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New hypothesis shows geometry of atomic nucleus

A summary of recent work by Dr. Robert J. Moon, adapted from an article by Laurence Hecht in the April 1987 German-language magazine Fusion.

The following summary of a groundbreaking new view of the atomic nucleus developed by University of Chicago physicist Dr. Robert J. Moon is adapted from a longer article by Laurence Hecht. Hecht collaborated with Moon to develop the implications of his geometrical model of the atomic nucleus for the periodic table and the arrangement of extra-nuclear electrons. Dr. Moon, an experimental physicist of vast experience, and a veteran of the World War II Manhattan Project, began his work at the University of Chicago in the 1930s under Prof. William Harkins.

While an elaborately refined set of rules exists to explain many phenomena observed at the atomic level, there remains no satisfactory model of the atomic nucleus, the central core of the atom around which a precise number of negatively charged electrons can be considered to orbit. Any attempt to produce a coherent theory of orbiting electrons, without knowledge of the structure around which these orbits are constructed, would seem to be doomed to failure. Nonetheless, a highly elaborated algebraic theory of the atom, designed to account for a mass of data gathered from spectral analysis and other operations, does exist in the form of the quantum mechanical model. Most of this theory presumes no more about the atomic nucleus than that it contains a certain number of positively charged particles agglomerated in a central mass.

It would seem past time to arrive at a more developed theory of the atomic nucleus, and Dr. Robert J. Moon has proposed a geometrical model of the nucleus to do just that.

The existing dogma of nuclear physics requires us to believe that protons, being all of positive charge, will repel each other up to a certain very close distance corresponding to the approximate size of the nucleus, at which point a binding force takes hold, and forces the little particles to stick together, until one should try to get them too close, at which point they repel again. So, the holding together of the protons in the nucleus is accounted for.

Since we disdain such arbitrary notions of "forces," and prefer to view the cause of such phenomena as resulting from a certain characteristic of physical space-time, a different view is demanded. Considerations of "least action" suggested to Dr. Moon a symmetric arrangement of the charges on a sphere, while the number of such charges and the existence of orbitals beyond the nucleus suggested a nested arrangement of such spheres, containing intrinsically the Golden Section ratios (see box).

The model

We are led immediately to the Platonic solids. The surfaces of the Platonic solids and related regular solids represent unique divisions of the surface of a sphere according to a least-action principle. All of the Platonic solids can be formed by the intersections of great circles on a sphere, the great circle being the least-action path on the surface of the sphere, and the sphere the minimal three-dimensional volume created by elementary rotational action.

The best way to see this is to consider the intersections of the great circles in a Torrianian, or Copernico-Pythagorean planetarium (cf. Johannes Kepler, *Mysterium Cosmographicum,* Dedicatory Letter, Abaris Press). In the device constructed by Giovanni Torriani to demonstrate Kepler's nested-solids model for the solar system, the vertices of the regular solids are formed by the intersections of great circles. Three great circles intersect to form an octahedron. Six great circles intersect triply in eight places to form the vertices of a cube and doubly in six places over the faces of the cube. Fifteen great circles intersect five-at-a-time in 12 locations, three-at-a-time in 20 locations, and two-at-a-time in 30 locations, forming, respectively, the vertices of the icosahedron, dodecahedron, and icosidodecahedron.

It is interesting that the tetrahedron is not uniquely determined in this construction, but is derived from the vertices of the cube. Dr. Moon has developed a nested model using four of the five Platonic solids, excluding the tetrahedron, to define the atomic nucleus in much the same way Kepler determined the solar orbits. In Dr. Moon's "Keplerian atom," the 92 protons of the naturally occurring elements are determined by two sets of 46 vertices. His proposed arrangement is as follows:

Two pairs of regular Platonic solids, the cube-octahedron and the icosahedron-dodecahedron may be called duals: The one will fit inside the other such that the vertices of one fit centrally on the faces of the other, each fitting perfectly inside a sphere whose surface is thus perfectly and symmetrically divided by the vertices. The tetrahedron is dual unto itself and therefore plays a part separate from the rest.

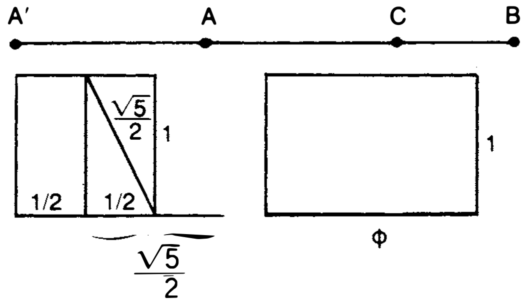
The four dual solids may form a nested sequence, cube, octahedron, icosahedron, dodecahedron with certain unique properties (**Figure 1**). The cube-octahedron nesting is clear, as is the icosahedron-dodecahedron (**Figure 2**). To fit the one pair of duals into the other appears at first to be a problem. For the six vertices of the octahedron do not fit obviously into the 20 faces of the icosahedron, nor could the fourfold axial symmetry of the former be simply inserted into the fivefold

An algebraic construction of the Golden Section

The Golden Section, or Golden Mean, divides a line into two segments, such that the ratio of these segments is proportional to the ratio of the whole length to the larger of the segments.

AC/CB = AB/AC

This being the case, when the length AB is extended by the segment AC, the ratio of the original to the new length, A'B/AB, will also be proportion to the Golden Section ratio.



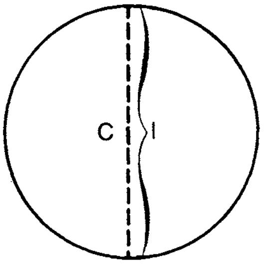
AC/CB = AB/AC = ϕ

(ϕ is the traditional symbol for the Golden Mean)

The Golden Section ratio is $(1+\sqrt{5})/2$, which is approximated by the number 1.61802. A simple construction of the ratio $(1+\sqrt{5})/2$ can be determined from the Pythagorean Theorem. Construct a square on an extended line. Draw a diagonal through one half of the square, and mark this length on the line. The extended line will be in the Golden Section ratio to the length of the side of the original square.

A geometrical construction of the Golden Section

The Golden Section can be constructed directly from a circle, as follows: Take any circle, and determine the length of its diameter by folding it in half. Now produce a tangent from any point on the circumference of the circle, which is extended so that it has the same length as the diameter. Connect the endpoint of the tangent to the center of the circle, and continue this new line until it reaches the opposite half of the circumference. This line will be cut in the Golden Section proportion (ϕ) by the diameter.



diameter length, l

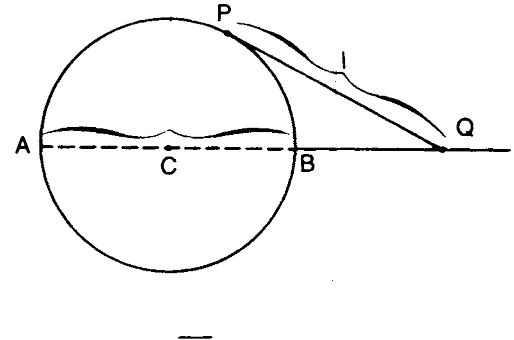
line PQ = line AB

line $\overline{PQ}^2$ = QB × QA

QA = AB + QB

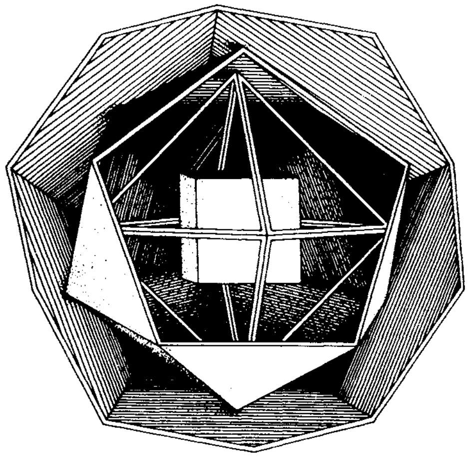
$\overline{AB}^2$ = (AB + QB)QB and

AB/QB = (AB + QB)/AB = ϕ



The relationship $\overline{PQ}^2$ = QB × QA can easily be shown by noting that PQB and PQA are similar triangles.

FIGURE 1
Nested sequence of four Platonic solids



axial symmetry of the latter. The octahedron may still be placed within the icosahedron in a manner that is beautiful. The ratio of five-to-four provided Dr. Moon a clue. Six vertices of the octahedron may be placed near to six vertices of the icosahedron, such that the distance from the nearby vertex of the icosahedron to the edge opposite it is divided in the Divine Proportion, as the Golden Section was called in the Renaissance (**Figure 3**).

The axis of the cube-octahedron pair is thus skew to the axis of the icosahedron-dodecahedron dual—a fact of great importance later.

Examining the edges of the figures so nested, considering that of the smallest inner figure, the cube, to be unity, we find:

Edge of cube	1.00
Edge of octahedron	2.12
Edge of icosahedron	1.89
Edge of dodecahedron	1.618

Note that the ratio of edges between the inner and the outer figures is in the Divine Proportion, $\phi = (\sqrt{5} + 1) \div 2 =$ approx. 1.618.

Then taking the radius of the sphere circumscribing the cube to be unity, the radii of circumscribing spheres stand in proportion:

Cube	1.00
Octahedron	1.733
Icosahedron	2.187
Dodecahedron	2.618

Note here, that the ratio of radii between inner and outer spheres is the square of the Divine Proportion.

So arranged, the four solids which are dual contain 46 vertices in a distinct ordering:

Cube	8
Octahedron	6
Icosahedron	12
Dodecahedron	20
Total	46

Building the nucleus

With the structure of the microcosm so determined, we are now prepared to demonstrate the unique arrangements of singularities that may exist within it. There are 92 such arrangements known as the naturally occurring elements (see **Fig. 6**) and some more that we can manufacture but not maintain for very long. Each element has a unique number Z of positively charged protons in its nucleus.

As a first approximation for the nucleus, Dr. Moon proposes that protons be placed at the vertices, beginning with the cube and moving outward. We thus get:

Oxygen (8)	Completed cube
Silicon (14)	Completed octahedron
Iron (26)	Completed icosahedron
Palladium (46)	Completed dodecahedron
. . . .	. . . .
Uranium (92)	Completed twin figures

Thus, the highly stable oxygen (making up 62.55% of the total number of atoms in the Earth's crust) and silicon (making up 21.22%) are represented by the first two completed figures. Together these two elements account for 84% of all the atoms in the Earth's crust. While the curve of relative abundance declines exponentially with increasing atomic number, iron, the completed icosahedron, is three orders of magnitude higher than the elements near it on the atomic number scale and makes up 1.20% of the atoms in the Earth's crust, and 5% by weight.

Filling the outermost figure, the dodecahedron, we reach palladium $Z = 46$. To go further, a twin structure joins at one of the faces of the dodecahedron (**Figure 4**) and begins to fill up its vertex positions with protons beginning on the outer-

FIGURE 2
Nesting of icosahedron in dodecahedron

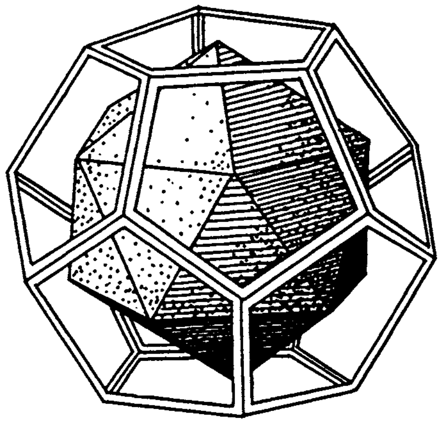
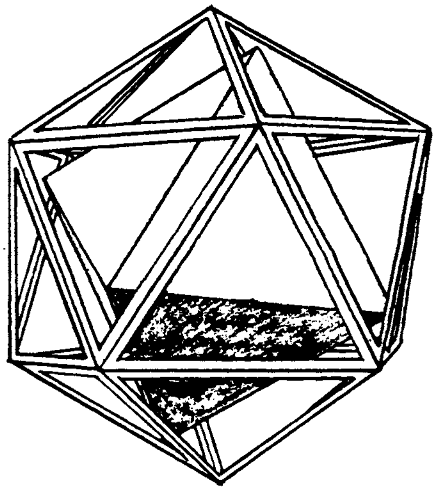


FIGURE 3

Nesting of octahedron in icosahedron



most figure. (47-Silver is the first.) Six positions are unavailable to it—the five vertex positions on the binding face of the second figure and the one at the face center where a vertex of the inscribed icosahedron pokes through.

Thus, on the second figure, 15 out of 20 of the dodecahedral vertices are available, and 11 out of 12 of the icosahedral vertices. We now fill 11 of the 20 available dodecahedral vertices, thus creating 47-Silver and continuing through 57-Lanthanum. Here, one face of the dodecahedron remains open to allow filling of the inner figures. The cube and octahedron fill next, producing the 14 elements of the lanthanide, or rare earth series (58-Ce to 71-Lu). Placing the proton charges on the inner solids causes a corresponding inward pulling of the electron orbitals. Thus, the otherwise unaccounted-for filling of the previously unfilled 4-f orbitals, and the mystery of the period of 14 for the rare earths, are explained.

The figure is complete at 86-Radon, the last of the noble gases. To allow the last six protons to find their places, the twin dodecahedra must open up, using one of the edges of the binding face as a "hinge."

87-Francium, the most unstable of the first 101 elements of the periodic system, tries to find its place on the thus-opened figure, but unsuccessfully so. Less than one ounce of this ephemeral substance can be found at any one time in the totality of the Earth's crust. 88-Radium, 89-Actinium, and 90-Thorium find their places on the remaining vertices. Two more transformations are then necessary before we reach the last of the 92 naturally occurring elements.

To allow for 91-Protactinium, the hinge is broken, and the figure held together at only one point (**Figure 5**).

The construction of 92-Uranium requires that the last proton be placed at the point of joining, and the one solid slightly displaced to penetrate the other in order to avoid two protons occupying the same position. This obviously unstable structure is ready to break apart at a slight provocation. And so we have the fission of the uranium atom, as hypothesized by one of those who first made it happen.

Dr. Moon was led to the elaboration of this theory on the basis of a review of the work of Klaus von Klitzing which he published in the October 1985 issue of the *International Journal of Fusion Energy*. Klitzing won the Nobel Prize in 1985, for the discovery of the quantum Hall effect.

Klitzing investigated the surfaces of semiconductors under extreme conditions—low temperatures and high magnetic fields. The Hall effect is a kind of resistance created by the Lorentz force which appears as a new, transverse electri-

FIGURE 4

Twin dodecahedra joined at one face

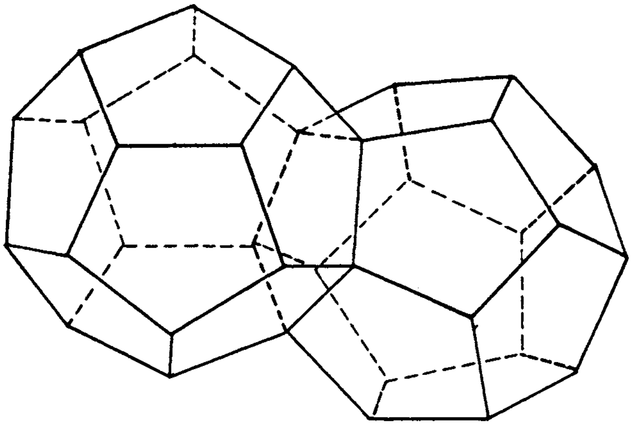


FIGURE 5

Twin dodecahedra with "hinge" broken

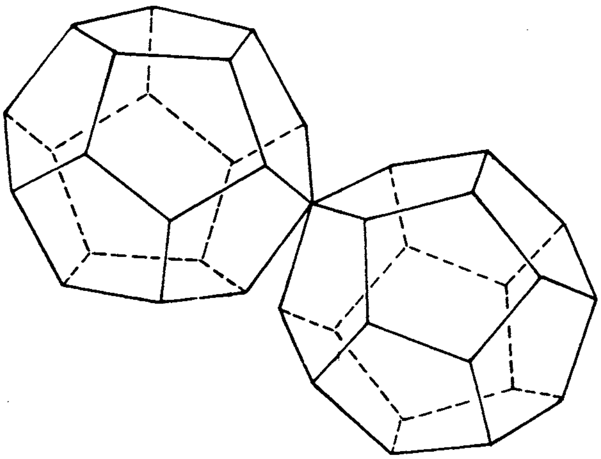


FIGURE 6
Periodic table of the elements

1 atomic number
H
1.0079 atomic mass

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

*	58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (147)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.9254	66 Dy 162.50	67 Ho 164.9304	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.97
†	90 Th 232.0381	91 Pa 231.0359	92 U 238.029	93 Np 237.0482	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (255)	103 Lr (256)

cal potential. It is generated when an electrical current flows in a conductor which lies in a plane perpendicular to the magnetic field.

According to a classical explanation, the Lorentz force will deflect the charged particles sideways. The particles will collect on the edge parallel to the electron velocity.

This charge separation leads to the buildup of an electrical field (the Hall field). This can be considered to create a compensating force to the Lorentz force, which ultimately annuls it, allowing an undeflected current to flow. When Klitzing investigated the surfaces of semiconductors under extreme conditions, he found a surprising result: The Hall resistance does not occur continuously, but as a step function, which depends only upon the constant value 25,812.815 ohms, and a value *n*, which depends upon the strength of the magnetic field, and the charge strength.

The value of this natural resistance turns out to be determined by the ratio of Planck's constant to the square of the electron charge—which also is a ratio which determines the fine structure constant (α = fine structure constant):[1]

$$\frac{1}{\alpha} = \frac{2h}{e^2\mu_0 c}$$

Moon was interested in the geometry which underlay the fine structure constant and the Hall resistance. He developed a two-dimensional model for this geometry, and then considered a three-dimensional model which involved the five Platonic solids. This model was like the one described, with electrons, rather than protons, arranged at the vertices of the figure. However, it brings together three, not two, completed dodecahedra. If we allow for one position to be lost by the joining, then there are 137 electrons.

This figure is of significance because it is the integer most closely related to the fine structure constant (1/137.036). The fine structure constant is of crucial importance for the entire concept of quantum physics. Its value, among other things, is the ratio of the velocity of an electron at the lowest level in a hydrogen atom, to the velocity of light.

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[1] See *Fusion*, May-June 1986, page 24.