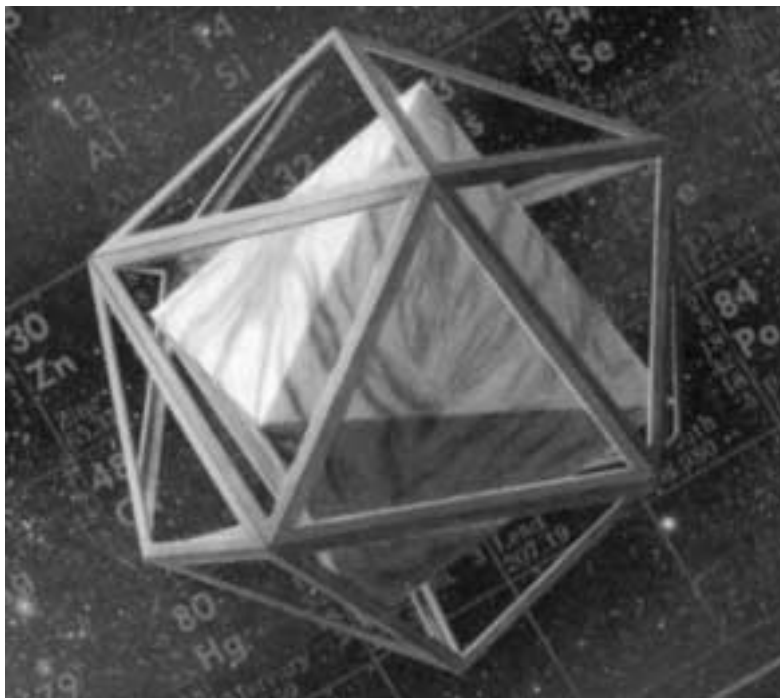


# REPORT ON WORK IN PROGRESS

# New Explorations with The Moon Model



Christopher Sloan (1988)

by Laurence Hecht  
with Charles B. Stevens

*Toward a new model of the nucleus, based  
on the pioneering work in physics of  
Robert J. Moon.*

*May 7, 2004*

## Introduction: Dr. Moon and the Ampère-Weber Electrodynamics

Recently, Charles Stevens and I, with assistance from young Jacob Welsh,<sup>1</sup> have been working on an elaboration of the model of the atomic nucleus developed in 1986 by University of Chicago physical chemist and physicist, Robert J. Moon, Jr. This is a report of that work in progress, quite unfinished, yet full of hope and possibilities for the future. As the work has gone in many different directions, somewhat like the first exploration of an unknown territory, it seemed the time had come to note down on paper some of the paths explored and places seen, before new and yet more inviting vistas draw us beyond, and we forget some of the fascinating detail of what we have already seen.

The main path now seems to lead us to an understanding of the electrodynamic basis for the Moon model. We have discovered a means of analyzing the geometric relationships among pairs of bound protons ("Weber pairs"), which overcomes the usual sort of obstacles one expects in dealing with systems of greater than two-body interac-



Stuart Lewis/EIRNS

*Robert J. Moon in 1986.*

1. The computer-generated images are developed from *Geometer's Sketchpad* by Jacob Welsh.

tions. As the stable configurations found so far, turn out to be precisely those of the Moon model, we have the strongest suspicions that we are only re-discovering some of the paths which led Moon to the original construction. This, too, is exciting.

The mode of presentation for this report is not strictly pedagogical, but rather more like that of an experimental log, where the subject is the recent several-months-long shared effort. Much care has gone into the preparation of charts, and the working up of diagrams intended to make the constructions comprehensible to anyone who has mastered the Platonic solids and the elementary Moon model construction. (See "The Geometric Basis for the Periodicity of the Elements," 1988, [www.21stcenturysciencetech.com](http://www.21stcenturysciencetech.com).) Difficulties will arise, however, for those unfamiliar with the Ampère-Gauss electrodynamics. Rather than rework the substantial body of material involved therein, for purposes of this report, we refer the reader to the original work, and to my reports in the Fall 1996 *21st Century Science & Technology*, as introduced by Dr. Jonathan Tennenbaum in the editorial in the same issue.<sup>2</sup>

The entirety of Dr. Moon's thinking in nuclear physics was shaped by his understanding of the superiority of the electro-dynamics of Ampère, Gauss, and Weber over the hegemonic

Faraday-Maxwell conceptions. Ampère's original experiments and the Gauss-Weber electrodynamics, with emphasis on Wilhelm Weber's 1871 paper,<sup>3</sup> were the point of reference for any scientific discussion with Moon, as Stevens recalled from his first 1974 meeting with him in Chicago (which was followed, shortly thereafter, by a meeting with Lyndon LaRouche at which the same topic was at the center).

The special feature of the referenced 1871 paper of Weber lies in the influence of the Leibnizian current of thought, which was brought into Gauss's Göttingen University through the influence of Abraham Kaestner (1719-1800). Leibniz's concept of *monad* emerges in Weber's thought, among other locations, in the recognition of a minimal distance,  $\rho$ , below which the so-called Coulomb force of mutual repulsion of like particles reverses. (We shall discuss this further below in connection with the "Weber pair.") From this, emerges the proper concept of the atomic nucleus, the

2. Laurence Hecht and Jonathan Tennenbaum, "The Atomic Science Textbooks Don't Teach," *21st Century*, Fall 1996.

3. Wilhelm Weber, "Electrodynamic Measurements—Sixth Memoir, Relating Specially to the Principle of the Conservation of Energy," *Phil. Mag.*, S.4, Vol. 43, No. 283 (Jan. 1872), pp. 1-20 and 119-149.

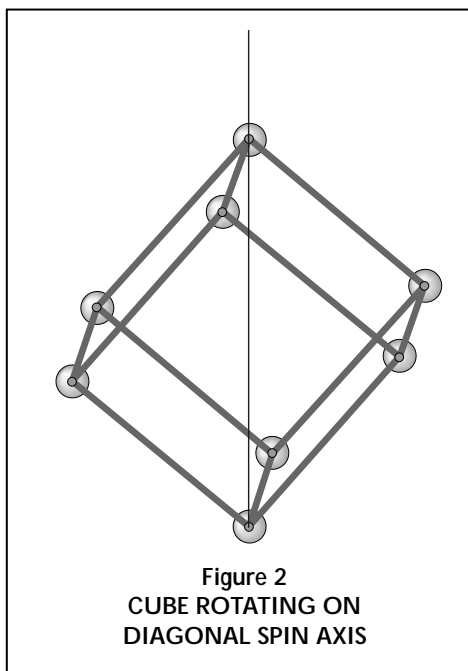
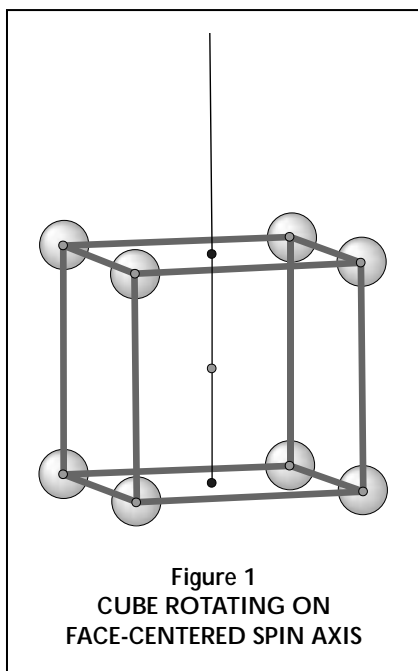
|   |          |          |          |        |          |        |         |        |          |        |          |        |        |        |          |          |          |          |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|---|----------|----------|----------|--------|----------|--------|---------|--------|----------|--------|----------|--------|--------|--------|----------|----------|----------|----------|-------|--------|--------|----|--|--|--|--|-------------|--|--|--|--|--|
|   | IA       |          |          |        |          |        |         |        |          |        |          |        |        |        |          |          |          |          |       |        |        |    |  |  |  |  | INERT GASES |  |  |  |  |  |
|   |          |          |          |        |          |        |         |        |          |        |          |        |        |        |          |          |          |          |       |        |        |    |  |  |  |  | O           |  |  |  |  |  |
| 1 | 1        |          |          |        |          |        |         |        |          |        |          |        |        |        |          | 2        |          |          |       |        |        |    |  |  |  |  | 2           |  |  |  |  |  |
|   | H        |          |          |        |          |        |         |        |          |        |          |        |        |        |          | He       |          |          |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | 1.00797  |          |          |        |          |        |         |        |          |        |          |        |        |        |          | 4.00260  |          |          |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
| 2 | 3        | 4        |          |        |          |        |         |        |          |        |          |        | 5      | 6      | 7        | 8        | 9        | 10       |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | Li       | Be       |          |        |          |        |         |        |          |        |          |        | B      | C      | N        | O        | F        | Ne       |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | 6.941    | 9.01218  |          |        |          |        |         |        |          |        |          |        | 10.81  | 12.011 | 14.0067  | 15.9994  | 18.99840 | 20.179   |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
| 3 | 11       | 12       |          |        |          |        | IIIB    |        | IVB      | VB     | VIB      | VIIB   | VIII   |        | IB       | IIB      | 13       | 14       | 15    | 16     | 17     | 18 |  |  |  |  |             |  |  |  |  |  |
|   | Na       | Mg       |          |        |          |        |         |        |          |        |          |        |        |        |          | Al       | Si       | P        | S     | Cl     | Ar     |    |  |  |  |  |             |  |  |  |  |  |
|   | 22.98977 | 24.305   |          |        |          |        |         |        |          |        |          |        |        |        |          | 26.98154 | 28.086   | 30.97376 | 32.06 | 35.453 | 39.948 |    |  |  |  |  |             |  |  |  |  |  |
| 4 | 19       | 20       | 21       | 22     | 23       | 24     | 25      | 26     | 27       | 28     | 29       | 30     | 31     | 32     | 33       | 34       | 35       | 36       |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | K        | Ca       | Sc       | Ti     | V        | Cr     | Mn      | Fe     | Co       | Ni     | Cu       | Zn     | Ga     | Ge     | As       | Se       | Br       | Kr       |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | 39.098   | 40.08    | 44.9559  | 47.90  | 50.9414  | 51.996 | 54.9380 | 55.847 | 58.9332  | 58.70  | 63.546   | 65.38  | 69.72  | 72.59  | 74.9216  | 78.96    | 79.904   | 83.80    |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
| 5 | 37       | 38       | 39       | 40     | 41       | 42     | 43      | 44     | 45       | 46     | 47       | 48     | 49     | 50     | 51       | 52       | 53       | 54       |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | Rb       | Sr       | Y        | Zr     | Nb       | Mo     | Tc      | Ru     | Rh       | Pd     | Ag       | Cd     | In     | Sn     | Sb       | Te       | I        | Xe       |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | 85.4678  | 87.62    | 88.9059  | 91.22  | 92.9064  | 95.94  | 98      | 101.07 | 102.9055 | 106.4  | 107.868  | 112.40 | 114.82 | 118.69 | 121.75   | 127.60   | 126.9045 | 131.30   |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
| 6 | 55       | 56       | 57       | 72     | 73       | 74     | 75      | 76     | 77       | 78     | 79       | 80     | 81     | 82     | 83       | 84       | 85       | 86       |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | Cs       | Ba       | *La      | Hf     | Ta       | W      | Re      | Os     | Ir       | Pt     | Au       | Hg     | Tl     | Pb     | Bi       | Po       | At       | Rn       |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | 132.9054 | 137.34   | 138.9055 | 178.49 | 180.9479 | 183.85 | 186.207 | 190.2  | 192.22   | 195.09 | 196.9665 | 200.59 | 204.37 | 207.19 | 208.9804 | (210)    | (210)    | (222)    |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
| 7 | 87       | 88       | 89       | 104    | 105      | 106    |         |        |          |        |          |        |        |        |          |          |          |          |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | Fr       | Ra       | †Ac      | Ku     | Ha       |        |         |        |          |        |          |        |        |        |          |          |          |          |       |        |        |    |  |  |  |  |             |  |  |  |  |  |
|   | (223)    | 226.0254 | (227)    |        |          |        |         |        |          |        |          |        |        |        |          |          |          |          |       |        |        |    |  |  |  |  |             |  |  |  |  |  |

|        |               |
|--------|---------------|
| 1      | Atomic number |
| H      |               |
| 1.0079 | Atomic mass   |

|        |          |        |       |       |        |        |          |        |          |        |          |        |        |
|--------|----------|--------|-------|-------|--------|--------|----------|--------|----------|--------|----------|--------|--------|
| 58     | 59       | 60     | 61    | 62    | 63     | 64     | 65       | 66     | 67       | 68     | 69       | 70     | 71     |
| Ce     | Pr       | Nd     | Pm    | Sm    | Eu     | Gd     | Tb       | Dy     | Ho       | Er     | Tm       | Yb     | Lu     |
| 140.12 | 140.9077 | 144.24 | (147) | 150.4 | 151.96 | 157.25 | 158.9254 | 162.50 | 164.9304 | 167.26 | 168.9342 | 173.04 | 174.97 |

|          |          |         |          |       |       |       |       |       |       |       |       |       |       |
|----------|----------|---------|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 90       | 91       | 92      | 93       | 94    | 95    | 96    | 97    | 98    | 99    | 100   | 101   | 102   | 103   |
| Th       | Pa       | U       | Np       | Pu    | Am    | Cm    | Bk    | Cf    | Es    | Fm    | Md    | No    | Lr    |
| 232.0381 | 231.0359 | 238.029 | 237.0482 | (244) | (243) | (247) | (247) | (251) | (254) | (257) | (258) | (255) | (256) |

THE PERIODIC TABLE OF THE ELEMENTS



one which always informed Dr. Moon's thinking: a monad-like existence determined by a universal ordering principle, as distinct from the reductionist's absurdity of a self-existent elementary building block, the Aristotelian *protyle*, which has dominated most thinking on the subject of atomic physics for the past century.

Dr. Moon was one of the great experimental physicists of the century, a true genius, although of a very self-effacing character, who waged a stubborn, lonely fight for truth amidst a degenerating culture. An appreciation of the Ampère-Weber electrostatics ran through all his work, from his first major experimental construction, the University of Chicago cyclotron, which he designed and built in 1935-1936 with a team of students from William Draper Harkins's physical chemistry department, to his last hypothesis, a half a century later, the Moon model of the nucleus. Whoever wishes to understand the Moon model in any depth, cannot avoid the pleasant and inviting challenge of mastering the original work of Ampère and Weber. It has been my hope that some new talents will soon take up this challenge, so that we might create a broader group of collaborators in this exciting work.

(1)  
**A Spin Axis of the Nucleus;  
Moment Arms and Isotopes**

This work began where I had left it about a year ago, in the examination of the possible placement of neutrons in the Moon nucleus, as it might bear on the singularities known as "magic numbers." The discovery, in the second decade of the 20th Century, of isotopic forms of the elements introduced a third dimension into the periodic table. New questions were now raised: Why do certain elements have a large number of naturally occurring isotopes, others very few, and others only

one? The experimental verification of Harkins's neutron in 1932 posed the same question in a new way: What determines the number of neutrons in each isotopic species? These questions are still unanswered. The symmetries of the Moon model offered the hope of finding a reason that Nature should favor configurations containing certain numbers of neutrons, and not others.

Early in the course of my recent re-examination, I introduced the hypothesis of an *axis of spin* for the nuclei. My previous investigation of neutron placement had considered the nucleus only from the standpoint of its spherical symmetry. I had thus assumed that the neutrons would fill the positions on the spherical shells of equal distance from the center, which are defined by unused faces and

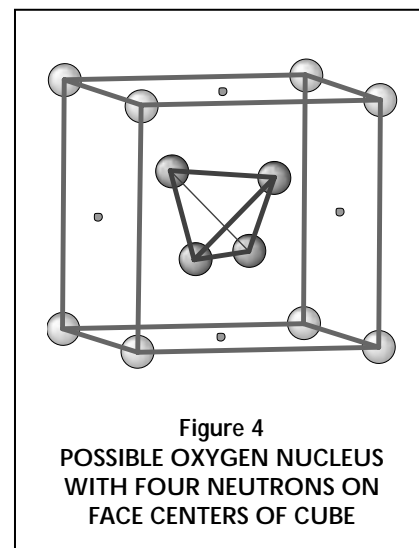
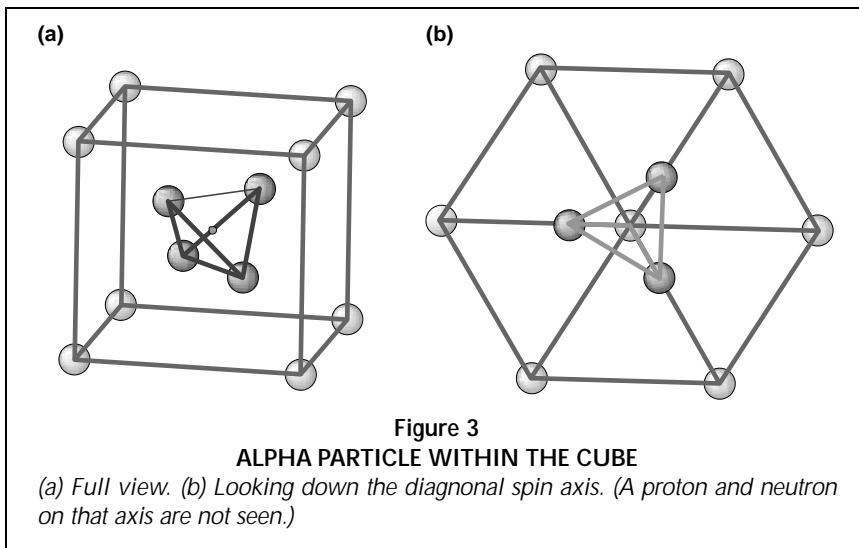
edge midpoints of the solids whose vertices defined the position of the protons. By introducing a spin axis, an entirely new consideration came into play, that is, the distance of the nuclear particle from the axis.

Making the assumption that the preferred configurations would be those which minimize the angular momentum around that axis, it now became possible to examine the assortment of isotopes in a new light. A graphic example will best help to explain this.

Consider the cube representing the oxygen nucleus. First, consider an axis of spin passing through opposite face centers of the cube (Figure 1). Assuming the mass of the protons to be equal and localized at the vertex points, the moment of momentum of a proton is determined solely by its distance from the axis. For a cube whose edge is 1, the distance is  $\sqrt{2}/2$ . The total moment for the 8 protons is  $4\sqrt{2} = 5.6569$ .

We may compare the value just derived to the moment produced when the cube is spinning on an axis which passes through two diagonally opposite vertices (Figure 2). In this case, two vertices lie on the axis. For a cube of edge 1, the moment of momentum for each of the other six protons is  $\sqrt{6}/3$ , and the total moment  $6 \times \sqrt{6}/3 = 4.88990$ , considerably less than that for the face-centered spin axis.

However, we must also take into account the moments of the neutrons. In placing the neutrons, we had always assumed that they must be contained within the shells of the protons. For this and other reasons, we had assumed an inner tetrahedron, or "alpha particle," whose vertices would first serve as the locations for the two protons and two neutrons of the helium nucleus, while for nuclei of atomic number greater than 2, these would serve as the location for neutrons. We portray that from two points of view in Figure 3. Figure 3 (a) is the view looking down the diagonal axis of the cube. Two protons and a neutron lie on the axis, although these cover one another, so only one sphere is visible at the center of the right-hand figure.



Here also, calculation of the moments on the tetrahedron shows that the favored configuration is that which spins on the diagonal axis of the cube.

Finally, we must consider the neutrons which lie on the cube. For oxygen, we assume four neutrons on the alpha particle, and four on the face centers, as pictured in Figure 4. The moments of certain neutron positions vary, depending on the axis chosen. The configuration of neutrons shown produces a minimum total moment for either spin axis. However, the total moment is least when the diagonal spin axis is chosen.

The concept of a spin axis for the nucleus seemed suggestive; however, there were many questions. Did the nucleus spin at all times, or only when subjected to external forces such as magnetism? How would its existence be manifested? We made some preliminary attempts to construct the first eight elements, calculating the moments for each principal isotope. There were many uncertainties. The first five elements contain many anomalous features. Why is lithium-7, with 3 protons and 4 neutrons the most abundant isotope? Why is 4-beryllium-9 stable, while beryllium-8 breaks up into two alpha particles? Why are 5-boron-10 and 7-nitrogen-14 odd-odd nuclei? We also examined the atomic numbers above oxygen. Here there were some more hints that the spin axis was a decisive feature determining why some isotopes occur and not others. But nothing was decisive.

## (2) The 'Axis of the Universe'

One day, as I was examining a Plexiglas model of the Moon nuclear structure, I noticed that one pair of faces of the octahedron appeared to be parallel to the overlying faces of the icosahedron (Figure 5). If this were true, then a unique axis passing through the diagonal of the dodecahedron and the underlying face center of the dual icosahedron, would then pass through the face center of the underlying octahedron, and down the diagonal axis of the cube. A unique axis of the whole Moon model configuration would thus be determined.

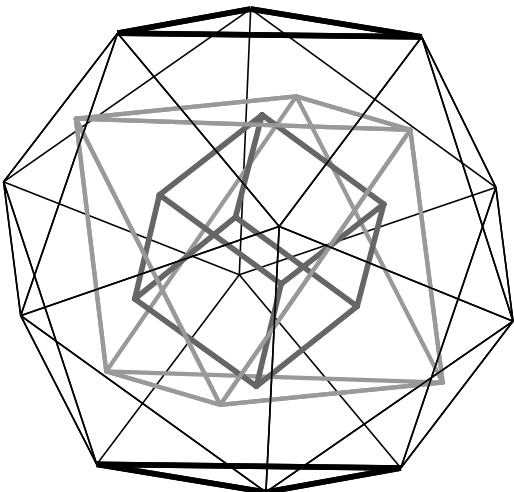
We called it the "axis of the universe (Figure 6)."

True, or merely appearance? From his studies of Gauss's *Pentagramma Mirificum*, Stevens was able to readily verify the parallelism of the unique pair of faces. The reasoning, in brief, is this: The vertices of the octahedron in the Moon model configuration correspond, directionally, to the positions of vertices in the figure known as the compound of 20 octahedra. The vertices of this compound figure can be determined by the rotation of any of the five cubes whose vertices correspond to the vertices of a dodecahedron. The cube is rotated such that one pair of vertices remain fixed in the dodecahedral vertices. The cube carries with it its dual octahedron. The face centers of any octahedron in the compound figure will then lie under the vertices of the dual cube which carries it. As two of these cube vertices are fixed in the dodecahedron, the corresponding two face centers of the octahedron will lie under them, which is to say, under the vertices of the dodecahedron.

Now, let the dodecahedron in that construction, correspond to the circumscribing dodecahedron of the Moon model (Figure 6). Then, a unique pair of face centers of the octahedron of the Moon model will lie under two diagonally opposite vertices of the dodecahedron. Ergo, the axis of the universe is established, for a unique axis then passes through the vertices of dodecahedron and cube, and the face centers of octahedron and icosahedron!

### A New View of Uranium

With the discovery of this axis, some new things now fell into place. A clearer picture of the twinned structure which describes the uranium nucleus was the first important result. Uranium, atomic number 92, is a singularity in the Moon structure, occurring where the twinned dodecahedra open on a hinge, and the hinge then breaks to produce a connection between only two protons. Moon had suggested that each of the two protons slightly interpenetrates the other structure. Stevens recognized that the twinned uranium nucleus would then line up on the axis of the universe, and that the two interpenetrating protons would likely position themselves at the



**Figure 5**  
**UNIQUE PAIR OF PARALLEL FACES OF**  
**ICOSAHEDRON AND OCTAHEDRON**  
**IN THE MOON MODEL**

*The faces of the icosahedron that are parallel to the octahedron are shown at top and bottom, emphasized by thick lines.*

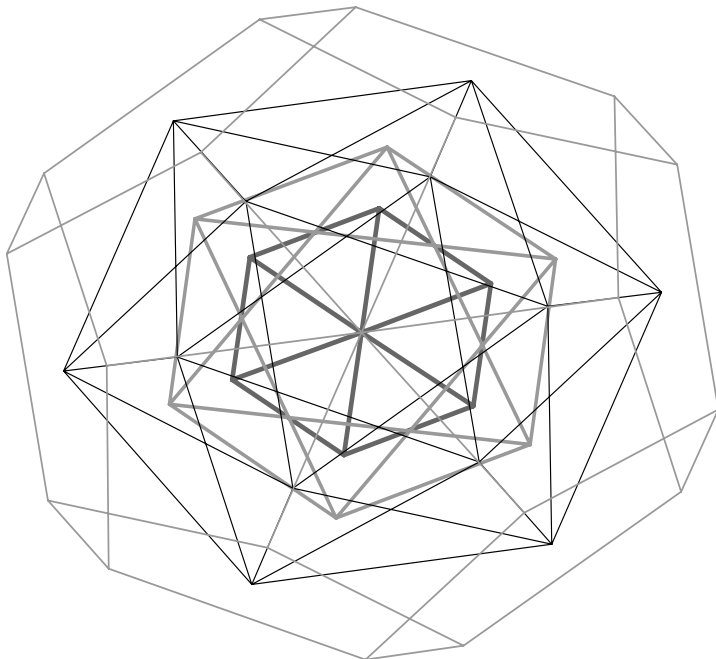
icosahedral face centers which lie under the dodecahedral vertex where they join. That would leave 73 neutron positions on each structure, precisely the correct number for the 146 neutrons of U-238.

|                             |           |
|-----------------------------|-----------|
| Cube faces . . . . .        | 6         |
| Cube edges . . . . .        | 12        |
| Octahedral edges . . . . .  | 12        |
| Icosahedral edges . . . . . | 30        |
| Icosahedral faces . . . . . | 13        |
| <b>Total . . . . .</b>      | <b>73</b> |

Secondly, our idea of minimal spin moments was reinforced. For the completed palladium nucleus, and for uranium, the "axis of the universe" forms the only symmetrical spin axis. Iron (the completed icosahedron) would have to spin on this axis, because the skew placement of the octahedron within the icosahedron could only be balanced when the unique pair of parallel faces was aligned perpendicular to the axis of spin. (See Figure 5.) The cube of oxygen, we had seen, would also prefer to spin on this axis, which coincides with the diagonal of the cube.

But silicon (the completed cube and octahedron) seemed to present a problem. From the standpoint of minimizing the angular moment, the axis of the octahedral "top" would be preferred. But this causes the inscribed cube to spin on its face-centered axis. If the minimization of angular moment were the only criterion, silicon would have to spin like a top on the diagonal axis of the octahedron. However, all the other completed structures of the Moon model followed the axis of the universe. A possible reason for this anomaly appeared when we examined the magnetic susceptibilities of the elements. Silicon is the only one of the completed Moon model structures to have a slight negative susceptibility (diamagnetism). The others are highly magnetic. We will discuss this further in Section 4.

The preference for the axis of the universe also suggested an explanation for two well-known curiosities of the periodic table: the argon-potassium anomaly and the apparent nuclear stability of tin. The shell model of the nucleus attempts to explain these two phenomena by the closing of assumed nuclear "shells" at 20 and 50. It is not convincing, to my mind. For, the shells may represent either neutrons or protons, sometimes both, and the presumed mechanism by which the stability operates (spin-orbit coupling) is a creation of dubious merit, which Maria Goeppert-Mayer adapted from the accepted model of the electron orbitals. The phenomenon called electron "spin," while representing something, is really not understood at all. It began as a hypothesized orbital motion, and ended as a piece of mathematical juggle.



**Figure 6**  
**THE 'AXIS OF THE UNIVERSE'**

*The Moon model's "axis of the universe" passes through the center of this figure. It is a diagonal axis for the dodecahedron and cube, and a face-centered axis of the icosahedron and octahedron. The unique pair of parallel faces of the icosahedron and octahedron is seen head on. (Note the hexagonal quality of the four solids in this view.)*

gling to fit the modified Bohr model.<sup>4</sup>

### The Argon-Potassium Anomaly

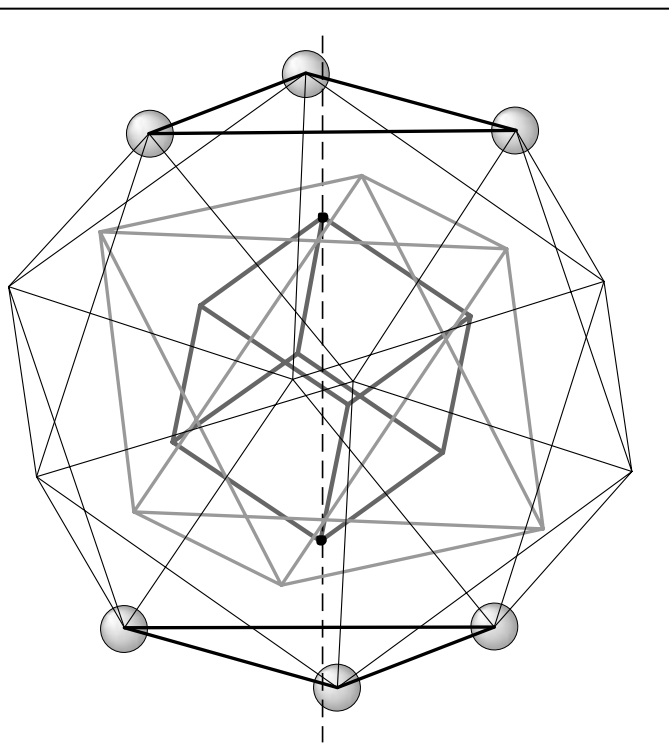
For elements of low atomic number, there is a tendency for the number of neutrons to equal the number of protons, or to exceed the proton number by one. The first significant excursion from this pattern occurs at 18-argon-40 with 22 neutrons. However, potassium and calcium which follow, each have 20 neutrons. Calcium has 20 neutrons and 20 protons, making it “doubly magic.”<sup>5</sup> Calcium is highly abundant in the Earth’s crust and the meteorite samples, and has six naturally occurring isotopes, considerably more than any preceding element.

Since Harkins, abundance has been associated with nuclear stability. From the Leibnizian standpoint of *transcreation*, all of the elements are being created all the time. But why some in preference to others?

The first three structures of greatest symmetry in the Moon model—the completed cube, octahedron, and icosahedron—correspond to the elements of greatest abundance in the solar system (oxygen, silicon, iron). The cases of calcium, and also tin, which is unique in having 10 naturally occurring isotopes, suggest how symmetries connected with the unique spin axis determine Nature’s preference for these structures.

Let us look, first, at calcium. In the Moon model structure, 14 protons produce the completed cube and octahedron of silicon. Calcium requires six more protons on the icosahedron (Figure 7). We suppose these go on the unique pair of parallel faces which we have already described on the icosahedron. Once these faces are complete, the axis of the universe is determined as the spin axis. (This would probably occur first at 19-potassium when one triangular face is complete, and the other, two-thirds so.) Prior to that, there is no well-defined

**Figure 7**  
**20-CALCIUM-40**  
*The last six protons of 20-calcium-40 form on the unique parallel faces of the icosahedron, allowing the structure to rotate on the axis of the universe (dotted line).*



rotational axis. Argon is probably placing its 22 neutrons on the inner alpha particle (4), cube faces (6), and cube edges (12). Thus, all neutron locations are filled.

Tin, at atomic number 50, is unique in having 10 naturally occurring isotopes. Only two other elements have as many as 8. This has long been considered a sign of the unusual stability of tin’s nucleus with 50 protons, and 50 is a magic number. The Moon model, considered in connection with the axis of the universe, gives a clear suggestion as to why: Palladium, at 46 protons, is the completed dodecahedron. To go beyond this, the structure must build a “twin,” starting on one of the pentagonal faces of the dodecahedron. Yet, once that twinning occurs, there can no longer be a symmetrical spin around the axis of the universe. Tin solves this problem by placing one of the four additional protons on the axis of the universe, and the other three on adjacent vertices. The whole structure (Figure 8) may then spin on the axis of the universe, just as palladium does. This explains the unusual stability of the tin nucleus.

The next nucleus, 51-antimony, is unable to maintain this symmetry (Figure 9). It must place the five protons beyond palladium around a pentagonal face of the dodecahedron. At this point, the twinned structure is truly determined, but the axis of the universe can no longer provide a stable spin axis.

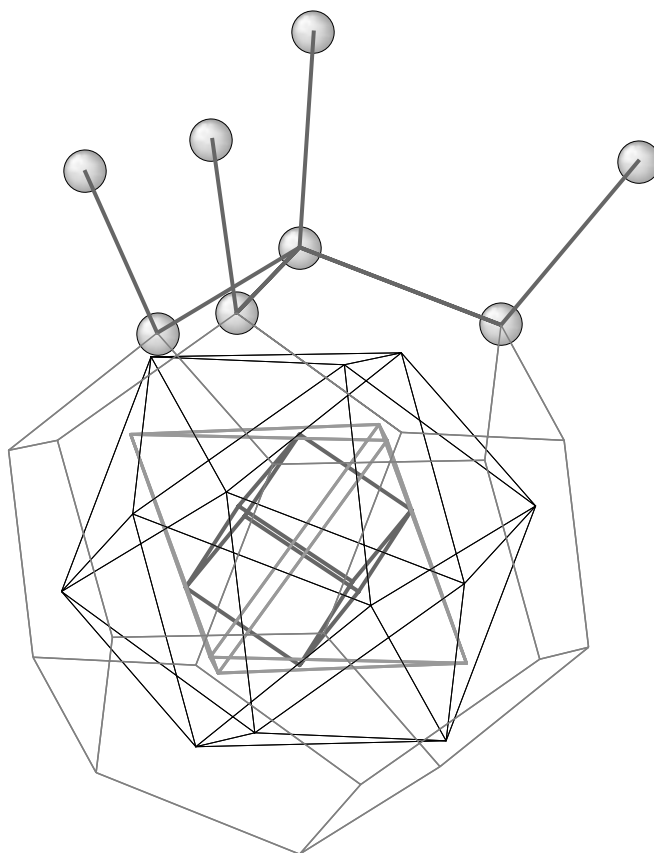
We pursued this idea of minimizing the spin moment around the axis of the universe, thinking we might be able to build the nuclei around this concept. Stevens calculated a table of moments for all the possible positions in the Moon model, and began attempting to construct the nuclei on the assumption of minimizing total moment. But some problems arose. There were things that didn’t “fit.” The light nuclei, such as lithium, beryllium, and boron, left us with uncertainties, as did the more complex nuclei that were not symmetric around this axis.

4. Maria Goeppert-Mayer had been a Göttingen student of Dr. Moon’s close friend at Chicago, physical chemist James Franck, a German-Jewish refugee. Under Franck and Moon’s influence at Argonne National Laboratory, just after World War II, Goeppert-Mayer began an investigation of the anomalies of the periodic table, which she usefully grouped, in a 1948 paper, under a concept of nuclear shells. According to biographical accounts, it was Fermi who suggested the bad idea of explaining the phenomena by the mechanism of spin-orbit coupling. Goeppert-Mayer received the Nobel Prize in 1958 for her elaboration of this mechanism.

5. The term “magic numbers” originated as a sly bit of humor by the physicists, intended to debunk attempts such as those of Harkins, Elsasser, and Goeppert-Mayer to discover a lawfulness in the properties of the elements constituting the periodic table. But the joke is on the physicists, for it is their belief in the magic efficacy of blackboard formulations which has proven to be useless in understanding the nucleus.

**Figure 8**  
**STABILITY OF THE**  
**'MAGIC NUMBER'**  
**50, IN THE MOON**  
**MODEL**

*Tin, atomic number 50, requires four protons beyond the completed palladium core. One of these can form above the "axis of the universe," and the other three above the three nearest vertices of the dodecahedron. The structure then spins symmetrically about the axis.*



(3)

### Concept of the 'Weber Pair'; Hypothesis of the Neutron; Attempt to Describe Mass Defect from the Nuclear Geometry; The Ontological Question

While Stevens was pursuing that path, I went back to the consideration of the structure I called the "Weber pair." This is the unique state of stable aggregation between two particles of like charge, whose existence Weber established in his 1871 memoir (cf. note 3), occurring below a minimal distance that Weber defined as  $\rho$ .

Employing modern determinations for the values of the charge in electrostatic units ( $e$ ), the proton mass ( $m_p$ ) and the velocity of light ( $c$ ), the value of  $\rho$  for two protons is equal to  $2e^2/m_p c^2$ , or approximately  $3 \times 10^{-16}$  cm. Within a sphere of this tiny diameter, two positive nuclear charges will attract. Weber shows in the referenced paper (Section 8 ff.), that two such like charges would maintain a stable state of molecular aggregation in an oscillating motion along a straight line connecting them. The particles would accelerate toward the center of the line connecting them, approaching the velocity  $c$ , pass through one another, and decelerate to zero velocity

upon reaching the circumference of the sphere of  $3 \times 10^{-16}$  cm diameter, at which point they would again be attracted toward each other. I call this the Weber pair.

I returned to a hypothesis I had pursued earlier,<sup>6</sup> that the Weber pairs would be placed along the diagonal axes of the Platonic solids comprising the Moon model. That is, instead of conceiving of each vertex as the position of a fixed proton, think of any pair of diagonally opposite vertices as the end points of a very short line along which the charge oscillates at extremely high frequency, according to the equation of motion described by Weber.

Many fruitful speculations followed. Among the most interesting was a new conception of the neutron. A moving charge will create around itself a circular magnetic field (to use the Faraday conception) whose strength would increase with velocity. Thus, an electron finding

itself in the vicinity of a Weber pair proton, would be pulled into a spiralling orbit around and along the path of the Weber pair. As the field increases with the velocity of the proton, the electron would be drawn in closer, such that the spiral would look like a corkscrew or pig's tail, which tightened as the charges moved toward the center.

A special sort of singularity must occur at the center of the Weber pair. The protons, moving at relative velocity  $\sqrt{2}c$ , must meet and pass through each other. The nuclear electron is then pulled in closest in its corkscrew orbit. I supposed that this is the point at which the neutron is created. Pulled into a very close orbit, the electron unites with the proton to form a neutral particle. Harkins's conception of the neutron (as Moon often recounted it), as an electron condensed on a proton, seemed to come to life.

If the proton thus turns into a neutron, one might ask how then there can be at least an equal number of protons and neutrons in the nuclei beyond hydrogen? The answer comes when we recognize that with the Weber pair, we are dealing with what today are called relativistic velocities (and at the singularity, a *superluminal* velocity). In the conventional view, there will be what Special Relativity sees as a relativistic mass increase sufficient to double the apparent mass of the proton. The quantification of this in accordance with known formulations is not possible, because we are in a new regime of particles accelerating to superluminal relative velocities. Weber's original formulation of the relativistic Fundamental Electrical Law, in which

6. Laurence Hecht, "Advances in Developing the Moon Nuclear Model," *21st Century*, Fall 2000, pp. 5-12.

it is the change in force between charges, and not their mass, which varies with relative velocity, does not easily resolve the difficulty. Thus, rather than a formal mathematical analysis, I sought to examine geometrically the probable bounding conditions of the process.

The first thing I noticed was that the conjectured neutron would appear in a circular orbit in a plane perpendicular to the center of the axis of the Weber pair. The neutrons could thus be thought of as circular hoops oriented perpendicular to these axes, which are the axes of the Platonic solids (cf. note 6). Thus, a sequence of cyclic solids would be created as protons were placed on the Moon model structure. First, four hoops for the four axes of the cube, producing the cuboctahedron of 12 vertices where the hoops intersect;

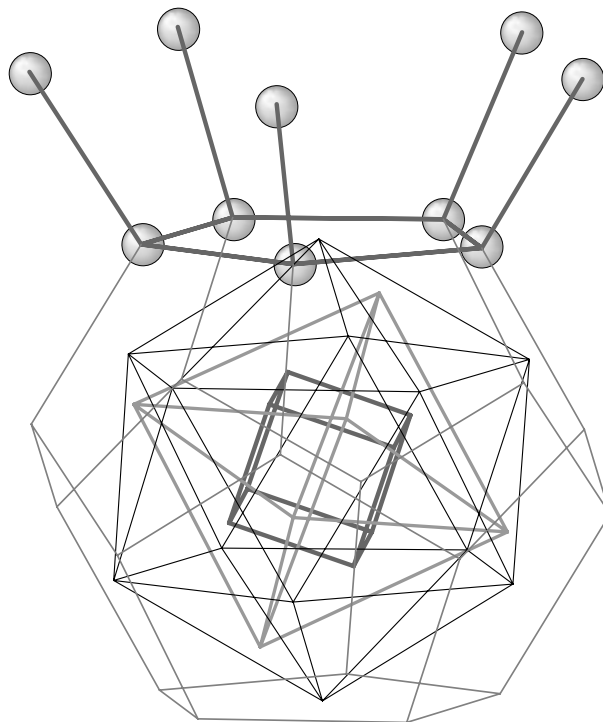
then three hoops for the three axes of the octahedron, producing an octahedron of 6 vertices; then six hoops for the six axes of the icosahedron, producing the icosadodecahedron of 30 vertices. If, in some way, the intersections of these hoops representing neutron orbits, might correspond to the creation of additional neutron orbits, there would then be a correspondence to the hypothesized neutron placements I had arrived at many years ago in considering the Archimedean solids.

#### Mass Defect As a Geometric Property of the Nucleus

This speculation concerning the neutron now led in another direction, to the consideration of mass defect. Mass defect is a concept that arose in the early stages of atomic physics. Calculations based on the deflection of particles in a field and the energy balance of particle collisions had led to precise measurements of the presumed mass of the proton, neutron, and electron. The atomic hypothesis assumes that the weight of the elements should equal the sum of these constituent parts. However, when the calculated mass of each element was compared to the measured atomic weight, a discrepancy was found which came to be known as the *mass defect*. The hegemony over physics of the Aristotelian notion of *energeia*, as opposed to the Platonic concept of power (*dynamis*), led to the explanation that the mass defect arises from the so-called *binding energy*; that is, the missing mass is used up in the form of the energy needed to hold the nucleons together. Einstein's equation for energy-mass equivalence can predict, from the mass defect, the amount of energy (actually, work) which will be produced by a nuclear reaction.

The poorly trained physicist searches, in vain, for a defini-

**Figure 9**  
**HOW ATOMIC**  
**NUMBER 51**  
**BECOMES UNSTABLE**  
*51-antimony, with five protons beyond the palladium core, begins to form the new, twinned dodecahedron. It will not spin stably on the "axis of the universe."*



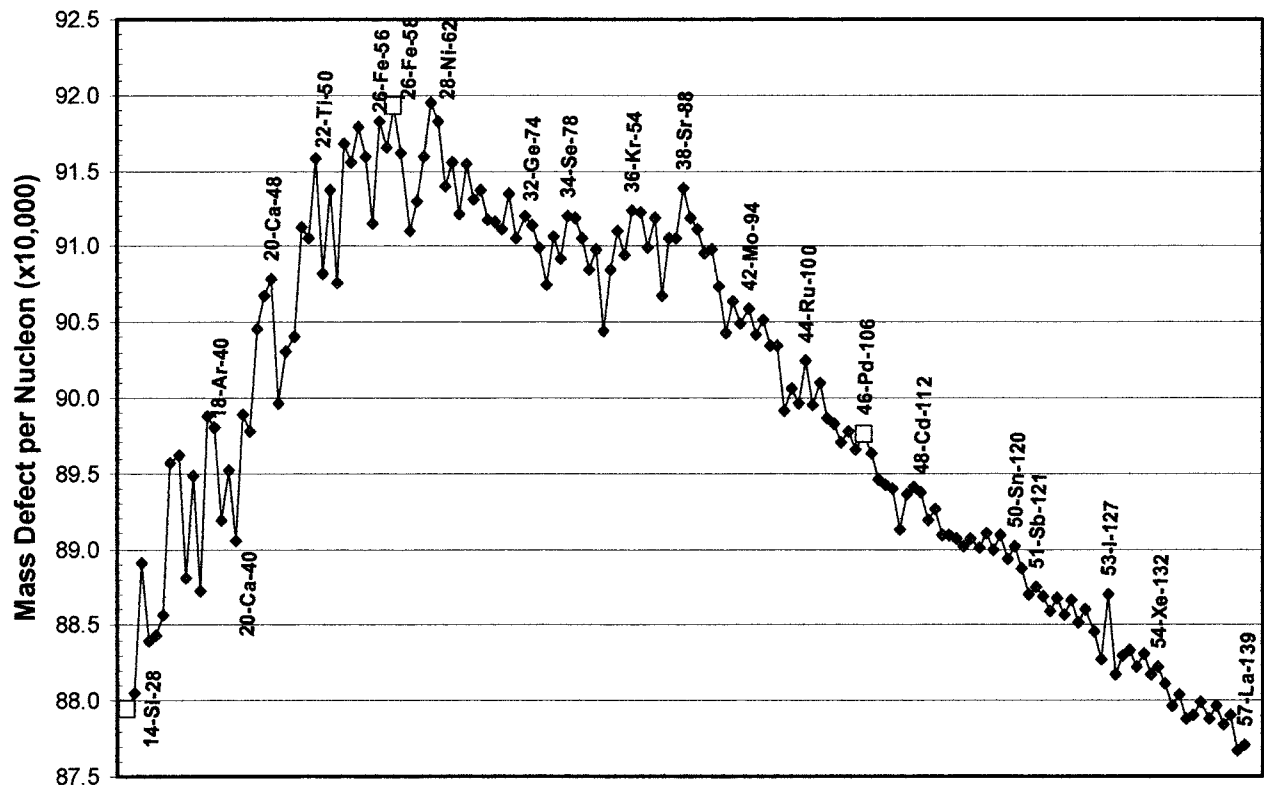
tional distinction between *energeia* and *dynamis*. "How does it change my formula?" he asks. What is missing is the concept. By invoking the equivalence of energy and mass to explain an anomaly in the periodic table, one is only displacing the problem to another realm. Why is energy equivalent to mass?

I supposed that the reason for mass defect would be found in the geometry of orientation of the Weber pairs. As I have many times noted, the 1846 Weber formulation for the Fundamental Electrical Law (which first appeared in Gauss's *Notebooks* in 1835), is strictly relativistic. When stated in the simpler form of his Law of Potential, Weber's electrostatics shows that the work done by one electrical particle upon another is dependent upon their relative velocities. The well-known formula derived from Special Relativity,  $E = mc^2$ , merely amounts to a restatement of Weber's law, interpreted in such a way that the mass, rather than the force between particles, changes with relative velocity. As Franklin D. Roosevelt's chief wartime science adviser, Vannevar Bush, noted in his 1926 defense of the Weber electrostatics, what is measured in experiments on moving electrons is not the *mass*, but the *charge-to-mass ratio*.<sup>7</sup> Thus, any experiment which purports to show a mass increase, as predicted by Special Relativity theory, can equally well be interpreted as evidence of a charge decrease; that is, a decrease in the measured force between particles, precisely the result one expects from the Gauss-Weber formulation.

Weber's formula describes the relation for the pair-wise

7. V. Bush, "The Force between Moving Charges," *Jour. Math., and Phys.*, Vol. V., No. 3 (March 1926).





Graph 1  
 MASS DEFECT PER NUCLEON OF NATURAL ISOTOPES FROM Si-28 TO La-139

Source: Calculations based on data from *Handbook of Chemistry and Physics*, Boca Raton, Fla.: CRC Press, 60th Edition (1980), pp. B-236 to B-274.

interaction of electrical particles. I hypothesized that in the nucleus, these Weber pairs would be oriented toward the vertices of the Platonic solids of the Moon model. The differing geometries would produce different charge effects, and therefore varying apparent masses of the nuclei.

On getting into such considerations, one recognizes that mass or gravitation, as Riemann and Weber suspected, must be an electrodynamic phenomenon. The orientation and relative motions of charges within the nuclei of attracting bodies are the source of what is called the gravitational "force." That means that when we weigh something, we are actually measuring an electrical attraction between the very rapidly moving charges of the Weber pairs.

The mathematical treatment of the interactions among the moving charges of the Weber pairs raises difficulties of even greater complexity than the insoluble n-body problem in gravitation. I wondered if the problem could be approached by looking at the geometry of the Moon model. To do so, I calculated and graphed the mass defect per nucleon for all the naturally occurring isotopes through 57-Lanthanum-139, wondering if I would find unusual values at the Moon model singularities. In this, I was partly disappointed. The graph of mass defect per nucleon (Graph 1) is essentially the same as the well-known curve of binding energy. It rises to a peak at iron through nickel, and then declines. There is nothing particular-

ly notable about the values for oxygen, silicon, or palladium. Nonetheless, the peak at iron is significant. There is no conventional explanation for it, but iron is one of the singularities of the Moon model. I believe it was at this point that I began to think of magnetism in connection with the Moon model.

#### The Ontological Question, Briefly

Before closing on the subject of mass defect, we will make a brief but necessary mention of the ontological question implied. Any truthful explanation of this singular phenomenon will require an overturning of generally accepted empiricist assumptions respecting "mass." What modern scientific thought takes as the most self-evident of qualities is, in truth, the most interesting of all ambiguities. One could summarize the failure of modern, generally accepted approaches in these few words: What should be the subject of investigation is assumed as already known. To proceed in this matter from any lesser ontological standpoint than that of Plato, Cusa, and Leibniz is foolery. The history of the subject shows that the fundamental breakthroughs occurred precisely where that standpoint was taken up and empiricist notions rejected.

Modern physical chemistry began with Antoine Lavoisier's adoption of the program laid out by Nicholas of Cusa in the "De Staticis" (On Statics) section of his *De Idiota Mente* (The

Layman on Mind): the application of the precision balance to the investigation of what we now call chemical and biochemical processes. Mendeleev's discovery of the periodic property of the elements required an explicit overturning of the Galileo-Newton assumption respecting mass, as he noted in the 1889 Faraday lecture:

The primary conception of the masses of bodies, or of the masses of atoms, belongs to a category which the present state of science forbids us to discuss, because as yet we have no means of dissecting or analyzing the conception. All that was known of functions dependent on masses derived its origin from Galileo and Newton, and indicated that such functions either decrease or increase with the increase of mass, like the attraction of celestial bodies. The numerical expression of the phenomena was always found to be proportional to the mass, and in no case was an increase of mass followed by a recurrence of properties such as is disclosed by the periodic law of the elements. This constituted such a novelty in the study of the phenomena of nature that, although it did not lift the veil which conceals the true conception of mass, it nevertheless indicated that the explanation of that conception must be searched for in the masses of the atoms; the more so as all masses are nothing but aggregations, or additions, of chemical atoms which would be best described as chemical individuals.<sup>8</sup>

Bernhard Riemann's conception of the *geistesmasse*, as developed in the "Philosophical Fragments,"<sup>9</sup> is the most far-reaching of approaches taken by modern mathematical physicists. Riemann and Wilhelm Weber's attempts to derive the electrodynamic origin of mass (gravitation) bear on this matter. Our explorations of the Moon model suggest that atomic weight and mass defect are expressions of the geometry of the nucleus. A clearer understanding of the Moon nucleus will thus shed light on this important question.

#### (4)

### **Magnetism As a Periodic, Nuclear Property; Curie and Langevin's Theory; Our Theory; Where Is the Electron? Palladium and the Great Harmony; Magnetism of the Lanthanides; The Self-sustaining Cube; Gadolinium.**

In thinking about properties which correlate to the singularities of the Moon model, my thoughts turned to magnetism. I recalled that Harkins had remarked on the strong paramagnetic susceptibility of oxygen and palladium. What we call *para-*

*magnetism* today was called *weak magnetism* by Pierre Curie, who systematically studied the magnetic properties of the elements. His work is summarized in an 1895 paper, one of the great works of physical chemistry, which remains a classic in the study of magnetism.<sup>10</sup> Curie discovered that the weakly and strongly magnetic substances shared the property that on heating, they lost their attraction to a magnet. Some elements fell into another category, the *diamagnetic*. These substances are repelled by either pole of a magnet, but much more weakly than the paramagnetic substances are attracted. Diamagnetism does not weaken with heating, with the one exception of the element bismuth, which is the most strongly diamagnetic.

A systematic study of diamagnetism had been carried out by Weber, using metallic bismuth. Weber proposed that diamagnetism is the result of induced molecular currents. Recall that Weber was a follower of Ampère, who had proposed that magnetism is the result of the presence of *molecular currents*, by which he meant resistance-free circuits surrounding what we today call the atom. On bringing a magnet into the vicinity of a substance, Weber supposed that an Ampère molecular current was induced. By the laws of induction of Nobili, Neumann, and Lenz, the which Weber had systematized under his Fundamental Law of Electrical Action, the magnetism produced by the induced current must be such as to oppose the motion of the inducing magnet. Else, as Weber noted, a small amount of work in the motion of the inducing magnet would be multiplied indefinitely. Hence the repelling force of diamagnetism.

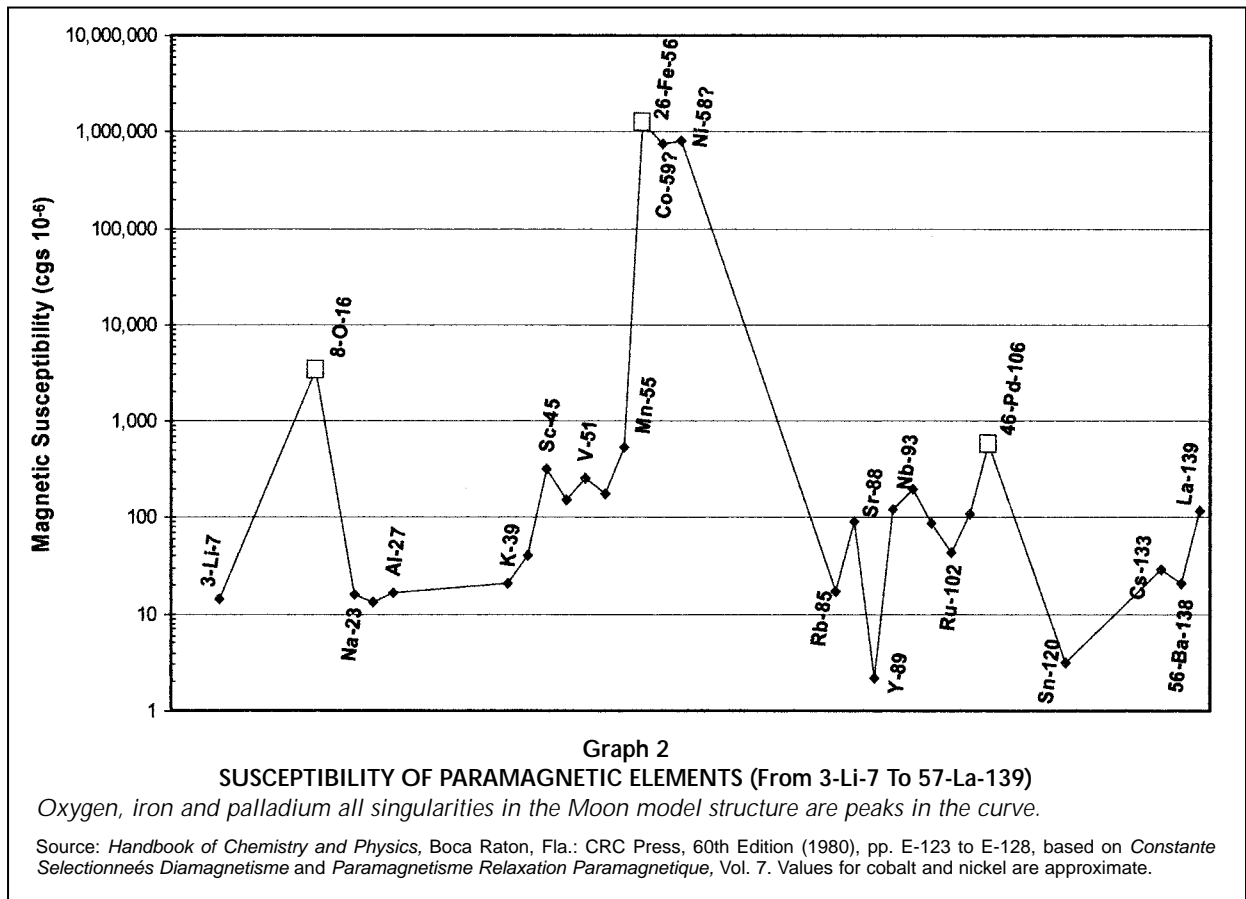
Weber thus hypothesized that diamagnetism was a natural property of all substances. Magnetism had to be the result of some special configuration of the inner parts which masked the natural diamagnetism. Curie's hard-won discovery that the magnetic property dissipated upon heating, tended to confirm the Ampère-Weber view of magnetism, which became generally accepted, even as their conception of electrodynamics was replaced by the Faraday-Maxwell formalism. Paul Langevin, a younger colleague of Curie, first proposed a systematic theory of electron orbitals as the cause of the magnetic property. In a 1905 paper,<sup>11</sup> Langevin drew on Curie's work on symmetries, which had characterized the magnetic field as possessing the symmetry of the cylinder. Langevin suggested that the electron orbitals in magnetic and paramagnetic substances must somehow arrange themselves such as to produce an overall cylindrical conformation, such that the currents act together like a solenoid. The diamagnetic substances, on the other hand, would possess a greater symmetry, such that an inducing field would not be able to orient the atom in any particular direction. From whatever direction the magnetic pole approached, it would induce a current in the electron orbitals which would oppose it. Langevin

8. "The Periodic Law of the Chemical Elements," by Professor Mendeléeff, Faraday Lecture Delivered before the Fellows of the Chemical Society in the Theatre of the Royal Institution on Tuesday, June 4, 1889. In D. Mendeléeff, *The Principles of Chemistry*, Third English Edition (London: Longmans, Green, and Co., 1905) and (New York: Kraus Reprint Co., 1969), Vol. II, p. 494.

9. The first English translation of Riemann's "Philosophical Fragments" appears in the Winter 1995-1996 issue of *21st Century*, pp. 50-62.

10. M.P. Curie "Propriétés magnétiques des corps à diverses températures" (Magnetic Properties of Bodies at Different Temperatures), *Annales de Chimie et de Physique*, Juillet (July) 1895, pp. 289-405.

11. P. Langevin, "Magnétisme et théorie des électrons" (Magnetism and the Theory of Electrons), *Annales de Chim. et de Phys.*, Vol. 8 (1905), pp. 70-127.



explained the gradual disappearance of the magnetic property with heat, by supposing that the thermal agitation of the atoms tended to give them a random orientation which eventually overcame the alignment produced by the cylindrical arrangement.

Langevin's is a masterful work of mathematical-physics hypothesis, and well ahead of its time, the properties of the electron having barely been established at the time of writing. I found the paper a useful sounding board for my own ideas on the subject, which I was developing at the same time as I was reading it. Yet, like most of modern physics, it was too pat. Something was missing. In the end, I could not disagree with the conception of a cylindrical symmetry to the electron motions. The correspondence of high magnetic susceptibilities with the Moon model singularities, where one finds the highest spherical symmetry, seemed to go against Langevin's fundamental premise of a cylindrical symmetry. The paradox was resolved when we considered the spin of the nucleus around the unique axis we had identified. The magnetism is then not the result of simple orbital motions of the electrons, but of the transport of the electron, orbit and all, by the nuclear spin. Stevens and I came to this conclusion as we examined the geometric properties of the Moon model at the singularities where magnetic susceptibility is a maximum.

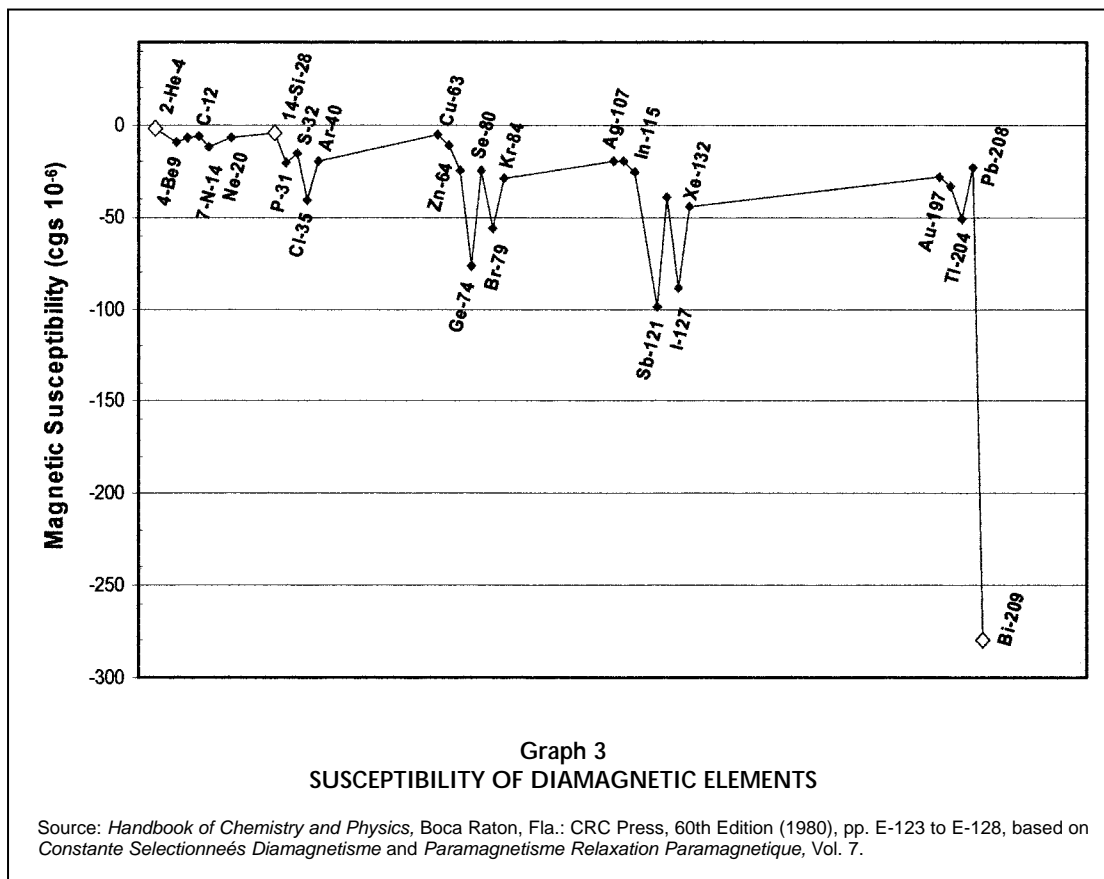
The first step was to assemble a table of the susceptibilities of all the elements. I show this data in a variety of graphical forms. In Graph 2, I show the susceptibility of the para-

magnetic elements from 3-lithium-7 to 57-lanthanum-139. Note that the y-axis is on a logarithmic scale. The extraordinary magnetism of the Moon model singularities at 8-oxygen and 46-palladium stand out, and of course 26-iron. (Cobalt and nickel are nearly as magnetic as iron; the question marks are there on the chart because I lack exact values for them.) Graph 3 shows the susceptibilities of the diamagnetic elements from helium to bismuth. Silicon, which represents the completed octahedron of the Moon model, is diamagnetic, although only very slightly so. This was an anomaly to be explained.

### Our Theory of Magnetism

The concept of magnetism we developed was based on the observation that the Moon model representations of the nuclei of oxygen, iron, and palladium, are precisely those which we discovered to rotate with perfect symmetry around the axis of the universe. Silicon, which shows a slight diamagnetism, will not minimize the mechanical moment of momentum of the nucleons when spinning on the axis of the universe, as we showed in Section 2. It prefers the "top" axis of the octahedron.

However, if it is not the motion of the nuclear charges, but the extra-nuclear electrons which are producing the magnetism (although even this assumption must be carefully examined), one must break through one of the great barriers of contemporary nuclear physics, and propose a causal relationship



between the nuclear geometry and the arrangement of electron orbitals, in order to establish a relationship between the nuclear motion and magnetism. In proposing that magnetism derives from a nuclear property, we may also seem to be defying the widely held belief, which goes back to Langevin's 1905 paper, that the disappearance of magnetism with heat is caused by thermal agitation of the atom. It is generally thought that nuclear properties do not respond to mechanical action such as heat. Yet must not the nucleus be involved?

#### Where Is the Electron?

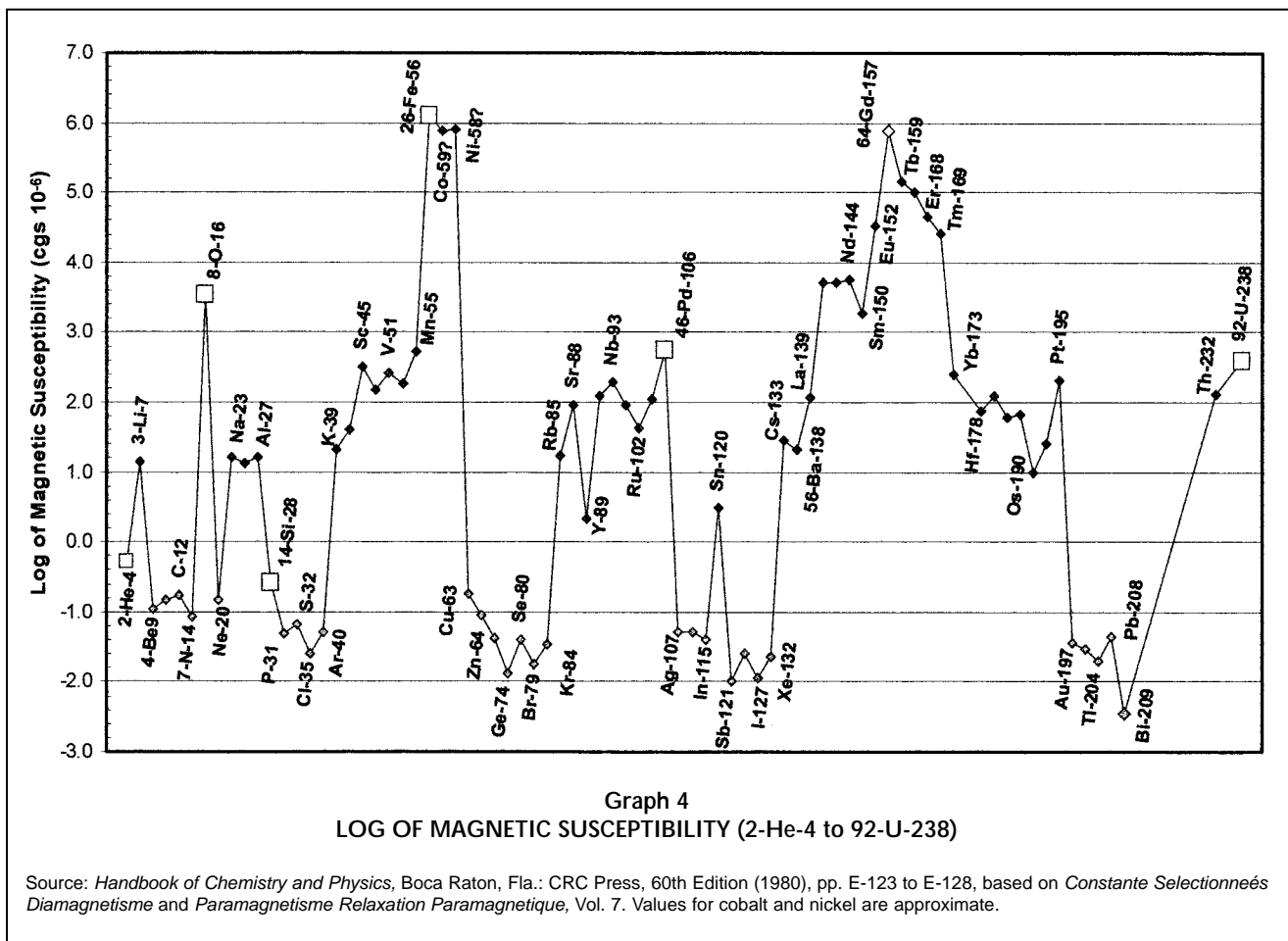
In connection with the concept of the neutron, described in Section 3, I had also conceived of a corkscrew-like extra-nuclear electron orbital, parallel to, but much larger than the paths traced by the nuclear electrons which are captured to become neutrons. The extra-nuclear electrons would follow spiral orbits around the Weber pair, but at a distance about 1,000 times farther out. For the same reason as the nuclear electrons, these orbits would tighten as they approach the center, converging like two opposed corkscrews. These electrons would then have opposing spin. As the charge density of the protons on the Weber pair is greatest at the center, because of their high velocity there, the electrons would also have greatest charge density around the center. For purposes of rough calculation, one could then simplify the electron spiral, into a circular orbit moving in a plane which is perpendicular to the Weber pair, and close to the center of the pair. If the angular velocity of the nuclear spin is high in

comparison to the orbital velocity of the electron in this reduced circular orbit, then it is not the orbital velocity of the electron, but the rotational velocity of the whole orbit which would act like the moving charge which produces the Ampère molecular current.

Weber's 1871 paper defines a stable state of aggregation of two unlike particles, in which the less massive particle revolves in a circular orbit around the more massive one. The radius of the stable orbit must fall within a minimal distance,  $\rho$ , determined in the same way as for the Weber proton pairs.<sup>12</sup> The radius of the electron orbit, so determined, comes to be 918 times greater than that of the Weber proton pair. Assuming that the electron orbital is conveyed with the spin of the nucleus, the velocity of the electron orbit would be considerably greater than that of the proton spinning much closer in to the center. Thus it would be the motion of the electron that is primarily responsible for the magnetism. The total magnetic moment would be a geometric sum of the electron and proton motions.

Suffice it to say that our supposition is entirely at odds with contemporary accepted views of magnetism. We attribute the magnetic moment to a collective motion of all the electron

12. The minimal distance,  $\rho$ , is equal to  $[e e' / c^2] [(e + e') / \epsilon e']$ , where  $e$  and  $e'$  are the charges of the two particles,  $\epsilon$  and  $\epsilon'$  their masses, and  $c$  is the Weber constant equal to  $\sqrt{2}$  times the velocity of light. Taking the proton-electron mass ratio as 1,837, the value of  $\rho$  for the electron-proton pair will be 918 times greater than that for the proton-proton pair.



orbitals, conveyed by the unidirectional spin of the nucleus. The accepted view attributes magnetism to the spin of certain extra-nuclear electrons. But that is not all, for our picture of the nucleus is so far different from the accepted picture (actually, there is no accepted picture) as to make any comparison impossible. The trained specialist recognizes immediately that if we are right, the whole edifice of 20th Century atomic physics must be rethought, as Dr. Moon had done. Moon was able to make breakthroughs where others could not, in part because he had a hands-on mastery of the crucial experiments on which the theoretical structure was built. He had done the experiments. Few of his peers had the combination of competence and courage to think in the same way. Today, the problem is far worse.

#### Palladium and the Great Harmony

There remained some internal inconsistencies in our hypothesis. For example, why is not the completed dodecahedron of palladium a stronger magnetic substance than iron? It carries more charges, and spins around the same unique axis. For another thing, how do we explain the high magnetic susceptibility of the lanthanide elements? In Graph 4, we show the available values for the magnetic susceptibilities of all the elements. The Moon model singularities are shown as squares. They all represent local maxima. But we also see here the high

susceptibility of the lanthanides, of which 64-gadolinium-157 is the peak.

In examining these paradoxes, some new geometric features of the Moon model became evident. Respecting palladium, we discovered that it is the first of the structures to have a shared axis. One axis of the cube and one axis of the dodecahedron line up along the axis of the universe. This produces a very curious dynamic for the two Weber pairs which share the same axis. By Stevens's analysis, the inner and outer protons will change places as the oscillation continues—palladium is a curious element.

In following this line of reasoning, one comes to recognize a great harmonic motion in the oscillations of the Weber pairs making up the more complex nuclei. Calculation shows the frequencies of these oscillations to be higher than any known radiation. The size of the nucleus also comes into question here. By the logic of the Weber electrodynamics, an increase in the number of Weber pairs would increase the attraction, causing the heavier nuclei to be smaller than the lighter ones, a conclusion which Dr. Moon frequently referred to. Yet there would be differing radii for the pairs arranged along the axes of the successive, nested solids. Some charges would have longer to travel than others. What is the sequence of their oscillations? Do all come to the center at once, or is there a kind of firing order?

Another item of overlooked significance, which is seen in Graph 4, "Log of Magnetic Susceptibility," is the periodicity of magnetism. Look at the values of magnetic susceptibility for the noble gases, Ne, Ar, Kr, and Xe. Look then at the values for the alkalis, Li, Na, K, Rb, and Cs. The Mendeleev periodicity and the Moon model periodicity are evident in the same graphic presentation. A still unsolved paradox lies here.

### Magnetism of the Lanthanides

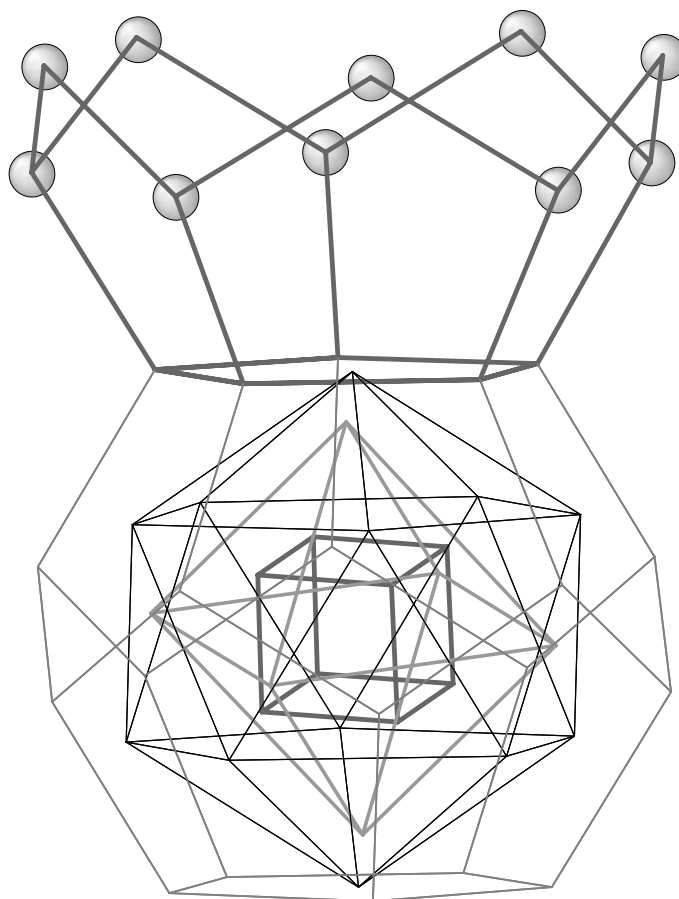
Our search for an explanation of the high magnetic susceptibility of the lanthanides also proved fruitful, and led us to a new understanding of the orientation of the Weber pairs. While I was assembling the data on magnetic susceptibilities, I suggested to Stevens that he try to figure out the reason for the magnetism of the lanthanides, and especially the very high magnetic susceptibility of gadolinium. One day he called with a partially formed idea, which involved returning to Dr. Moon's original construction for the lanthanides, a construction which I had slightly varied, thinking it would better explain the placement of neutrons. We got together that day, and came up with an explanation for gadolinium as well as a new insight into why the charges must orient to the axes of the Platonic solids.

The first time I saw Dr. Moon present his idea of the nucleus, using a model constructed out of used aluminum printing plates, his explanation for the anomaly of the lanthanides stood out in my mind. The 14 elements which share the same chemical properties as lanthanum, usually shown in a separate row at the bottom of the periodic table, had a reason for existing! In the building of the twin dodecahedron after palladium, the first 10 protons, which bring us to 56-barium, form the scaffolding of the new dodecahedron with a structure that looks like a scalloped salad bowl (Figure 10). At that point, the cube and octahedron build inside, forming the 14 lanthanides.

Recently, in trying to understand the continued reappearance of the "magic number" of 82 neutrons from barium through the first four lanthanides, I had hypothesized a rather complicated variation on Moon's construction, in which five vertices of the dodecahedron and five vertices of the icosahedron were the first to form. Stevens's insistence on the "salad bowl" in his still partial attempt to explain gadolinium caused me to wonder. In a joint session one afternoon, several long-standing problems were solved at once.

### The Self-Sustaining Cube

In Ampère's original statement of the law for the force between current elements, upon which the work of Carl Friedrich Gauss and Wilhelm Weber immediately rested, there appears an angular term by which the inverse square

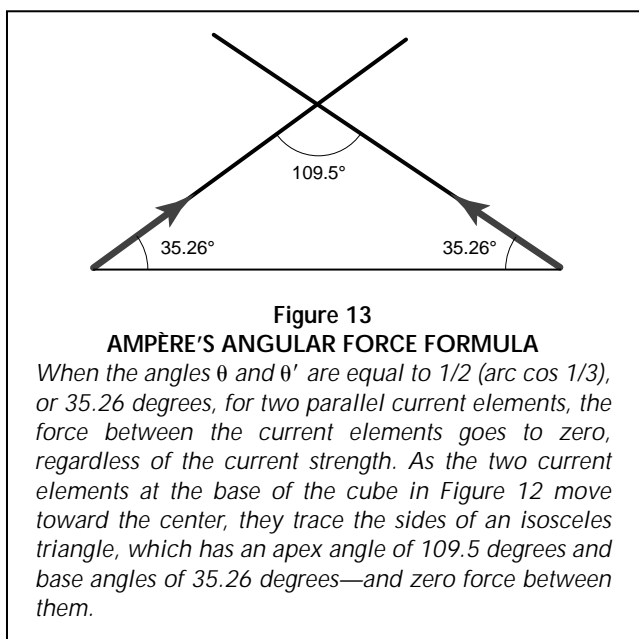
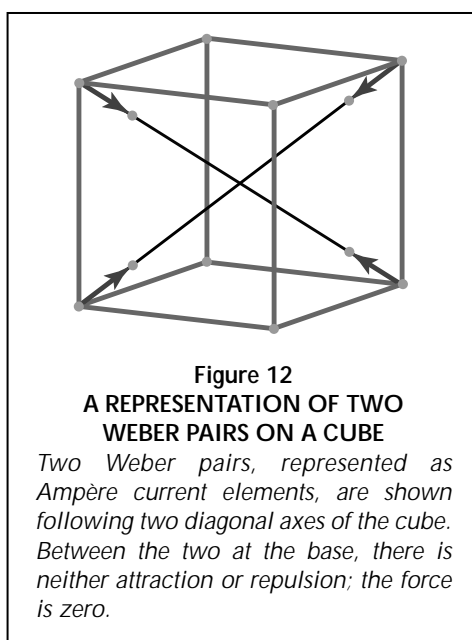
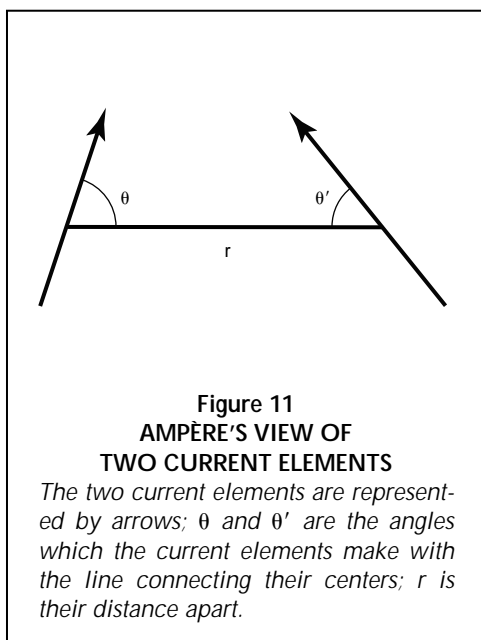


**Figure 10**  
**THE 'SALAD BOWL' BEGINS TO FORM**  
**ON THE TWINNED DODECAHEDRON**

*To reach 56-barium, 10 protons are added onto a twinned dodecahedron, creating a structure with the appearance of a scalloped salad bowl.*

law for the force between static charges must be multiplied. The angular term is  $[\sin\theta \sin\theta' \cos\omega - 1/2(\cos\theta \cos\theta')]$ , where  $\theta$  and  $\theta'$  are the angles which the current elements make with the line connecting their centers, and  $\omega$  is the spatial angle between the current elements.<sup>13</sup> (See Figure 11.) This means that there will be certain values of  $\theta$  and  $\theta'$  for which the force will be zero. Ampère's formal representation embodies the results of one of his earliest electrodynamic experiments, which showed that parallel, current-carrying wires either attract or repel, according as the current is flowing in the same or opposite directions. Clearly, at some intermediate angle, the force between the current elements would reduce to zero, before increasing again.

<sup>13</sup> Cf. footnote 3.  $F = ii' (ds \cdot ds')/r^2 [\sin\theta \sin\theta' \cos\omega - 1/2 (\cos\theta \cos\theta')]$ , where  $i$  and  $i'$  are the current,  $ds$  and  $ds'$  the lengths of the current elements, and  $r$  their distance apart.



However, current elements cannot be separated from the circuits which contain them, and there is therefore no empirical means of observing the force between current elements. It may be determined only by creative imagination, by hypothesis. The Ampère angular force formula is one of the more brilliant of those products of the creative imagination, which lie behind all fundamental discovery in physical science.

Stevens and I had been aware for many years of the case referenced in Peter Graneau's book on the Ampère force<sup>14</sup> for

14. Peter Graneau, *Ampère-Neumann Electrodynamics of Metals* (Nonantum, Mass: Hadronic Press, 1985).

parallel current elements. When the angles  $\theta$  and  $\theta'$  are equal to  $1/2$  (arc cos  $1/3$ ), or 35.26 degrees, for two parallel current elements, the force between current elements goes to zero, regardless of the current strength. We recognized that the angle was closely connected to the cube and tetrahedron. From the center of the circumscribing sphere, the side of a cube subtends the angle (arc cos  $1/3$ ), or 70.53 degrees. Its supplement of 109.5 degrees, also known to chemists as the tetrahedral angle, subtends the angle between two diagonally opposite vertices on a face. I had tried

many times to make this cohere with the Moon model, always impeded by the fact that I was imagining the current elements to lie at the center of the sphere, where they crossed.

Stevens's proposal to place the current element at the vertices of the solid, (which is to say the surface of the sphere), solved the problem almost instantly, when one recognized that the current coincides with the direction of the Weber pairs; that is, it is moving down the diagonal axes of the Moon model solids. Consider the two Ampère current elements, which are shown at the base of the cube (Figure 12). As they move toward the center, they trace the sides of an isosceles triangle whose apex angle is 109.5 degrees, and whose two base angles are 35.26 degrees (Figure 13). There is thus zero force between them. We must also consider the force between any two of the current elements in Figure 12, which are separated by an edge of the cube. Their angular separation is 70.5 degrees, and a simple calculation shows that they will attract.

However, a curious thing happens when we add the next two Weber pairs, to complete the cube which represents oxygen in the Moon model (Figure 14). We discover that the attractive forces, which all fall along the edges of the cube, resolve in the direction of the cube's diagonal. This is easily seen when we consider a single current element (shown at vertex A) moving toward the center of the completed cube. It will be attracted by the three current elements, which are distant by an edge length. The directions of the attraction are along the three perpendicular directions of the cube's edges. The vector sum of these three motions is the diagonal of the cube, as can be seen by inspection.

Weber pairs arranged along the four axes of a cube, thus produce an electrodynamically stable configuration. From any vertex, the Ampère force along the three adjacent faces reinforces the direction of motion of the charge toward the center. From the same vertex, the Ampère force along the

face diagonals of the cube is zero. We thus have the curious condition that the motion of current elements along the diagonals of a cube generates a mutual attraction which reinforces the motion! The cube is a self-organizing structure for grouped charges.

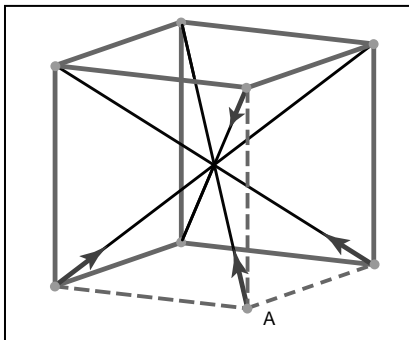
This suggests a reason that, from the standpoint of electrodynamics, the cube will be the first stable configuration of the Moon model.

We have still to examine these relationships more closely. The octahedron, which forms next, must be examined in the totality of its relationship to itself, and to the cube, and so forth.

### Gadolinium

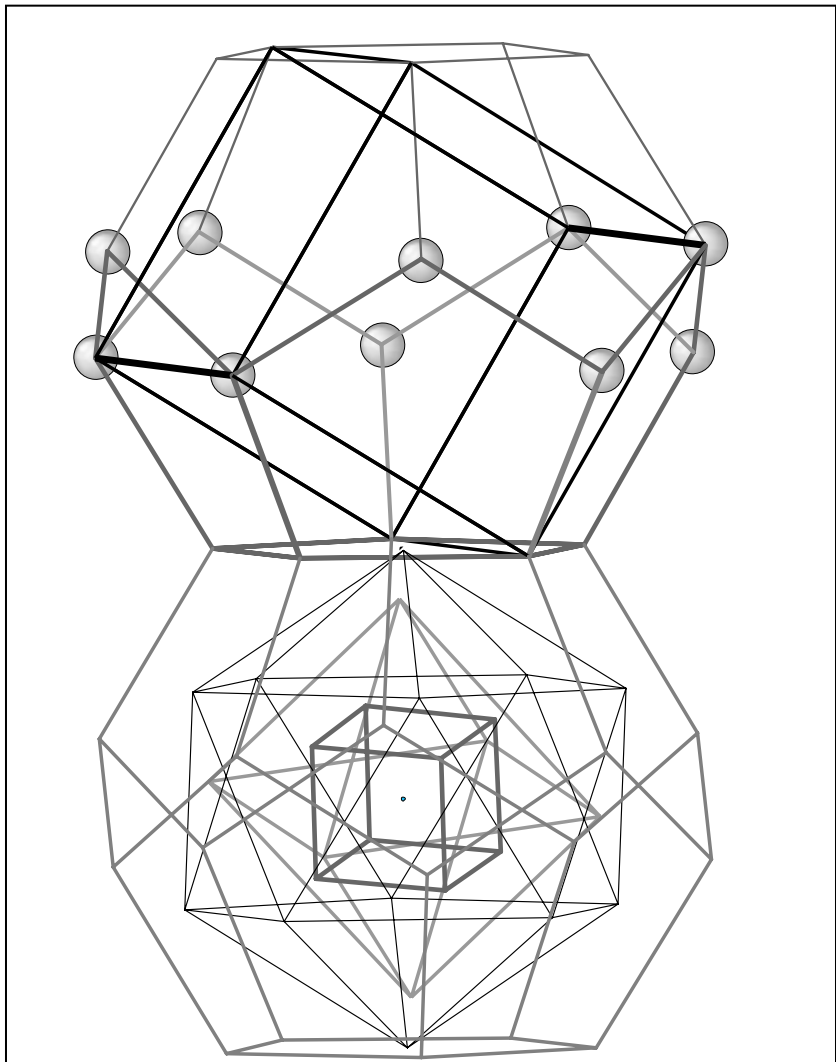
The case of gadolinium, the lanthanide with a magnetic susceptibility approaching that of iron, gave us a preliminary insight into the stability of the dodecahedron. Upon Stevens's insistence that the "salad bowl" must be formed at 56-barium, I abandoned my overcomplicated construction of the lanthanides, and immediately recognized that 64-gadolinium would be the completed cube inside the salad bowl. Shielded by the salad bowl, the cube could spin freely within, while the heavier barium nucleus stood more or less still, providing an arguable basis for the high magnetism. But could the cube spin so? What is the stability of the "salad bowl" structure? On examining this from the same standpoint of Ampère force relationships, it became clear that the geometry of the cube within the dodecahedron was at work. The same relationship of Ampère pairs which causes the stability of the cube is at work in the dodecahedral salad bowl of Figure 15. The salad bowl itself is thus a stable configuration. The cube which forms within it (not the large cube in the diagram, but the smaller one which corresponds to the oxygen cube) must then orient to the diagonal axes of the dodecahedron. These and other complex interrelationships remain to be worked out.

—Laurence Hecht is editor-in-chief and Charles B. Stevens is Associate Editor of 21st Century.



**Figure 14**  
**THE SELF-SUSTAINING CUBE**

The current element proceeding from vertex A is attracted by the three nearest current elements. The direction of attraction is along the three edges shown as dashed lines. The vector sum of the attractions is in the direction of the diagonal that the current element is already pursuing. Weber pairs placed along the four axes of a cube thus produce an electrodynamically stable configuration.



**Figure 15**  
**WHY THE 'SALAD BOWL' IS STABLE**

The stability of the salad bowl is created by the cube implicit within the dodecahedron. Note the two bold edges of the cube, which also connect pairs of vertices of the salad bowl. Current elements moving along the dodecahedral diagonals between these vertices will experience a zero-force in one direction. The same occurs for other pairs on the salad bowl, creating a stable structure.