AN ARTIST'S ATOM

KENNETH SNELSON

ABSTRACT

The author discusses an ongoing work of art, visualized with the help of a graphics computer. Because quantum physics is mathematical and non-pictorial, laypeople find it nearly impossible to understand how the atom's electron structure works. The artist's purpose is to develop an architecture for the atom, a model appealing to the visual mind. More and more, largely through the introduction of graphics computers, people have come to expect pictures of virtually everything. The art work described here attempts to help in this way in regard to the building block of matter, the atom.

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The diversity of art in galleries and museums in the last decade suggests there are as many directions in art as there are facets of civilization. Much mainstream art lives close to literature, politics, philosophy, poetry, technology or theater.

My interest has been in the countless ways nature provides for organizing physical forces to form structures. My sculptures (Fig. 1) have been linked variously to constructivism, engineering, mathematics or science. The fact that I was schooled in art makes me feel most comfortable with the constructivists because, at root, we share a common interest: that of putting together separate parts to create a new whole.

For a long time I have been attracted to the mystery of that primal natural structure, the atom, an interest that has produced an art work which I call a "Portrait of an Atom" -- expressed in pictures, sculptures and writing. In this paper for Leonardo, I have used a graphics computer for the images.

As a sculptor, I've longed to see a lifesize replica atom, perhaps with robotic controls, to watch it perform its virtuoso assortment of tricks and tasks; of transmitting light and, catching it again, expanding and contracting; of linking up with its sisters, brothers and cousins to form huge chains of geometrical precision; to see it demolished only to self-reconstruct; to watch its host of electrons flashing about the nucleus, forming the frictionless perpetual motion machine that a real atom is.

Within the mechanism of those magical spheres of electrons, I perceive the supreme poetry and mystery of nature; a wondrous work whose details are still an unsolved riddle.

My atom piece grew out of the kind of disappointment many inquisitive people have with science's mathematical, non pictorial, atom which invariably leaves the visual, non algebraic, mind feeling deprived of real understanding. I believe the reason that visualizations are limited goes back to the twenties and thirties and those men who laid the rules for what was admissible and what was not in the "new quantum theory" after Werner Heisenberg discovered his famous uncertainty principle. The tone of the time comes through in a quote from the great physicist, Max Born, Nobel winner for his interpretation of quantum wave mechanics: "not every question about atoms can be answered, but only those questions which are compatible with Heisenberg's principle of uncertainty... What lies within the limits is knowable ...What lies beyond, the dry tracts of metaphysics, we willingly leave to speculative philosophy." To me, this says that artists are granted title to the plot of ground where atom models grow. Perhaps artists are indeed the last of the metaphysicians and speculative philosophers.

In constructing my invented atom, I have freely rummaged through science's literature to resurrect models of the past, selecting a useful feature from this one and adding it to parts of another. The work of Niels Bohr, Louis de Broglie, G.N. Lewis, Irving Langmuir, Alfred Parsons and even Erwin Schroedinger's statistical description are part of my picture. Most come from a time when models purporting to show how electrons move around the nucleus were not yet banned. All of them are interesting and each has reasonable questions to ask. It is hard for me to believe that throughout the vast universe of space and time, all civilizations coming up against uncertainty in the submicrocosm simply put an end to speculative reasoning which, in other fields, produces feasible theories about the unknowable. My aim is an attempt in this direction, to design an atomic building block which a thoughtful Creator might have planned while endowing basic matter the same reasoned beauty as the rest of the universe. Being not quite God, I have not created a model which explains everything, but it does pose interesting questions. Since space here is limited for discussing its many features, I hope that each computer generated image and caption will be worth a thousand words.

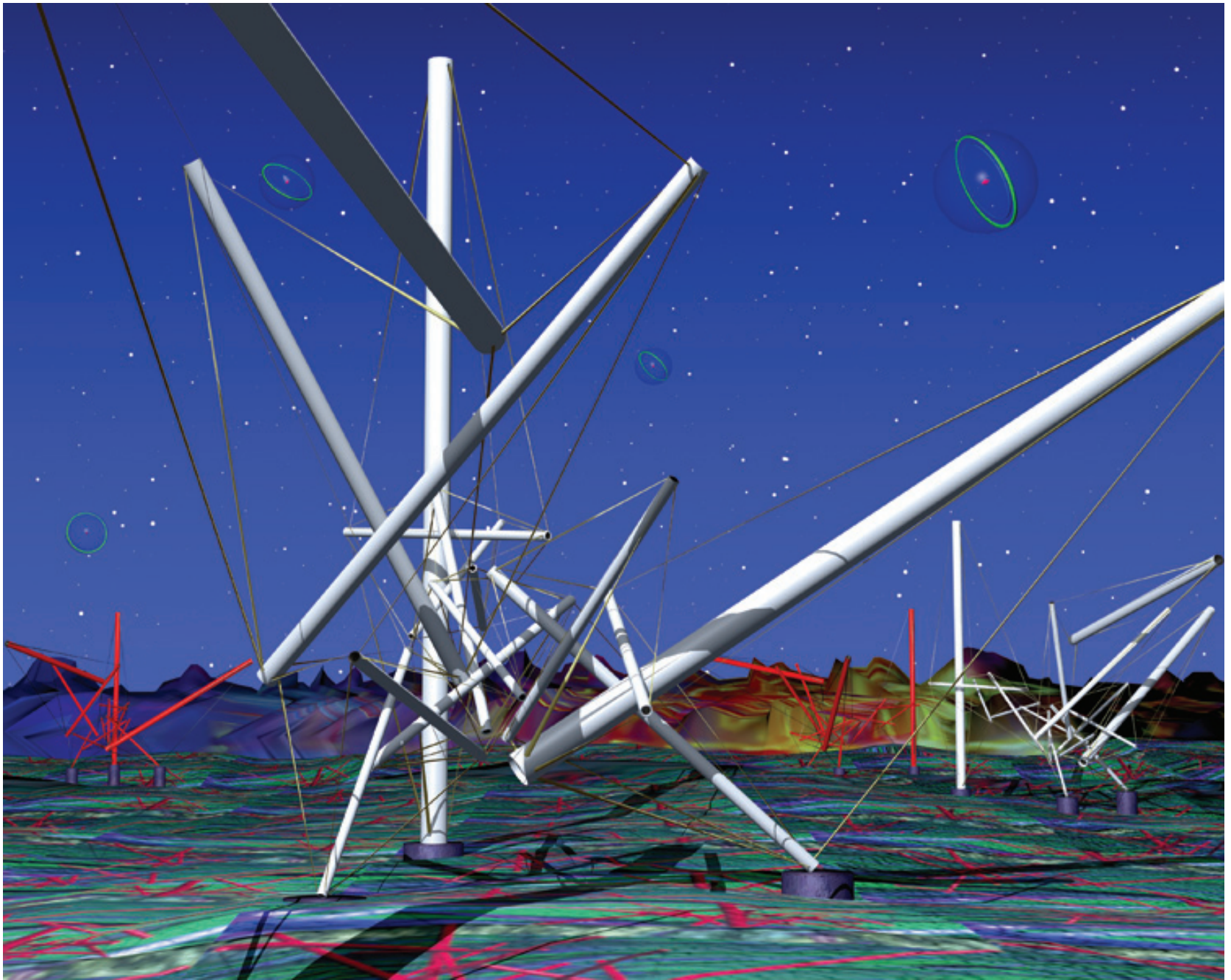Kenneth Snelson with his Silicon Graphics 3130 workstation, 1988

Fig. 1 *Forest Devils' Moon Night,* 1991

A computer generated image of my sculpture, *Forest Devil*,
sited somewhere beneath the moon of another world.
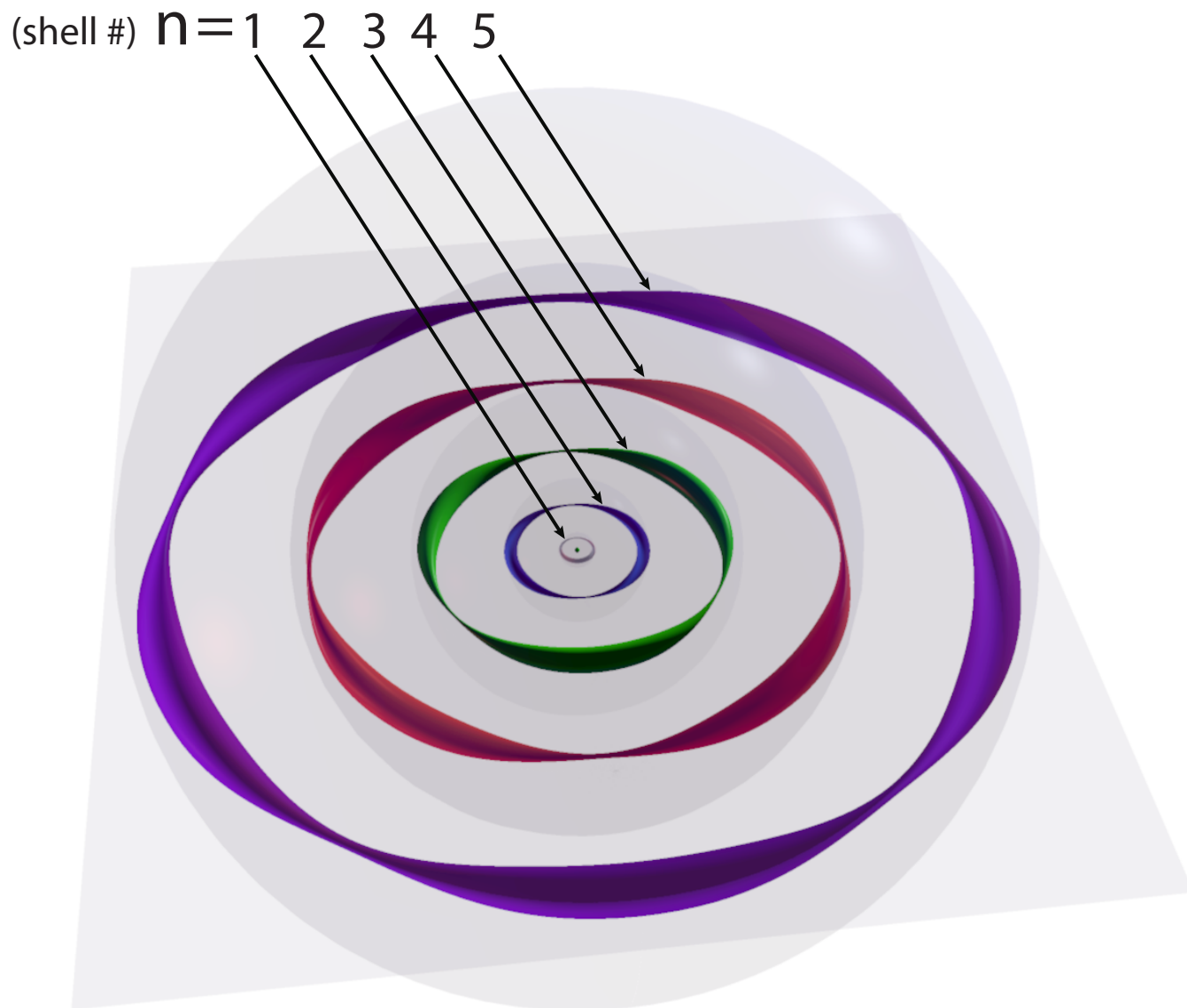
(shell #) n = 1 2 3 4 5

Fig. 2 BOHR-DE BROGLIE HYDROGEN ATOM MODEL

The Niels Bohr-Louis de Broglie hydrogen atom is flat, not spatial at all, but elegant, nonetheless. Described as a "wave of matter", the electron in its orbit travels on specific race tracks around the nucleus. It jumps from one orbit to the next only by receiving or transmitting energy (light). Just as Bohr's earlier model required the electron to perform electrical work when moving from shell to shell, so does de Broglie's. To maintain the proper wavelength at each shell the electron encircles at a unique distance from the nucleus. In the first shell, where it travels fastest, its matter-wave is shortest of anyplace in the atom; there it can fit in one vibration, a single wave like a snake grabbing its tale. In the second shell it fits in two waves, in the third shell, three, and so on.
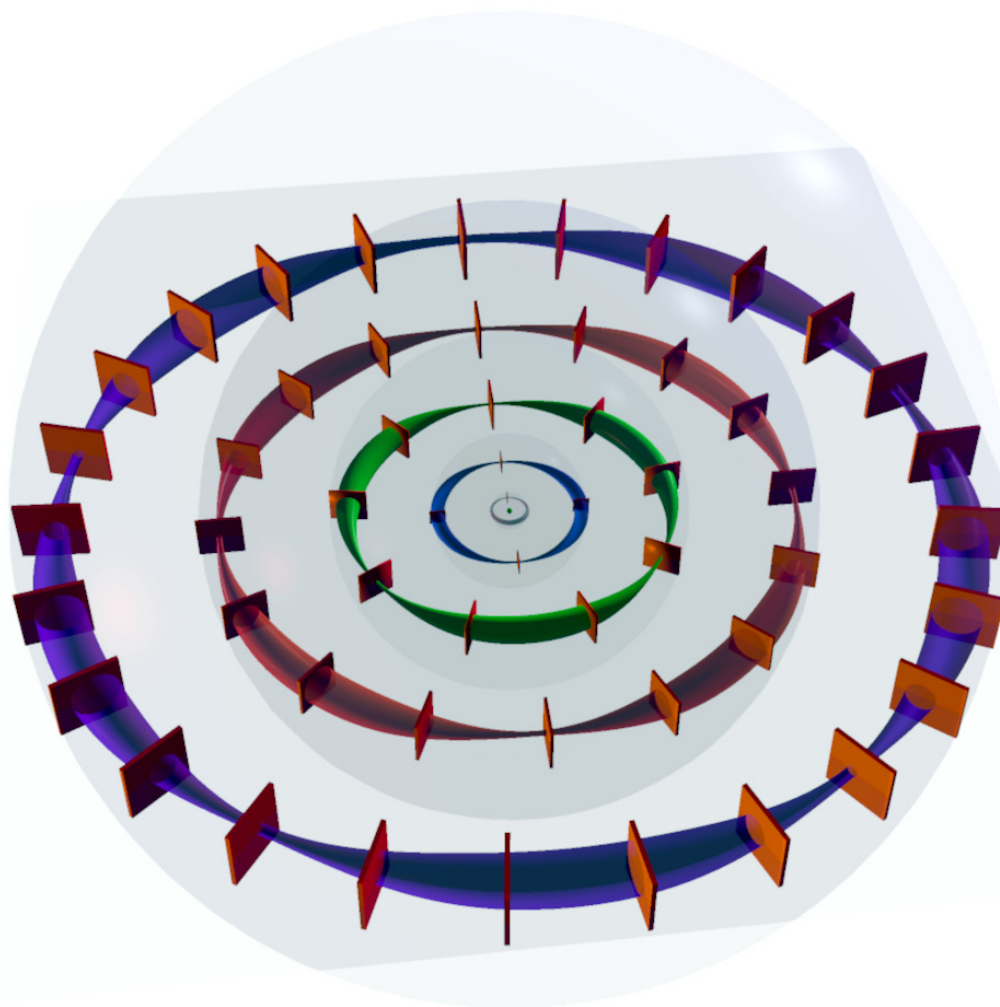
Fig. 3 ***QUANTUM MARKERS ON THE BOHR-DE BROGLIE ATOM***

QUANTUM MARKERS ON THE BOHR-DE BROGLIE ATOM

This embellished Bohr-de Broglie picture is to illustrate a remarkable quantum feature inherent even in the one-electron hydrogen atom. The square hurdles positioned around the matter-wave orbits are equal-space indicators. The distance between adjacent hurdles, regardless which shell, is the exact circumference of the first shell orbit; the electron's lowest rung on its energy ladder. When the electron rises or drops to a higher of lower shell, its matter-wave lengthens or shortens by its quantum measuring stick, the ground state module.

As shown in the illustration, at shell two each of the two waves is twice as long as shell one's wave. At the fifth shell, where the orbit contains five whole waves, each wave is five times the length of the first shell wave. This makes the entire fifth shell orbit twenty-five times as long a trip for the electron.

The important point is that every shell in the atom requires the electron to have its assigned wavelength, a passkey that admits the de Broglie orbit into that shell. It is forever on automatic pilot, locking in at an exact altitude from the nucleus and correcting its velocity and wavelength depending on which energy sphere.

DE BROGLIE-SNELSON MATTERWAVE ORBITS

ONE-WAVE ORBIT

Appropriating Louis de Broglie's matter-wave orbit, my model describes the electron as a circular wave. Inside each donut orbit the particle electron is a blur, its negative electrical force diffused equally over the entire circular course. It transfers from one shell to another only during an energy transaction, taking in or transmitting light.
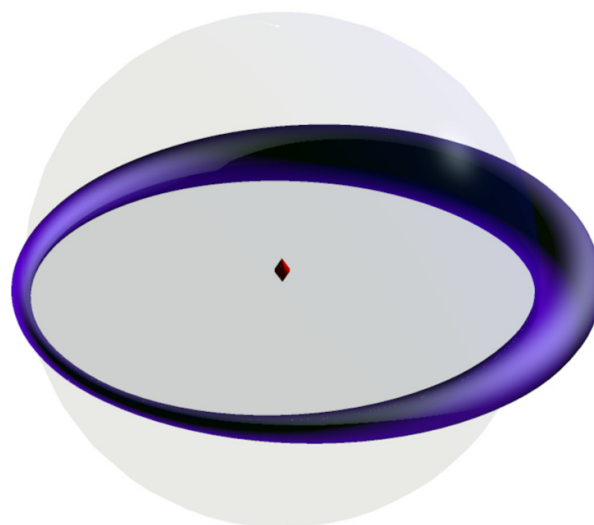

Fig. 4 **ONE-WAVE ORBIT**

SHELL TWO'S OPTIONAL ORBIT

In order to provide the Bohr-de Broglie atom with three dimensionality, my model offers the electron at shell two, where two whole waves are expected, a one-wave, auxiliary, state. In this optional role the electron reduces its circumference by one whole wave. Keeping its wavelength and velocity the same, the two-wave state is collapsed into a one-wave halo orbit. The picture includes a transparent cone in order to show that this halo orbit, since it is not centered on the equator, projects in a specific direction from the nucleus.
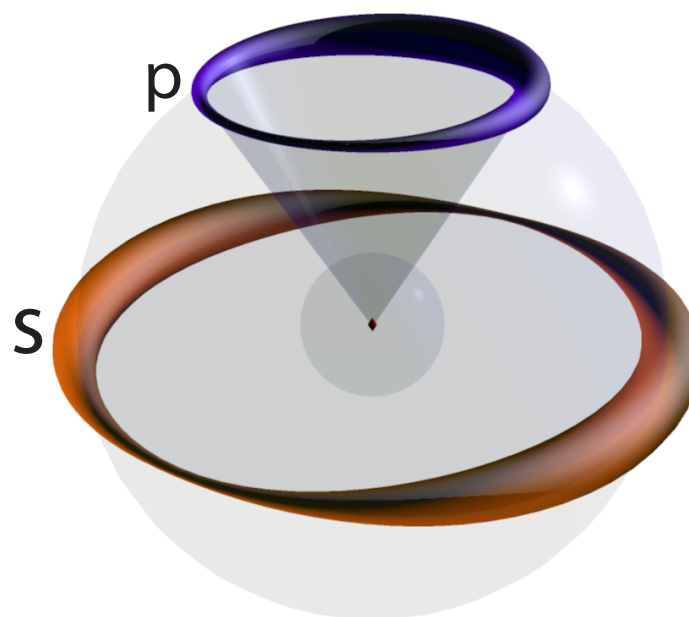

Fig. 5 **SHELL TWO'S** "S" **and "p" ORBITS**

THE THIRD SHELL'S *s, p, d* ORBITS

At the third shell where a three-wave orbit is expected, the electron gains yet another auxiliary form. It has the following choices available for its geometrical uses and energy needs:

(1) Its de Broglie three-wave "s" state surrounds the equator;

(2) It can choose a shortened, two-wave, "p" displaced, orbit;

(3) In a final shrinkage it becomes a one-wave, "d", halo, orbit. Again, the cone from the nucleus shows how the one-wave orbit becomes an index pointing out from the nucleus. Folded in this way, the "d" state's orbital magnetism is concentrated in a space one third that of its 3-wave "s" orbit. By this means, in my model, atoms achieve bonding contact with their neighbors.
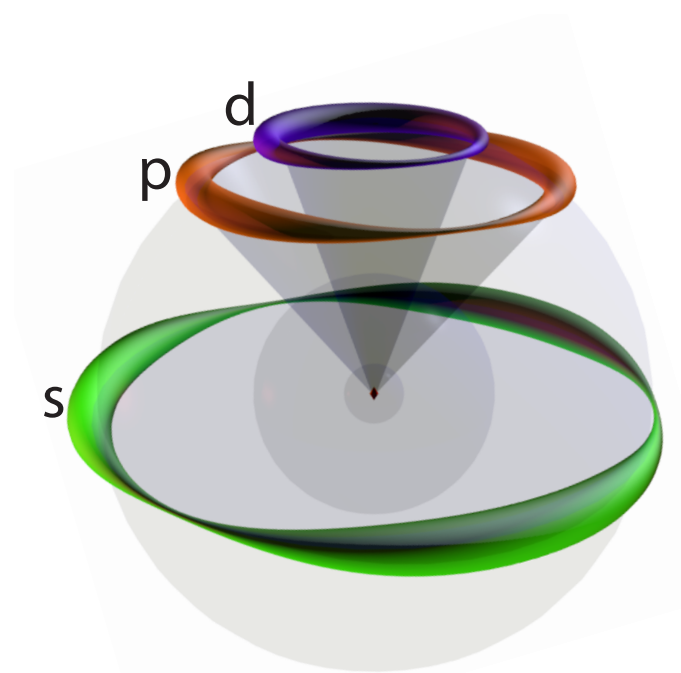

FIG. 6 **SHELL THREE'S *s, p and d* ORBITS**

AUXILIARY ORBITS

Shown here, superimposed, is the hydrogen electron's orbital options for shells one through five. The electron can be at only one of these energy levels at a time. Except for the ground level which is its home base, each energy state is a momentary, storage position for incoming and outgoing light. Those orbits lying on the equator are from de Broglie's original model. The off center orbits are from the Snelson model. With these choices the atom has endless three-dimensional flexibility.
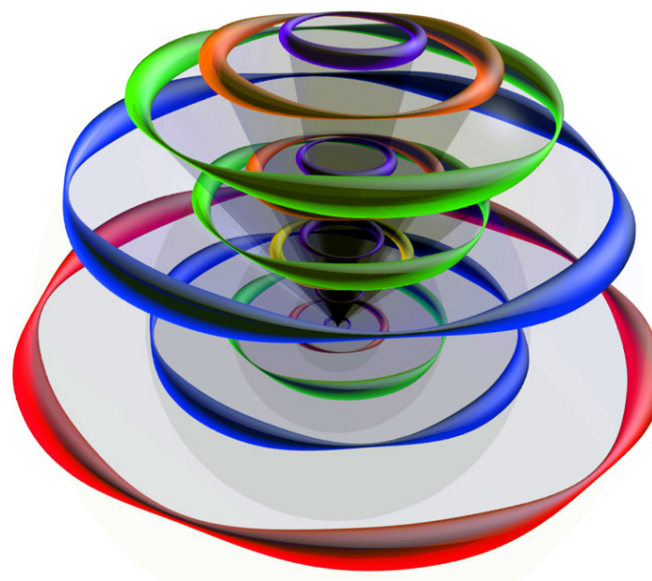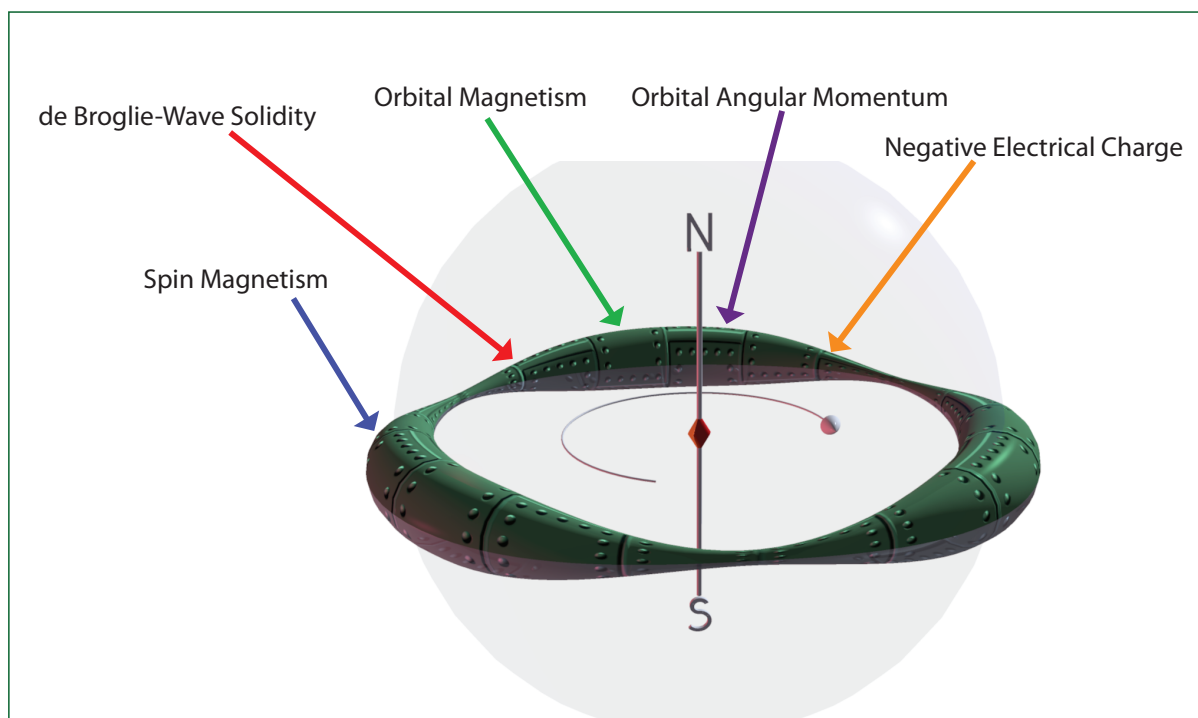

Fig. 7 AUXILIARY ORBITS

FIG. 8 *ARMORED ORBIT WITH ARROW INDICATORS*

de Broglie-Wave Solidity

Orbital Magnetism

Orbital Angular Momentum

Negative Electrical Charge

Spin Magnetism

N

S

ARMORED ORBIT WITH ARROW INDICATORS

Each matter-wave comes equipped with a set of five forces enabling it to act as a self-contained engine. In addition to its negative electrical charge which binds the electron to the atom, and its inherent spin magnetism the circulating charge generates its own orbital magnetism. This is a primitive current-loop magnet with north on one face and south on the other -- like heads and tails of a coin.

A forth force also arises from the particle electron's circulating motion. The orbiting mass of the particle generates an angular momentum, giving each orbit the stability of a guidance gyroscope.

What possibly can be the meaning of the steel cladding in the above image? It is only a graphic way of noting that matter-waves are different from light waves that pass through one another like ectoplasm. The riveted steel is a metaphor for the electron wave's powerful cushioning against encroachment by other electrons. The de Broglie matter-wave is its own shield; and its effectiveness depends not merely on electrical repulsion but on a space-filling phenomenon known as Pauli's exclusion principle. Pauli's numbers are a kind of inventory system needed to label electron energy levels. For my needs, I prefer to consider that it speaks of a physical phenomenon -- an as yet unnamed force that amounts to the sum total of what we know as solid matter -- of why we cannot walk through walls or pass our hands through tables. This elusive yet ever-present force finds its threshold at the individual electron's orbit and provides the atom with its "bones", the compressive strength that enables matter to behave as *matter* rather as light. Thus, the atomic electrons meet one other not as tiny flying objects jostling about the atom but as building blocks, each with its own set of useful forces.
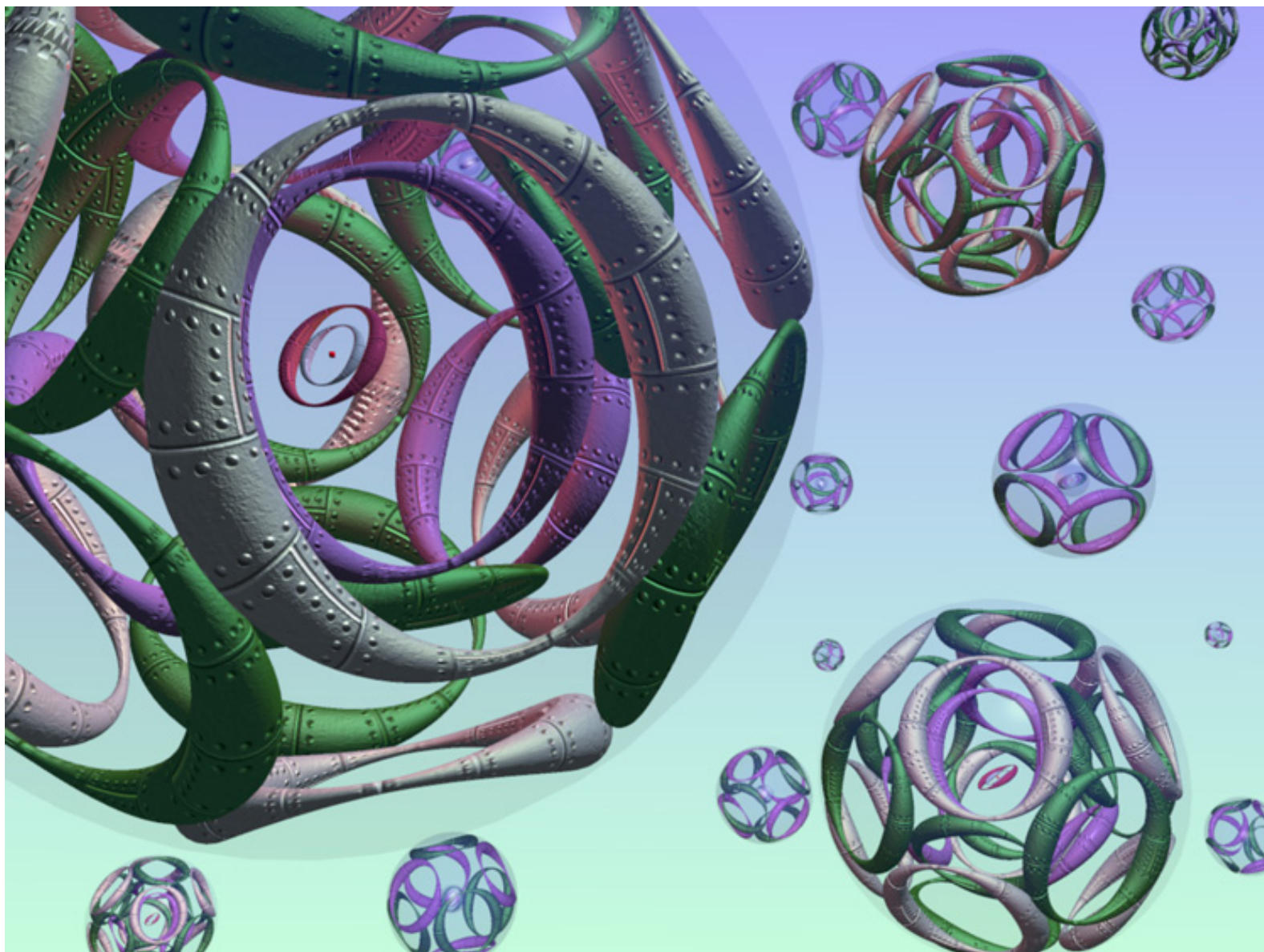
Fig. 9 *A SKY FULL OF ATOMS IN ARMOR*

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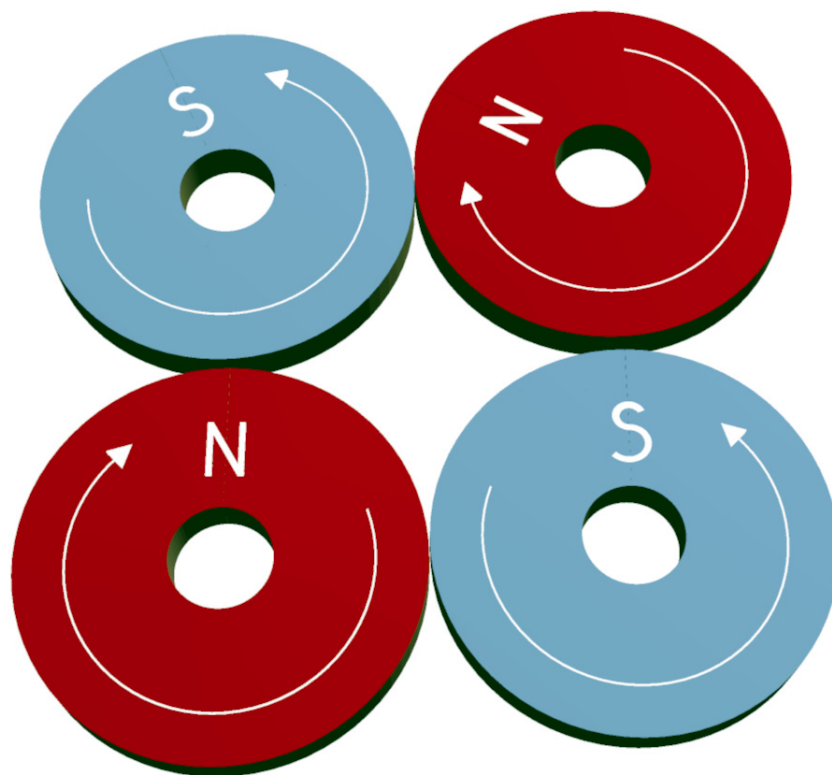War games and jousting events with brigades of armored atoms.

FIG. 10 FOUR MAGNETS, ANTIPARALLEL

FOUR MAGNETS, ANTIPARALLEL

An electron orbiting in a circle produces a ring-shaped magnetic field as shown in figure 8. It is a planar magnet with poles arranged north to south on opposite faces. A pair of them will attract one another when edge to edge, north to south -- an antiparallel association. They also attract face to face in parallel. A third mode, unexpected, is to have two magnets of different diameter, one large enough to encircle the other. Fitting this way they will link in antiparallel. By

these magnetic means electrons can join together despite their electrical aversion of one another. The above image shows permanent magnets substituting for electron orbits. In N-S alternating arrangement, they cling together edge to edge. As indicated by the arrows on the magnets, electrons would arrange their orbits with clockwise/counterclockwise rotation in order to attract magnetically.
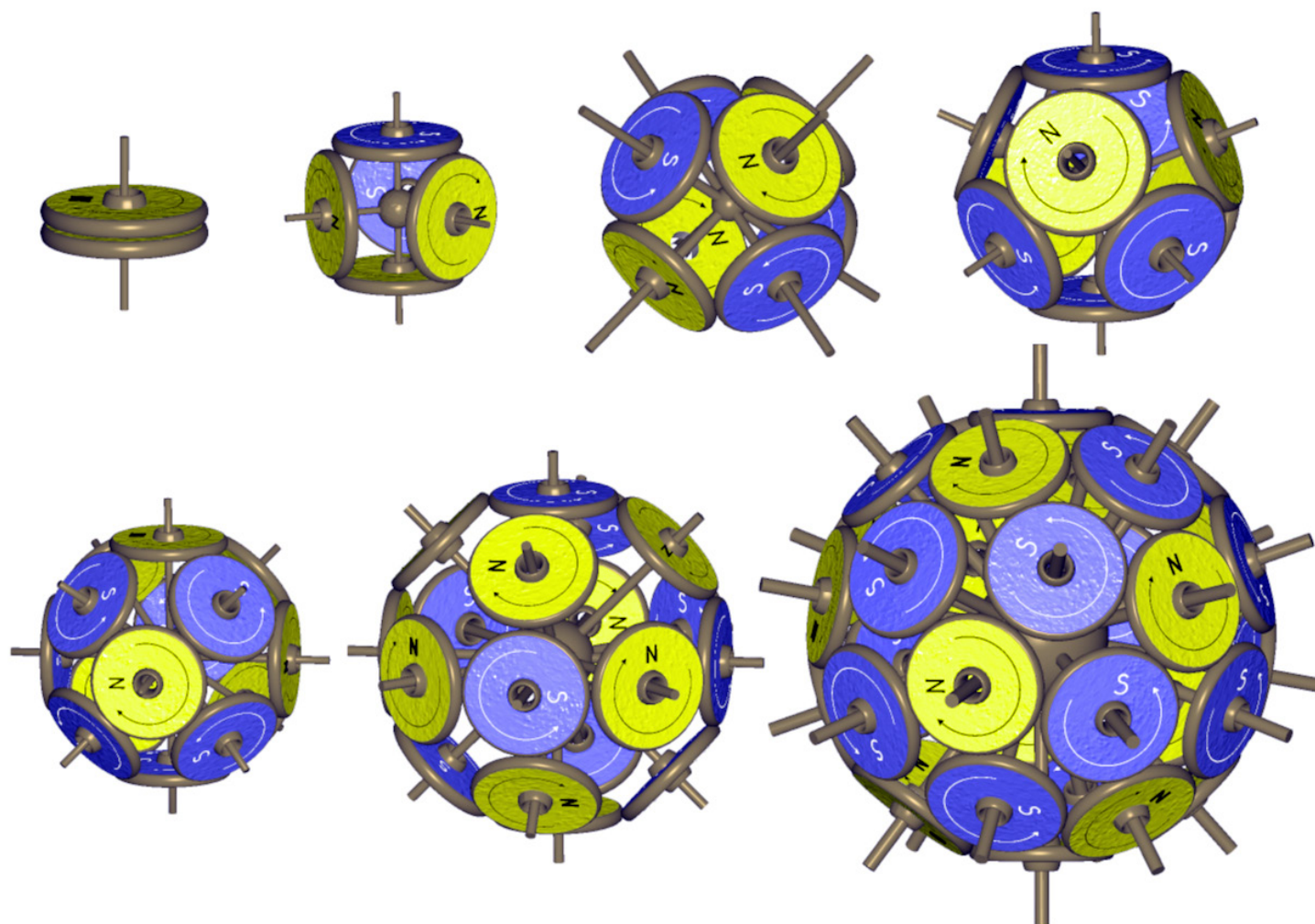
Fig. 11 *SEVEN MAGNET CIRCLE- SPHERES WITH ALTERNATING POLARITY*

SEVEN MAGNET CIRCLE-SPHERES WITH ALTERNATING POLARITY

The magnetic north-south relationships of Figure 8 can be applied to spheres as well. Spherical patterns can be formed with 2, 5, 8, 10, 14, 18, or 32 ring-shape magnets. These mosaic configurations in my atom model describe filled shells and subshells of electrons. Magnetism permits them to bond together despite their urge to fend one another off. Though the electrons' magnetic force is calculated to be far weaker than the electrical force, magnetism, in my model, becomes effective when acting within the milieu of an atom which, overall, is a sphere of electrical neutrality.
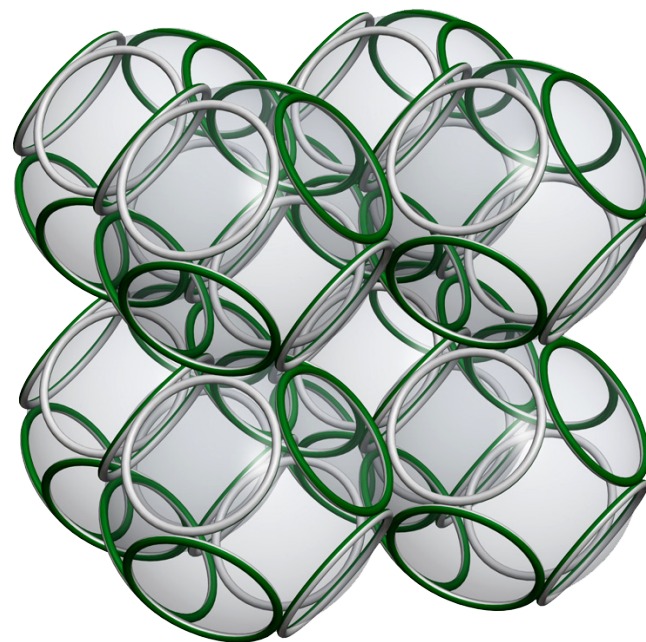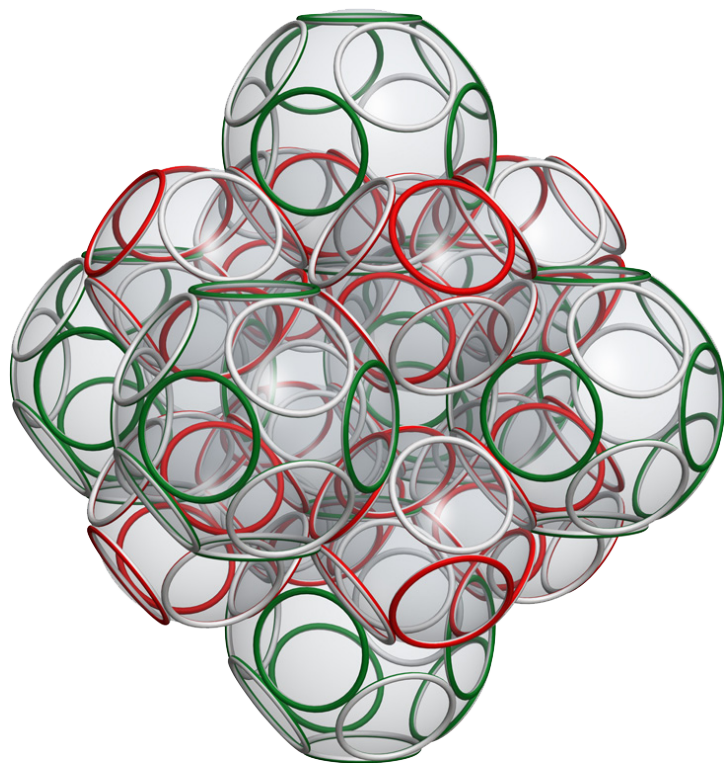
FIG.12 **MULTIPLE CELLS WITH MAGNETIC CONTINUITY**

MULTIPLE CELLS WITH MAGNETIC CONTINUITY

Several of the magnet configurations translate in space in patterns of crystalline order, repeating from cell upon cell of endless magnetic continuity.
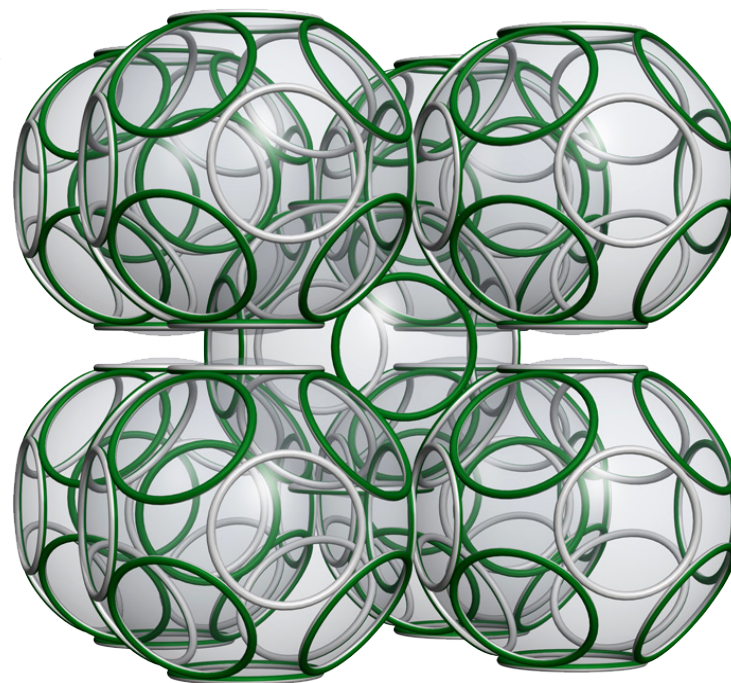
Fig. 13 CHAIN BRIDGE STRUCTURE

CHAIN BRIDGE STRUCTURE

This spherical chain bridge, reminiscent of a da Vinci war machine, is useful as an analogy for the atom. The stones, like the electrons' orbits, push at one another around their sphere at the same time they are pulled toward the center, here, with massive chains. These are analogous to the atom's electrical forces that draw the electrons inwardly toward the positively charged nucleus. As sturdy solid matter, the stones press on one another with a force equivalent to the tension on the chains. In an oversimplified way, it tells why atoms do not collapse. The structure also points out that while the atom is, all in all, a dynamic one, it ends up having static characteristics. Missing from this analog model, though, is the electron's quantum condition which enables even a single "stone" to avoid falling into the nucleus.

CHARGE CLOUDS WITH
ORBITAL RING COLLARS

This shows the identity between the geometry of the orthodox balloon charge cloud atom and my orbital wave electrons. These are shown overlaid on the textbook bonding orbital balloons. In terms of probability, the electron in any one lobe spends most of its time in the fattest portion. These domains are where the electrons in my model spend all their time.
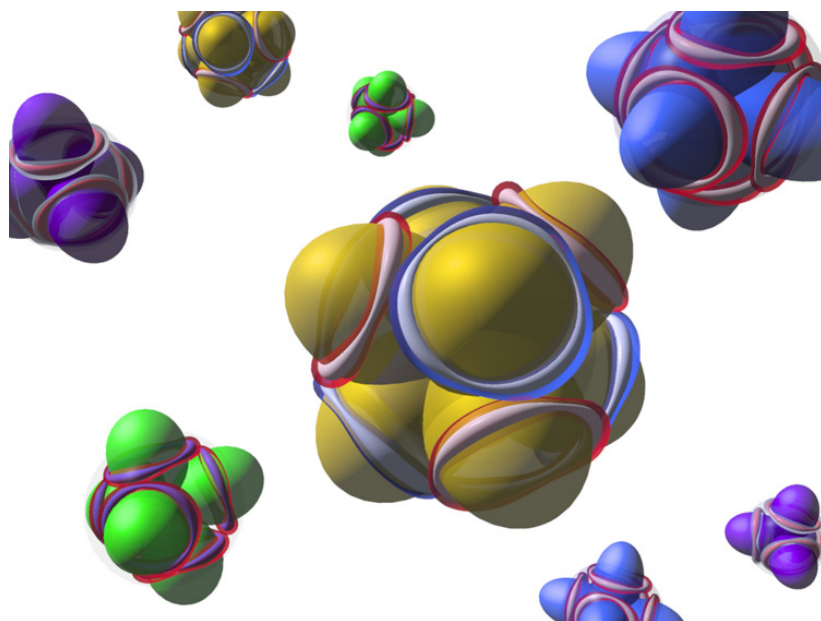

Fig. 14 *CHARGE CLOUDS WITH ORBITAL RING COLLARS*

MATTER-WAVE CONFIGURATIONS

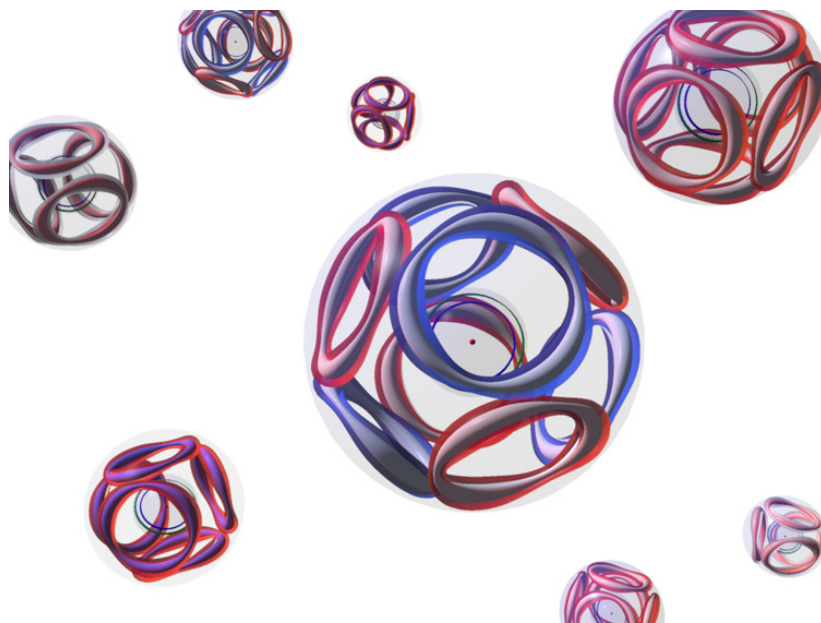The balloons have been removed, leaving only the circular matter-waves for atoms with several electrons.
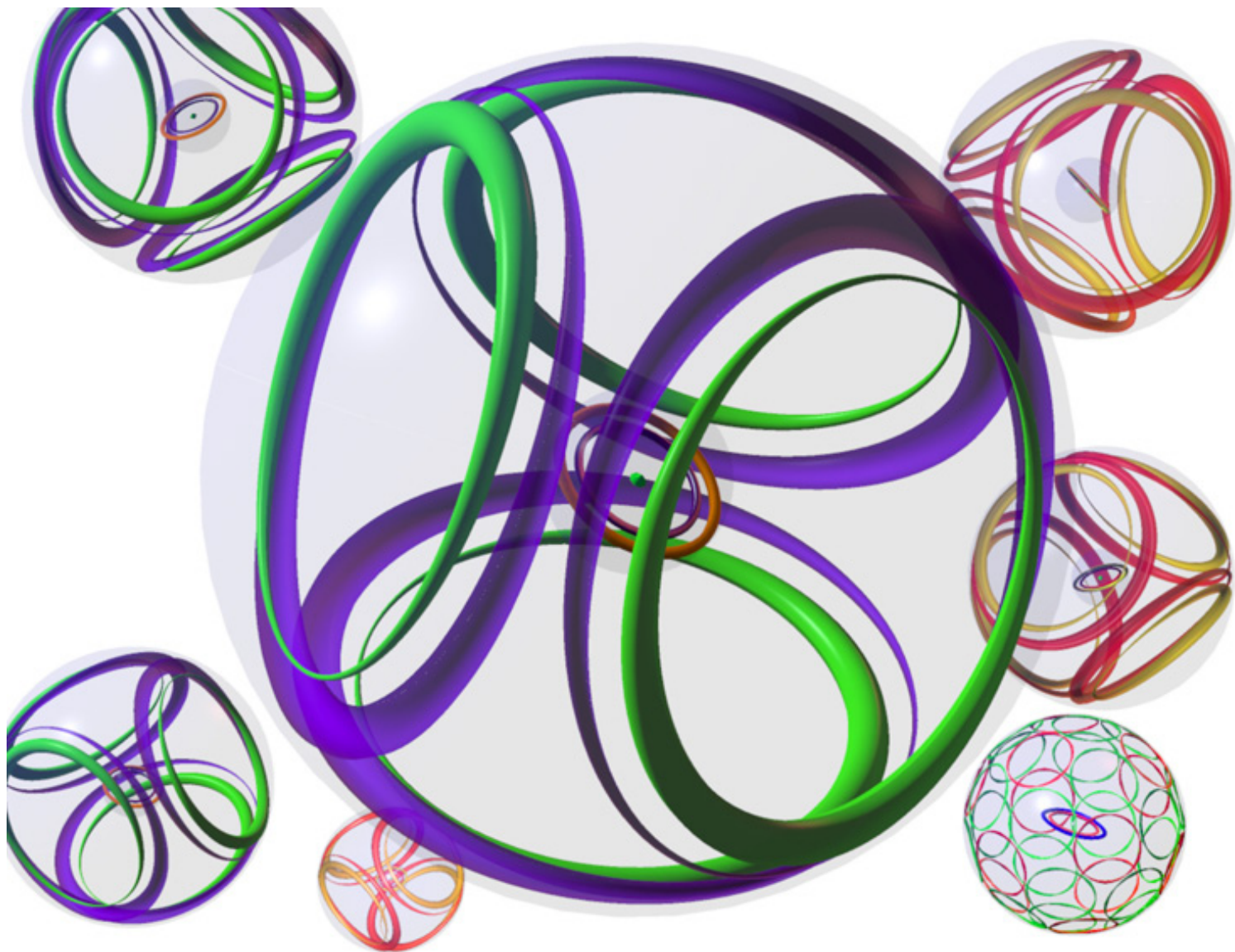

Fig. 15 *MATTER WAVE CONFIGURATIONS*

Fig. 16 *NEON ATOM*

NEON ATOM

Six wandering neon atoms plus an unidentified odd atom at the lower right. Each neon has ten electrons. The two nearest the nucleus form a closed, first, shell. Eight in the larger sphere form a closed, second, shell. Each of these -- the helium shell and the neon shell -- are bound with magnetically paired sets of electrons.
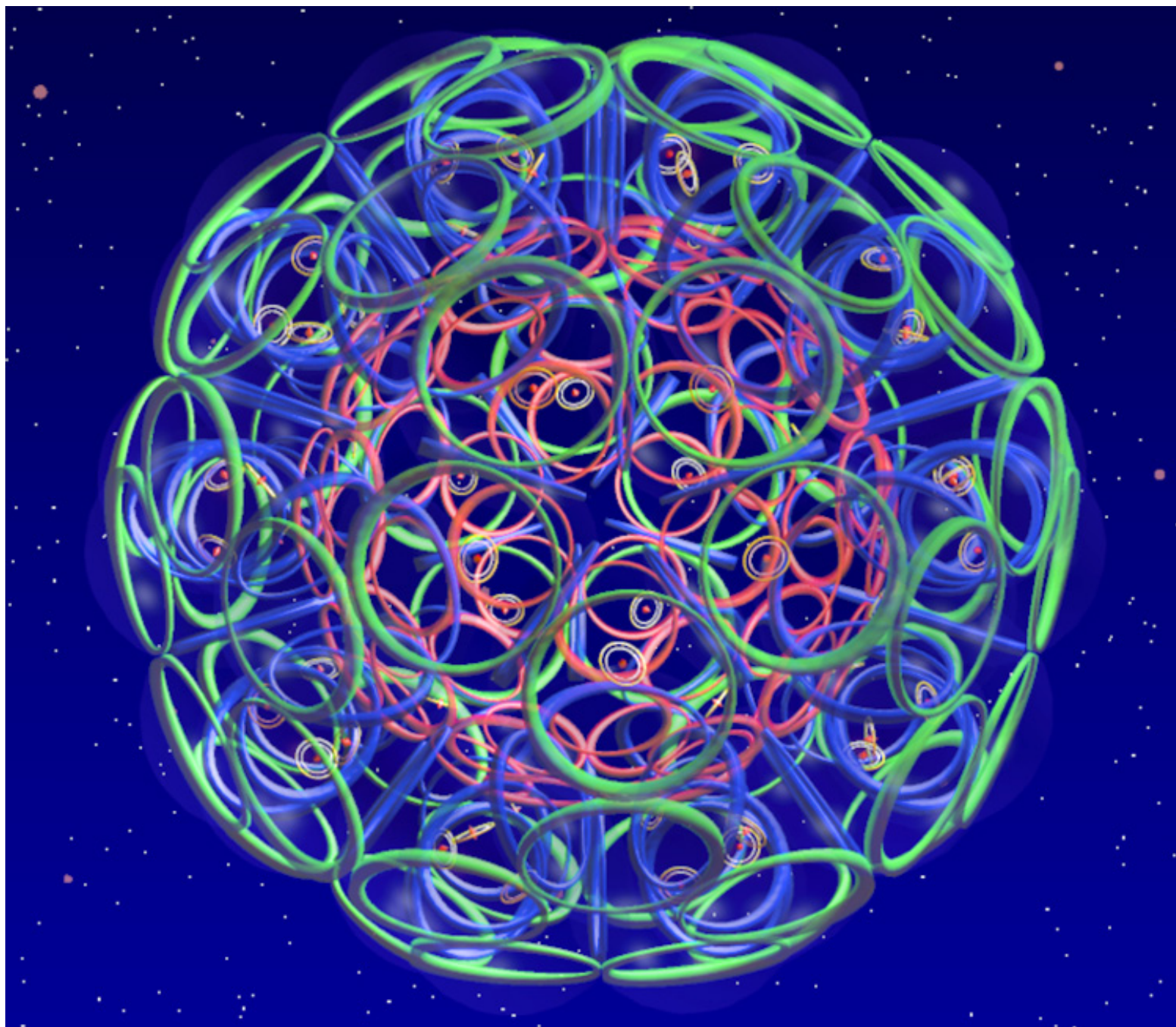
Fig. 17 *C60 SOCCER BALL MOLECULE*

C60 SOCCER BALL MOLECULE

A picture of the C60 fullerene or soccer ball molecule, composed of 60 carbon atoms linked together in a ball.
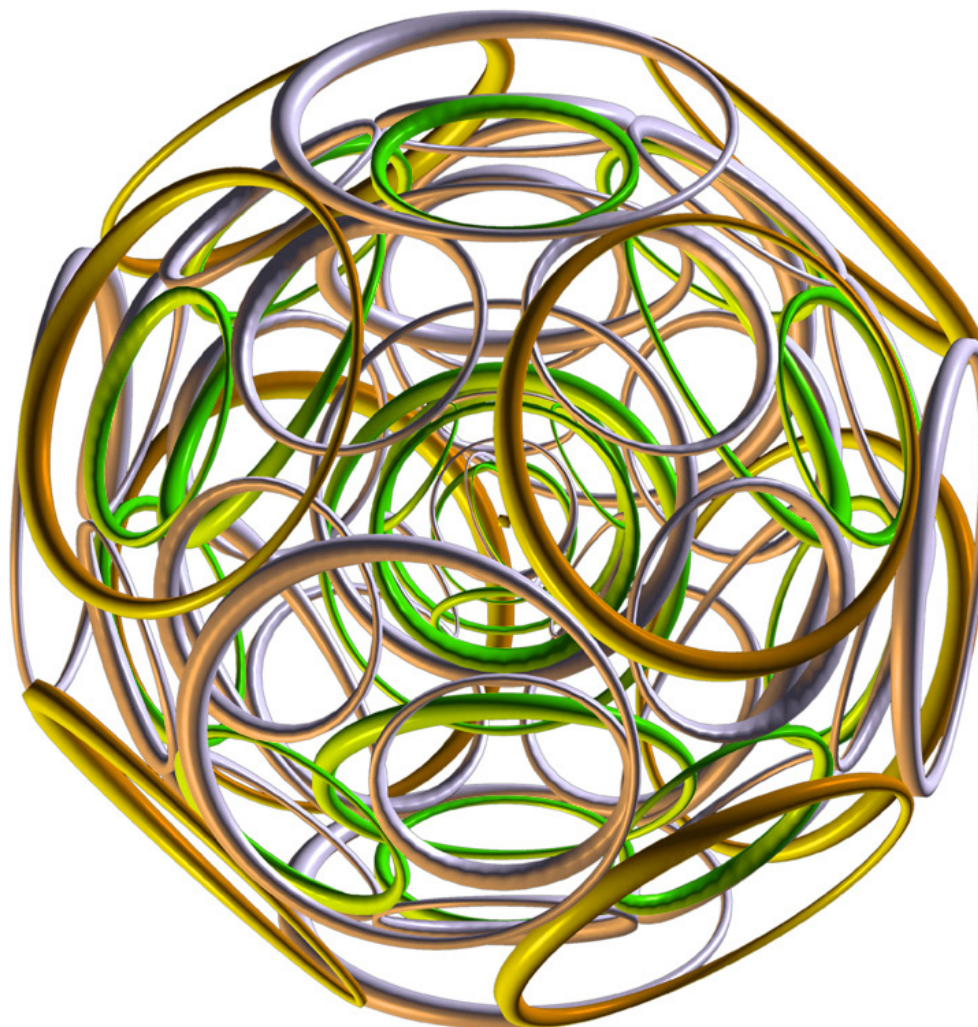
Fig. 18 ***EIGHTY-TWO ELECTRON ATOM***

EIGHTY-TWO ELECTRON ATOM

Shown here is an example how my atom model can represent even the heaviest of atoms with all electrons stored neatly in their proper shells and subshells. This one contains eighty-two matter-wave orbits which, by atomic number, identifies it as an atom of lead. With the alchemy of a computer, discarding three electrons, it can readily be transmuted into gold.