PART III

ON THE MECHANICS OF THE UNIVERSE

SECTION 9

The Problem of Physics

The task now is to elaborate on what has been presented so far, to provide detail of the origin of the universe. This is called for in two senses:

First

> So startling and novel a theory of the origin asks for more detail. It is easy to say that the universe started as a random but inevitable change of absolute nothing into something and anti-something in a conservation maintaining fashion, that the impossibility of infinity required this to happen, and that the result is our universe; but the very statement demands more details. How did this happen, what happened, what events, what processes ?

Second

> What about science as it is today ? How does this origin relate to 20th Century physics, 20th Century cosmology, science's proven theories and its hypotheses ?

The development called for should be complete from the very beginning forward to the universe as we know it today. Furthermore, it should be able to meet the standards of science and the experimental method by relating logically and verifiably to reality. In particular the development should:

- Be completely consistent with known science.
- Predict new relationships or effects.
- Successfully survive new experiments testing its predictions.

The sections following the present one are such a development. In addition, the new data that the Origin provides makes it possible to advance and resolve some of the major unresolved problems of physics, doing so to the standards just cited.

Before proceeding, however, it will be useful to discuss some aspects of the present state of science, particularly physics. The discussion first requires a brief over-view of today's physics, however, the purpose being to introduce the subject and set a common general ground from which to proceed.

A BRIEF OVER-VIEW OF "TRADITIONAL 20TH CENTURY PHYSICS"

By "Traditional 20th Century Physics" is meant the physical sciences as understood and practiced up to, and without taking account of the new developments to be presented in this work. The approach to the exposition is quite different from the usual. 20th Century physics developed out of detailed investigation of the various specific physical effects that could be observed. The development of these into sciences progressed from specific detailed data collection and analysis to a generalized theory or body of theories uniting the specifics. The subject is usually so presented; that is, the presentation usually parallels the original evolution of the knowledge. But once the total body of developed specifics and resulting fundamental theories exists, it is more logical to describe that body of knowledge by starting at the common central data, letting the development be toward the specific from the general.

All of physics is fundamentally reducible to:

- *Particles*, the basic material or matter of the universe,
- *Forces*, which act on or interact between or among particles, and
- *Motions* of the particles as a consequence of the forces.

Various manifestations, combinations and interactions among these produce all of the tangible world that we experience as perceiving living beings:

- substances and objects, including ourselves;
- Light, heat, energy;
- the world, the universe, life.

The various manifestations, combinations and interactions follow essentially simple and direct modes of behavior called "physical laws". Most of these have been discovered or deduced by mankind by observation, measurement and analysis of the resulting data over the span of the many years of rational human endeavor. These laws are organized by man into "scientific disciplines", arbitrary but reasonable subdivisions of the total body of behavior of the universe. Some of these are for example: chemistry, optics, thermodynamics, mechanics, biology, electricity, and so forth.

PARTICLES

At the macroscopic or "every-day life" level, particles are the tangible objects of the world: everything from planets to ball bearings, stars to food, rain drops to people. But those macroscopically tangible things are not solid continuous objects but assemblages of myriad minute parts. If one proceeds from the tangible object down through the successive levels of its components to the minute level one finds a progression as in Figure 9-1 on the following page.

- the object;
  - materials called compounds of which the object is a structured assembly;
    - molecules, one molecule being the least quantity of a compound that yet has the characteristics of the particular compound;
      - elements, the components of molecules, fundamental substances not resolvable into simpler ones by chemical means;
        - atoms, one atom being the least quantity of an element that yet has the characteristics of that element;
          - atomic particles, the component "building blocks" of atoms.

Figure 9-1

At each more minute level the complexity and variety decreases. At the sub-atomic level the variety of particles is quite modest.

The atom, of which hundreds of kinds exist and of which only about fifty kinds are significant in every-day life, consists of a nucleus made up of particles of two types and a number of particles of a third type in orbit around the nucleus in a fashion somewhat analogous to the orbits of planets around the sun. The two nuclear component particles are the proton and the neutron; the orbital particle is the electron.

These particles have only two significant characteristics in themselves: their mass and their electric charge. (Physicists attribute a third characteristic, called spin, in some cases but it is not so much a literal spin as an explanation of behavior in certain circumstances (e.g., magnetic field). The mass of a particle (or any object) relates to the amount of change in motion of the particle that results from an amount of force acting on it. The charge of a particle (or any object) relates to the amount of force the particle exerts and experiences due to interaction with another charge (of another particle). The masses and charges of the minute sub-atomic particles are very minute also, but the number of such particles in macroscopically tangible objects is so large that the total mass and charge effects give us the experiences of every-day life.

The atom, then, consists of a nucleus that is a combination of some number Z of protons, another quantity $(A-Z)$ of neutrons, and a "cloud" of orbital electrons also of quantity Z. The relative masses and relative charges of the particles are as given in Figure 9-2.

particle	relative mass	relative charge	quantity in atom
proton	1836	+1	Z
neutron	1837	0	A-Z
electron	1	-1	Z

Figure 9-2

Thus the atom has almost all of its mass concentrated in the nucleus and has an overall net charge of zero since the charges of the protons and the electrons cancel.

Z is called the atomic number. It is an integer, one or more, and it is Z that makes the primary differences among the elements. A is called the atomic mass number, is an integer of value one or more and is an indication of the mass of the atom but is not the exact relative mass. A few common atoms are illustrated in Figure 9-3.

Name of Atom / Element	Z	A
Hydrogen (water, life forms)	1	1
Carbon (coal, life forms)	6	12
Nitrogen (air, life forms)	7	14
Oxygen (air, water, life forms)	8	16
Aluminum	13	27
Silicon (sand, glass)	14	28
Iron	26	56
Lead	82	207

Figure 9-3

Other sub-atomic particles in addition to the proton, neutron and the electron have been discovered or suspected. They can be placed into categories as follows:

Anti-particles

The anti-proton (negaproton), anti-neutron and anti-electron (positron) are all identical to their non-anti counterparts except that they have the opposite polarity of charge. (The neutron is neutral in any case; however, there is reason to consider a neutron to be some form of combination of a proton and an electron, for which the anti-neutron would be an analogous combination of a negaproton and a positron.)

Like the proton, neutron and electron, their anti- counterparts are stable, that is, they apparently exist with infinite lives and do not subdivide. (This is true of the neutron and anti-neutron only when in an atomic nucleus. Alone each decays, into a proton and an electron (for the neutron) or a negaproton and a positron (for the anti-neutron) with a mean life time before decay of about 1110 seconds.)

Presumably anti-atoms, composed of Z negaprotons, $A\text{-}Z$ anti-neutrons and Z positrons, can exist, but not in the presence of non-anti-matter because they would mutually annihilate each other.

Non-atomic Particles

Particles that exist separately from atoms, the neutrino and the photon. Both are stable, each occurs abundantly in nature and neither is solely a product of atom smashing. Each is not so much a "particle" as a particle hypothesis to explain observed physical behavior.

"Strange" Particles

A large number of other sub-atomic particles have been detected. In general they are only "fragments" encountered after "smashing" atoms with truly immense relative energies and have extremely short mean life times (for example 0.000,000,01 seconds).

FORCES

Just as the large variety of tangible objects in the universe simplifies to combinations of only a few fundamental particles, so, also, the large variety of forces experienced in the tangible world simplifies to a small number of fundamental forces which in various manifestations, combinations and interactions yield the forces of the complex tangible world. These fundamental forces are: gravitational forces, electric forces and "nuclear binding forces".

Gravitational Force

Gravitation is the force attracting all objects toward other objects. It is the "weight" which keeps our feet on the ground. Its mechanism is not understood by traditional 20th Century physics, but its mode of behavior is well understood. Mass being that characteristic of matter that determines the amount of motion of a particle due to a certain force acting on it, as previously stated, it turns out that the gravitational force is proportional to mass. The gravitational force between two masses m_1 and m_2, separated by distance d, is as equation 9-1.

$$F_{gravitation} = k \cdot \frac{m_1 \cdot m_2}{d^2} \qquad (9\text{-}1)$$

[Newton's Law of Gravitation]

The k is a constant of the proportionality, which may be unity if suitable units of F, m and d are chosen. It is called the "universal gravitational constant" and is commonly designated as G.

Electric Force

As with gravitational forces, there are two electric forces: electrostatic and magnetic. The electrostatic force is due to the charge of particles and depends on the amount of the charges, q_1 and q_2, and their distance of separation d as in equation 9-2, below.

$$F_{electrostatic} = k \cdot \frac{q_1 \cdot q_2}{d^2} \qquad (9\text{-}2)$$

[Coulomb's Law]

The k (not the same one as for gravitation) is the constant of proportionality. This is quite analogous to gravitation except that whereas the gravitational force is always in the direction of attracting the masses (so far as is known to traditional 20th

Century physics) the direction of the electrostatic force is attractive if the charges are of opposite sign (polarity) and repulsive if the signs are the same.

The other electric force, the magnetic force, acts between charges in motion relative to each other. Its magnitude depends on the amount of charge flow I, called "electric current", and the distance of separation d of the two flows as in equation 9-3.

$$F_{magnetic} = k \cdot \frac{I_1 \cdot I_2}{d} \qquad \text{[from Ampere's Law]} \tag{9-3}$$

The direction of this force is mildly complex and is discussed in detail in section *11 - Field and Charge*.

Nuclear Binding Force

Since the nucleus of an atom contains a number, *Z*, of like-polarity charged particles (protons) close together, it should be expected that the electrostatic repulsion would force them apart. (Gravitational attraction is too weak to be of significant effect here.) Nevertheless, generally the nucleus stays together and many nuclei are quite stable. Traditional 20th Century physics hypothesizes that some other force, of unknown details, but quite powerful over the short distances involved within the atomic nucleus, must act to counteract and overcome the nuclear protons' mutual electrostatic repulsion. This force is called nuclear binding force.

It is referred to here as hypothesized because it cannot be observed as the other forces can. Rather it is postulated because of the necessity for some solution to the perceived problem in the nucleus.

The relative magnitudes of these three kinds of forces are significant in appreciating their function in nature and the problems in dealing with them. The nuclear binding force is estimated to be about 100 times stronger than electrostatic force in a similar configuration. Similarly it has been calculated that the gravitational force, in a similar configuration (between two protons), is about 10^{-36} times the electrostatic force (10^{-36} = 0.000 ... 36 zeros ... 001), immensely weaker. Gravitation is strong in its effects because it is always attractive. The individual gravitational attractions of vary large numbers of particles add to give the gravitational effects that we experience.

Motions

Forces occur as interactions between particles. We can only detect forces by detecting the change in the motion of particles that the force causes. The effect of a force on a particle is a tendency to change the motion of the particle. "Tendency" means here that the force will cause a motion change to the extent that it is not opposed by another force. The laws governing this behavior are simple and few, as was the case with particles and forces. They are called Newton's Laws of Motion.

1 - A particle moves in a straight line at constant velocity when not acted on by any forces.

2 - A force acting on a particle imparts an acceleration (rate of change of velocity) to the particle:

(a) - In the same direction as the force.
(b) - Of magnitude per equation 9-4.

$$(9\text{-}4) \qquad \text{acceleration} = \frac{\text{force magnitude}}{\text{particle mass}}$$

(This relationship is, in effect, the definition of mass. The *k* constant of proportionality that has appeared in the other relationships is here included in the mass.)

3 - Whenever a force acts on a particle, which force is always due to interaction with another particle, a force of equal magnitude and opposite direction acts on the other particle.

Concerning the first of these laws, in the macroscopic world one gets the impression that everything slows down to a halt if left alone, that one must continuously impart force to even maintain velocity. This appearance is because in the macroscopic world of our personal experience there are other natural forces present and acting on the object that oppose its motion (for example: wind resistance, friction). Thus the object is always naturally decelerated. But in the total absence of any force acting on the object or particle its motion is at constant velocity, whatever velocity the last force to act left it with.

The question of standard of reference enters in here. A particle moving at constant velocity as seen by a "stationary" observer will appear to be at rest as seen by an observer moving with the same velocity as the particle. The problems that arise from this consideration and related matters that it leads to can be quite complex. They are treated at length in sections *11 - Field and Charge and 13 - Relativity*.

Concerning the second law, all such accelerations can be analyzed as consisting of two components: One in the same direction as that of the velocity of the particle and the other at right angles to that velocity, as in Figure 9-4,

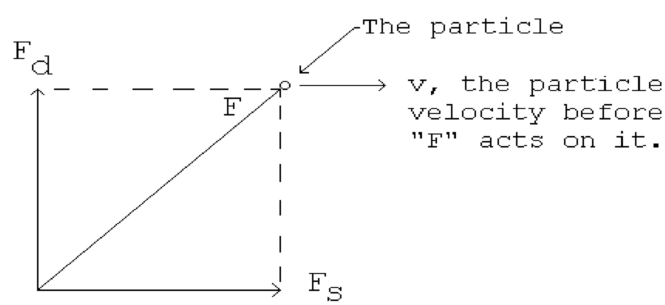

Figure 9-4

below. The components, F_s and F_d, acting simultaneously are equivalent to the actual force acting, F. F_s tends to change the speed of the particle without affecting its direction; F_d tends to change the direction of motion without affecting the speed.

The third law results from the nature of the force laws just presented. The statement of the force magnitude in terms of the charges or masses from which the force arises did not make a distinction as to which charge or mass the force acted on. It acts on both. If one particle attracts the other then the other attracts the one.

Motion can be linear, curvilinear or oscillatory. Any complex motion can be constructed from those components, or, inversely, any complex motion can be analyzed into some combination of those components.

> Linear motion is simply motion in a straight line. It is the motion that occurs if F_d equals zero.
>
> Curvilinear motion is simply motion over some curved path; it occurs when F_d is not zero.
>
> Oscillatory motion is quite common and important. It occurs in either of two ways.

Linear Oscillation

> This takes place when F_d is zero and F_s varies appropriately with the distance of the particle from the position in which it would rest, that is its position with no action by forces external to the system of which the particle is a part.
>
> For example, a weight hanging from a spring has some rest position. If the weight is displaced either up or down from that position (by a force external to the weight-spring system) and then released the weight will oscillate up and down, above and below the rest position. (The force exerted by a spring is proportional to the spring's displacement from its rest position.) When the weight is below the rest position the upward pull of the spring becomes greater than the downward pull of gravity so that the net force becomes upward. That force decelerates the falling weight and then accelerates it upward. When the weight is above the rest position the opposite is the case. Were it not for friction effects, which oppose the oscillation everywhere, the weight would continue in oscillation until some other force acted on it. In every day life the oscillation damps out.

Simple Harmonic Oscillation

> This can take place when F_d is constant at a suitable value and F_s is zero. In this case the particle travels in a circle - it orbits the center of the circle. If one were to view the path of the particle edge on to the plane of its motion, the particle would appear to be in linear oscillation. Within limits, variation in F_d and F_s will yield a variation in simple

harmonic oscillation where the path of the particle is an ellipse rather than a circle (a circle is merely a special case of ellipse).

The value of F_d required to make a particle of mass m orbit circularly at radius R around the center of the circle and at velocity v is given in equation 9-5, below.

$$(9\text{-}5)\qquad F_d = \frac{m \cdot v^2}{R}$$

[F_d is called the centripetal force in this case.]

FIELD

Up to this point it has been stated that particles interact with certain forces between them, but nothing has been said about how such an effect gets from one particle to the other. Particles could interact by actual collision. While this should happen occasionally it is not the interaction treated so far and it is the far rarer and less significant interaction.

The principal interactions are via the forces already set out, which involve action-at-a-distance, not collision. To explain how the force gets from one particle to another it is stated that each particle generates, or has associated with it, a "field of force", a different field for each different kind of force. Thus there is electric field, magnetic field, gravitational field, and so forth. It is the field which is said to act on the affected particle imparting force to it. The field of a particle is said to extend throughout all space according to the force law involved. For example, the electrostatic force is as already given in equation 9-2, repeated below.

$$(9\text{-}2)\qquad F_{electrostatic} = k \cdot \frac{q_1 \cdot q_2}{d^2}$$

[Coulomb's Law]

Therefore equations 9-6 and 9-7, below, are the electrostatic field.

$$(9\text{-}6)\qquad E_1 = k \cdot \frac{q_1}{d^2}$$

[Electric field of charge #1]

$$(9\text{-}7)\qquad E_2 = k \cdot \frac{q_2}{d^2}$$

[Electric field of charge #2]

The force on q_2 due to the field of q_1 is then as given in equation 9-8, which is the same as the original equation 9-2.

$$(9\text{-}8)\qquad \text{Force on } q_2 = E_1 \cdot q_2 = \left[k \cdot \frac{q_1}{d^2}\right] \cdot q_2$$

The force on q_1 due to the field of q_2 is analogous.

Since charge involves electric field and charge in motion adds magnetic field, a charge in oscillatory motion will exhibit both fields and, since the motion varies the fields vary. Such oscillating field is called electromagnetic field. (There is also an analogous field in gravitation of little every day significance.) The oscillating fields generate field waves that propagate outward from the source. These electromagnetic waves are the cause, the basis of: light, radiant heat (e.g., sun heat), radio and television signals, and so forth. The differences among these various effects are merely the frequency, the repetition rate, of the oscillations.

The propagated electromagnetic (E-M) waves propagate energy and momentum, treated below. While their nature as waves is well established, they also exhibit behavior as if the propagation were particles. The particles are photons, one of the fundamental particles indicated above in the general discussion of particles. (Gravitational waves are believed to involve an analogous particle called a graviton. Such fields are so weak that they have been difficult to detect.) E-M propagation is treated extensively in sections *14 - Magnetic Field* and *15 - Quanta and the Atom*. It suffices here to set out that changes in motion (acceleration) of particles having charge result in the propagation of E-M field. (In one special case, the orbiting electrons of atoms, such propagation does not take place except for orbit changes. This is treated in section *15 - Quanta and the Atom*.)

The physical laws describing electric, magnetic and E-M field are a body of laws discovered by a number of researchers over a period of time. Their full elaboration and codification is due to Maxwell, however. Maxwell's Equations embody the results and are a complete description of the behavior of electric, magnetic and electromagnetic field.

ENERGY AND MOMENTUM

Two other concepts related to the fundamentals of particles, forces and motions are energy and momentum. These are familiar concepts at our macroscopic level, energy relating to the ability to do work, to activity; and momentum relating to the tendency of heavy (massive) objects to resist change in their state of motion. More precisely:

Momentum is the product of the mass and the velocity of a particle (any particle whether "heavy" or not). Its rate of change equals the net force acting on the particle and vice versa. (Heavy objects in motion have a larger momentum and therefore require a larger force to slow or stop the motion. It is for that reason that we macroscopically think of momentum as a property of massive objects.)

Energy is "the ability to do work" where "work" is the product of a force acting on a particle and the distance through which the force acts while changing the particle's motion. In spite of that definition energy occurs in a variety of forms not macroscopically apparent as involving forces, particles, motion or distance such as heat energy, electrical energy, etc. At the fundamental particles level all energy appears as particle motion (including photons).

Another form of energy is as mass. That is, mass can be converted to energy and vice versa so that mass and energy appear to be two different forms of the same thing. The energy resulting from conversion of mass to energy is also actually manifest as particle motion (again including photons).

Instead of specifying a particle and its motion by stating its mass and velocity, one could state its energy and momentum (momentum has magnitude and direction as does velocity). Since field can conceptually replace force as a fundamental of the universe and energy and momentum can conceptually substitute for mass and velocity, one could revise the opening statement of this development and state, "All of physics is fundamentally reducible to: Field, Energy and Momentum." This is not a useful approach, however. It analyzes reality accurately but not most effectively for the purpose of developing science. It is somewhat analogous to analyzing a pie into a slice and the remainder rather than the crust and the filling. Both are accurate but the latter is a more useful and effective analysis. Field, energy and momentum can only be detected by us by our detecting the related or consequent motions of the particles involved. Thus the particles-forces-motions analysis is more useful.

Nevertheless, the formulation, field - energy - momentum raises implications of a level of reality beneath the presented particles-forces-motions, a conception giving rise equally to and being fundamental and common to all of particles, forces, motions, field, energy and momentum. This, however, is a digression beyond the present over-view of 20th Century physics and a pre-view of developments to come.

STATISTICAL PHYSICS AND "UNCERTAINTY"

As already pointed out, forces and the effects of fields can only be detected by observing the consequent changes in motions of particles. The very act of observation further changes the particles' motions, however, because observation requires something (light, magnetic field, etc.) to interact with the particle to obtain the information. If this effect of measuring is relatively small, the observed measurements will be reasonably accurate. For atomic level size particles, however, the perturbation due to the act of observing is so relatively large as to make direct measurement impractical.

This means that it is not possible to observe the position and velocity of an individual such particle, nor to observe changes in those characteristics of the particle, because of unacceptable inaccuracy. This consideration led to the Principal of Uncertainty, formulated by Heisenberg, which quantitatively defines the theoretical limit on measurement accuracy relative to the object being observed. These considerations have then further led to the contention that, since the motions cannot be measured they are not in the purview of science, "which deals only in observable, measurable facts". The line of thought was then extended to the point of conceiving particles as not having specific positions or motions at any given instant of time, having rather only statistical probabilities of being in various locations with various velocities.

These and other considerations led to development of Wave Mechanics, which is the description of the physical laws of particles' behavior in terms of statistical or probabilistic statements, and Quantum Mechanics, which is an abstract mathematical model. Schroedinger's Equations embody the wave mechanical treatment of the atom and atomic level phenomena. The equations of the probability distribution in space of such a particle are wave-like in form. Experiments have also given results indicating wave-like behavior by particles of matter. As a result the concept has developed that, not only does light have a wave nature in some instances and particle nature in others, but that matter, also exhibits a dual particle - wave nature.

This conflict between the particle and wave nature of both light (E-M radiation of all kinds) and matter has not been completely resolved. It has been bypassed by deeming light to be photons that are "packets of waves" so that it can exhibit either particle (packet) or wave behavior as the case may require.

FROM FUNDAMENTALS TO SPECIFICS

With the foregoing central core of physical fundamentals at hand it is now possible to explore how they combine and interact to yield the macroscopic world. Just as the variety and complexity decreased in the analysis from the macroscopic world down to the fundamentals of physics, so the inverse is true in proceeding back. Not all of the diverging paths can be developed here because of limitations of time and space. The developments all exist in the various libraries of science.

Instead, one selected path will be traced out to illustrate the actual situation. The path selected is that of that most common and, to us, most necessary and useful substance, water. The starting point is the fundamentals:

particles -- proton, neutron and electron
forces -- gravitational, electric, nuclear binding
motions -- linear, curvilinear, oscillatory.

The simplest combination of particles into an atom yields the Hydrogen atom, which consists of a nucleus of one proton with one electron in orbit around the nucleus. (Small amounts of Hydrogen atom variations, called isotopes, also exist. The isotopes of Hydrogen are called Deuterium, which has one neutron in the nucleus in addition to the proton, and Tritium, which has two such nuclear neutrons.) If no force acted on the electron, it would travel in a straight line rather than in an orbit. The electrostatic attraction between the proton (+) and the orbiting electron (-) does not succeed in drawing them together; rather it is the correct amount of attraction to deflect the electron into an orbit around the proton at the electron's orbital radius and velocity.

Using equations 9-2 (electrostatic force) and 9-5 (centripetal force), the relationship for the electron orbit is as in equation 9-9 which simply states that the electrostatic attraction equals (is) the required center-directed F_d, the centripetal force.

$$F_{electrostatic} = F_{centripetal} \tag{9-9}$$

$$k \cdot \frac{q_1 \cdot q_2}{d^2} = \frac{m \cdot v^2}{R}$$

q_1 = charge of proton
q_2 = charge of electron
d = distance between proton and electron
= radius of circular orbit
= R
m = mass of electron
v = velocity of electron

All of the quantities in equation 9-9 are fixed characteristics of the particles involved except the velocity, v, and the orbital radius, R. Thus for any R there is a v for which the orbit is stable. If actual v were too small the electron would "fall" toward the proton decreasing R until stability occurred or the electron collided with the proton. If actual v were too large R would increase until stability occurred unless v were large enough for the electron to escape entirely.

All such orbits should result in radiation of E-M waves, however, because of the electron's oscillatory motion, its continuous acceleration at right angles to its path. That should cause the electron to lose energy and therefore lose velocity, "falling" continuously toward the proton until colliding with it. For most values of R, the orbit radius, that is in fact the case, but certain discrete orbits do not exhibit that behavior. For reasons unknown to 20th Century physics those discrete orbits are stable and non-radiating. They occur in groups called shells. The innermost shell (smallest R) can accommodate two electrons in stable orbits. Thus Hydrogen has shell space left over for one additional electron to fill the shell.

The Hydrogen atom is, of course, the atom of the lightest element, Hydrogen. Except at extremely low temperatures / high pressures it is a gas, a collection of Hydrogen atoms that are free to move about randomly relative to each other. (Actually, they tend to take the form of two-atom molecules where each atom in effect fills its shell space for a second electron by using the other atom's orbital electron. Thus the two atoms share the two electrons and are a molecule of Hydrogen.)

The Oxygen atom has a nucleus of 8 protons and 8 neutrons. There are 8 electrons in orbits in essentially the same fashion as that of the Hydrogen atom's single electron. The forces and motions are more complex because there are in effect 9 separate charges (8 electrons and the nucleus) all interacting. The stable (non-radiating) orbit structure turns out to yield an innermost shell with space for 2 electrons and a second shell with space for 8 electrons. Since the shells tend to fill from the innermost one outward, the Oxygen atom has two electrons filling its inner shell and the other 6 electrons in the outer shell so that there is space for 2 more electrons in the outer shell.

As a consequence, two Hydrogen atoms and one Oxygen atom can combine to form a stable molecule. The electrons of each of the Hydrogen atoms tend to fill the vacancies in the Oxygen outer shell. The condition can be viewed as if the Hydrogen atoms lose their electrons and the Oxygen atom gains them as two extra electrons. The Hydrogen is then left with a net positive charge and the Oxygen with a net negative charge so that there is a strong force of attraction between them. The result is a molecule of water, H_2O. (Actually the Hydrogen and Oxygen "share" the electrons, which are in a constant complex orbital motion under the influence of all of the charges present.)

While each of the 3 atoms in this water molecule is electrically neutral, having equal quantities of protons and electrons, so that the molecule is also electrically neutral overall, it is not locally neutral because the various charges in the molecule cannot take a symmetrical arrangement. The water molecule thus acts as if it is a piece of matter with one polarity of charge at one "end" and the opposite at the other. The molecule is said to be "polar". As a consequence molecules of water tend to stick or clump together (by the electrostatic attraction of the polar charges) forming droplets of water. The molecular polarity also tends to induce polarity in other encountered molecules so that water tends to stick to them.

(Induced polarity comes about as follows. The "+" pole of a polar molecule, if near another molecule, tends to repel its "+" charges and attract its "-" charges thus giving it an induced polarity.)

The force exerted by the polar water molecules is large enough that a number of molecules acting together can actually pull apart one of the water molecules. Thus water consists of H_2O molecules with pieces of ruptured H_2O molecules mixed in. The pieces are usually individual Hydrogen atoms, (H), and partial molecules consisting of 1 Oxygen and 1 Hydrogen atom, (OH). The rupturing process usually results in the single Hydrogen atom losing its orbital electron (leaving its shell empty) and the Oxygen-Hydrogen fragment gaining the electron (full outer shell). These pieces of water molecules are called ions: Hydrogen ions, H^+, with 1 unit of positive charge because of the lost electron and "Hydroxyl" ions, OH^-, with 1 unit of negative charge due to the extra electron. Those opposite charges tend to reunite the ions if they get the opportunity. In water new ions are continuously being formed and existing ones being combined.

If a different substance the molecules of which are not held to each other strongly enough (e.g., salt or sugar as compared to coal or steel) is mixed into the water the water molecules will disassociate the other substance's molecules from each other. They then can mix freely in and within the water. The result is called a solution, the other substance having been dissolved. Some of its, now free and individual, molecules may also be ruptured into ions, that is "ionized". Some of those ions may combine with one or more water ions of the opposite charge resulting in a new type molecule.

Of course, water has three principal forms: solid (ice), liquid (water), and gas (steam). The difference among these is, macroscopically, the temperature of the H_2O. That temperature is merely a reflection of the amount of energy, considered here as heat, present in the H_2O. If the individual molecules have low energy (and likewise, therefore, the overall substance on the average has little energy, low temperature) then they can have only low velocity and momentum and cannot move freely relative to the attraction among the polar molecules. In this condition the molecules are locked into fixed locations in a solid structure. They have some energy expressed as vibration or oscillation in place; which is the heat energy still in the ice.

If the energy of the H_2O molecules in ice increases sufficiently (the temperature increases sufficiently) a point is reached where the molecules can break free of their fixed positions. The molecules would receive this added energy either by collision with other molecules or by encountering photons of E-M waves delivering their energy and momentum to the molecule in the interaction. With this additional energy the vibrations-in-place become large enough to let the molecules move away from the rigid locations of the solid state. The transition through this stage is called melting. The molecules are still bound to the overall body of water in this state. That is, their energy is large enough to allow relatively free motion around the other molecules, but it is not large enough to enable a molecule to escape completely from the polar attraction that keeps the water droplet intact.

A sufficient additional increase in the molecules' energy can make them completely free of each other, of the droplet. In this state the energy of each molecule is expressed in essentially straight line motion until a collision occurs. This is the steam state of H_2O; it has become a gas.

In actuality the molecules do not each have the same energy as the other. Whether ice, water or steam, some of the molecules have energy much lower than the average of the substance at that time and others have energy much higher. The energies are a collection of smoothly varying amounts from quite low to quite high with the major portion in the region of energy corresponding to the temperature. Even in water, then, an individual molecule may obtain enough energy to, in itself, be steam. If this happens near the surface of the water, the molecule may depart as gaseous water. This process is evaporation. Even ice evaporates, some of its molecules obtaining enough energy to do so, but the rate of evaporation is much less in ice than water.

If the gaseous water (or any gas) is enclosed in a container then it will exert pressure on the walls of the container. Pressure is a force, normally uniform over an area of surface, exerted on that surface. The pressure is caused by the gas molecules bouncing off the surface. (If a heavy ball is bounced off a person there is a tendency for the person to be pushed or knocked away by the reaction. The pressure of a gas is the effect of millions, billions or more minute such bounces per second.) The analysis of the behavior of such a gas in these terms is the Kinetic Theory of Gases. Its full development relates the pressure, volume, temperature and energy of the gas.

This sample of from fundamentals to specifics in physics, while not brief in absolute length, is of course only the most brief of summaries of only a small slice of the total world, of scientific knowledge. Its purpose has been primarily to introduce the subject and set a common general ground from which to proceed. The development of the thesis will shortly be seen to cover in full depth and detail all of the fundamentals treated, and with rigorous derivation throughout. To some extent the brevity so far carries oversimplification in it inherently, but not to the point of significant error. (No bibliography is given; the bibliography is the physics shelves of any good library.)

PROBLEMS IN THE METHODS AND STRUCTURE OF 20TH CENTURY PHYSICS

20th Century physics has to some extent directed itself into a relative dead end. Superb, exquisite, mathematics has tended to substitute for reality. Worse, the mathematical point of view now tends to prevent creative research, direct thinking, the adventure of the mind that produces scientific insight and progress. Consider the following.

> Maxwell's Equations and their development describe fully what happens, where, to what extent, etc. with regard to electric, magnetic and electromagnetic field. But in no sense do they explain how or why. The ability to describe and predict E-M field effects is not the understanding of E-M field. It is as if one insisted that the steam engine is explained by Boyle's and Charles' Law of gas pressure, volume and temperature. Even if one "throws in" the entire Kinetic Theory of Gases a steam engine is not obtained from the mere mathematics.
>
> Quantum mechanics and its development describe the behavior of matter in many circumstances, but in no sense does it explain how, why, what actual mechanism produces the observed behavior.
>
> Perhaps most serious of all, theoretical Heisenberg Uncertainty has been confused with reality. The ability to

> measure is not the limit of reality, it is only the limit of our ability to experimentally observe it. There is an underlying reality that is, and that Uncertainty has barred science from pursuing by the confusion of measurement and material reality.

The overthrow of determinism by the probabilistic / statistical point of view has cut science off from whole aspects of reality and is a prime example of mathematics' over-domination of science. To illustrate by analogy, the height of adult male humans varies, and a statistical distribution function of the height of all adult male humans in the world could be developed. From this one could obtain probabilistic statements concerning expected heights for various population samples. But any individual has a specific height.

Similarly, an electron in an atom has a specific location at any instant of time and a specific orbit just completed not, and regardless of, the quantum mechanical description of these in terms of a probability distribution in space, and regardless of our inability to observe and measure them directly. (The electron orbit is the locus of the electron's center of Coulomb, or electrostatic, action.)

These problems in 20th Century physics' way of thinking have tended toward denial of causality. Physical laws are (validly) accepted but without explanation of how the processes they describe occur nor from where the characteristic constants inherent in most such laws derive. The focus on mathematics coupled with the major impact of uncertainty and quantum considerations on the way of thinking about and approaching research in physics have tended to result in a loss of interest in seeking to answer the questions of why and how things are as they are. They even have led to it being considered reasonable to ignore conservation if it pertains to events of magnitude less than the Heisenberg uncertainty of the events.

The situation is somewhat like that of the pre-Copernican understanding of the "heavenly bodies". The earth-centered point of view resulted in complicated descriptions of the paths of the bodies. But, although the descriptions were complicated and based on erroneous underlying science, they were accurate nevertheless in describing and predicting the motions of the bodies as viewed from Earth. Just as with the erroneous (in underlying science) but successful (in describing events) geocentric astronomy, likewise any description and its mathematics no matter how sophisticated, no matter how successful at describing that which is known, no matter how successful at predicting behavior, cannot be accepted as the final answer if they do not conform with the underlying reality.

(The scientists are not alone in this introversion of their field; that is, excessive abstraction into a tool of the field to the detriment of the overall area of study. The "western" philosophers today concentrate to some extent more on the "meaning of meaning" than on man and reality.)

Why this has happened to physics is not really pertinent, but it can be suspected that it stems partly from the difficulty of challenging the established mode of ideas. It is especially difficult to challenge 20th Century physics' exquisite mathematics. Since the mathematics is within itself completely provable, derivable, logical and internally consistent, there is a tendency for it to acquire an aura of unchallengability. Then, the "sanctity" of the mathematics tends to be attributed also to the physical theories and reasoning that the mathematics describe, a quality that they may not merit. Likewise, the dominant mathematics, a complete description of <u>what</u> happens, tends to obscure investigation and understanding of the underlying <u>why</u>.

Nuclear physics has an additional problem. Acknowledging that the analogy is somewhat brutal, nevertheless the research is conducted in a fashion analogous to the study of the composition and fundamental parts of a limousine by hurling everything from roller skates to motorcycles at it with as much energy as possible and then analyzing the resulting pieces. It is true that little alternative seems to be available for experimental procedures for studying the atomic nucleus, but to take the resulting "pieces" very seriously as a key to understanding the nature of matter makes only quite limited sense when the magnitude of the disruptive energy used to generate the pieces is considered. Furthermore, those "pieces" may not be so much fundamental "building blocks" of matter as the fragments into which the matter naturally breaks under such energies, so to speak a reflection of the "fault lines" in the matter.

The situation of the discovery by these methods of over 100 nuclear particles clearly indicates that something is wrong. The physicists themselves recognize this situation and express it partly by the names that they give "tongue in cheek" to particles, effects and theories: "strangeness" and "charm" as the names given certain physical behavior or characteristics and "quark" as the name of a hypothetical particle (did this come from the "... hark, hark the Quark ..." of *Alice in Wonderland* or from James Joyce's "... another quark for Master Mark ..."?). Of course, even the theoretical quark, that is, theoretically "designed" to simplify and give pattern to the array of new particles generated experimentally, and fairly successful at so doing, ended up being a family of various quarks, none of which has been demonstrated to be a natural phenomenon.

Qualitative and quantitative understanding of the stability of some isotopes and the radioactive instability of others is still an uninvestigated mystery as is the mechanism causing the various and widely different mean life times before decay (or half-lives) and even more specifically how, when and why such decay occurs in a particular nucleus. Probabilistic / statistical rules do not address the problem.

In addition to these relatively unrecognized problems of the state of 20th Century physics there is the well-recognized problem of the wave / particle duality of both E-M radiation and matter. Both matter and E-M radiation exhibit behavior consistent with their being wave in nature in some circumstances and particulate in nature in others. The two seem to be inconsistent and, consequently, both concepts and the physics based on or related to them are less solidly founded than would be desired. Clearly, there has to be an underlying reality that clarifies and simplifies the whole, but physics deals with this only by recognizing the problem and speaking of "wave packets" without any detail, description, theory or experimentation to address it.

A similar situation exists with the "stable" orbits of electrons in atoms. It is clearly known that they are stable and they are so referred to, but there is no idea as to why, how that stability occurs, even though it appears to violate everything else that is known. It is not sufficient simply to name them "stable orbits" and then leave the subject.

Then there is the theory of relativity. Without going into details here, which are rigorously treated in the later section *13 - Motion and Relativity*, the special theory of relativity, while elaborated in detail and experimentally verified to a considerable extent, lacks the under-pinning of an explanation of the mechanisms underlying the mathematically described and logically necessary behavior. The general theory, in addition to this defect, is somewhat more of a "theory" than a "theorem". One of its major problems is its dependence on field, particularly gravitational field, the field concept having its own deficiencies as already referred to, the lack of understanding of the mechanism and the lack of an interest in finding out.

But in addition, gravitation is so little understood that it cannot be really integrated into the rest of physics. Unlike the other constants of the physical world, the universal gravitational constant stands by itself unrelated outside of itself and purely empirical. The problem is that the mechanism of gravitation has not been solved, yet this is the same gravitation on which the general theory of relativity so strongly relies.

The purpose of this critique of the status of 20th Century physics is not to create trouble nor to "rile up" scientists nor to attribute fault. Rather the purpose is to point out the need for a new point of view, to encourage minds to open to new possibilities, to explore so that new advancement can be made. Logic and experimental verifiability must still be supreme, but they need new material upon which to operate.

Which brings the discussion back to the original problem. Science has been tracking the investigation of reality back from the present to the past and from the macroscopic down to the sub-microscopic. Of necessity this has been a process of experimental data collection - hypothesis - test iterated from the tangible world, present to our unaided senses, back and down to the unsensible world of field, sub-atomic particles and energy (in the physics realm) and a cosmic beginning of a dense singularity that exploded in the "big bang". The method was the only one available, but it has become ever more difficult to make further progress as progress gets further from the macroscopic now.

But the Origin has introduced a new element into the reasoning process. By defining the very beginning it has defined the final end to which the reasoning back / down process tends but which it cannot reach unaided. Now the investigation can proceed convergingly in two directions: from the Origin forward / up and from 20th Century physics backward / down.

In addition the time has come to address the problem of field: electric, magnetic, gravitational, etc. field, and use field meaningfully to make further progress rather than merely letting it be a name for "action at a distance" without any understanding of what it is and how and why it does what it does.

There are three converging elements of knowledge, partial understandings of overall material reality: the Origin, matter, and field, as illustrated in Figure 9-5, below. From these it should be possible to deduce a model of reality that is in conformance with and explains all three elements of the converging data, an overall unifying conception of material reality.

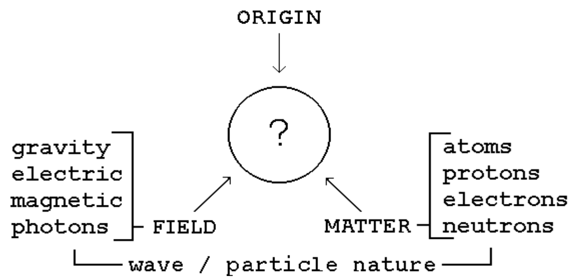

Figure 9-5

The remainder of this Part III will present such a model.

Footnote 9-1

It is necessary that the model and the associated thinking develop gradually. The universe turns out to be quite simple and rational, but that rational simplicity must be approached gradually as we adapt to new concepts the point of view that is inherent in our contemporary experience. The behavior that we experience is the large scale result of fundamental behavior that, at first, will seem strange to our thinking, that may take, perhaps difficult, adjustments of our conception of material reality.

Consequently, the final form of the model evolves to completion only at the end of the development after passing through interim stages that, while not fundamentally wrong, are not necessarily the ultimate most accurate description of the underlying reality -- approximations that accommodate for the moment the rate at which our thinking can adjust.