Magnetism in Solids

Neodymium Proton Rings Compared to Iron Rings

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Abstract—The nucleus of neodymium is modeled using rules from my theory of static nuclear shapes. Spherical protons and neutrons are stacked using twenty rules. An experiment showed that protons touch protons in a random-bead model. Protons make lines of protons in iron and neodymium. Those proton lines make two rings in both elements. The theory is called The Static Nucleus Theory of the Face-Armored Cubic Lattice. The theory is for all elements. This paper starts with images of the nuclei of neodymium and iron, using cubes of stacked beads. Each face of the cube is covered by pyramids that form rings of protons. The chronology of fourteen research decisions is reported in this paper for the first time. Geometric reasoning and knowledge of the properties of elements were used for the theory, instead of algebra and energy balances. Iron is ferromagnetic because it has two rings of protons. The iron atom has 12 magnetic lines of flux in a vortex that gathers the 36 lines of flux from a neodymium atom. That increases the B field of a pole of a bar magnet.

Index Terms— Magnetism in Solids, source, ferromagnetic, mechanistic, eddy current

I. INTRODUCTION

Iron bar magnets were expected by André-Marie Ampère to have tiny loops of currents. Modern explanations feature the unpaired electron spins empowering NdFeB magnets. A new theory helps strengthen the credibility of Prof. Ampère's guess about Fe magnets by asserting that superconducting currents flow in loops of 12 protons in Fe. Some electron spins are unpaired because some protons are touching protons and they form a line of protons. A line of flux is defined as being drawn from each proton to one electron and those two particles are not independent in magnets and atoms. In most elements, the positions of electrons are driven by positions of protons and outside influences.

II. COMPARE Nd to FERROMAGNETS

A. Two proton rings in Nd and Fe

The iron nucleus has one of the simplest shapes of all elements and simplicity has delivered the ferromagnetic property. Fe is abundant in stars and it has very stable isotopes. Two proton rings in Fe each have 12 protons. The comparison of the Fe and Nd proton rings is helped by Fig. 1. Protons naturally make lines of protons, and bends in the lines make rings of protons. Fe has a lone proton in the center of each proton loop. Those two axial protons are on the surface of Fe and they allow the ferromagnetic property. Proton rings cause Fe to be ferromagnetic.



Figure 1: white protons and dark neutrons on Fe and Nd

Nd has two proton rings, with 18 protons in each ring. Nd is seen to be different from iron, without a central proton on the nuclear

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surface. Each nucleus has a cube, partially hidden there, at the (111) crystallographic orientation. Fe has a cube, with no protons beneath the rings. It is all neutrons in the center of iron. Lighter elements have two core protons. Nd has a cube with 14 protons hidden beneath the surface. The six faces of each cube are covered by piles of nucleons (protons and neutrons). There is no rule to make rings of protons. Rings are constructed because of decision number seven, described later. It says that protons touch protons and make lines of multiple protons without branching, unless branching is unavoidable. An exception is for nitrogen's triple bond, which has a branch of proton lines that makes three protons be prominent.

Nd (Z=60) is based on the cerium foundation element (Z=58). Fig. 2 shows the plan abstraction for the transition elements with atomic numbers Z from 25 to 29 and the rare-earth elements with Z from 58 to 61. Protons and neutrons are not treated differently, when stacking the cubic lattice and when stacking the black pyramids that cover the faces of each cube. (The cube has red circles, if your paper has color). Some circles were added to indicate where protons go onto the surfaces of two foundation elements (Fe and Ce) to make incremental elements like copper. (The protons are blue circles, if your paper has color). Electrons are not shown at this scale, but they are shown in Fig. 5. (The electrons are red circles, if your paper has color). A foundation element has a cubic core and six pyramids to armor the faces of the cube. An incremental element is made from a foundation element with some protons and neutrons added.

The proton rings of iron have the ideal shape and many elements have rings with bends that are unlike iron. Iron has six bends pointing away from the nucleus and some nonferrous elements have bends pointing inwards. Iron is simply a 3-layer cube with six two-layer pyramids that nestle onto the faces of the cube. Only neutrons are in the core of iron, between the rings. Nd has 14 protons in the nuclear core.

Nd is an incremental element, based on the Ce nuclear foundation. To make Nd, two protons are added to Ce to close the kinks in the proton rings. The prominent white proton at the bottom right of Fig. 1 smooths out one proton-line kink of Ce to make Nd. The theoretical superconducting current easily flows in an outward pointing bend for Nd. Without that added proton, the bend points inward and that prevents easy currents in a proton ring.

Figure 6 is a close-up of the proton marked Nd that smooths out the inward kink of the Ce foundation element. That prominent proton is also seen in Figures 1, 2, and 5 at the 4 o'clock position. That proton is also seen in Fig. 3 at 2 o'clock and in Fig. 4 at the 10 o'clock position. The lines and arrow indicate the current path through the Ce proton ring, which bends inward into the nucleus. That may prevent a superconducting current. The added proton marked Nd allows a superconducting current to flow in the proton ring because the current will bend outwards from the nucleus through that added proton. An outward bend has more freedom for the flux positions than for the flux associated with the Ce current path. Those two paths in Fig. 6 feature the white proton marked Nd and the proton to the left of that, below the Ce symbol.

B. Gadolinium Compared to Neodymium

The Fe ring's center has an axial proton in Fig. 1 but Nd has no surface proton on the axis of the rings. Gd is element 64, so it has 4 more protons than Nd. Those protons go on the axis of the rings. The axial protons of Fe and Gd seem to be functional, maybe preventing rotation of flux lines. The nonferrous Nd is changed into an element with the ferromagnetic property by adding four axial protons. Those two protons, in the middle of each ring, change Nd into Gd. Cobalt also has two protons in the middle of one ring and one proton in the middle of the other proton ring. Nickel has two axial protons in the center of the rings, link Gd.

In summary, a ferromagnetic element must have two coaxial rings of protons and the rings have bends that do not point into the nucleus. That is so an electron can send flux to a proton without the flux going into the nucleus. Also, a ferromagnetic element must have a proton in the center of each ring, on the surface of the nucleus.

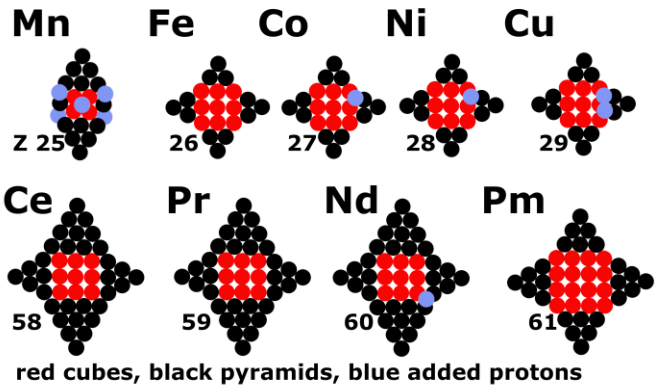


Figure 2: plans for stacking nucleons for chemical elements

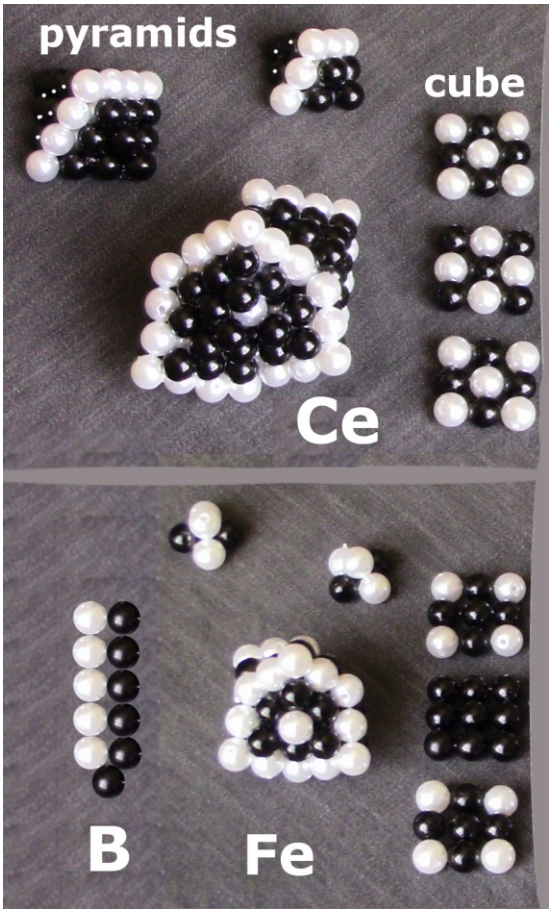


Figure 3: Nd is based on Ce with its cube and pyramids

The establishment of fixed nuclear shapes with published proton coordinates empowers researchers in magnetism and chemistry. This is combined with a mechanistic visualization of a proposed *paired electron-proton*. No microscope has magnification to see lines of flux of each pair in a bar magnet. Theory is all we have at this nuclear scale. The quantum theory is useful in some cases, but a mechanistic explanation is preferred, when appropriate. The axial proton in iron may repel the vortex so it does not hit the counter-rotating areas across the vortex. The precision of this theory is surprisingly successful. Nd is not ferromagnetic because without axial protons, the flux can rotate and hit the lines of flux that are across the vortex, causing the rotation to stop.

In Fig. 5, Fe has the north flux coming from the top proton ring. A south magnetic pole comes from the iron nucleus at the bottom proton ring. Gd is the same as Fe for having permanent superconducting currents in both rings, flowing in parallel directions. The 48 electrons are dots at the top of Fig. 5 and they are paired with 48 protons in the Nd and Fe nuclei. (The electrons are red circles, if your paper has color). The electrons circulate clockwise and the proton ring currents in Fe also flow in a clockwise direction. That makes the primary proton current induce a reversed secondary electron eddy current.

III. RESEARCH DECISION CHRONOLOGY

The neodymium nucleus is modeled with a degree of certainty. The reader is naturally skeptical that a vast problem has been solved with simple ideas. The Static Nucleus Theory of the Face-Armored Cubic Lattice was produced during May, 2017 in a sequence of fourteen research decisions. All 118 chemical elements were modeled using the rules that resulted in the iron nucleus having a plausible shape being proposed. **First**, I decided to try to make progress in physics by announcing a law or shape from nature. **Second**, nuclear shapes needed to be proposed, to fill the blank pages of the books on chemical elements. **Third**, Fe was chosen as the first element to be evaluated because its ferromagnetic property is so easy to measure and magnetism has been thoroughly studied by past scientists. **Fourth**, a static nucleus theory was chosen because other researchers had tried using many dynamic nuclear ideas. Spherical nucleons were chosen to be stacked to have the Z and A values according to standard tables for chemical elements (atomic number and mass number). **Fifth**, crystallographic arrangements would be attempted with cubic, random, or hexagonal close-pack (HCP) arrangements of spherical nucleons for nuclei. **Sixth**, experiments were done using a random collection of 26 protons and 31 neutron beads. That showed that protons must touch protons because there are not enough neutrons to isolate them. **Seventh** decision: protons can make lines of multiple protons, while avoiding making branched lines. **Eighth**, the core of Fe was modeled using a cubic stacking of proton and neutron spheres (Fig. 2 and 3). The six faces of the cube were planned to be covered by piles of nucleons. **Ninth**, the cubic core would stack a 3x3x3 lattice of nucleons because Fe-57 would get 27 nucleons in the core. (8 in the core seemed too small and 64 in the core, too large). **Tenth**, simple arithmetic revealed how plausible it is to use 6 piles of protons and neutrons (nucleons) to cover the 6 faces of the cube. The mass number was calculated to be precisely appropriate, using the cube and six pyramids:

$$A = 57 = 27 + 6(N)$$

where N is 5 nucleons to cover each face with a pyramidal stack. **Eleventh**, the integer results from that calculation gave me hope that this is an excellent candidate structure for the Fe nucleus. So, I continued the research. The atomic number was calculated, and the answer fit together like a key in a lock.

$$Z = 26 = 8 + 6(3)$$

Twelfth, symmetry and electrostatic repulsion were used for allocating protons in the cube. The core protons are at the 8 corners of the cube. **Thirteenth**, the maximum distance from a neutron to a proton is one neutron diameter. That ensures that neutrons do not decay quickly. Protons feed neutrons. **Fourteenth Decision**, 19 foundation elements simply have pyramids on six faces of the cube. 90 incremental elements add nucleons to the surfaces of foundations. The 20 Rules of Nuclear Structure are in [Folmsbee 2022].

IV. CONFIRMATION WITH OTHER ELEMENTS

The proposed shape of iron seemed like a plausible source of the ferromagnetic property, as Ampère had predicted. The next work involved all 117 other elements that may also look like magnets. Only four ferromagnetic elements exist above 0 C temperature, so the theory's credibility can be judged by which elements have a shape that is most similar to iron.

A. Co, Ni, Cu, Mn, Cr

All elements were evaluated using the cubic core, and good results were easily obtained. For example, of the 118 elements modeled, the ones with proton rings most like Fe were Gd, Co, and element 28, Ni. Other elements have rings, but with kinks in the rings or other differences that are less like Fe. Most importantly, element 29, Cu, has a proton that short circuits the two rings. The manganese nucleus also has a short circuit. Chromium's model has two rings that are not coaxial, but have a mutual area of about 30% of each ring, implying that antiferromagnetism is caused by that. Cr is the only antiferromagnetic element and the models show that Cr has a unique shape, compared to the other 117 elements. Fig. 1 and Fig. 3 show a triangular shape for iron's ring. An atom of iron [Trishin 2021] has a triangular shape like the proton ring, indicating that a mechanistic connection exists, where proton lines drive electron positions. The three tips of the **north** atomic triangle are from **three-of-six faces** of a cube. The south pole should be driven by the other three-of-six faces on the cubic lattice of nucleons. Those facts help prove that this theory is, plausibly, the correct theory of matter.

B. Oxygen and Barium Shapes Compatible with Theory

Oxygen has a theoretical angle of 104.5 degrees between one line of protons and a second line of protons. That angle matches the famous "water molecular bond angle". The angle is arccosine $(-\frac{1}{4})$ according to vector geometry for the cubic lattice with HCP pyramids. That is evidence that the oxygen nucleus uses the face-armored cubic lattice of nucleons. Oxygen makes a double helix with its protons. Pear shaped nuclei match theory to experiment [Bucher 2016]. Barium, radon and radium pear shapes are known

from colliders. They are similar to the shapes that I drew for the periodic table [Folmsbee, 2022]. Few other elements had experiments that show nuclear shapes. There are several other elements that provide clues that this is the correct theory of nuclear shapes. Also, the "average binding energy per nucleon graph" has changes in slope where the 19 foundation elements' data is plotted (Britannica, nuclear-binding-energy).

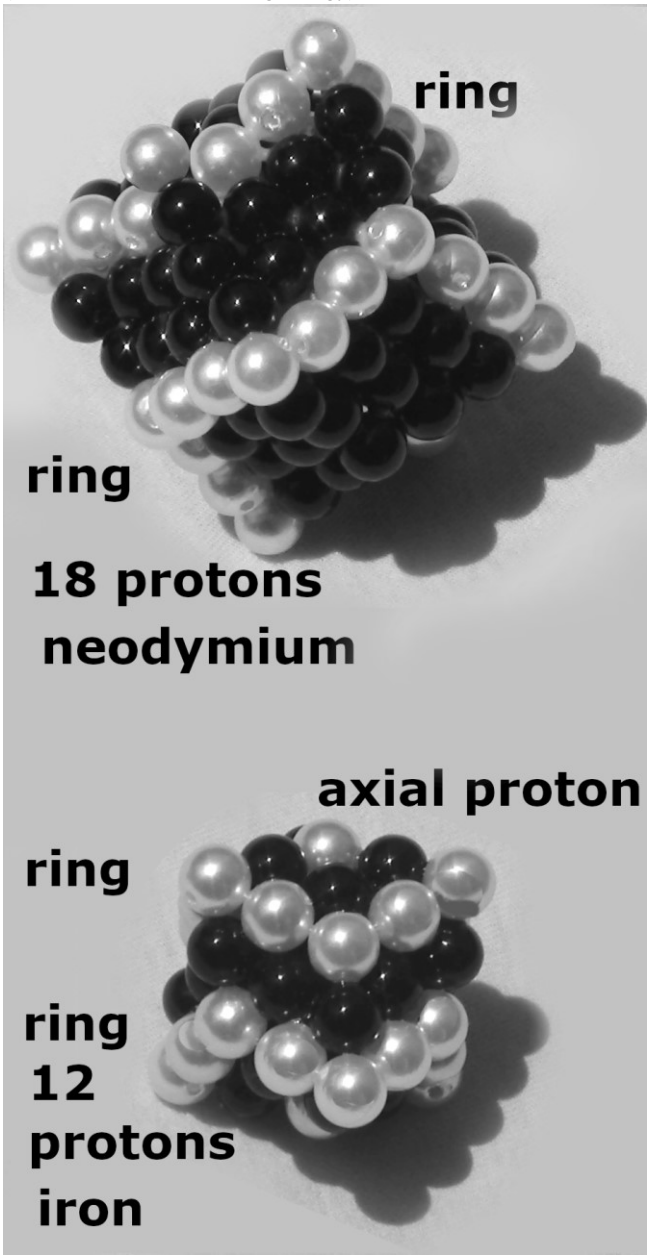


Figure 4: side views of two elements

V. DISCUSSION

A. Goals

A flux amplifier invention is needed to make magnetic logic gates. This functional theory can be a tool to predict magnetic interactions between different elements. Oxidation states can be related to lines of protons. The ends of the lines can be counted to compare to an element's oxidation state or valence.

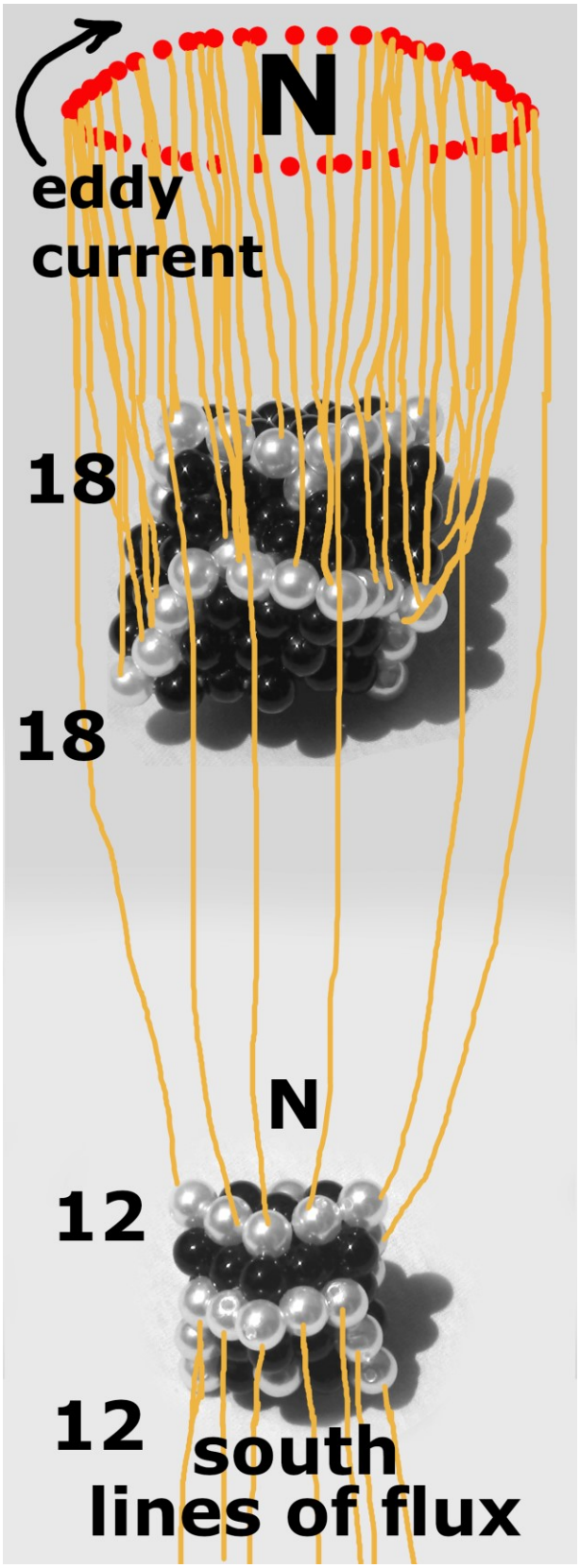


Figure 5: 12 protons in iron drive 48 electron eddy current

Spintronics can be given a new nomenclature for magnetic phenomena based on a limited number of mechanistic abstractions.

It is a goal to make progress beyond formulas that use the magnetic "exchange interaction" and to connect nuclear protons to molecular electrons and other electrons in magnets and conductors. Molecules can be tried to replace the effect of Nd in an iron magnet. Now that it is clear what Nd does, that task is easier.

B. Integer Modules for Nuclear Construction

Nd and all elements heavier than boron have a cube module with six pyramids. Iron uses those modules to make a very stable theoretical shape. Experiments show that iron's nucleus is very stable, matching the theory. The sizes of the pyramid modules range from zero to six layers thick. Nd has four three-layer pyramids and two four-layer pyramids (Fig. 2 and 3). Those integer numbers of modules and layers were chosen and then the A and Z for those pyramid modules were found to be equal to those from standard tables for cerium. Ce is a foundation element and Nd gets two protons added on Ce. Every combination of cube size and pyramid size were used, limited by the 20 Rules. Notice how the surfaces in Fig. 4 have the HCP lattice. That causes stability for these isotopes. The HCP on the surface is due to a cubic lattice at the core. This modular plan gave surprisingly good results for elements of all mass ranges. Nuclear physics is much simpler than was expected. Other researchers used modules of helium nuclei to build heavy element theories about C and O. The carbon nucleus has the smallest modules with a 2-layer cube and 4 protons as pyramids. I presented this theory at the American Physical Society April Meeting in 2022. That poster session on Broadway in New York City used iron as the first step to understanding carbon and how its planes of protons drive the flat crystals of graphite.

Integer Geometries in Magnetic Solids

In Fig. 5, a south pole is at the bottom, which has its source in an iron nucleus. The Fe proton rings have superconducting currents, in theory. A magnetic vortex from the top Fe proton ring current creates the north magnetic pole. The 12 lines of flux emerge as a north vortex that rotates clockwise. The flux vortex for the south pole rotates the same clockwise direction as the north vortex. The distinction is the measurement equipment that rotates 180 degrees to face north or to face south. The electrons are drawn as dots with an arrow to show motion. (The electrons are red circles, if your paper has color). The eddy current is at the top of Fig. 5. The 48 electrons include 12 connected by lines of flux to one iron proton ring and 36 eddy electrons connected to two proton rings in neodymium. The motion of the Fe vortex concentrates the free lines of flux from Nd.

The north pole in Fig. 5 is from a clockwise proton current in the Fe nucleus. Lines of flux illustrate a rotating vortex that connects proton rings to the eddy current. The eddy has a clockwise motion of electrons. A clockwise proton loop current induces the eddy current to move. It can be a spin current for electrons or a charge current. The discrete lines of flux from Fe induce motion in adjacent lines of flux from Nd.

Two proton rings are better than one for producing the ferromagnetic property. Chlorine has a ring of 8 protons and magnesium has a ring of 12 protons. No magnetic effect is proposed for a single ring of protons in a chemical element's nucleus. The two rings are required for iron so that some electrons make an eddy on one side of the nucleus and other electrons make an independent, remote eddy on the other side of the nucleus. A single proton ring cannot build two magnetic poles of two electron eddies that are remote from each other, in this proposed theory.

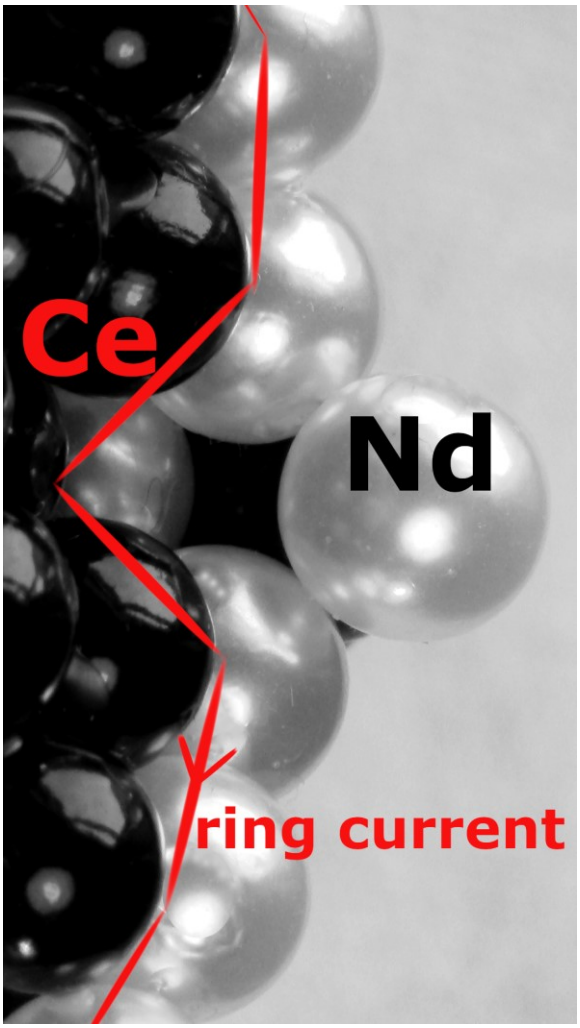


Figure 6: proton ring detailed kink smoothing for Nd from Ce

In Fig. 6, a proton ring current bends into the cerium nuclear interior with line segments to touch a white proton. (The proton ring current is drawn with red lines, if your paper has color). Changing to the element neodymium would divert that current to move out from the nucleus and into the proton marked Nd. Neodymium has two more protons than cerium, and they are positioned to smooth out the two rings.

An incorrect theory gives correct-seeming answers rarely. A correct theory of physics gives correct-seeming answers quickly and easily. I assert that this is the correct theory of nuclear charge distributions and neutron positions.

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