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CIRCLES, SPHERES AND ATOMS

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Publications, Exhibitions:
"A Design for the Atom," Industrial Design Magazine, Feb., 1963
“Discontinuous Compression Structures”, Feb., 1965 U.S. Patent #3,169,611*
Model for Atomic Forms”, October, 1966, U.S. Patent #3,276,148*
“Model for Atomic Forms”, July, 1978, U.S. Pat.#4,099,339*
Kenneth Snelson, “Portrait of an Atom”, 1981, Maryland Science Center, Baltimore, Maryland, U.S.A.
Exhibition, “The Nature of Structure”, N.Y. Academy of Sciences, 1989
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Abstract:

The author describes his four-decade interest in the geometry of small nonoverlapping circles on spheres and their relation to normal polyhedra. He discusses the varieties of circle-sphere geometry and their association with mosaics of circle-shape permanent magnets on spheres. He outlines the stages in developing his long-running, open-ended, artwork, an analog model of the atom’s electronic architecture based on circlesphere geometry.

> “If you have had your attention directed to the novelties of thought in your own lifetime, you will have observed that almost all really new ideas have a certain aspect of foolishness when they are first produced.” Alfred North Whitehead:

Standard polyhedra, tetrahedra, cubes, octahedra... have a sister variety of hedra whose faces are circles instead of polygons. I call these interesting forms that lack a customary name, "circlespheres". The occasional references I have found for circles on spheres in mathematics are concerned with the problem of how, most economically, to pack a number of equal nonoverlapping circles on a sphere.

Circlespheres have led me, as an artist, into a quite different path from that of mathematicians. My fascination from the beginning, going back forty years, was with the visual and tactile experience of exploring the many varieties of circlespheres and, finally, with an intense period of studying the history of models of the atom, I began working on what has become a complex multimedia artwork, "Portrait of an Atom", whose geometrical order is of this fascinating circle geometry.

My study began not from any special interest in the mathematics of circles and spheres but rather from exploring the straight-line geometry of my steel tube and cable sculptures. They were, in 1960, an unusual and new type of structure I had discovered twelve years earlier and called "Floating Compression". The engineer/architect Buckminster Fuller later made up the name that has stuck: "tensegrity" from tension and integrity.

To define tensegrity is difficult because it has become a buzzword for any object or architectural idea that includes visible tension wires. In my art, tensegrity refers to a lightweight modular structure of three or more compression struts pushing out against a closed network of nonredundant tension wires. The whole system is so arranged that the struts contact only the external prestressed tension network, not one another.

Kenneth Snelson, "Easy Landing", Baltimore, Maryland, U.S.A.

Figure 1: Snelson sculpture "Easy Landing"

I was working in my studio all that year, 1960, building models to learn more about the many tensegrity forms, their modular properties and the puzzle of putting these complicated, often frustrating, structures together. It was an especially exciting time because I knew it was not likely that anyone anywhere had studied the floating compression principle before. I did consider that in some ancient day, in China perhaps, a scholar had traveled the same path, maybe constructing objects out of silk cord and bamboo sticks. If so the record was not to be traced in everyday sources.

In order to move on from one discovered form to another, deciding what to do next, I often asked “what if”. One such question came from noticing the changes that were possible in a single configuration if I altered the lengths of tension members. Put it this way: because the tendons can be lengthened or shortened relative to one another thereby changing the form while still maintaining a stable structure, I might construct a series of transformations and then photograph them in sequence and see the changes in animation.

For example, to see the way the octahedral 12-strut tensegrity form can transform into a cube, I constructed just four stages of the mutation. To do it properly would have required a dozen or more in-between stages. Nonetheless the propeller-spinning of each strut could be clearly seen from one stage to the next.

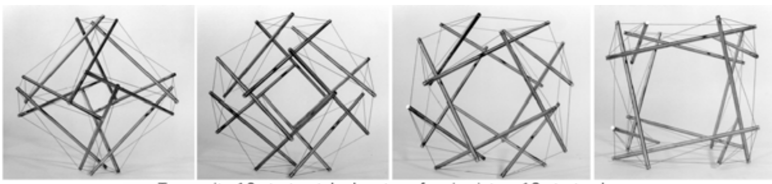

Figure. 2: Four-frame transformation of a tensegrity 12-strut form

This study of spinning rods had distracted me from tension lines and compression struts to focus on the implied cyclical motion within the forms. These traces would of course be circles. In an effort to describe the rotations I first made cardboard disks and taped them together but the results were inelegant and they did not truly define the sticks’ motion planes. They did awaken my interest in looking seriously at hedra composed of circles.

Most opportunities in life arrive by accident. My circle-motion fascination would soon have faded had it not been that my studio was but a short walk to New York’s Canal

Street, which in those years was still a place to go rummaging through stores stocked with odd industrial mistakes and manufacturing surplus items. With my mind fixed on rings and circles I discovered at "Industrial Plastics" a big bin of thin bracelet-like plastic rings. They were light yellow, semitranslucent and mixed 3, 4 and 5 inches in diameter.

Suddenly from puzzling over what kind of circle objects -- washers? large keyrings? -- I might use to construct rings on spheres, I had stumbled onto a supply of perfect rings, more than I possibly could have imagined, ten for a dollar. Seeing this as a rare opportunity I bought three hundred on the first visit and the next day, fearful they would be disappear, I returned to the store and at a very special price emptied the entire bin of somewhat over five-hundred rings.

Back in the studio, I devised a rotating jig for drilling 2, 3, 4... tiny holes in the edges of the rings at the contact positions the particular form required. I began tying them hole-to-hole with nylon fishing line and tight square-knots to create the various circlesphere cages simply from deducing what symmetry choices were likely.

I set only these initial rules, virtually the same ones applied by the mathematicians investigating the problem of economical packing.

1. Non-overlapping small circles must be of the same size on a sphere.

2. The space between the circles, that is the interstitial spaces, must be smaller than a circle's diameter; open nets are disallowed.

Over the following days and weeks I drilled hundreds of holes and with worn and raw fingers I tied hundreds of knots in creating what became an impressive assortment of circlespheres and their spaceframe matrices. In the process of constructing them I quite fell in love with the beauty and order of these unusual objects.

Some of the unit cells are clearly familiar polyhedra except with circle faces but others are uniquely circlespheres with no polyhedron equivalent.

In normal polyhedra, the faces take up the total surface. There are no in-between spaces. In circlespheres the opposite is true: the gaps between circles are concave polygons; triangles, squares, pentagons or hexagons.

Four of the circlesphere forms have triangle interstices only: A 3-circle prism has, top and bottom, two triangle openings. The 4-circle tetrahedron has triangles at the 4 vertex locations. A cube made of 6 circles has 8 triangles at the corner positions. A 12-circle pentic-dodecahedron has 20 triangles at the icosahedral positions.

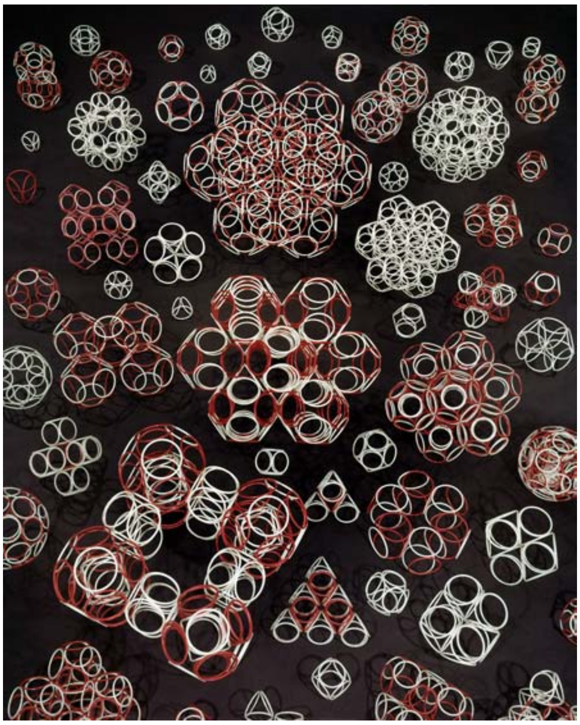

Figure 3: Plastic-ring circlesphere studies

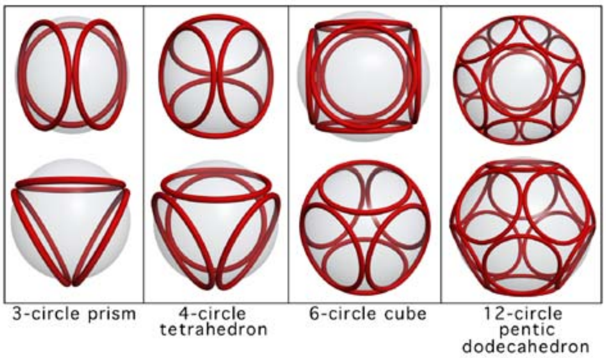

Figure 4: Circlespheres with triangle interstices

A few circlespheres such as the 12-circle rhombic and the 12-circle trapezo-rhombic dodecahedrons have both triangle and square interstices.

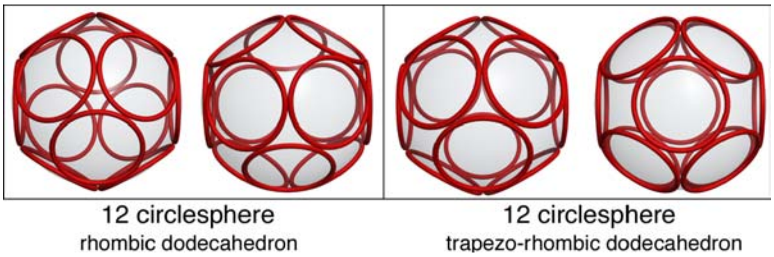

Figure 5: Two twelve-circle rhombic forms

Most interesting though are the figures whose open spaces involve an even number of circles, 2, 4 or 6. These sets can be checkerboarded with 2 colors so that no rings of the same color contact one another.

There are 7 such sets. The list includes the simplest of all: 2 circles in contact straddling the equator. The 2 rings share a common face-to-face interstice but they are assigned opposite colors.

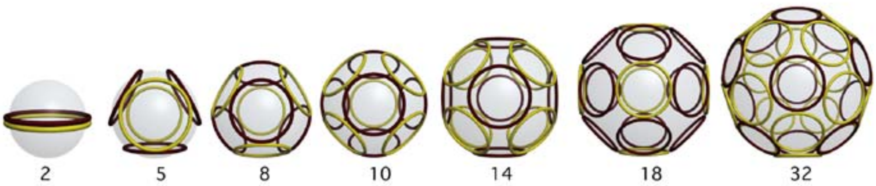

Figure 6: Seven circlespheres with checkerboard alternating colors)

The checkerboard cages are those with 2, 5, 8, 10, 14, 18 and 32 rings.

The 8-circle checkerboard arrangement is octahedral. The 2 other 8-circle figures, an antiprism and a curious figure I call a "bird house", are composed partly of triangular interstices so they do not checkerboard.

Among the 7 binary cages, only the figure with 18 circles, a rhombicuboctahedron, has open spaces comprising 6 rings and is the least sturdy of all the circlespheres.

Because my plastic circles included 3, 4 and 5 inch rings I experimented briefly with the possibilities of using different size rings on a sphere but there seemed to be no way to be certain the varied rings were forming a true sphere. Clearly one might apply any number of smaller and larger circles on a big sphere and arrive at many orders of complexity.

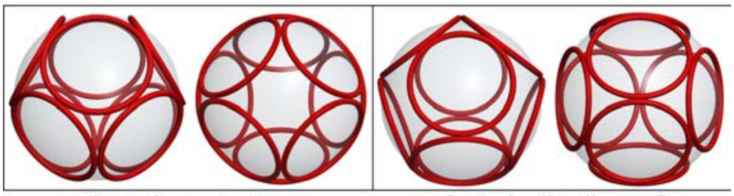

Figure 7: Eight-circle antiprism and “birdhouse” figure

I did discover an interesting fact about the 4-circle tetrahedral sphere: that any size-combination of four rings in tangent contact assembled as a tetrahedron will define a true sphere. I constructed two demonstration devices to illustrate this principle in different ways.

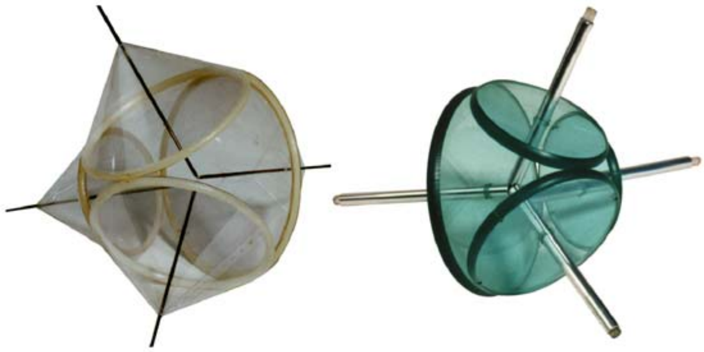

Figure 8: Two tetrahedral illustration devices

After a few months of tying rings together, photographing them and deciding what to do next, I could ook about my studio and see a dense garden of skeletal cells and matrices, including special sets with checkerboard patterns throughout.

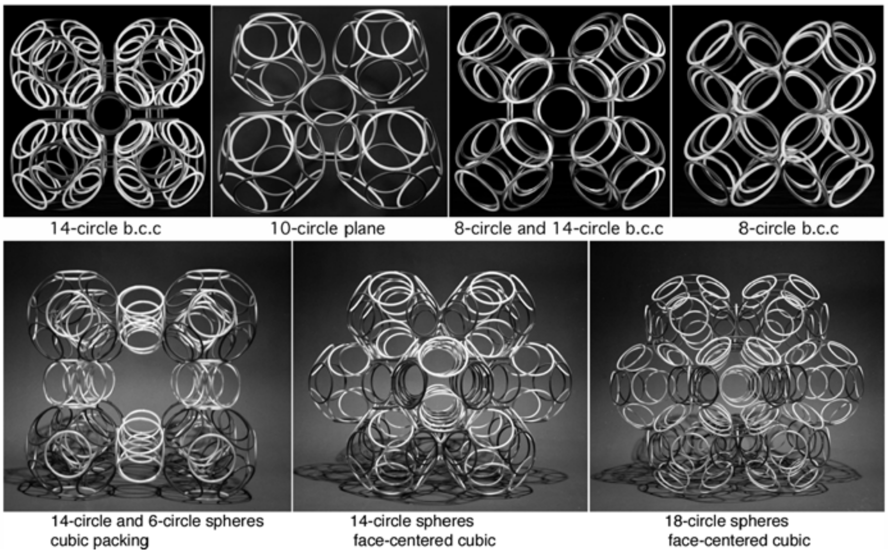

Figure 9: Plastic ring binary-circlesphere matrices

These many cages sat on every available surface; additionally many hung from the ceiling. As the numbers grew I was endlessly delighted to reflect on my good fortune of finding Industrial Plastic's surplus rings, uninteresting to passersby who saw only a bin-full of surplus junk, whereas they had now become a jewel-case of surprising geometrical objects.

It was in May of 1961 I was buying nylon line at a hardware store when my eye fixed on a rack with magnetic refrigerator towel hooks. They were round. Thinking always of the circlespheres and the binary mosaics, I had a flash of association, a link connecting binary checkerboard spheres and the physical binariness of north and south magnetic polarities. Chance and fortune do indeed favor the prepared mind. My mind was on the checkerboarded 8 circles of the octahedral circlesphere so I bought 8 of the magnetic hooks.

Back at the studio I excitedly pried the magnets out of their steel casings. Yes, they were round disks made of ceramic magnetic material and they measured 30mm in diameter by 3mm thick. At the center of each magnet was a 5mm hole; an important detail. I stacked up the 8 magnets with all poles in parallel, that is all facing the same direction, and they stuck tightly together. If I tried to reverse 2 or 3 of them they repelled with equal force. Placing one next to another lying on the table I verified that they were magnetized through the flat surface with north and south poles on opposite faces like heads and tails of a coin – or, as I later learned, like the magnetic field of a current loop of electricity.

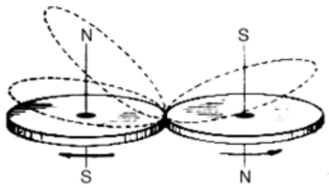

Figure 10: Two magnets antiparallel

With 2 magnets lying flat next to one-another if both had their north poles facing up, their parallel edges repelled one another. If I flipped one magnet over, their edges clicked together: magnetic antiparallel. So that's the way their fields of magnetism work.

Could they be made to connect successfully if placed in the proper positions of the 8-circle sphere? I tried in every way possible to hold them and make them stand up to form an octahedral circlesphere but they simply collapsed in a jumble. Apparently they needed to be somehow mounted in position so I constructed a brass and plastic armature to loosely support the magnets in the octahedral face positions.

Setting each one on its own axle, north to south, north to south, they magically clung together edge-to-edge on the armature, forming a perfect octa-circlesphere; astonishing how they linked one-to-another. I found that if I held any one of the 8 with thumb and forefinger and turned it like a wheel, surprisingly, the entire set followed along, an 8-gear differential.

Figure 11: 8-magnet circlesphere mosaic

No single learning event in life has come close to the elation and wonder I felt at that moment, discovering a quite unexpected relationship, straight from the core of the cosmos, so it seemed to me: a marriage of natural binary principles. The first, a fundamental mathematical property of symmetry points on a sphere; the second, the simple bipolarity of north/south magnetism. Clearly the 8-circle magnet cell was but one of seven checkerboard circlespheres that could perform in the same remarkable way.

I ordered a quantity of magnets from the manufacturer and constructed the remaining six checkerboard spheres, going on then to make examples in which the north/south association of the individual cells are continuous through an endless magnetic circlesphere spaceframe.

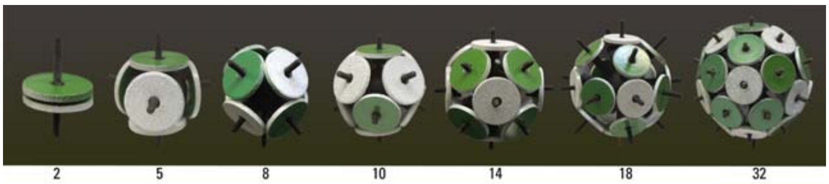

Figure 12: Seven circlesphere magnetic mosaics

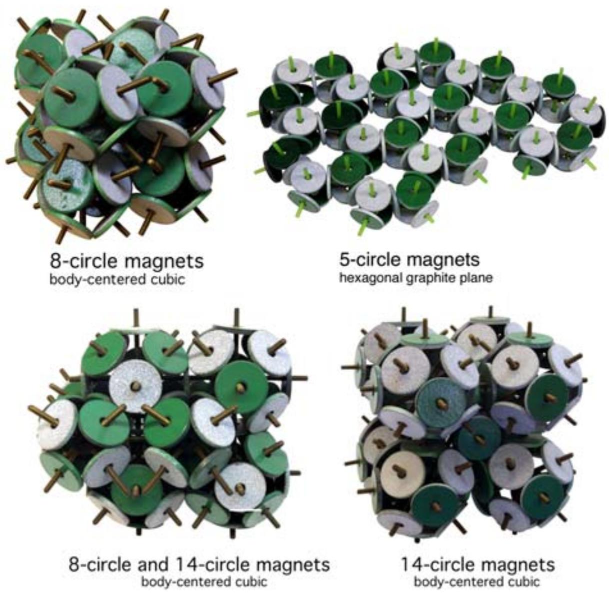

Figure 13: Magnet circlesphere matrices

If instead of permanent magnets these matrices were composed of current loops the electrons traveling in the wires would also be moving in the same clockwise/counterclockwise three-dimensional, endless, chain.

Years later when I could finally think far enough distance from my circlesphere occupation I made what seems now an obvious extension of the magnet mosaics: The checkerboard principle works just as well with certain normal polyhedra by using flat polygon shaped magnets polarized on opposite faces. The polyhedra that can be checkerboarded include the octahedron, the cuboctahedron, the rhombicuboctahedron, the icosidodecahedron, the rhombicosidodecahedron, and others.

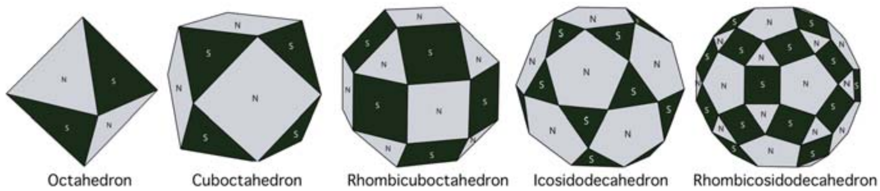

Figure 14: Five, magnet-polyhedra

Like the circle magnets some of the magnet polyhedra can translate indefinitely as endless magnetic space frames. Unlike the circle-magnet spheres these systems are self-supporting without armatures.

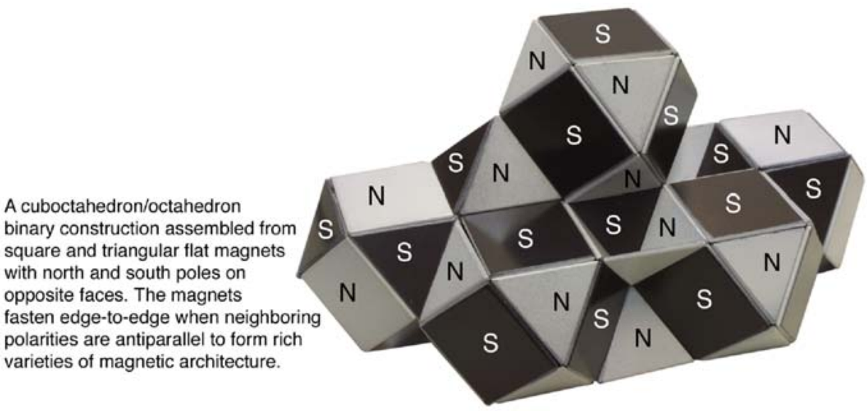

Figure 15: Magnet, octahedral-cuboctahedral, architecture

Following my initial amazement in discovering the spherical magnet-mosaics I began to consider if they might have a relationship somehow to familiar works of nature: "Salutations, nature. I've just invented a little something –- a correlation between magnetism and geometry -- which despite your labors and eons of principle-juggling in every realm, you know nothing about!" Yes, indeed.

Might these magnet spheres somehow have a connection to radiolaria? Those beautiful single-cell sea creatures are more or less spherical. Though they do have geometrical structure they are not known to link one-to-another in complex arrays via magnetism. No, my wonderful magnet objects definitely were building blocks, not isolated creatures.

Consider the most elementary facts about atoms: that they bond one-to-another in many kinds of order; that electrons in atoms are the source of the active magnetism in the round magnets; that electrons fill the atom's shells in discrete numbers; that the textbook numbers of electrons in the shells and subshells: 2, 6, 8 ,10, 14, 18 and 32, were tantalizingly close to the numbers of magnets in the checkerboard spheres: 2, 5, 8, 10, 14, 18 and 32. It was such similarities as these that drew me to thoughts of magnet spheres and the atom.

Those who have studied even a limited amount of physics and also those who have read about the quantum atom and the quantum revolution which began at the first part of the last century know that science does not know what an atom would look like if we could magically shrink down to the submicrocosm and try to see it -- nor how the atom's electrons do their work to create its amazing performance as a tiny electro-mechanical device. For this reason all atom models are inventions of the mind based on some kind of analogy from the visible world.

Analogies of various sorts were chosen for early models from 1900 to 1924 including a culinary one, J.J. Thomson's plum pudding model. The Lewis-Langmuir octet atom referred to the geometry of a cube. Best known is Neils Bohr's Solar-planetary electron atom. The current standard one, Erwin Schroedinger's atom, has been likened to vaporous clouds.

I had in mind a new analog model based on the circlesphere geometry and the properties of the magnet mosaics. But how?

Other than student recollections of college physics I knew little about the history of the atom or contemporary theories. It was only through wishing to resolve my new dreams of geometrical atoms that I begin to go deeply into the subject of atom models and to start collecting what became a very sizeable library of atomic physics and the history of the atom starting with Democritus and Leucippus in ancient Greece, the Roman poet Lucretius and on to many contemporary works on atomic physics and spectroscopy. I was not trying to learn about the intricacies of the nucleus, only the whole atom and its electrons.

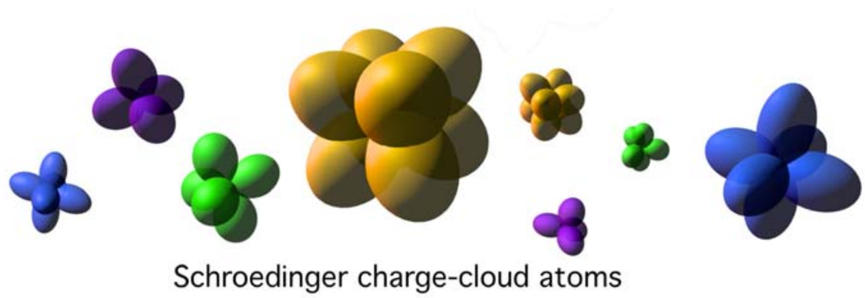

Figure 16: Schroedinger charge-cloud atoms

I found a handful of 20th century models and a host of special case models, most of which were in spectroscopy and these were replete with Zeeman effect, Paschen-Back effect, Grotrian diagrams plus curious labels for the ordering of electrons for different purposes. Many designations -- "s" electrons, "p", "d" and "f" electrons -- have traveled down from nineteenth century spectroscopy. The series of letters, referred to as "quantum numbers", stood originally for "sharp", "principal", "diffuse" and "fundamental" as people tried to decipher the spectral lines. When more labels following "fundamental" were called for they simply proceeded in alphabetical order: "g", "h", etc. Much of the terminology was coined and established years before anyone understood that it was the atoms' vibrating electrons that were the cause of the lines.

It was not until the discovery of the nucleus in Ernest Rutherford's laboratory and Neils Bohr's 1913 planetary model of the hydrogen atom that the mystery of the spectral lines and the form of the atom began to come together. Bohr's atom gave the world a simple picture to hold on to, an image of the building block of all matter. Considering the enormous advances in science's understanding of the atomic world since that time it does seem remarkable that Bohr's first glimpse into a very complex submicroworld has become the global image for what atoms ought to look like. Students at any level who first encounter the atom through physics or chemistry classes are taught first about the Bohr planetary model and then are instructed to forget it since it is all wrong. The concept of electrons encircling the nucleus like planets is indelible though. Its ghost dominates even the Schroedinger charge cloud model with its ellipsoidal electron lobes imitating the shape of the 1916 elliptical orbits of the physicist Arnold Sommerfeld as auxiliaries (p, d, f…) for Bohr's circles. Through talking with scientists over the years it has become clear to me that they too cling to the image of electrons encircling the nucleus like planets despite years of study in the formalisms of quantum physics.

By 1930, because the Heisenberg uncertainty principle demonstrated that any attempt to trace an electron in orbit would prove futile, atomic physicists decided to ban all models that tried to define the workings of the atom's electrons. The last such successful physical atom model arrived in 1924, the French physicist Louis de Broglie's matterwave adaptation of Bohr's 1913 planetary picture. No additional ones have been recognized since that time.

With my wish to construct a circlesphere model my best hope was to begin with Louis de Broglie whose ingenious insight proved that material objects have a wave aspect, mirroring Einstein's discovery that radiation, light waves, have a particle aspect, photons.

De Broglie pictured the hydrogen atom's lone electron, not as a tiny missile racing in orbit, but as a circle-shaped standing-wave like a vibrating guitar string surrounding the nucleus. Like Bohr's particle electron, the matterwave inhabited only fixed orbits on electrical spheres quantized in steps like notes on a keyboard. The wave-orbits, starting with the smallest, were numbered, 1, 2, 3, etc., the atom's system of shells. In order to transfer up or down from one sphere to another the electron was required to perform electrical work, taking in or giving off specific amounts of energy, photons.

In physics or chemistry textbooks one finds only a brief passage on de Broglie's atom, stating that the matterwave's length depends on the electron's velocity. The faster it moves the shorter its wavelength. Major emphasis is placed on the fact that at each larger circle surrounding the nucleus the electron includes an additional whole wave; that the orbit closest to the nucleus, called the ground state, has one wave, the second shell two waves, the third, three, the fourth four.

Examining de Broglie's model more carefully I found another curious property, not really hidden but certainly never commented on. It actually came from Bohr's solar system atom following the law that planets more distant from the Sun travel slower than those closer-in. Similarly, the pilot wave electron in the de Broglie model changes its velocity according to what shell it is orbiting. The slower the electron travels the greater is its de Broglie wavelength and vice versa. Remarkably, the matterwave grows longer at each level from the ground state on up, by exactly the length of the ground state's circle. Shell 2's two waves are each twice as long as the ground state's wave making its complete orbit four times the circumference of the ground state. Shell 3's waves are three times the ground state orbit, making its circle nine times as long. Shell 4's four waves are four times the ground state's wavelength making its orbit sixteen times as long. This phenomenon highlights how beautifully musical a structure the atom must be.

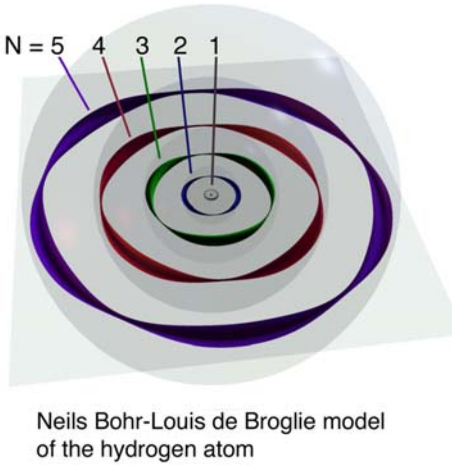

Figure 17: The Bohr-de Broglie hydrogen atom

If indeed anyone attended closely to this wave-growth aspect of the de Broglie atom his response most likely would have been, "so what?" But to me it indicated how the atom uses this elegantly simple quantization principle to provide itself with a vast inventory of geometrical variations even for the one-electron hydrogen atom.

To follow the argument requires only that we set aside the fixation that electrons must encircling the nucleus like a planet in the thrall of gravity. Consider instead that electrons belong to their own world and have their own unique structure. In my model here is how matterwaves do their work: The modular change of the de Broglie wave from shell-to-shell tells us that at each level or sphere the electron has a specific velocity and therefore a set wavelength. One way to put it is that the electron is locked on autopilot. At each particular sphere it has a vibration frequency like a musical tone which it uses in that shell and at no other.

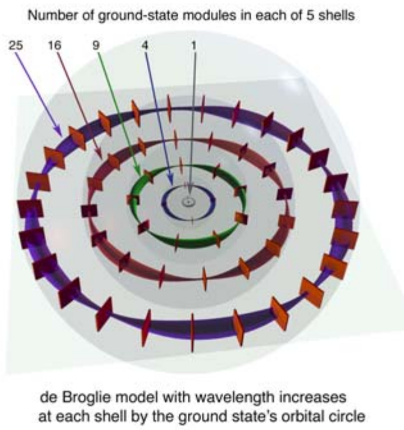

Figure 18: De Broglie matterwaves with measured markers

I propose that admission to the shell is dependent not on the electron's encircling the equator but only that it show up with the correct wavelength and velocity. This means that a two-wave orbit around the equator, a great-circle, can transform itself into a one-wave small-circle orbit -- not surrounding the shell's equator but rather in a small-circle off-center cap on the sphere. Again, I emphasize that both of these matterwave orbits have identical wavelengths. It is simply that the 2s orbit has two such waves and the 2p, small circle state, has only one wave. But let us see how this process works out for the larger shells.

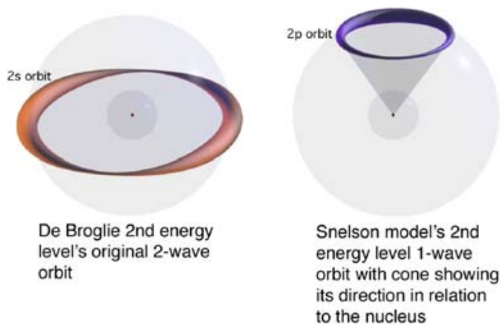

Figure 19: Second shell showing the 2-wave orbit and 1-wave orbit

At the third shell, recall that the de Broglie model provides the matterwave with three whole waves at the equator. By the shrinking the three waves into two the electron acquires a two wave (3p) state. The maximum contraction produces a one-wave halo orbit.

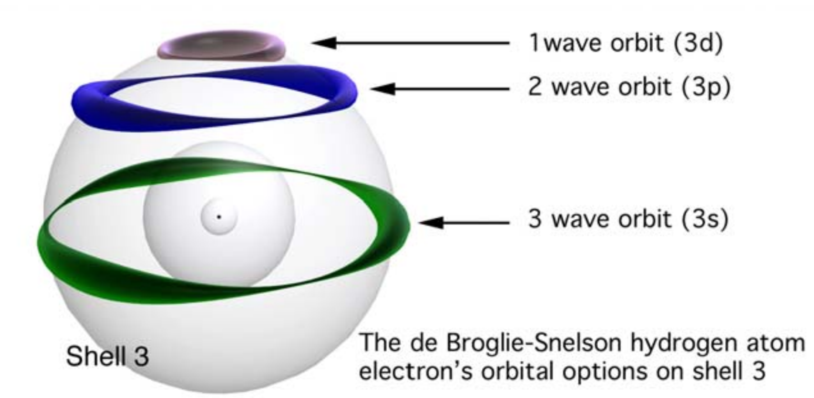

Figure 20: Third shell with 3-wave, 2-wave and 1-wave orbits

At the fourth shell, the four-wave equatorial orbit can transpose into a three-wave (4p) orbit, a two-wave (4d) or a one-wave (4f) orbit. At shell five the five wave (5s) de Broglie equatorial orbit can become a four-wave (5p) orbit, a three-wave (5d) orbit, a two-wave (5f) orbit or a one-wave (5g) orbit.

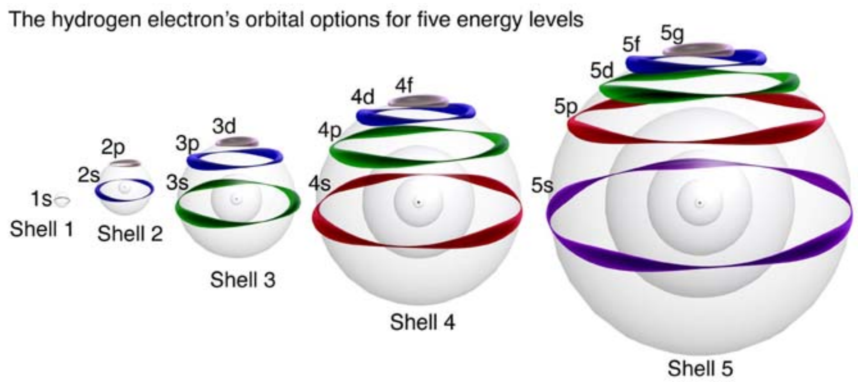

Figure 21: Five shells: the hydrogen electron's matterwave options

I hope it is clear that with this assortment of orbits the hydrogen atom's electron can be at only one place at a time. These so-called "auxiliary orbits" are those locations where the electron can climb to or fall from. They are transitory. Energy coming into the atom lifts the electron momentarily to a higher level and it descends once again to its most likely residence, the ground state.

For the circlesphere model this principle produces the auxiliary orbits required for each shell: "s" state, "p" state, "d" state, "f" state, etc. Of course this mechanism for the electron's energy states is unthinkable if we can think only of planets. If we give it consideration as a wave phenomenon because it works in terms of the optional orbits, it then makes admirable sense.

In that de Broglie's model addressed only hydrogen with its one electron no one has ever proposed how the plurality of electrons in heavier atoms would be arranged if his model had gone that far. Would they all crowd around the equator? In my model the matterwave orbits have the exclusionary property of larger pieces of matter. They actually fill their own space like genuine objects and cannot encroach on another's space without interfering with the integrity of the wave. The energy needed to upset the matterwave is the energy that would be needed to eject the electron from the atom.

The matterwave's solidity barrier is in itself a force: when pushed against it pushes back. The mystery of why matter occupies space -- why two things cannot be in the same space at the same time -- remains a mystery even if, as I propose, the threshold of solidity is not at the atom's edge but rather at the periphery of the individual electron matterwave. Light waves pass through light waves unimpeded; matterwaves do not pass through matter.

For atoms with many electrons the prime equatorial space is unavailable because of the common demand for territory. As in a crammed elevator they push one another, forcing the entire shell's assembly into one-wave orbits and into the most economical spherical pattern available. The goal always is to settle on the lowest energy state like water seeking its level in a pond. It is here that the circlesphere magnetic connections enable neighboring electrons to associate more economically.

In brief, then, here is my artwork atom: The electrons are circle-shaped standing-wave objects that occupy exclusive space. Each matterwave is a perpetual, friction-free, disturbance on an equipotential sphere. The electrical sphere on which they ride is real only because the electrons give it form. Without them the protons' electrical field is but a force radiating from the nucleus but without punctuation.

The electron orbits are individual devices, each equipped with five distinct forces through which they interact with one another:

1. Pauli solidity: De Broglie's matterwaves posses a barrier property enabling them to exclude one-another. Thus the solidity of material objects begins at the atomic level with the individual electron. All structures need both tension and compression. While electrical attraction to the nucleus is the atom's tension strength, the matterwave's solidity is its compression resistant strength.

2. Negative charge: The particle electron's negative charge. It is the electrons' attraction to the nucleus that binds them to the atom: a tension force. In a normal atom electrons and protons neutralize electricity. In orbit this negative field is evenly distributed throughout the circular matterwave.

3. Spin: Particle electrons, even outside the atom, have an intrinsic magnetic and top-like property called "spin". No one knows if electrons actually spin but magnetic deflection experiments make it seem so. For my model, I invoke spin as the standard model does except that in a charge cloud lobe where there is no electron trajectory it is quite ambiguous to declare that a spinning top is pointing "up" or "down". In my model the electron's top-like orientation can be in the same direction the electron travels within the matterwave orbit or by inverting it can "spin" in the opposite direction.

4. Orbital Magnetism: A second magnetic field which arises out of the particle's electrical charge circling in orbit -- analogous to the magnetic field created by current flowing through an electrical current loop. Orbital magnetism can be either added-to or diminished by the orientation of the electron's spin; an energy-conserving toggle.

5. Angular Momentum: The electron's tiny mass revolving in orbit gives rise to a gyroscopic force that adds to the wave-orbit's stability.

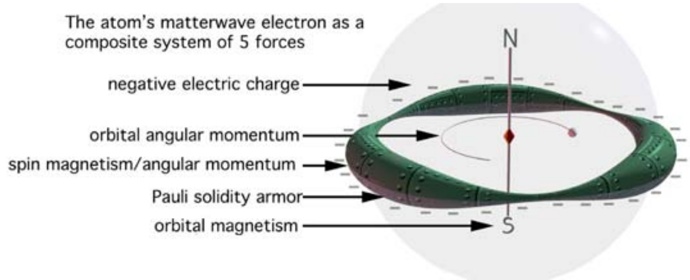

Figure 22: The de Broglie atomic matterwave orbit's suite of five forces

As individual ring shaped modules the matterwave orbiting electrons are the atom's building blocks. They keep one-another out but they can adhere through magnetic attraction. In constructing an atom the electron waves fill up the shells one-by-one and when a shell becomes crowded the next members start a new shell. Magnetism plays a significant role in designing the shell's circlesphere configuration.

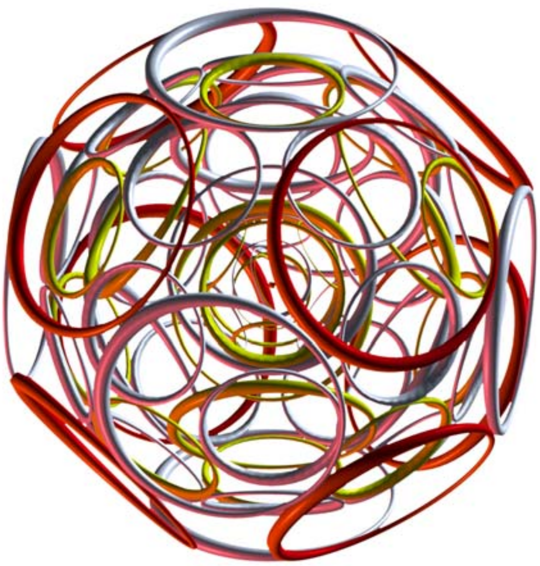

Figure 23: A many-electron atom

Though orbital magnetism's attraction between electrons is calculated to be a hundredth of the strength of their mutual electrical repulsion, I believe the atom's use of its magneticly equipped matterwaves is much underrated. The fact is, the electrons in the atom's positive electrical sphere neutralize electricity so their repulsion one-to-another is depleted. By analogy, an object submersed in water weighs less according to the water it displaces. A similar effect influences electron-to-electron repulsion and this enables the orbital and spin magnetic forces to be effective in determining the arrangement of the shell's electrons.

Though they are but pseudo objects, ethereal pathways of perpetual motion, they are the atoms-within-the-atom that give form to its unique structure. They are the substance of all the things we know as matter from a puff of steam to the hardness of a diamond.

My atom model has been shown in art museums as well as science museums. For the purpose of publishing I have been granted two U.S. mechanical patents defining the model's magnetic/geometric principles. A web search will turn up numerous links connecting educational websites to the "Snelson Atom".

Again, this is a work of art and speculative reasoning, not science. Even so, over the years I have enjoyed discussing my atom model and corresponding with many scientists including Linus Pauling, Richard Feynman, Philip Morrison, Eugene Wigner and Hans Christian von Baeyer. None have given it a ringing endorsement. One physicist said, "Just because it's beautiful doesn't make it right." Another said, "It's just not the way an atom ought to look."

Science writers advise us over-and-over that to reach down into the quantum world is to enter a realm so unfamiliar, so strange, that we should not expect things to make any sense. It is no doubt this self-fulfilling belief that has kept scientists from arriving at their own reasonable model of the atom's electron structure. The choice of appropriate geometries is limited and it is certain that when the atomic physicists' peculiar world-view concerning the atom swings in another direction, as attitudes do over time, the phenomenon of circlespheres and their association with magnetism will be discovered as a rich field to explore.

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