interaction between two charges in accordance with Coulomb's Law

(12-17)
$$\text{Force} \propto \frac{\text{Charge} \cdot \text{Charge}}{\text{Separation Distance}^2}$$

the charge of both of the interacting centers enters into the Newton's Law relationship in the Force part, the Mass part of the relationship being like an inert characteristic of the substance.

In the Universal Physics formulation (equation 12-3, repeated here)

(12-3)
$$\begin{bmatrix}\text{Acceleration}\\ \text{Resulting}\end{bmatrix} = \begin{bmatrix}\text{Wave}\\ \text{Potential}\\ \text{Impulse}\end{bmatrix} \times \begin{bmatrix}\text{Responsiveness}\\ \text{of the Center}\end{bmatrix}$$

$$\text{Acceleration} = \text{Wave} \times \text{Responsiveness.}$$

the quantity that is called oscillation amplitude, U, the role of which corresponds to that of traditional charge, Q, enters into the formulation somewhat differently. The source center's amplitude is a factor in the Wave and the encountered center's amplitude is a factor in the Responsiveness.

While the traditional formulation is not incorrect in the answers that it yields, it is incorrect as a reflection of the process or events occurring. While the electrostatic effect interaction magnitude is quite mutual and both charge magnitudes enter into the effect, they do not do so in the same way. It has already been shown that two charges do not attract or repel each other relative to where they are, but rather relative to where they were at the time ago equal to their separation distance divided by the velocity of the waves, the velocity of light. Likewise each charge is a propagator of waves and is an encountered center. These two actions are not identical. The process is better described by the formulation that embodies the two aspects, Wave and Responsiveness, in which formulation the source center amplitude / charge enters into the Wave factor and the encountered center amplitude / charge enters into the Responsiveness factor.

Thus as here formulated, responsiveness is not simply the inverse of mass since it includes the encountered center's amplitude / charge. Figure 12-2, below, presents a comparison of the two methods of viewing the event. The figure makes clear that the difference is (in traditional 20th Century physics terms) whether the resulting acceleration is expressed in terms of applied <u>force</u> or applied <u>field</u>.

<u>Traditional</u>

$$\text{Acceleration} = \text{Force} \times \frac{1}{\text{Mass}}$$

$$= \frac{Q \cdot Q}{d^2} \times \frac{1}{\text{Mass}}$$

$$= \frac{Q_s}{d^2} \times \frac{Q_e}{\text{Mass}}$$

$$= \begin{bmatrix} \text{Electric} \\ \text{Field at} \\ \text{Radius } d \end{bmatrix} \times \frac{Q_e}{\text{Mass}}$$

<u>Universal Physics</u>

$$\text{Acceleration} = \text{Wave} \times \text{Responsiveness}$$

:

:

substituting
for responsiveness
with equation 12-10

:

:

$$= \text{Wave} \times \left[K_{cs} \cdot \lambda_c \cdot U_c \cdot c \right]$$

Figure 12-2

Field and Wave, not Force and Wave, correspond. Each is the unrealized potential that becomes action via interaction with an encountered charge / center. Therefore the *Charge/Mass* of the left half of Figure 12-2 is the same as the *Responsiveness* of the right half of the figure as follows (with letting m_e symbolize the encountered mass).

$$\frac{Q_e}{m_e} = K_{cs} \cdot \lambda_c \cdot U_c \cdot c \tag{12-18}$$

And since, from equation 12-14, rearranged

$$m_e = \frac{h}{\lambda_c \cdot c} \tag{12-14}$$

then

$$Q_e = \frac{h}{\lambda_c \cdot c} \cdot \left[K_{cs} \cdot \lambda_c \cdot U_c \cdot c \right] = h \cdot K_{cs} \cdot U_c \tag{12-19}$$

which relates the charge of the encountered center to that center's amplitude, and is a simple direct proportionality because h and K_{cs} are constants.

If time could be stopped so that the waves were frozen in whatever position that they had in space, then the spherical waves as propagated by a center would appear as a series of successive nested shells, each of a successively greater radius, the radius being

$$(12\text{-}20) \qquad R_w = n \cdot \lambda_w$$

where: $n = 1, 2, 3 \ldots$ for the successive shells
λ_w = the wavelength of the waves

and the thickness of each shell is the wavelength, λ_w. One such shell is depicted two-dimensionally in Figure 12-3, below.

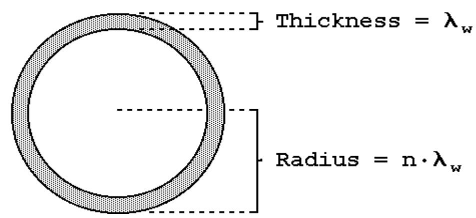

Figure 12-3

If the thickness is much less than the radius then numerical accuracy is not significantly affected by whether the radius is measured to the inner or the outer edge of the shell or to half way between, it can be taken as simply $n \cdot \lambda_w$.

Again, the wave propagated by the center-of-oscillation and the center's oscillation are of a *[1-Cosine]* form as already presented. That is, the wave and center are of the forms

$$(12\text{-}21) \qquad \text{Wave} = U_w \cdot [1 - \text{Cos}(2\pi \cdot f \cdot t)]$$

$$\text{Center} = U_c \cdot [1 - \text{Cos}(2\pi \cdot f \cdot t)]$$

A cross-sectional view of this wave in space, that is a graph of its amplitude variation along a radius while traversing the thickness, is depicted in Figure 12-4, below, from which it is clear that the area under the curve of amplitude variation is equal to $U_w \cdot \lambda_w$. (For large n the inverse square radial decrease in U_w over one λ_w can be omitted.)

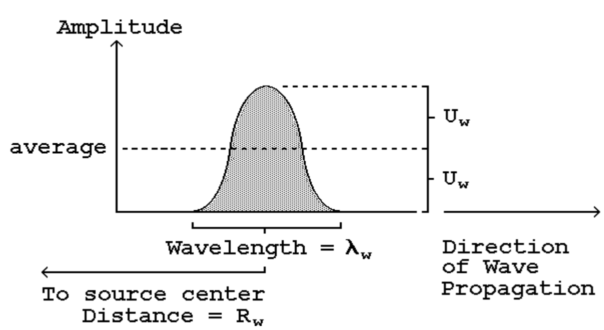

Figure 12-4

The amount of potential impulse in one complete spherical shell, in one wave cycle, is the amount where a radius traverses the shell, a "shell cross-section" so to speak as obtained above from Figure 12-4 as $U_w \cdot \lambda_w$, multiplied by the spherical surface area of the shell.

(12-22)
$$\begin{bmatrix}\text{A Cycle}\\ \text{of Wave}\end{bmatrix} = \begin{bmatrix}\text{Medium Density Over}\\ \text{a Shell Thickness}\end{bmatrix} \cdot \begin{bmatrix}\text{Shell Sphere}\\ \text{Surface Area}\end{bmatrix}$$
$$= [U_w \cdot \lambda_w] \cdot [4\pi \cdot R_w{}^2]$$

This quantity does not change as the wave propagates; it is merely more dispersed or "thinned" out as the wave propagates further, as R_w increases. Therefore it is the total medium density variation in any of the cycles of propagating waves (the "shells" of Figure 12-3) and as is generated by any one cycle of the oscillation of the source center. Thus the wave amplitude, U_w, is the source center amplitude, U_c, spread out over the surface of the sphere of radius R_w, the distance of the wave from the source center.

(12-23)
$$U_w = \frac{U_c}{4\pi \cdot R_w{}^2}$$

This is all that there is to the wave. Consequently, by substituting equation 12-23 into equation 12-22 the single wave potential impulse of the source center is obtained as

(12-24)
$$U_c \cdot \lambda_c$$

The *[Electric field at radius d]* or *Wave* of Figure 12-2 is that single wave quantity multiplied by the repetition rate, the frequency, f_w, so that the charge, Q_s, is

(12-25)
$$Q_s = [U_c \cdot \lambda_c] \cdot f_c$$
$$= U_c \cdot c$$

which relates the field of the source center to that center's oscillation amplitude and, therefore, relates the charge of the source center to its amplitude.

Combining equations 12-19 for Q_e and 12-25 for Q_s and recognizing that every center is always simultaneously in both source and encountered roles, then it must be concluded that every Q is

(12-26)
$$Q = U \cdot c \qquad \text{and} \qquad K_{cs} = {}^{c}/_{h}$$
[but see equation 12-32]

Since (per equation 12-25) frequency and wavelength enter into the value of the charge or field of a center only as the product of the two, which product is a constant, the speed of light, c, the charge and field of a center are independent of the center frequency and wavelength. Thus if all centers oscillate at the same amplitude, U_c, then they will each be of the same charge and have the same field strength. (The question of how the amplitude of all such centers, e.g. protons and electrons, comes to be the same is addressed in a later section.)

This total wave / field corresponds to the charge, Q, the constant fundamental charge of the universe, the charge of the electron (in $-U$) and the proton (in $+U$), and the positron and the negaproton. (The correspondence of the wave field to the charge is the same as the theorem in traditional 20th Century physics (Stokes theorem) that the integral of the electric field over a closed surface equals the enclosed charge.)

TWO SUCH CHARGES INTERACT ELECTROSTATICALLY AS FOLLOWS.

(1) The total potential force in the wave series as propagated by the source center is (from equation 12-25)

$$U_c \cdot c \tag{12-25}$$

(2) The total wave series potential force per unit area of wave front at the encountered center is the quantity of step (1) divided by the spherical surface at the encountered center where

R = the distance between the two centers.

$$\frac{U_c \cdot c}{4\pi \cdot R^2} \tag{12-27}$$

(3) The responsiveness of the encountered center is (equation 12-10)

$$\text{Responsiveness} = K_{cs} \cdot \lambda_c \cdot U_c \cdot c \tag{12-10}$$

(4) The resulting acceleration is, therefore (substituting steps (2) and (3), above, into equation 12-3 per equation 12-7)

$$\text{Acceleration} = \begin{bmatrix} \text{Wave potential} \\ \text{impulse per unit} \\ \text{area at the en-} \\ \text{countered center} \end{bmatrix} \cdot \begin{bmatrix} \text{Responsiveness} \\ \text{of the} \\ \text{encountered} \\ \text{center} \end{bmatrix} \tag{12-28}$$

$$= \frac{U_c \cdot c}{4\pi \cdot R^2} \cdot K_{cs} \cdot \lambda_c \cdot U_c \cdot c$$

(5) The mass of the encountered center is (from equation 12-14)

$$m = \frac{h}{c \cdot \lambda_c} \tag{12-29}$$

(6) The force is, then (substituting steps (4) and (5), above into equation 12-1)

$$\text{Force} = \text{Mass} \cdot \text{Acceleration} \tag{12-30}$$

$$= \left[\frac{h}{c \cdot \lambda_c}\right] \cdot \left[\frac{U_c \cdot c}{4\pi \cdot R^2} \cdot K_{cs} \cdot \lambda_c \cdot U_c \cdot c\right]$$

and rearranging

$$= \frac{[U_c \cdot c] \cdot [h \cdot K_{cs} \cdot U_c]}{4\pi \cdot R^2}$$

and substituting per 12-25 and 12-19 yields the result

(12-31)
$$\text{Force} = \frac{Q_s \cdot Q_e}{4\pi \cdot R^2}$$

which is Coulomb's law as it naturally occurs.

It is convenient at this point to attribute the 4π of the above expression to the k_{cs} of the preceding derivation. If that is not done it will turn out that the 4π is attributed to the $Q's$ as $[4\pi]^{1/2}$ associated with each Q. Attributing the 4π to the k_{cs} does no logical harm if treated consistently throughout as it is merely a matter of definition. It will have the advantage of avoiding expressions with excessive $4\pi's$ or, even worse, excessive $[4\pi]^{1/2}'s$ sprinkled around.

The only immediate action is to interpret the $k_{cs}/4\pi$ part of equation 12-30 as being simply k_{cs} which requires replacing the second part of equation 12-26 with

(12-32)
$$k_{cs} = \frac{c}{4\pi \cdot h}$$

If a constant of proportionality, k, is introduced to accommodate choice of the units of charge, and the constant 4π is absorbed into that new constant, then the result (using q for charge since the added constant requires an accordingly different variable) is

(12-33)
$$\text{Force} = k \cdot \frac{q_s \cdot q_e}{R^2}$$

which is Coulomb's Law as originally formulated. (See detail notes *DN 3 - The Units of Charge and of Coulomb's Law*, which follows this section.)

Now, here, Coulomb's Law is not a law obtained by inference from empirical data as is the Coulomb's Law of traditional 20th Century physics. Rather, it is a derived result from the prior Universal Physics theory. The derivation steps were:

(a) The concept of field / wave and charge / center-of-oscillation.

(b) Acceleration = [Wave (from the center-of-oscillation)] times [Responsiveness (of the center)].

(c) Development of Responsiveness in terms of center and wave interaction.

(d) Development of Wave in terms of center behavior and propagation characteristics.

(e) Development of the relationship between encountered center charge and its oscillation and source center charge and its oscillation.

(f) Combination of the above resulting in Coulomb's Law.

The above derivation depends on Newton's 2nd Law of Motion. Newton's laws of motion are derived from Universal Physics fundamentals in section *16 - A Model for the Universe (6) - The Neutron, Newton's Laws*. As will be seen, the effects of Coulomb's Law and Newtons Laws of Motion are really one integrated activity.

SUMMARY

In summary we have, then:

- Centers-of-oscillation which may oscillate at various frequencies but at constant amplitude,
- which amplitude corresponds to, is, the fundamental universal unit of electric charge,
- and which oscillation frequency corresponds to, is, the mass of the particle realized by the center-of-oscillation,
- and which individually and in the aggregate are the matter of the universe.
- The centers propagate spherical waves of potential impulse at the "speed of light", which waves interact with other centers resulting in force and motion.

The fundamental physical constants of the universe are:

c = the velocity of wave propagation in the medium (the speed of light),

Q = the oscillation amplitude of centers (the fundamental unit of electric charge)

(As used above Q is the "natural" electric charge and equals $c \cdot U_c$ while q is the form of electric charge more commonly used and equals U_c; therefore $Q = c \cdot U = c \cdot q$.) (It is here that moving the 4π from the charge to the k_{cs} provides its benefit.),

h = the energy equivalent of wave and center oscillations (Planck's constant).

Everything presented so far is quite compatible with the established aspects of 20th Century physics. The unifying concept of wave and oscillation and the improved concept of mass provide some clarifications and improvements in point of view, however. Einstein's and 20th Century physics' expectation of the unity of field and matter is here realized. Furthermore, the relationships

$$E = h \cdot f \qquad \text{and} \qquad E = m \cdot c^2$$

can now be more clearly seen as a fundamental reflection of reality. In effect oscillation is energy and is mass, the two being alternative expressions of the one thing by using different physical units. The terminology "prime matter and energy" used in *Part II -- On the Origin of the Universe* now becomes "prime oscillation," one simple thing.

The fundamental stable "particles", the electron and the proton are centers-of-oscillation (the proton in $+U$ and the electron in $-U$) with similar corresponding "anti-particles" the positron (positive charged electron, in $+U$) and the negaproton (negatively charged proton, in $-U$), and they have rest frequencies and wavelengths of

$$\lambda_{e-} = \lambda_{e+} = 2.28 \cdot 10^{-10} \text{ cm} \qquad \lambda_{p+} = \lambda_{p-} = 1.24 \cdot 10^{-13} \text{ cm}$$

$$f_{e-} = f_{e+} = 1.32 \cdot 10^{20} \text{ Hz} \qquad f_{p+} = f_{p-} = 2.42 \cdot 10^{23} \text{ Hz.}$$

These particles, called "particles" because of the way that we have learned to think about them, especially because Newtonian mechanical computations on their actions are frequently valid, have been found to exhibit wave behavior in some circumstances. This wave - particle duality of the behavior of particles has been one of the unresolved problems of traditional 20th Century physics.

It can now be seen that they are neither particles nor waves, but the centers-of-oscillation which have been shown above to behave in Newtonian fashion (in fact the Newtonian fashion is due to them) and which actually do time-vary in wave fashion (their oscillation and wave propagation) while exhibiting the identifiable local characteristics of a particle complete with apparent radius and size (cross-section). However, the matter- or particle-waves known to traditional 20th Century physics are not the above rest oscillations that have been presented so far. Rather, the wave phenomena of traditional 20th Century physics, electromagnetic waves and matter waves, are the result of motion of the particles, kinetic energy / mass not rest energy / mass treated so far here.

Consequently, it is now time to address motion of the centers-of-oscillation.

Footnote 12-1

Concerning "Rest Mass"

That mass can be converted to energy and vice-versa and that mass and energy appear to be different forms of the same underlying thing has been mentioned several times. More precisely, all particles except the photon and the neutrino exhibit a characteristic "mass" when not in motion. This "rest mass" is the ratio of a net force acting on the particle to the resulting acceleration from at rest.

The theory of relativity and experimental observation show that as a particle's energy increases, which increase in energy is the kinetic energy of its motion and equals the net work done in imparting the motion, the mass increases. Thus at rest a particle has its rest mass and in motion it has a larger mass. The larger mass is a quite real mass. A particle in motion requires a greater force acting on it to produce the same acceleration that a lesser force produced when acting on the particle at rest.

The photon and the neutrino have zero rest mass. They are never at rest, however, and they do have mass corresponding to their energy of motion.

DETAIL NOTES - 3

The Units of Charge and of Coulomb's Law

Properly stated, the law of electrostatic interaction between two charges, called Coulomb's Law, is

> "Given two electric charges separated in space by some distance, the magnitude of the force exerted by each of the charges on the other is directly proportional to the product of the charges and inversely proportional to the square of the distance between them."

In symbols this is

(DN3-1)
$$F = k \cdot \frac{Q_1 \cdot Q_2}{R^2}$$

where k = the constant of the proportionality.

Unfortunately the manner in which the law was originally formulated and other complications led to various systems of units.

It is desirable for simplicity that the units for the quantities in such laws be so as to have the constant of proportionality, k, be unity. Then the constant of proportionality can be omitted and the statement of the law involves only the actual variables pertinent to the law.

There are many examples of physical laws in which this was accomplished:

Force = Mass × Acceleration
(not k × Mass × Acceleration)

Voltage = Current × Resistance
(not k × Current × Resistance)

and so forth.

Of course, what is desired is that this be done ($k=1$) successfully for all systems of units that might be used. Commonly encountered systems of units are:

(1) cgs ≡ length in centimeters (cm)
mass in grams (gm)
time in seconds (sec)

with other units following accordingly as prescribed by the physical laws involved, for example:

$$\begin{aligned} \text{force} &= \text{mass} \times \text{acceleration} \\ &= \text{mass} \times {}^{\text{length}} / \text{time}^2 \\ &= \text{gm} \times {}^{\text{cm}}/\text{sec}^2 \\ &\equiv \text{dyne} \end{aligned}$$

(2) MKS ≡ length in meters (m)
mass in kilograms (kg)
time in seconds (sec)

$$\begin{aligned} \text{force} &= \text{kg} \times {}^{\text{m}}/\text{sec}^2 \\ &\equiv \text{newton} \end{aligned}$$

It would appear then that one need merely rearrange Coulomb's Law so that it can be used to define the units of charge as

(DN3-2) $$Q^2 = \frac{F \times R^2}{k}$$ [DN3-1 rearranged, and since this is only for units, $Q_1=Q_2=Q$]

and an orderly, simple arrangement of units would result. But, unfortunately it does not. From equation DN3-2 the units of Q are as follows.

(DN3-3) $$Q = [F \times R^2]^{½}$$ [k is dimensionless for finding the natural units of Q]

$$\begin{aligned} &= [\text{force} \times \text{length}^2]^{½} \\ &= [(\text{mass} \times \text{acceleration}) \times \text{length}^2]^{½} \\ &= \left[\text{mass} \times \frac{\text{length}}{\text{time}^2} \times \text{length}^2\right]^{½} \\ &= \left[\frac{\text{mass} \times \text{length}^3}{\text{time}^2}\right]^{½} \end{aligned}$$

The following table, Figure DN3-1, indicates the manner in which common units work out in this formulation in different systems of units.

Quantity	cgs Units	MKS Units	Ratio cgs/MKS
length	cm	m	10^2 cm/m
mass	gm	kg	10^3 gm/kg
time	sec	sec	1
velocity	cm/sec	m/sec	10^2 cm/m per sec
force	dyne	newton	10^5 dyne/newton
charge	$\left[\frac{\text{gm} \times \text{cm}^3}{\text{sec}^2}\right]^{½}$	$\left[\frac{\text{kg} \times \text{m}^3}{\text{sec}^2}\right]^{½}$	$10^{9/2} = 10^4 \cdot \sqrt{10}$ cgs units per MKS unit

Figure DN3-1

Most quantities in the table experience value changes by a multiple factor of ten in going from *cgs* to *MKS* units, which is simple. The digits of a quantity remain the same, only the position of the decimal point changes from one system of units to another. But charge will not fit that simple pattern. If for example a certain value of charge in some situation in *cgs* units were to be $4.803 \cdot 10^{-10}$ the corresponding value in *MKS* units would be $1.519 \cdot 10^{-14}$. That is not simple and orderly as desired because the digits of the quantity as well as the power of ten change with the change in units used.

A second complication arises when it is further found that the k in Coulomb's law is not always the same. Its value depends on the nature of the material substance (or lack of it) intervening between the two charges, for example: air, glass, oil, free space (perfect vacuum), etc.

Recognizing, then, that the desirable procedure of choosing the fundamental unit of new quantities so that $k = 1$ is hopeless in this case of charge, k is set up as a constant that is dependent on the intervening material and retained as part of the physical law. The k is designated $1/\varepsilon$ (Greek letter epsilon). For free space the epsilon is designated as ε_0. For one system of units the "natural electrostatic units" (and for the free space condition) $k = 1$ can still be retained as $\varepsilon_0 = 1$.

Coulomb's Law then becomes

(DN3-4) $$F = \frac{Q_1 \cdot Q_2}{\varepsilon \cdot R^2} \qquad \text{[Anywhere]}$$

and

(DN3-5) $$F = \frac{Q_1 \cdot Q_2}{\varepsilon_0 \cdot R^2} \qquad \text{[In free space].}$$

The more or less orderly arrangement in Figure DN3-2, below, results as established in practice, and is as simple and orderly as can be obtained in the circumstances. The "Elemental Charge" in the table is the value of the charge of an electron or a proton, the fundamental electric charge of the universe, in each system of units.

The esu (cgs, natural electrostatic) units is the system in which Coulomb's Law was originally developed (implicitly), where the value of the charge is $4.803 \cdot 10^{-10}$ and $\varepsilon_0 = 1$. The units, abcoulombs, are equal to statcoulombs divided by the velocity of light, c. An *abcoulomb* is *10 coulombs*. The rationalized system of units recognizes the significance of the 4π factor in the law and takes it into the ε_0 rather than the more awkward step of changing the charge to its otherwise value times $1/\sqrt{4\pi}$.

(For a thorough analysis of systems of units see Chapter 3, *Handbook of Engineering Fundamentals*, First Edition, Ovid W. Eshbach, New York, John Riley & Sons, 1947.)

The *Rationalized Meter - Kilogram - Second (MKSR)* system in Figure DN3-2, below, is now established as the standard system of units to be used internationally. The system is now referred to as *SI Units*, that is *Standard International* Units.

System of Units	Elemental Charge	Value of ε_0	Correct Statement of Coulomb's Law For in Free Space
esu (cgs, natural electrostatic)	$4.803\cdot 10^{-11}$ statcoulombs (Q)	1	$F = \frac{Q_1\cdot Q_2}{\varepsilon_0\cdot R^2}$ $= \left[\frac{Q_1\cdot Q_2}{R^2}\right]$
emu (cgs, natural electromagnetic with ε as it "naturally" occurs, see after the Figure)	$1.602\cdot 10^{-20}$ abcoulombs (q_{abs})	$\frac{1}{c^2}$	$F = \frac{q_{1abs}\cdot q_{2abs}}{\varepsilon_0\cdot R^2}$ $= \frac{c^2\cdot q_{1abs}\cdot q_{2abs}}{R^2}$ $= \left[\frac{Q_1\cdot Q_2}{R^2}\right]$
MKS (MKS with an adjustment factor in ε)	$1.602\cdot 10^{-19}$ coulombs (q)	$\frac{10^7}{c^2}$	$F = \frac{q_1\cdot q_2}{\varepsilon_0\cdot R^2}$ $= \frac{c^2\cdot q_1\cdot q_2}{10^7\cdot R^2}$ * → ** → $= \frac{(10^4\cdot\sqrt{10})^2}{10^2}\cdot\frac{c^2\cdot q_{1abs}\cdot q_{2abs}}{10^7\cdot R^2}$ $= \left[\frac{Q_1\cdot Q_2}{R^2}\right]$
MKSR ("rationalized" MKS)	$1.602\cdot 10^{-19}$ coulombs (q)	$\frac{10^7}{4\pi\cdot c^2}$	$F = \frac{q_1\cdot q_2}{4\pi\cdot\varepsilon_0\cdot R^2}$ $= \frac{c^2\cdot q_1\cdot q_2}{10^7\cdot R^2}$ $= \left[\frac{Q_1\cdot Q_2}{R^2}\right]$

* (This is the cgs/MKS units ratio applied to each charge.)

** (The abcoulomb/coulomb ratio applied to each charge.)

Figure DN3-2

The table brings up the question as to why the speed of light is so involved in this system-of-units matter. The reason is the direct involvement of the speed of light in the actual wave-center interaction. The speed of light is the wave propagation speed of the medium in which the entire action takes place. This same circumstance develops in traditional 20th century physics where it is shown that the speed of light is

(DN3-6)
$$c = \frac{1}{\sqrt{\mu \cdot \varepsilon}}$$

where μ is a magnetic constant of proportionality analogous to the function of ε electrostatically. (ε is called the *dielectric constant* and μ the *permeability*.) Equation DN3-6 gives the speed of light in any substance. In free space it is as in equation DN3-7, below.

(DN3-7)
$$c = \frac{1}{\sqrt{\mu_0 \cdot \varepsilon_0}}$$

In free space (and in most electrostatic interactions not in free space) $\mu_0 = 1$, so it can be omitted from the equation for the purpose here. This yields

(DN3-8)
$$c^2 = \frac{1}{\varepsilon_0} \qquad \text{or} \qquad \varepsilon_0 = \frac{1}{c^2}$$

as it appears in the above table.