A Physical Model for Atoms and Nuclei—Part 1*

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Abstract. A physical geometrical packing model for the structure of the atom is developed based on the physical toroidal ring model of elementary particles proposed by Bergman.[1] From the *physical* characteristics of real electrons from experiments by Compton [2,3,4] this work derives, using combinatorial geometry, the number of electrons that will pack into the various physical shells about the nucleus in agreement with the observed structure of the **Periodic Table of the Elements.**

The constraints used in the combinatorial geometry derivation are based upon Joseph's simple but fundamental ring dipole magnet experiments and spherical symmetry. From a magnetic basis the model explains the physical origin of the valence electrons for chemical binding and the reason why the periodic table has only seven periods.

The same geometrical packing model is extended to describe the physical geometrical packing of protons and neutrons in the physical shells of the nucleus. It accurately predicts the nuclear "magic numbers" indicative of nuclear shell structure as well as suggesting the physical origin of the nuclide spin and the liquid-drop features of nuclides.

Introduction

Quantum Mechanics and Relativity Theory form the foundation upon which modern physics rests. Yet some philosophers and scientists object to these very successful theories, because they involve assumptions known to be false and because they are mathematics theories that fail to give a physical understanding of the processes occurring.

Both Quantum Mechanics and Relativity Theory are based on the assumption of point-like particles. However, electron scattering experiments, for which Robert Hofstadter [5] received the Nobel Prize in 1961, have shown that neutrons, protons, and other elementary particles have a measurable finite size, an internal charge distribution (indicative of internal structure), and elastically deform in interactions (See Figure 1). The size and shape of the electron was measured by Compton [2, 3, 4] and refined more

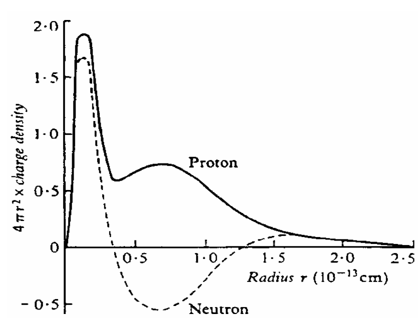

Figure 1.
Charge Density of Proton and Neutron

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completely by Bostick [6, 7], his last graduate student. The finite size, internal particle structure, and elastic deformation of shape are ignored by both Quantum Mechanics and Relativity Theory.

In modern relativistic quantum theories of the atom and nucleus, it is postulated that the charged electrons and protons move in their respective shell orbits with specific angular momentum about the center of the nucleus without continuously radiating electromagnetic energy. These postulates violate both Ampere's and Faraday's laws of electrodynamics from which Larmor's formula for total power P radiation from a moving charge is derived, *i.e.*,

$$P = \frac{2e^2}{3c^3}\left|\frac{dv}{dt}\right|^2 \tag{1}$$

Larmor's formula agrees with all the macroscopic experiments with accelerating charges. It requires all accelerated charged particles to emit radiation continuously while being accelerated. However, radiation from the orbiting electrons and protons in the atom postulated by quantum theory is not observed and violates energy conservation.

Quantum models of the atom are unable to show that the forces in the atom are in dynamical equilibrium for S states with zero angular momentum. Normally some angular momentum is needed to give rise to a centrifugal force to balance the electrical Coulomb force attracting the negatively charged electron toward the positively charged nucleus. Otherwise, the Coulomb force causes the electron to fall into the nucleus and annihilate itself with a proton.

For S states, quantum mechanics postulates that the negative electron vibrates back and forth *through the nucleus* without interacting with the positively charged protons. This postulate violates electrodynamics laws without any physical justification.

In quantum mechanics the self-field of finite-size elementary particles and their changes due to deformation are ignored. These are real physical and experimentally measurable effects.

Quantum theories lead to a 100 percent random basis for events of the physical universe. This is in disagreement with common sense experience and the notion that all effects are produced by some cause.

Despite the shortcomings of Quantum Mechanics and Relativity Theory, they have persisted as pillars of modern physics. Their status is due in part to the fact that they yield mathematical formulas that accurately predict many phenomena. Also, no better alternative theories have yet been identified and accepted.

This situation has been changed by three events. The first event occurred in 1915 when Ewald and Oseen [8, 9] discovered the extinction effect in electrodynamics. Experimentally they found that when light passes through any media, even the best man-made vacuum, it is absorbed by atoms and re-emitted in such a way that it moves with the speed of light plus the velocity of the atoms on which it was absorbed. In 1963 Fox [10, 11, and 12] realized that this experimental evidence allowed the famous Michelson-Morley modified Fizeau experiment of 1886 to be explained by classical electrodynamics using the Galilean transformation instead of relativity theory. Basically the extinction effect invalidated the second postulate of Relativity Theory that the speed of light was c in all reference frames.

The second event occurred in 1978 when Barnes [13] published his remarkable proof from electrodynamics showing that all the known results predicted by Special Theory of Relativity (STR), *i.e.* the change in mass of elementary particles with velocity, the change in electromagnetic fields of elementary particles with velocity, and the change in decay half-life with velocity could be predicted exactly from classical electrodynamics of finite-size elastically deformable elementary particles.

Once this proof was published, scientists began to realize that Relativity Theory cannot be applied to real physical finite-size elastically deformable elementary particles without always obtaining a bad result. This is due to the fact that electrodynamics is sufficient by itself without help from another theory.

The third event occurred in 1990 when Bergman [1] called attention to a successful physical model for the electron, proton, and other elementary particles based on a spinning toroidal ring of continuous charge. This model depicts the electron and the proton as thin rings of charge circulating at the speed of light. The continuous charge in the ring is repulsive to itself due to the Coulomb interaction. This force is exactly balanced by the *magnetic pinch effect* due to the current in the ring. The balance of electric coulomb and magnetic Lorentz forces determines R, the radius of the ring (See Figure 2). The half-thickness of the ring r is extremely small.

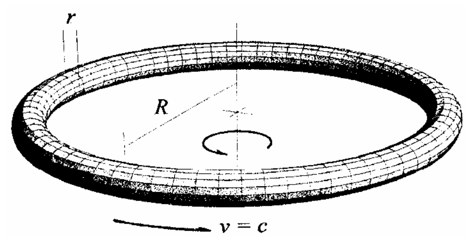


Figure 2
Spinning Ring Model of Elementary Particles

Bergman speculates that the electric and magnetic forces on the ring must in general be unequal with the electrical repulsive forces predominating at small radii and the magnetic pinch effect predominating at large radii. Bergman suggests that there are special values of the radius for which the electric and magnetic forces are equal, but no explicit proof of this has been given. Furthermore, Bergman notes that the dynamic radius of an electron closely bound to a proton in a neutron would be significantly smaller than the radius of an electron weakly bound to a distant proton in the hydrogen atom due to the elasticity of the toroidal ring model.

Three features of the spinning charged ring model of electrons and protons are especially important to the structure of the atom. The dominating characteristics provided by the ring model are first, the physical size of each particle; second, the magnetic dipole exhibited by each particle; and third, the property that a charged spinning ring, which is surrounded by static electric and magnetic fields, does not radiate continuously.

Planck's constant h, the fundamental constant of quantum mechanics, is derived by Bergman [1] to be

$$h = \frac{e^2}{2\pi\varepsilon_o c}\ln\left(\frac{8R}{r}\right) \tag{2}$$

The value of h is determined from the ring structure by the balance of electric and magnetic forces. Since Bergman's model is a physical model, it allows one to predict from first principles Planck's constant h, spin, magnetic moment, mass, and other physical properties of elementary particles.

According to the rules of logic employed in science, whenever one theory is able to predict the value of the fundamental constant of another theory and give a physical explanation of it, that theory is automatically superior. Thus Bergman's physical model of elementary particles is superior to and more fundamental than all quantum models.

Due to the objections mentioned above to the theories of Quantum Mechanics and Relativity plus the three events also described above, it seemed appropriate that new work be undertaken to develop a new theory of the atom and nucleus based on real physical electrons, protons, and neutrons that have finite size, ring charge structure, and are elastically deformable.

The New Model of the Atom

The scattering experiments performed by Rutherford showed that the atom consists of a tiny massive nucleus with containing protons and neutrons with the less massive electrons on the outer surface. Ampere's law and Faraday's law require that the electrons radiate electromagnetic energy continuously if they move in an orbit about the nucleus. Since continuous radiation of the proper frequency for the electron to be orbiting the nucleus is not observed, it is logical to assume from classical electrodynamics that the electrons do not orbit the nucleus.

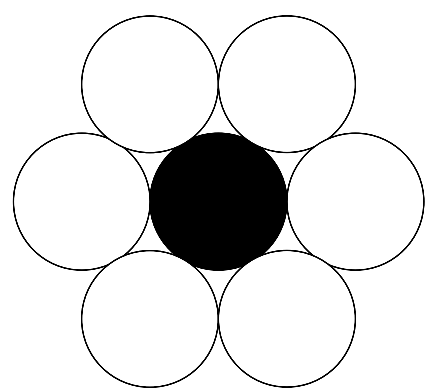


Figure 3
Classic Problem in Combinatorial Geometry

If electrons in the atom do not orbit the nucleus, but rather come to some stable equilibrium distance from it due to the balance of electric and magnetic forces, then it should be possible to predict the way the electrons pack themselves in layers or shells about the nucleus. Finding the structure of the atom should be a problem of geometry.
There is a field of geometry, called Combinatorial Geometry that concerns itself with relations among members of finite systems of geometric figures subject to various conditions and constraints. Two of the important topics addressed by Combinatorial

Geometry are *packing* and *covering*. An example of packing is the number of equal sized disks in a plane about a central disk. It is easily seen that six equal circular disks may be placed around another disk of the same size, subject to the constraints that the central disk is touched by all the others and that no two disks overlap (see Figure 3).

In the three dimensional case it is possible to place twelve balls (solid spheres) around a given ball, subject to the constraints that all the balls touch the central ball and no two balls overlap.

Now in the case of the atom, consisting of a central nucleus with finite size electrons packed about it in layers or shells, one can also use Combinatorial Geometry. In this case, there are additional constraints. The balls or electron rings have a magnetic moment and an electrical attraction to the nucleus or central shell.

Shell	Size	Total Electrons
#1	1 great circle of 2 electrons	2
#2	2 great circles of 4 electrons	8
#3	3 great circles of 6 electrons	18
#4	4 great circles of 8 electrons	32
#5	5 great circles of 10 electrons	50

Table 1
Shell Sizes that Satisfy Packing Constraints

From observation and general symmetry principles, one assumes that each layer or shell of the atom must be constructed in such a way that the total magnetic moment in each shell sums to zero and the cancellation of the magnetic moments is perfectly spherical, *i.e.* all great circles that pass through the arrangement of electrons must have the same number of electrons and no magnetic moment.

In order to learn more about the magnetic constraints, ceramic ring magnets of 9/8 inch diameter, 1/4 inch thickness, and a 5/16 inch center hole were obtained from Radio Shack for performing key experiments. The north pole of each magnet was painted white. The magnets were then hung by string in a circular ring to determine the equilibrium arrangement. Only a circular ring with an even number of magnets was found to come to equilibrium in a circular arrangement. When the arrangement of magnets with an even number of magnets came to equilibrium, the magnets were oriented such that they precisely alternated the north-south orientation as one proceeded around the ring (see Figure 4).

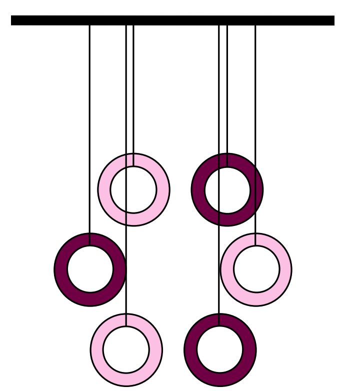


Figure 4
Equilibrium Position of Ring Magnets in a Circle

Spherical symmetry implies that no matter which great circles of electrons are packed in a shell, the same precise pattern of alternation of magnetic orientation should exist. This constraint along with the one requiring an even number of magnets in each great circle is sufficient to determine the sizes of each of the packing shells of electrons about the nucleus. Using the method of enumeration, *i.e.* examining each possible shell size one by one, one finds that the successive shells that satisfy the packing constraints are described by Table 1.

An illustration of shell #2 is provided by Figure 5, which shows a filled shell of eight electrons consisting of two groups of four rings each. The principle magnetic flux line for each group is also shown. The spinning charged ring electrons shown in Figure 5 are all located on two great circles (which are not shown).

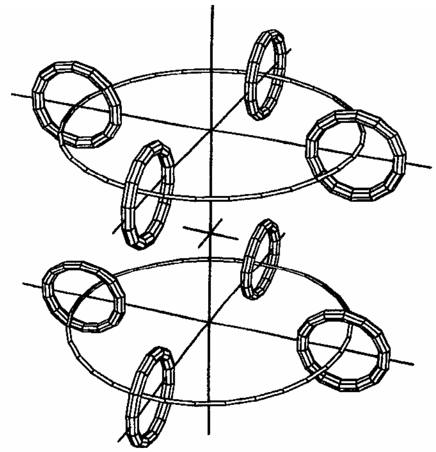


Figure 5
Filled Shell of 8 Electrons

A larger shell of 18 electrons, shell #3 of Table 1, is illustrated by Figure 6. In this arrangement, three groups of six electrons form the filled shell. All the ring electrons are located on three great circles.

In order to study the relative magnetic binding strengths of each of these great circle shell sizes, an apparatus was constructed consisting of a wooden board with circular arrangements of 2, 4, 6, 8, 10,... wooden pegs spaced such that ring magnets could be mounted on the pegs while comfortably touching one another in a circular pattern. One of the pegs was removed from each great circle of magnets, and the force to remove the associated ring magnet was measured. In order to eliminate the effect of friction, the board was held on edge, and the weight on the magnet needed to pull it away from the great circle was measured (including its own weight). Figure 7 illustrates the experimental apparatus.

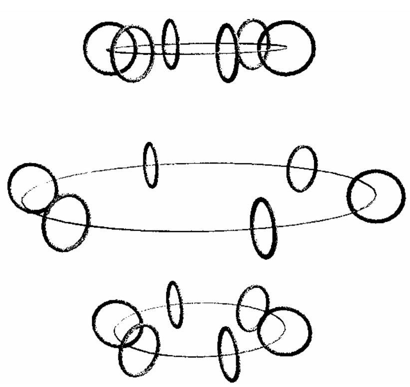
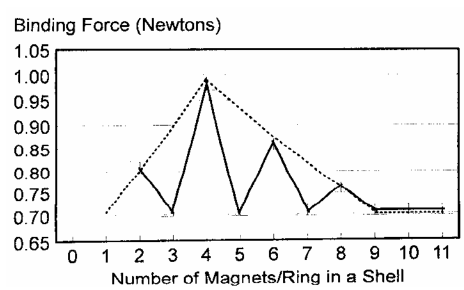


Figure 6
Fixed Shell of 18 Electrons

The results of these magnet experiments are shown in Graph 1. The graph shows the relative binding strengths of the various great circle configurations of ring magnets. Note that great circles of four ring magnets are most tightly bound. This suggests that in atoms, the shells of *two* great circles of four electrons will be strongly bound, giving rise to valence like effects observed in chemical bonding. Also note that great circle arrangements of ten or more ring magnets show no more inclination to bind in a circular shape than an odd number of ring magnets. From this result, one does not expect shells of 50 electrons or more to be found to exist in the atomic electron shells. Thus the atom should have only 4 electron shell sizes, *i.e.* 2, 8, 18 and 32 electrons.



Graph 1
Binding Force per Magnet by Ring Size
(Experiment with Board and Magnets)

Additional magnet experiments were performed to obtain a crude measure of the relative binding strength of *whole shells*. This was done by using two layers of ring magnets for shell size #2, three layers of ring magnets for shell size #3, *etc.,* and measuring the force necessary to remove one stack of ring magnets. The results are shown in Graph 2. The magnet experiments suggest that shells of 18 electrons are most tightly bound and that shells of 32 electrons are slightly less bound than shells of eight.

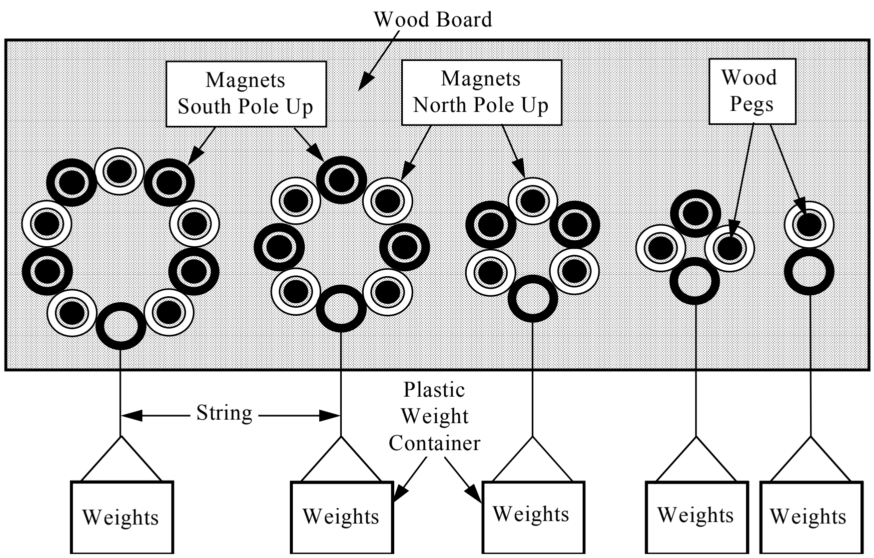
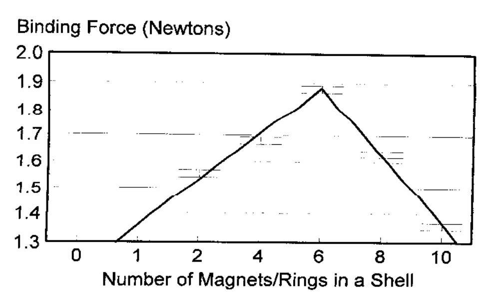


Figure 7. Experimental Apparatus

Additional ring magnet experiments were done to determine how many shells with the same number of electrons might be stable when packed about the nucleus.

This is done by forming a great circle of magnets for each shell and arranging them in a concentric manner on a very smooth flat surface. The configuration of two rings is found to be stable when the outer ring has the opposite magnetic orientation of the inner ring next to it. When three or more concentric rings of the same number of magnets are constructed, the configuration is found to be unstable with rings rearranging to form other sizes. Thus the ring magnets like to be oriented in pairs in all directions. This causes two concentric rings of the identical number of magnets to be stable.



Graph 2
Binding Force per Magnet by Shell Size
(Experiments with Board and Magnets)

From an analysis of the electrical forces of attraction or each electron shell with the nucleus and the total binding strength for each shell, the order of the shells is determined by the configuration with minimum energy. For example, the electrical attraction of each magnetic shell with the positively charged nucleus increases with shell size. As a result, a larger shell can displace a smaller shell with fewer charges, provided that the space it occupies is large enough to hold the larger shell. This constraint allows larger shells to displace the second shell of a pair of smaller shells.

Taking this into account and noting that the first shell size is paired with the nucleus itself, one obtains the following shell structure for the atom:

Total electrons	Shell electrons	Nucleus at center	K shell	L shell	M shell	N shell	O shell	P shell	Q shell
2	2	N↓	↑2						
10	8	U↓	↑2	8↓					
18	8	C↓	↑2	8↓	↑8				
36	18	L↓	↑2	8↓	↑18	8↓			
54	18	E↓	↑2	8↓	↑18	18↓	↑8		
86	32	U↓	↑2	8↓	↑18	32↓	↑18	8↓	
118	32	S↓	↑2	8↓	↑18	32↓	↑32	18↓	↑8

Table 2
Distribution of Electrons in Packing Shells

Note the arrows indicating the opposite orientation of the magnetic moments of the electrons in one shell with those of another. The structure shown in Table 2 is identical with that given in the Periodic Table of the Elements. Table 3 shows in detail how the fourth shell displaces the third shell.

Conclusions

The geometrical packing model presented for the atom is very successful in describing some atomic data. The approach taken here is more fundamental and straightforward than the methods used by quantum mechanics and the special theory of relativity. The new model does not incorporate the philosophically objectionable assumptions of quantum mechanics. It replaces features of quantum models that are known to be inconsistent or in violation of proven laws. Unlike the quantum models, the geometrical packing model is not simply mathematical, but it is a physical model with boundaries, sizes, and structures. In this sense the model satisfies a major goal of physics which is, after all, to describe matter of the physical universe.

Although the framework of a new theory of matter has been presented, the basic approach needs to be extended to give successful descriptions of black body radiation, the photoelectric effect, and the energy levels of the atom before it can fully displace the quantum models. (Please note that this work has been successfully completed and published [14]. It will be featured in a future issue.)

Atomic Symbol	Atomic Number	Electron Shells 1st Shell	2nd Shell	3rd Shell	4th Shell
Ar	18	2	8	8	
K	19	2	8	8	1
Ca	20	2	8	8	2
Sc	21	2	8	9	2
Ti	22	2	8	10	2
V	23	2	8	11	2
Cr	24	2	8	13	1
Mn	25	2	8	13	2
Fe	26	2	8	14	2
Co	27	2	8	15	2
Ni	28	2	8	16	2
Cu	29	2	8	18	1
Zn	30	2	8	18	2
Ga	31	2	8	18	3
Ge	32	2	8	18	4
As	33	2	8	18	5
Se	34	2	8	18	6
Br	35	2	8	18	7
Kr	36	2	8	18	8

Table 3
Step by Step Buildup of the Fourth Shell

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