THEORY OF MOTION: THE OSCILLON HYPOTHESIS

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Abstract

A reasonable assumption about fundamental nature is the existence of the smallest, simplest, most elementary particle and form of motion, here called an oscillon. The oscillon is hypothesized to be a physical system of two separated points, one a constant center point and the other a moving point of tangency. Like a pendulum, the moving point oscillates relative to the center in a three-dimensional frame of reference. Inherent in the motion of the system is the capability of self-measurement.

1. The Smallest, Simplest Particle

Since the invention of electrical current, more than two centuries ago, investigation of matter and radiation has revealed that nature is simple. The constituent particles are few and infinitesimal. From the stable fundamental microcosmic particles, a macrocosm of astonishing complexity has been constructed by means of a multitude of spatial interactions.

A proton and an electron arrange themselves in an atom of hydrogen. In stars, hydrogen atoms transform and fuse into the other elements, which combine to form the myriad material molecules of the terrestrial world. From an ancient, microscopic, single-celled creature evolved the diverse species of viruses, bacteria, plants, and animals.

In 1758, Roger Joseph Boscovich published *A Theory of Natural Philosophy*, in which he made an early attempt to model the atom, visualizing the particle as a point. That concept has been useful ever since, because neither the atom nor any other particle has been directly observed and measured, although a great deal has been learned indirectly. In the full range of physical things, the point is the smallest object observable or imaginable. In geometry, the point is defined as having position but no extent.

Following Boscovich, a hypothesis of the smallest, simplest particle suggests a system of two points at minimum separation, one of which is a constant center point, and the other is a varying point of tangency. For convenience, this hypothetical two-point minimal oscillating particle is named the oscillon (see Figure 1, below).

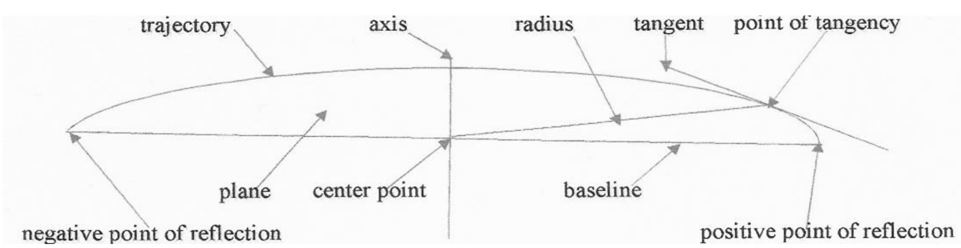


Fig. 1: The Oscillon, Its Frame of Reference, and the Trajectory and Direction of Its Motion

The variation of the position of the point of tangency relative to the center is an oscillation through an angle of pi (180°). Its trajectory, which is a semicircle, terminates at two points of reflection. The direction of motion at one point of reflection is positive, and at the other is negative. The period of the oscillon is the time between reflections, and two periods constitute a cycle.

Measurement is an integral part of motion and interaction. Nature demonstrates this fact in the inverse square relation that determines the motion of a planet orbiting a star. In the microcosm, there are no “observers”; therefore, the process is one of self-measurement by the oscillon. Measurement is the quantification of spatial and temporal relations. In order to measure, the oscillon uses the spherical frame of reference based on its center point.

The oscillon has the ability to measure four quantities: distance, angle, direction, and period. These are sufficient for its purpose. A line from the center to the point of tangency is a *radius*, and the particle, its oscillation, and its frame of reference are based on the radial dimension. A line through the moving point of tangency, at right angles to the radius and in the direction of its motion, is a *tangent*, which defines the tangential dimension. Together, the radial and tangential dimensions define the *plane* of the oscillon. A line through the center at right angles to the plane is the *axis*, which locates the axial dimension. The three dimensions jointly determine the structure, frame of reference, and motion of the oscillon.

It is worth noting that the tangential dimension does not pass through the center. It is the external dimension, while there is an orthogonal line through the center that is parallel to the tangent. Nature here demonstrates its beautiful symmetry, in that the radial dimension passes through both the center and the point of tangency, the tangential dimension only passes through the tangent point, and the axial dimension only passes through the center.

The units of measurement used by the oscillon are self-referential. Its radius is the unit of distance. The angle between the points of reflection is pi. The direction of motion from a point of reflection is either of two opposites: positive and negative or clockwise and counterclockwise. The oscillon’s period of motion from one point of reflection to the other is the unit of time. The system of numbers used by the oscillon is probably not the decimal system, which was derived from the number of human fingers and toes. A reasonable conjecture is that the numbers 0, 1, 2, and 3 fulfill all its functions.

1.1. An Ur-Particle

Is there an elementary particle that is the building block of all the stable elementary particles? Is a small, simple particle all that is needed to construct the known particles? Do such minimal particles interact, combine, and transform in ever more complex relations? Is there an ur-particle—the original, most primitive form of motion in the universe?

If so, what would the smallest, simplest particle be like? There is nothing smaller physically than a point, described by Euclid as having place but no extent. The universe is well defined as the infinity of points.

A particle is a quantity of space that is physically separate from and particular from all other quantities. It has an interior and an exterior. It is three-dimensional. The possession of a center distinguishes one particle from all others because no object has two centers, nor does one thing have the same center as another.

1.2. Nature’s Economy

We know that matter (hydrogen, atoms, elements, molecules, and chemicals) is made of only two particles: the proton and the electron. We know that plants and animals, from the smallest viruses and bacteria to the largest whales and redwoods, are made of cells. We understand that nature tends to stick to the tried and true. Having found a way that works, nature does not need an alternative.

Is it logical to assume that all of nature, including space, is made of a single foundational form of motion, and that the complexity that we observe is merely a variation in the dimensionality of the interactions of ur-particles?

2. Frame of Reference

What is the meaning of *frame of reference*? Grammatically, *frame* is a noun; and *refer*, the root of *reference*, is a verb. A noun represents a thing, object, or entity, and a verb represents an action, experience, or phenomenon. Thus, when describing a frame, object-words like *base*, *figure*, *line*, *plane*, *point*, *space*, and *vertex* are used.

When describing a reference, action-words like *differ*, *measure*, *oppose*, *pass*, *process*, *project*, *relate*, *start*, *use*, and *view* are used. Also used are words that describe quantities, such as *angle*, *distance*, *radian*, *ratio*, *separation*, and *unit*, as well as numbers such as 0, 1, 2, π, and π/3. Relations and qualities are described by using words such as *axial*, *constant*, *dimensional*, *directional*, *external*, *internal*, *invariable*, *minimal*, *natural*, *physical*, *radial*, *real*, *straight*, and *tangential*.

The oscillon, a system of two points in a spherical frame of reference, has self-knowledge and a capability of measuring both itself and beyond. It has the means of sensing its surroundings and the potential of interacting with other such systems.

2.1. Continuous Measurement

The measuring done by interacting particles in the microcosm is similar to that of birds in a flock, or fish in a school, or NASCAR drivers in a race. It is dependent on a continuous feed of information about the adjacent members of the group in all directions. The members achieve an optimum distance between individuals by maintaining a balanced separation from their immediate neighbors.

They do not “record” the precise numerical length of a measurement. Because each individual is moving relative to the combined trajectory of the group, the distance from each other is subject to variation at any time. This necessitates continuous comparison and continuous response. Of course, that is what an interaction is—a process of feedback whereby every action is a reaction, and one’s output is another’s input.

The process of interaction involves more estimation than measurement. The question is not so much “How far away is the other?” as “Is its distance changing?” This involves an assessment of ratios that relate to directions of movement. The measurer responds with actions and changes, such as: accelerating, getting closer, going down, moving up, pitching, rolling, slowing, turning left, turning right, yawing, and so on. Measurements like this are valid only in the present, to be redone over and over, in a process that needs no recording.

3.2. The Self’s Point of View

There are two views of a phenomenon: (1) the view from the center, called the internal viewpoint or the self’s view; and (2) the view from an infinite number of surrounding points, called the external viewpoint or the observer’s view.

The centers of interacting oscillons, by a process akin to natural selection, determine the distinction between front and back, left and right, up and down, in and out, forward and reverse, and clockwise and counterclockwise. It is the orientation of structure and the alignment of motion of one to the other within their common frame of reference that enables them to specify the various different or opposite directions that each is experiencing.

3.3. Absolute Space and Time

There has been a debate in natural philosophy since the time of Newton about whether there is such a thing as absolute space or absolute time. The question, which relates to motion, measurement, frame of reference, and units to be used, is asked from the point of view of an observer-measurer.

I have assumed that the observer is irrelevant to a description of nature, and that the central point of view is paramount. A particle has a center and a frame of reference that are constant, unchanging, and therefore absolute. Each particle has a unique center and its own frame of reference.

For a self-measuring oscillon, there is an absolute space and time, defined by its own frame of reference and by units based on itself and its motion. Thus, a particle's absolute space is not the same as that of any other particle. But since all oscillons are identical, the process and method of self-measurement are the same. The distance-unit and time-unit of nature are absolute.

3.4. The Purpose of Senses

Biochemical evolution has produced animal senses of great diversity and acuity. Our senses operate at all scales—from very large, such as touch and gravity, to very small, such as light waves and pheromones. However, the purpose of these senses is the same as the "senses" of the oscillon: namely, to provide a frame of reference for internal and external measurement and for effective interaction with the environment.

Vision is the most useful human sense because of its range: near to far, large to small, dark to bright. It is light-dependent, and direct and reflected light are ubiquitous in our environment.

3.5. Are There More Than Five Senses?

Reference is often made to the five senses of hearing, sight, smell, taste, and touch. Listing only five is meaningful if we are talking about what our conscious mind is ordinarily aware of. However, there are other senses that operate at a more unconscious level, such as:

1. Sense of gravity (up and down)
2. Sense of balance (vertical and horizontal)
3. Sense of time (fast and slow)
4. Sense of distance (near and far)
5. Sense of temperature (hot and cold)
6. Sense of pressure (soft and hard)
7. Sense of moisture (dry and wet)
8. Sense of weight (light and heavy)
9. Sense of identity (self and other)
10. Sense of change (constant and variable)

4. Oscillation, Interaction, Locomotion, and Wave Motion

Is it a universal characteristic of motion to be two-stroke? Is every type of motion a back-and-forth cycle? Is there a power stroke followed by a return stroke? Does every trajectory lead to a return to an earlier position? Is there always reflection and repetition? Is there motion in one direction followed by motion in the opposite direction? Both oscillation and rotation exhibit this characteristic.

A piston moves “down” on the power stroke and “up” on the exhaust stroke. Humans move with bipedal locomotion: when one extended leg plants on the ground and thrusts forward, the other leg bends in the air and swings back through the same angle and distance. While the body travels relative to the ground, the legs oscillate relative to the torso.

4.1. Synodic Motion

Synodic is a good word to describe the interaction of particles. The Gage Canadian Dictionary gives the Greek origin of the word as *syn*- “together” + *hodos* “going.” The synodic period of one planet relative to another is the time between their nearest approaches to each other when their gravitational interactions are greatest. A planet’s synodic motion is the orbital trajectory determined by its varying gravitational interaction with the other bodies of the solar system.

The interaction of particles results in motion that is synodic. Microcosmic input/output and action/reaction processes are continuous and uniform. Synodic motion is natural motion.

4.2. Motion in the Plane

All trajectories have a center; all trajectories are planar; all trajectories are cyclic. A trajectory is the path taken by a moving point in relation to a constant point. The constant point is the center of the frame of reference containing the two points. A trajectory is the time-related change in the direction, angle, and distance of the moving point relative to the fixed point.

Only two-dimensional trajectories are possible in nature’s three-dimensional space. All trajectories are in the plane that contains the center and all possible positions of the moving point. Planar trajectories may be rectilinear or curvilinear and may have the shape of a line, spiral, circle, ellipse, parabola, or hyperbola. Trajectories are finite in distance and continuous in time.

Nature imposes the limits of a minimum and a maximum on motion. These are manifested in the oscillon. The distance between the varying point and the constant point is the minimum. The distance between the points of reflection of the varying point is the maximum. The radius of the oscillon is a minimum, and the semicircular trajectory is a maximum.

4.3. No Nature Without Motion

So far as we know, everything in the universe is in motion. Nothing is at rest. Motion never stops. When a person is unconscious, the lungs breathe, the heart beats, the nerves fire, and the Earth rotates and revolves in a rotating galaxy. Every form of energy, work, force, power, or change involves motion.

There are two types of motion: oscillation and locomotion. When a particle oscillates, part of it changes position relative to its center, but the whole stays in the same place. When a body is in locomotion, its center moves relative to another center, and the whole moves from one place to another.

4.4. Repetitive Motion

In common practice, the word *oscillation* is used synonymously with *vibration*, *swing*, and *wave* to describe the repetitive motion of objects that return to their starting positions. Familiar examples are sound waves, seismic waves, ocean waves, ripples on a pond, and vibrating strings. In these cases, there is a material medium through which energy propagates after the application of a force. The oscillatory movement of the air, earth, water, or fiber continues as long as the force is applied, and then, as the energy dissipates, the medium returns to its original state.

The movement of a pendulum is an oscillation. The Gage Canadian Dictionary defines *pendulum* as "a body or mass hung from a fixed point so as to move to and fro under the forces of gravity and momentum" (p. 1089). The period of a pendulum is the time taken to swing from one limit to the other, and the cycle is the time of a to-and-fro motion. The angle of swing is the amplitude. The frequency of a regularly repeating motion is the number of cycles completed in a given time.

To discuss the oscillation of a solitary particle in an imaginary empty universe, I find the analogy of the pendulum most helpful, since I am looking for a regularly repeating motion, self-generated, free not forced, and to and fro, with a curvilinear trajectory. However, rather than having a continuous spinning or rotating trajectory, the motion reaches a certain point, reflects without stopping, and continues in the opposite direction to the starting point.

4.5. Attractive Interaction

Regarding a pair of identical self-measuring, oscillating particles, there are an infinite number of possible spatial and temporal relationships. If their positions are within range—that is, if their external frames of reference overlap—then interaction may occur. Two of these interactions are meaningful, but only one results in stability.

The spatial relation of identical particles is symmetrical if they are in the same plane, and if their points of reflection are co-linear. Their temporal relation is synchronized if their periods are in phase. If their directions of motion are opposite, one clockwise and the other counterclockwise, then the interaction is attractive. If they are oscillating in the same direction, both clockwise or counterclockwise, they repel each other.

4.6. A Solitary Particle

How should a particle be defined? Is it the smallest division of space? Is it the minimum volume? Is it the smallest quantity of motion? Does it have the shortest radius? Is it a quantity of one?

A natural object or phenomenon may be defined in terms of its properties, which are determined by observing it, measuring it, breaking it, and causing it to interact with other objects. To answer the question of what a particle is, we can imagine a time and a place in which there is only one particle. Since there is nothing external to such a particle, and it is not interacting with any other particles, the only view of its existence is from within. That view is of the properties of the particle in and of itself, its being, its reality, and its physicality.

4.7. Natural Selection

Natural selection, the felicitous phrase introduced by Charles Darwin, is the way nature deals with alternative spatial relations. Is it possible for particles to interact in a way that is different from the existing arrangement? Can the same particles interact in more than one spatial configuration?

The more complex the particle, the more alternatives are possible. Particles of matter form complex molecules, or chains of atoms. An atom of carbon can combine with atoms of other elements in a seemingly limitless number of ways.

Over time, all alternative spatial configurations may occur by chance. Nature “tries” to see if an alternative works or results in “error.” If the alternative is a stable interaction, harmonious with existing nature, then it may be selected and become common.The history of the universe is a process of successive natural selections.

4.8. Wave Motion Is an Optical Illusion

All the familiar terrestrial waves occur in a material medium. Ripples in a pond and whitecaps on a lake occur in water; sound is a movement of air; and seismic waves are a quaking of the ground. The molecules of the medium oscillate in place. Water waves and ground tremors are transverse waves, meaning that the motion of the particles is at right angles to what we perceive as the direction of the wave. In air, the motion is longitudinal—that is, the molecules are oscillating in the same direction that the sound wave is propagating. These familiar waves are caused by macrocosmic events such as a golf ball landing in a pond, the wind interacting with the surface of the ocean, or a sudden slip of two plates of the Earth’s crust along a fault line.

What we experience as a wave—that is, a horizontal movement of the medium from the originating phenomenon to another location—is an illusion. The real motion is a sequence, over time, of microcosmic particles oscillating relative to a constant center and interacting with adjacent particles. The brain, receiving information through the visual sense, interprets the observations by using its experience of time—that is, memory—so that it seems like something is moving from place to place.

The illusion becomes obvious when we observe the actual motion of a medium of macrocosmic particles oscillating in sequence, creating what is called a stadium wave, also known as a Mexican or audience wave. Here the particles are human bodies, and the oscillation is a vertical movement by each person from the sitting to the standing position with an extension of the arms over the head, followed by a return to the seated position. It appears to our brain that something is moving around the oval stadium in an up-and-down fashion, and that that movement has the shape of a wave.

The participating individuals in the audience, facing inward, interact with their neighbors on one side by means of vision and create the wave by moving in an orderly, regular, and uniform sequence. This is metachronal motion (from the Greek *meta-*, “before,” and *chron-*, “time”)—that is, motion produced by sequential action.

A diagram of wave motion is also illusory. It is a curved line of crests and troughs relative to a baseline, indicating a trajectory or direction of motion. In fact, the motion is of particles oscillating transversely to the baseline, and there is no physical connection between the particles other than their interaction in a common frame of reference.

4.9. The Medium of Light

Light and the other frequencies of electromagnetic radiation are also transverse wave motions. Light is emitted by stars and propagates through space in all directions. Some of it is absorbed or reflected by material bodies. Scientists generally have accepted that starlight is a wave, but there is no consensus about the medium through which it is propagating.

Is space the medium? If so, what is space made of? Is it ether? That is a hypothesis based on the assumption that the medium of light is made of matter. However, no experimental evidence of an ether has ever been demonstrated, which indicates that the medium is not material. Other hypotheses about space and the medium of light have been proposed, but the debate continues.

Experiments using stadium waves could demonstrate the different frequencies and wavelengths of the motion of interacting particles. The motion of particles when waves intersect could be investigated. Various periods of oscillation and intervals of interaction could be researched.

5. The Model of an Oscillon

An oscillon is a system of two points. One of the points is a constant, invariable center. The center is zero: a point of reference, a viewpoint, a base, and an origin. The other point is a variable, moving point of tangency. The oscillon is a binary system made of points, of which there are two; they are separate and different, one constant and the other in motion. The center point and the point of tangency are real, physical, and natural.

An oscillon has identity, dimensionality, size, and shape. It has an interior and an exterior. The oscillon has a frame of reference, which is a process of measurement of distance, angle, direction, and shape (see Figure 1, above). The process makes use of lines, figures, planes, intersections, angles, and numbers, which are not physical. A frame of reference is not physical, but the act of referring is real.

The distance between the oscillon's center and point of tangency is a radius that is constant. The straight line between the center and the initial position of the point of tangency is the baseline of the frame of reference. The radius, which passes through both the center and the point of tangency, defines the radial dimension of the oscillon. The distance between the points is the minimum physically possible separation, whose length is one distance-unit.

The numerical name of the center is zero (0) and of the point of tangency is one (1). A radius has two directions: outward from the center to the point of tangency ($0 \rightarrow 1$ or $1 \leftarrow 0$), and inward from the point of tangency to the center ($1 \rightarrow 0$ or $0 \leftarrow 1$). Conventionally, the outward direction is frontward and positive, and the inward direction is backward and negative.

There is an extension of the baseline from the center in the negative direction. On this line, at 1 distance-unit from the center, is the opposite point of tangency—that is, the point of reflection. The distance between the starting point and the point of reflection is 2 distance-units. The line between them is a diameter, and each of its segments is a radius. The number of the opposite point of tangency is 2.

The space between the baseline and any other line through the center, and the difference in their directions, is an angle. The center—that is, the point of intersection of such lines—is the vertex of the angle. One such line is the co-linear extension of the baseline radius, and the measure of the angle between the radius and the extension is pi. The angular measure is the same, regardless of the direction of measuring. Pi is a number. The equivalent of an angular measure of pi is 180 degrees.

A line through the point of tangency at an angle of 90° to the radius is a tangent. The tangent, which passes only through the point of tangency, defines the tangential dimension of the frame of reference. The radius and the tangent together establish the plane. The tangent has two directions—of which, conventionally, one is right and positive, and the other is left and negative.

A line through the center at an angle of 90º to the plane is an axis. The angle is constant. An angle of 90º is a right angle, and the relation of the axis and plane is perpendicular or orthogonal. The axis, which passes only through the center, defines the axial dimension of the frame of reference. It has two directions: conventionally, one is up and positive, and the opposite is down and negative. The radius, tangent, and axis are all perpendicular to each other, and this relation is constant.

An oscillon is a fundamental particle with an oscillating point of tangency. Any line through the center in the oscillon's plane is a radius. There is a point of tangency on such a radius at 1 distance-unit from the center. Thus, in relation to the baseline of the frame of reference, a radius and tangent, moving in tandem in the plane, have angular variability. Tangents in the plane at opposite points of tangency are parallel to each other. The difference between the directions of any radius in the plane and the baseline of the frame of reference is an angular measure that varies from zero to pi. The direction of the angle from the baseline is either positive or negative.

The internal frame of reference of an oscillon is based on two physical points: the center point and the point of tangency. The frame has three dimensions: the first is radial, the second is tangential, and the third is axial. The separation of the points and the angular relation of the dimensions are constant. The shape of the frame of reference is spherical.

5.1. The External, Tangential Frame of Reference

The common center of two oscillons is the point of intersection of their common tangents. That is the center of tangency, and it is co-linear with and equidistant from the centers of the particles. It defines their common frame of reference and lies on their common radius (see Figure 2, below).

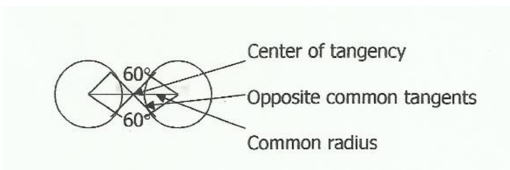


Fig. 2: Diagram of Center of Tangency and Center of the Common Frame of Reference of Two Interacting Oscillons

The angle of intersection of pairs of common tangents depends on the distance between the oscillons. When the separation is zero, the particles are tangent to each other, and the angle is zero. The common tangents coincide, and the particles are touching.

The oscillons also have common tangents that are co-linear. Their angle of intersection is 180º. Such tangents are parallel to each other and to the common radius.

When the interaction of two oscillons is stable, their separation is minimal and non-contiguous. Their centers and the center of tangency form a common radius. Their common tangents intersect at supplementary angles of 60° and 120°.

The acute angle between the tangents is 60°, and the angle between a tangent and the common radius is also 60°. This special intersection is equiangular—that is, all six angles between the tangents and radius are 60°.

5.2. The Tetrahedral Frame of Reference

A 60° angle is special because it is the angle of the equiangular, equilateral triangle, the simplest two-dimensional plane figure, or polygon. Similarly, it is the angle of the tetrahedron, the simplest three-dimensional "solid" figure, or polyhedron. The Greek roots of these words are: *tri-* "three," *tetra-* "four," *poly-* "many," *-gonia* "angle" or "corner," *-hedra* "side," "face," or "plane," as well as *stereo-* "solid" or "three-dimensional." A tetrahedron has four vertices, six edges, and four planes or faces, each of which is an equiangular triangle. Three edges intersect at each vertex at an angle of 60°, and two planes meet at each edge at a dihedral angle of 71.529°.

Thus, the common frame of reference of such stable interacting oscillons is tetrahedral. The center of tangency, where the tangents intersect, is both a vertex of a tetrahedron and the base of this frame of reference. An edge of a tetrahedron is a segment of a tangent. The rest of the frame is a continuous array of co-vertical tetrahedra derived from this starting point. None of these lines, points, and figures are physical, but they make up a real frame of reference that is indispensable to the measurement that relative motion requires (see Figure 3, below).

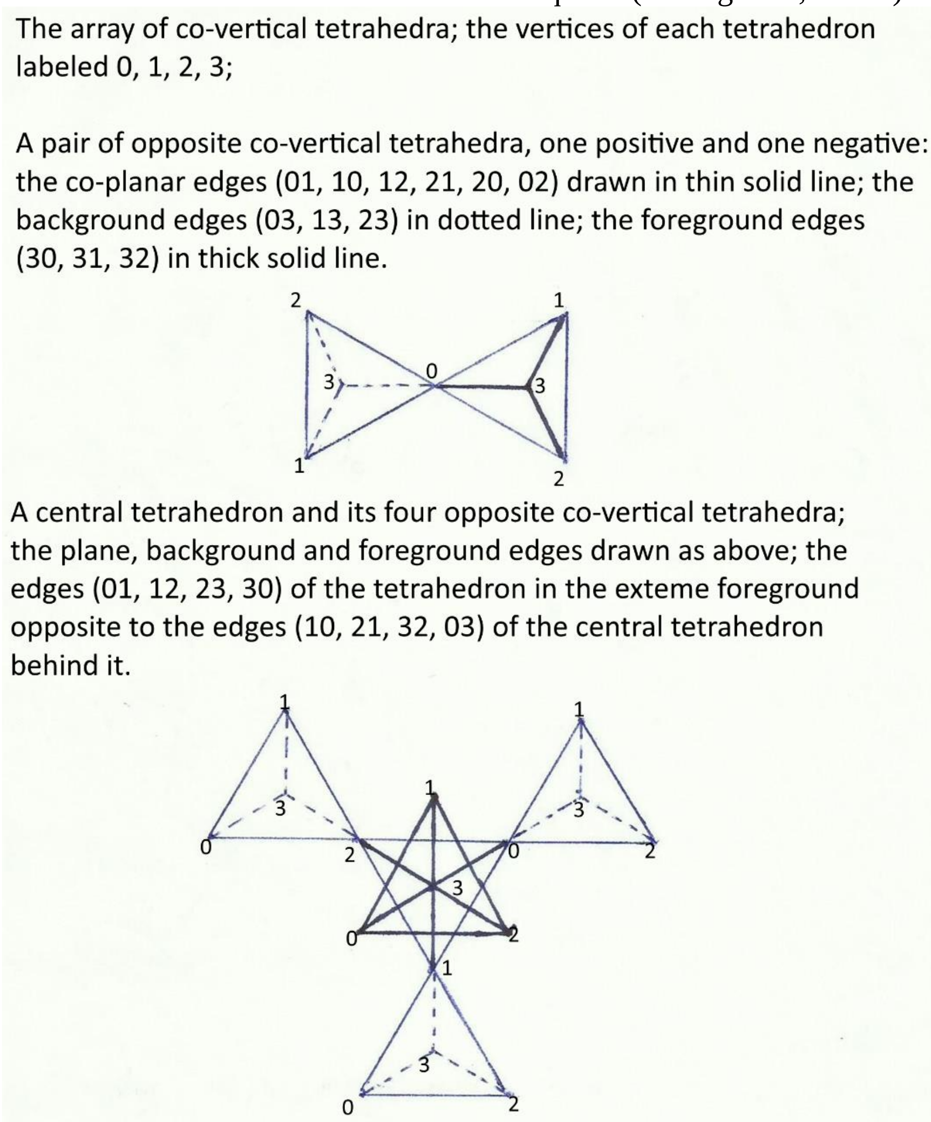


Fig. 3: Diagram of Co-Vertical Tetrahedra

The tetrahedra connected to each other at their vertices enclose a space with the figure of a truncated tetrahedron. The edges of the tetrahedra form the eighteen edges of the truncated tetrahedron, which also has twelve vertices and eight planes. This frame of reference is also referred to as the space-filling combination of tetrahedra and truncated tetrahedra.

A regular polyhedron, such as a tetrahedron or truncated tetrahedron, is the locus of spheres (see Figure 4, below): the circumsphere passes through the vertices, the insphere is tangential to the planes, and the midsphere is tangential to the edges. In the external frame of reference, the spherical internal frame of reference of each interacting oscillon coincides with a midsphere of a truncated tetrahedron.

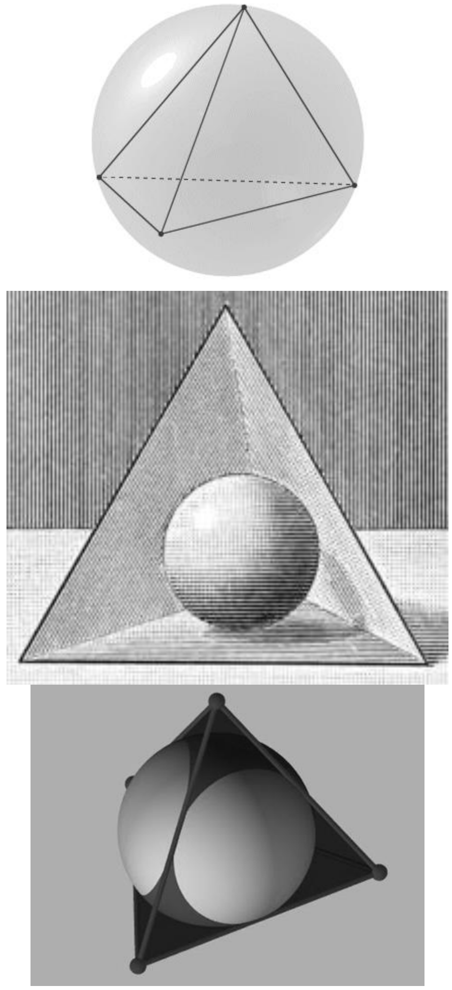


Fig. 4: The Spheres of a Tetrahedron: Circumsphere (top), Insphere (middle), Midsphere (bottom)

5.3. The Midsphere of the Truncated Tetrahedron

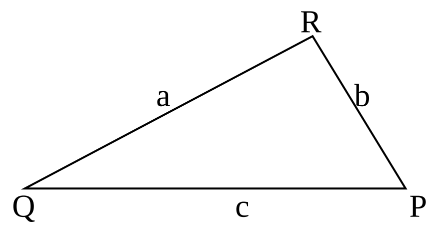
This tetrahedral array is an external tangential frame of reference of a spherical frame of reference. The midsphere of a truncated tetrahedron is the locus of an oscillon and its internal frame of reference. None of the components of the frames—the baselines, edges, faces, planes, spheres, tetrahedra, triangles, truncated tetrahedra, and vertices—are physical objects. The array exhibits symmetry in four planes.

The common vertex of a pair of co-vertical truncated tetrahedra is the common center of the midspheres of the pair of truncated tetrahedra. In a tetrahedral frame of reference, the center of tangency of two co-planar oscillons coincides with the common center of such spheres. The angle between intersecting tangents is 60°, and the angle between such tangents and the radius of the pair is also 60°. The angle between the common radius and the point of tangency, at the center of an oscillon, is 30°.

If the radius of an oscillon is 1 unit, then, calculating from the geometric relation between sides and angles in a 90-60-30 right triangle, the distance from the center of the oscillon to the common center of the pair is $2 \div \sqrt{3}$ units (1.154). The length of an intersecting tangent segment is $1 \div \sqrt{3}$ units (0.577). The length of an edge of a tetrahedron is also $1 \div \sqrt{3}$ units.

5.4. The 30-60-90 Triangle

The Pythagorean Theorem states that in a right triangle, the square of the length of the hypotenuse equals the sum of the squares of the lengths of the legs. The 30-60-90 triangle is a special right triangle and is half an equiangular, equilateral triangle. Triangle QPR, below, is a 30-60-90 triangle, and the following is the proof that the length of the hypotenuse is twice the length of the shorter leg, and the length of the longer leg is $\sqrt{3}$ times the length of the shorter leg.



Angle QRP = 90°
Angle RPQ = 60°
Angle PQR = 30°
RP = shorter leg = b
QP = hypotenuse = 2(RP) = c = 2b
QR = longer leg = $\sqrt{3}$(RP) = a
Since $c^2 = b^2 + a^2$
And $a^2 = c^2 - b^2$
$a^2 = (2b)^2 - b^2$
$a^2 = 4b^2 - b^2$
$a^2 = 3b^2$
And $a = \sqrt{3}b$
$b = a \div \sqrt{3}$
$c = 2a \div \sqrt{3}$

Let triangle QPR be the base of the tetrahedral external frame of reference of a pair of interacting oscillons. Then:
Q = center of an oscillon
R = point of tangency of an oscillon
P = common center of interacting oscillons
QR = longer leg = radius of the oscillon
RP = shorter leg = tangent segment of the oscillon
QP = hypotenuse = common radius of the pair of oscillons

Then QR (radius) = a = 1
And RP (tangent) = b = 1 ÷ $\sqrt{3}$ = 0.57735
And QP (radius of the pair) = c = 2 ÷ $\sqrt{3}$ = 1.1547

5.5. Tangential Relations

An oscillon also has an external frame of reference. This is the common frame of reference of two oscillons or, more specifically, of two centers. Thus, it is also the frame of reference of two spherical internal frames of reference. The part of the internal frame that is external to a particle is the tangent. The frame of reference of two interacting particles is defined by the spatial relation of their tangents.

The external frame of reference is tangential and has no physical center. The center of the frame is the point of intersection of the common, shared tangents of the interacting particles. The center of the frame is also the midpoint of the line that joins the centers of the two oscillons.

5.6. An Array of Co-Vertical Tetrahedra

The tetrahedral frame of reference is an array of co-vertical tetrahedra; each tetrahedron shares a vertex with four other tetrahedra (see Figure 5, below). The spaces between the tetrahedra are truncated tetrahedra. The combination of tetrahedra and truncated tetrahedra is space-filling. The array of tetrahedra is three-dimensional and continuous, and has four planes of symmetry.

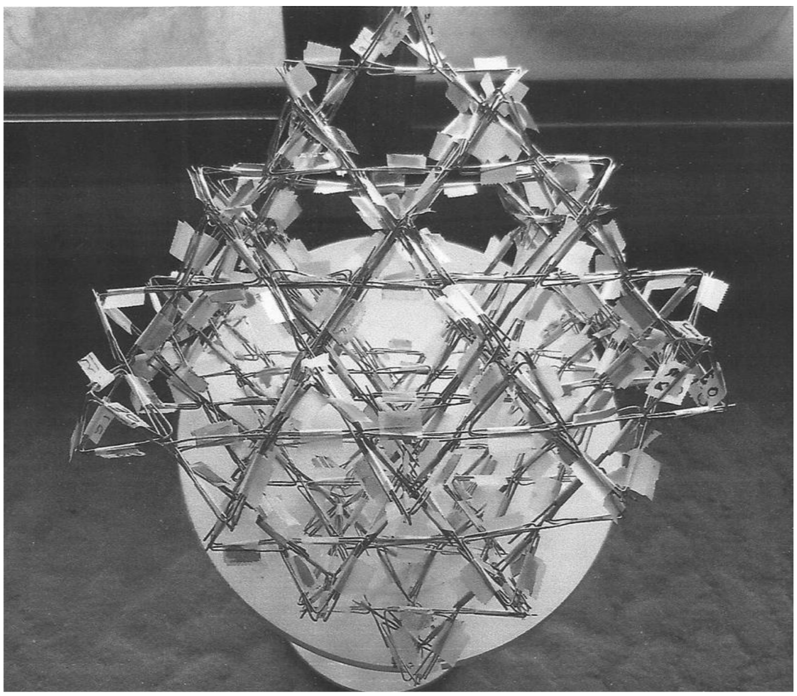


Fig. 5: Model of the Array of Co-Vertical Tetrahedra Made of Paper Clip Wires and Translucent Tape

5.7. The Space Filling Combination of Tetrahedra and Truncated Tetrahedra

This construction is a model (see Figure 6, below), built of paperclip wires, transparent tape, and balloons, of:

1. An array of co-vertical tetrahedra.
2. The tetrahedral frame of reference of two interacting stable fundamental particles at minimum separation.
3. The space filling combination of tetrahedra and truncated tetrahedra.
4. The common tangential frame of reference of a pair of spherical frames of reference.

5. A description of the linear, planar, perpendicular, parallel, and symmetrical relations of the polyhedra.
6. An illustration of a variant sphere packing, that is, the linear, perpendicular, parallel, and layered relations, of non-contiguous midspheres.
7. A representation of the direction of the ordering of the vertices, by means of labeling the vertices with the numbers 0, 1, 2, and 3.

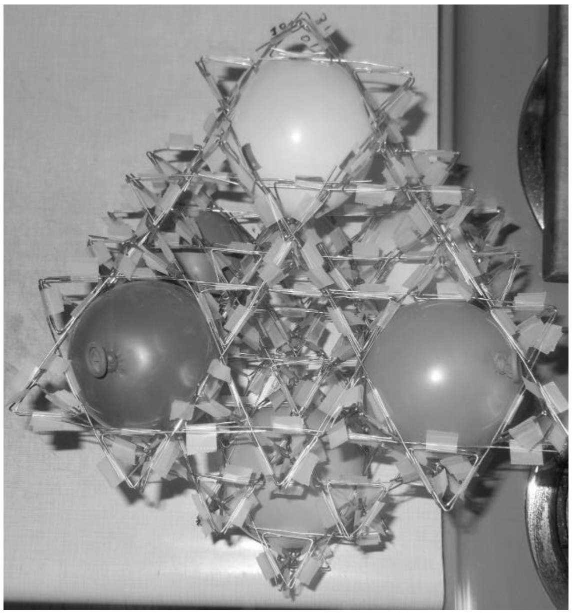


Fig. 6: Model of the Space-Filling Combination of Tetrahedra and Truncated Tetrahedra

In Figure 6, the balloons represent the midspheres of truncated tetrahedra. The midspheres are separated by a truncated tetrahedron occupied by segments of four midspheres. A balloon is missing from the central truncated tetrahedron because of difficulty of access. This arrangement of seven non-contiguous midspheres is a close sphere packing.

6. Interaction of Two Oscillons

Regarding a pair of identical, self-measuring oscillating particles, there are an infinite number of spatial and temporal relationships. If their positions are within range and their external frames of reference overlap, then interaction may occur.

The spatial relation of identical oscillons is symmetrical if they are in the same plane, and if their points of reflection are co-linear. Their temporal relation is synchronized if their periods are in phase (see Figure 7, below).

In pairings A and B, the motion of both oscillons is either clockwise or counterclockwise. In pairings C and D, the motion of one oscillon is clockwise, while the other is counterclockwise. In pairings A and C, the motion of both oscillons is either to the left or to the right. In pairings B and D, the motion of one oscillon is to the right, while the other is to the left.

The two oscillons in C and D are front to front—that is, their moving points of tangency meet at adjacent points of reflection. When interacting oscillons are back to front, as in A and B, the moving points do not confront each other.

The interaction illustrated in pairing D is attractive and stable. The combined motion of the two oscillons resembles wave motion. The motion illustrated in A, B, and C is not connected in a symmetrical, synchronous, and comprehensive fashion and does not have the shape and order of waves. Therefore, the orientation of the pairs of oscillons in A, B, and C does not result in attractive, stable interaction.

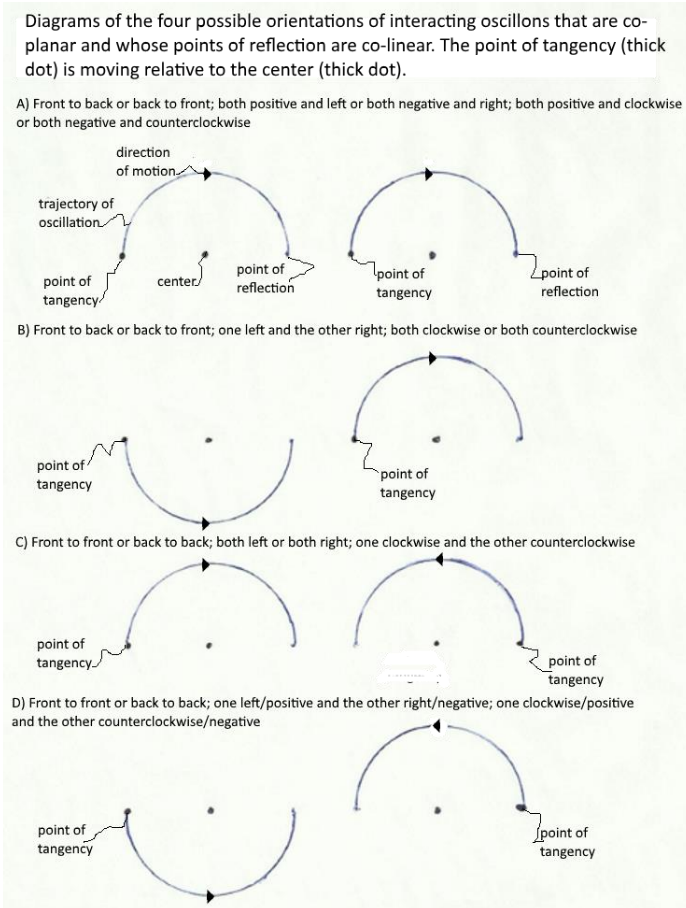
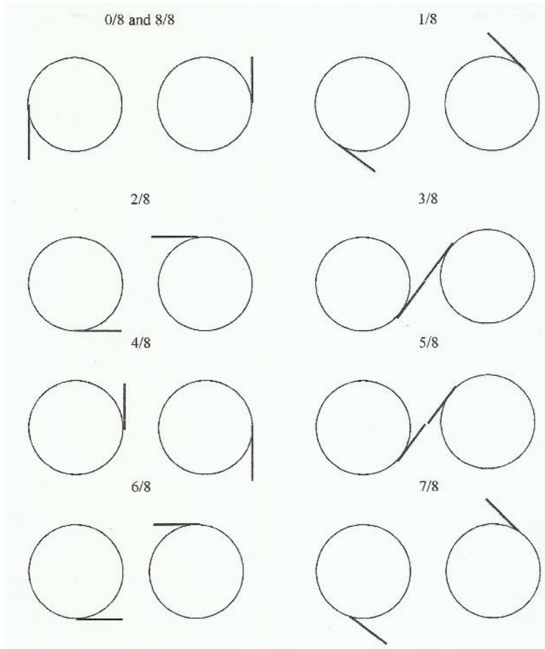


Fig. 7: The Four Possible Orientations of Interacting Oscillons That Are Co-Planar and Whose Points of Reflection Are Co-Linear

The diagrams are drawn from the external point of view, and the motion is described as seen by an observer. This means that the sense of a left or a right direction is that of the observer and applies to both oscillons. However, the view from the center of an oscillon, when it is interacting front to front with another oscillon, is such that its sense of positive and negative, or of left and right, is opposite to the other’s sense and applies only to itself.

6.1. The Cycle of Oscillation

The cycle of oscillation of a pair of oscillons can be demonstrated, in the absence of animation, by the diagrams in Figure 8, below.



Legend:

circle = spherical frame of reference of an oscillon
straight line = tangent segment of an oscillon
intersection of line and circle = moving point of tangency
1/8= fraction of cycle of oscillation

Fig. 8: Cycle of Eight Positions of a Pair of Interacting Oscillons (one clockwise, the other counterclockwise)

Eight positions of the moving point of tangency are shown, and between each position the point moves through an arc of one-eighth of a circle.

At the initial position (0/8 cycle), the point of tangency and one of the two points of reflection coincide. Halfway through the cycle (4/8), the moving points encounter each other at the opposite point of reflection. After reflecting, the points return through an angle of 180° to their original positions (8/8), and the cycle is complete. Another reflection initiates a new cycle.

6.2. Action at a Distance

What is the range of the oscillon's external frame of reference? To what distance from the oscillon's center does its capability of measuring extend? At what maximum separation does the oscillation of one particle affect the motion of another such that they interact attractively?

I have assumed that "action at a distance" is a definitive principle of natural phenomena. Particles are not contiguous. The oscillons' moving points of tangency have separate trajectories that do not coincide. Their internal spherical frames of reference do not overlap. They never touch.

However, the tangential dimension is external to both the oscillon and its frame of reference, except at the oscillating point of tangency where a tangent intersects a radius. The length of the such tangent is indefinite, but we can assume that a segment is at least as long as a radius, i.e., one distance-unit in each direction.

When oscillons are interacting stably and their common frame of reference is tetrahedral, a pair of 30-60-90 triangles are formed by their co-linear tangents, their parallel radii and the line joining their centers (see Figure 2). Assuming that the length of a radius is 1 unit, then the length of a co-linear tangent segment is 1 ÷ √3 units = 0.577. The length of the hypotenuse of the triangle, from an oscillon's center to the common center, is 2 ÷ √3 units = 1.154, and the distance between their centers is 4 ÷ √3 units = 2.309.

The length of the moving point's trajectory between points of reflection is π units = 3.1416. The length of the segment of the moving point's curved trajectory, from the point where a radius and tangent intersect to the line joining the centers, is π/6 units = 0.5236.

All these natural values are derived from the internal and external frames of reference, and the length of the trajectory, 3.1416 units, is the longest. If, for example, the length of the tangent segment were 3.1416 units, then the angle of intersection of co-linear tangents with the common radius would be approximately 18°, and the distance between the centers would be about 6.6 units. Therefore, the range of interaction and measurement, the extent of the external tangential frame of reference, is within the limits of a maximum length and minimum angle of the intersecting tangents.

7. Natural Units of Measurement

The oscillon is a self-measuring oscillating particle, whose center, radius, period, and trajectory are constant. The path of the oscillon's motion is semicircular like a pendulum. This means that the distance of its oscillation and the speed of its motion are also constant. Its units of measurement are self-referential. The natural distance unit is the radius of the oscillon, and the natural time unit is its period.

Using the formula *c* (circumference) = $2\pi r$ (radius), and, giving the radius a value of 1, we calculate that the variable point of tangency of the oscillon moves π distance-units, and its speed is π distance-units per time-unit. For the oscillon, since it does not calculate or use formulas, π is a measurement like the other natural units.

The oscillon is the smallest, simplest, and most fundamental quantity of space and motion. The separation of its center and point of tangency is the least possible distance given by a natural differentiation of one part of space from another and is therefore a minimum. Since its radius is a minimum distance, it follows that its oscillation is a maximum distance, and its rate of motion is a maximum speed.

7.1. The Speed of Light

The speed of light is a fundamental quantity of nature. It has been measured at 299,792,458 meters per second. Its symbol is *c*. All frequencies in the spectrum of radiation—including gamma rays, x-rays, ultraviolet light, visible light, infrared light, microwaves, and radio waves—travel at this speed. It is also the speed of electricity, and is assumed to be the speed of neutrinos.

Speed, a ratio of two measurements, is a quantification of motion. Usually, it is an expression of distance per time, such as 60 kilometers per hour. Or it can be time per distance, as in, "It takes about five hours to fly from Toronto to Vancouver." Direction is the third measurement implied by speed. The scientific term for *speed* with a specified direction is *velocity*, but the two words are often used interchangeably.

In interstellar space, light travels at a constant speed. When propagating from one material medium (such as air) to another (such as water or glass), the speed diminishes. *C* is a maximum speed. No object, particle, ray, or wave can travel faster than *c*.

The constant and maximum properties of the speed of light need to be explained. What do those properties mean in relation to the motions and interactions of microcosmic particles? What is revealed by the numerical value of 299,792,458, a measurement in the decimal system of numbers and the metric system of units? Why that number and not some other?

The speed of light can be expressed in different systems of measurement, as indicated in Table 1, below:

Table 1: The Speed of Light in Various Units of Measurement

Inches per second	1.18028×10^{10}
Feet per second	0.983571×10^{9}
Yards per second	3.27857×10^{8}
Meters per second	2.99792458×10^{8}
Kilometers per second	2.99792458×10^{5}
Miles per second	1.86282397×10^{5}
Leagues per second	0.62093×10^{4}

7.2. The Metric System

Measurement requires a specification of units, and the Système Internationale (SI) is the standard used in science, commerce, construction, transport, and other activities. In this system, the basic unit of distance is the meter and of time, the second. Both of those man-made quantities were originally derived from measurements of the planet Earth. The polar circumference is the base for distance, and the period of rotation is the base for time.

The rotation period of a day was divided into hours, minutes, and seconds. The numerical value of those units was based on the system of angular measurement, already in use, of the circle divided into 360 degrees, which in turn was loosely based on the number of days per year. That resulted in a day of 24 hours, an hour of 60 minutes, and a minute of 60 seconds.

The shortest unit, the second, is conveniently close to the normal cadence of counting and to the human heartbeat. The day is equal to 86,400 seconds ($24 \times 60 \times 60$), and the second is equal to 1.1574×10^{-5} (1/86,400) times the length of the day. The scale of these artificial time units extends to shorter or longer time periods, such as milliseconds or millennia, of any order of magnitude.

When the metric system of measurement was devised in France after the revolution of 1789, the new standard unit of distance was based on the supposedly measured and calculated distance from the North Pole to the equator through the meridian of Paris. This quantity, which was defined as the meter, was recorded on a platinum bar by marks separated by one 10-millionth of the measurement. The length was similar to previous units based on a man's pace or an archer's arrow.

For distances greater or less than a meter, the metric system uses the orders of magnitude of the decimal system of numbers. Commonly used distances, such as the nanometer (10^{-9} meter) and the kilometer (10^{3} meter), are named, and prefixes have been derived for the others. The megameter is usually written 10^{3} kilometers.

7.3. The Ratio *c/π*

A comparison of the speed of light and the speed of the oscillon, both of which are constant and maximum, shows that their numerical values (c = 299792458 and π = 314159265, respectively) are similar in a significant way. The ratio (c/π) of the two quantities is 0.95426903.

Is this proximity a coincidence, or is it a clue to the mysteries of nature? Is it possible that the natural distance-unit, the radius of the oscillon, equals $0.954269 \times 10^{-?}$ meters, the order of magnitude being uncertain.

The size of a hydrogen atom is 1×10^{-10} meters, and the size of a proton is 0.84184×10^{-15} meters.[1] The proton-to-electron mass ratio is 1,836 to 1. The highest frequency gamma ray has a wavelength in the range of 10^{-13} meters—some scientists say 10^{-15}. The size of a neutrino is unknown. The oscillon, postulated to be the precursor particle of these microcosmic phenomena, must be smaller than any of them and have an order of magnitude in the range of 10^{-16} to 10^{-18}.

Acknowledgments

These notes, which were originally intended for personal use, have been selected from notebooks made during thirty years of research into the microcosm, and are arranged here in a more or less logical order. Doubts about mainstream cosmology and the conviction that all natural phenomena are uniformitarian were the impetus for that research. I would like to thank Paul Weisser, Ph.D., for his invaluable editorial assistance in preparing these notes for publication.

[1] *Scientific American*, 303:4, 24.