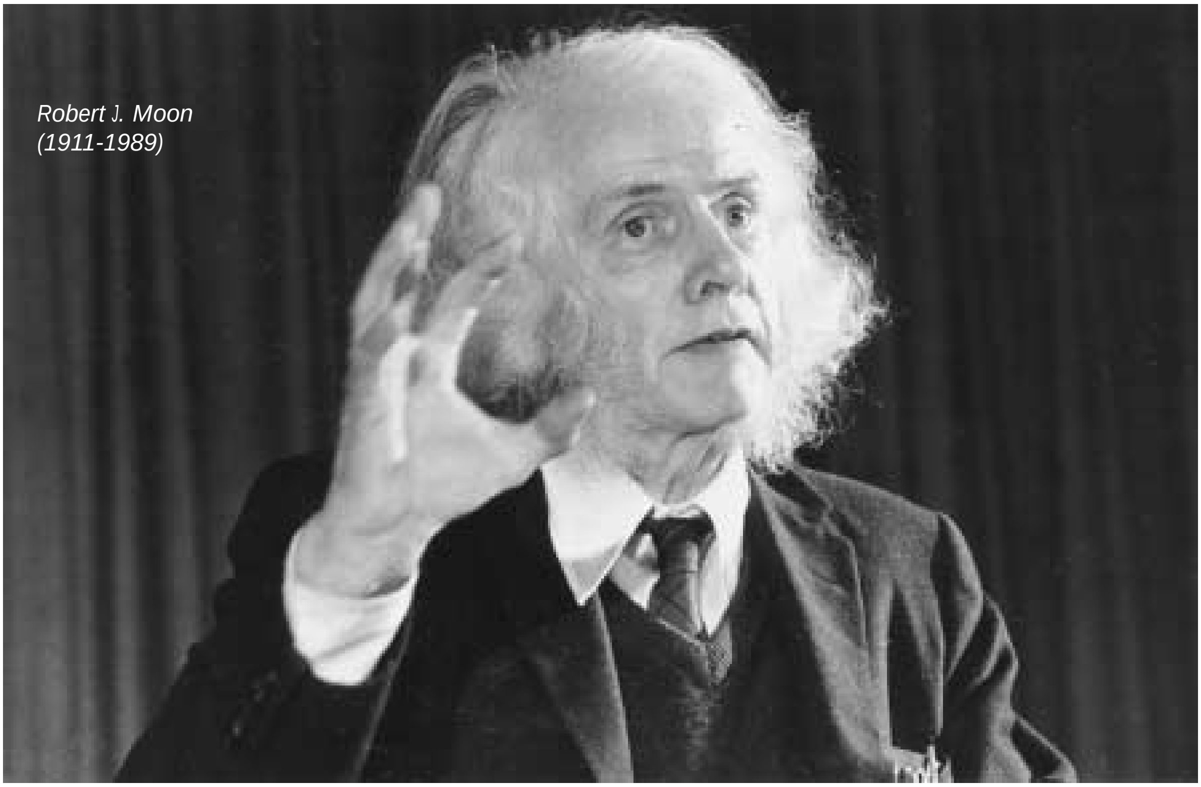
THE LIFE AND WORK OF



EIRNS

A previously unpublished transcript of a presentation by Dr. Robert J. Moon, Jr., Sept. 4, 1987, in Leesburg, Virginia.

Dr. Moon was introduced by Laurence Hecht, saying, "I asked Dr. Moon to give two lectures on the development of his model. The question I asked him to address tonight is: 'How did he do it?' "

* * *

This goes back a long ways, as anything of this sort does for all of us. I was born into this world. It is an exciting world; it's a world in which there are many challenges. So, I was born some time ago: Feb. 14, 1911, when Halley's comet was about, and my mother says she showed it to me. I don't remember it, but I did see it this last time out at the farm [near Leesburg, Va.], with the 8-inch telescope, and I watched it for hours. It was very intriguing, indeed.

Well, now this whole thing begins, I should say, with this sort of thing. All the way through I've been running into various things that are exciting, exciting things to do as you grow up. Even as a youth, I had quite a few exciting things to do. We lived out in the country. We had four cars; there were 10 acres. We had a pig apiece and a cow apiece, each one of us four boys. That may not sound so exciting, but you had to milk them morning and night, by hand, separate the cream. But we did it. That was back in the days when you could put the cream in a can, about 600 feet from the house, on the road. They would come by and pick up the cream—the creamery would—and bring the can back. But, no one would steal it. It was very interesting. Right up there on the road, a nice five-gallon can of cream—good cream—it was from Jersey cows. Then, of course, we had the job of separating the cream, and that was all done by hand, with a De Laval separator.

DR. ROBERT J. MOON

1.

Robert J. Moon On How He Conceived His Nuclear Model

So these are the the sort of things that I grew up with. We had automobiles to repair; batteries to rebuild; generators to rewind; and, a lathe to do some wood turning, because there were a lot of trees on the farm and we would cut them down and turn them into lamps and things like that. So all of these things were a lot of fun.

How Does a Transformer Work?

And one of the mysteries to me, was the thing that really makes electricity possible today, and that was Faraday's law of induction. That was a question, if you have a transformer—did any of you think about a transformer? How does a transformer work? How do you go from 110 volts down to 6 volts, for example, of alternating cur-

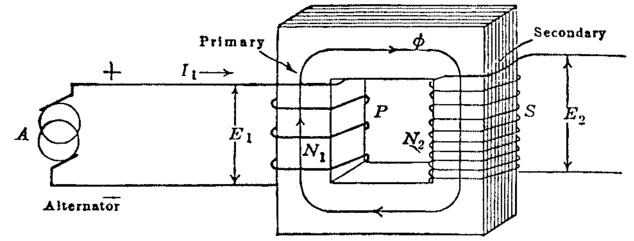


Diagram of a simple transformer, showing an iron core with two coils. The ratio of the turns of the coils gives the increase of the voltage.

Source: Chester L. Dawes, *A Course in Electrical Engineering*, Vol. II (New York: McGraw-Hill Book Company, Inc., 1928.

rent? Well, that was the question I tried to answer [laughs]. I tried to figure out a bunch of relays, first. And then I finally discovered that you had such a thing as impedance—reactive impedance—which didn't use any energy. So, the current could go through the reactive impedance, which was the coil, around an iron core, and outside that was a coil with fewer turns. And the ratio of the turns gave the reduction of the voltage, the ratio of the voltage. So that if you were going from 120 volts down to 6 volts, that would be a ratio of what, 20? So one-20th the turns, but a larger wire. Well, this thing could be turned on all the time, and it didn't use any energy, except when you pushed the doorbell button.

So then I—well, from this you begin building transformers. It's a lot of fun to build transformers. I built one for a lead-burning outfit, in order to repair storage batteries. You had to get a very high current and a low voltage. Anyway, so these are some of things—I think you run into similar things, all of you. I don't mean to say that I am any exception. I just happened to run into these things, and they were all very exciting. Electricity was taking the place of gas, and gas lights, and also the carbon light began to disappear, and the incandescent filament began to take place. Automobiles began to come.

We had an old 1916 Overland. That was another thing. Anyway, I had the problem of repairing it in the middle of the Jordan River—really a creek. You didn't have bridges then, you just ran through the gravel. And it stopped. The car stopped, and so my father went to get some help somewhere [laughs], to find a farmer with a telephone. You know, there weren't too many telephones, and so [laughter], before he got back, I decided that I had better look into it. So I began to analyze it.

Well, these are things all of you do. You probably analyze problems. So I analyzed it, and turned the headlights on and found that there were no lights. So I decided it must be electrical. I began to explore and found that one of the battery connections was loose. I cleaned it up and put it back on, and the lights went on. Then my father came back. He hadn't found a telephone, so I said "Well, I think the car will go." And it did.

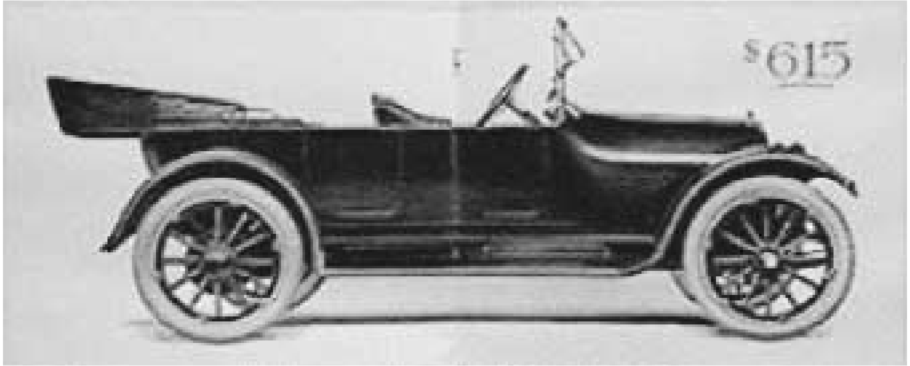
Question: How old were you then?

I was about five years old [laughter].

So, anyway, these are the things that run across our paths. There are challenges. We are are born into a changing world because as we know now, we can have so many people in this world. And, we got away from the idea of living on a farm, and relying on the weather to produce the food and all. And you didn't know whether you were going to starve, or have an abundance. And then the city came along—and Lyn [LaRouche] has emphasized this too—that a man, working in the city, with ideas, could produce things that would help increase the farm production. And I think we're still in that same period today. We have made a lot of tractors, haven't we? But it seems, somehow, we're not making many tractors, today. And yet we need farming. So I don't think we would want the population to be cut down, do we? But, it looks as though some people may have that idea.

So, anyway, I went to college in my home town. It was very interesting, because I was able to do a lot of things. And I think many of you could do the same thing too, even in today's colleges. If you ask the head of the physics department or a chemistry department or biochemistry department, or what not, to do a few little extra experiments, on your own, and particularly with a lot of equipment that hasn't been used. Try that! Anyway, that's what I was permitted to do. A lot of beautiful equipment was just in the physics storeroom, and that was a great thing for me. Luckily, the laboratory space in the afternoon was all mine, and I could use any of that equipment, and do any of the experiments that I read about. So it was a lot of fun.

And, these are things that I think that come to us. And you see these—I'm talking about the '20s now—I graduated in 1930 from college. But, the things that were going on, that made it exciting, were very much connected with fusion. They were talking about the millennium coming—that's a thousand years of peace and prosperity, in which there won't be any deaths or sicknesses and so on. They were talking about that, and I began to wonder about the energy for the millennium.



A 1916 Overland from the company sales brochure, at a price of $615.

They knew about the heat of the stars at that time, in spite of the fact that we hadn't gone so far in physics with it. The chemists had gone far enough. They had determined, just from the molecular weights of hydrogen and helium, they knew that if four hydrogens went together to make helium that you get—there's quite an excessive mass there—and that would go to make energy, and that was the heat of the stars. And this was also shown by the astronomers, who found that the old stars had a lot of helium and little hydrogen, and the young stars had a lot of hydrogen and little helium. So, therefore, the process was hydrogen going to helium; was a nuclear process. And that's what our Sun is and was—I guess it was from the very beginning. But that immediately suggested fusion. And I guess that's been one of the big callings that I seemed to have to do.

Well, then there were a lot of things that happened. I went up to the University of Chicago. And, I don't know: Did many of you go to college, without [applying by letter]? Some of the people I know, write three or four colleges, to get admitted. And then [laughs], they're admitted to maybe two or three of them, and then they finally decide where to go. But then, it was a much simpler process. I began reading the literature—and if you read the literature, you find where the work's being done, in which you're interested. And so, the reason I chose the University of Chicago, was that this Professor [William Draper] Harkins there, had published quite a bit on the neutron—they didn't call it the neutron then. But in 1917, he wrote a whole series of papers [on the neutron]—I have practically all of his papers.

And so that led me to the University of Chicago, and then to come in, and say to the Physics Department: "Here I am." Because Harkins was a physical chemist. And here I was with a design for an experimental fusion experiment: Bring protons in; bring electrons in this way; pulse a magnetic field, and condense the electrons on the protons, and get helium, probably. That was the experiment I had wanted to do for my doctorate. But, Physics said, "Oh, no! Rutherford says that there isn't any more to be learned about nuclear physics" [laughter]. So, as far as Physics was concerned, it turned out that I was the third person to be turned down like that. The first two were Robert Mulliken in 1920, and then Sam Allison in 1925. And here I came along in 1930 and I get the same response. So they were pretty well, they were fairly certain about Rutherford's edict.

Anyway, Harkins took me right away. We started building equipment. I wanted to do the fusion work, but he said we have to get some equipment built, which was right. I knew that. So, the next thing that happened was that I had learned of a particle being, or, behaving like a wave. That was de Broglie, who had presented . . . that as his doctoral thesis. He said that an electron could be a wave, or any particle could become a wave. And, that was exciting to me. At the Solvay Congress [in 1927], he presented a second solution, which came out later to be the quantum potential—I was very much interested in that—to be rediscovered by David Bohm about, oh several years later—about '51, I think it was.

Waves and Particles

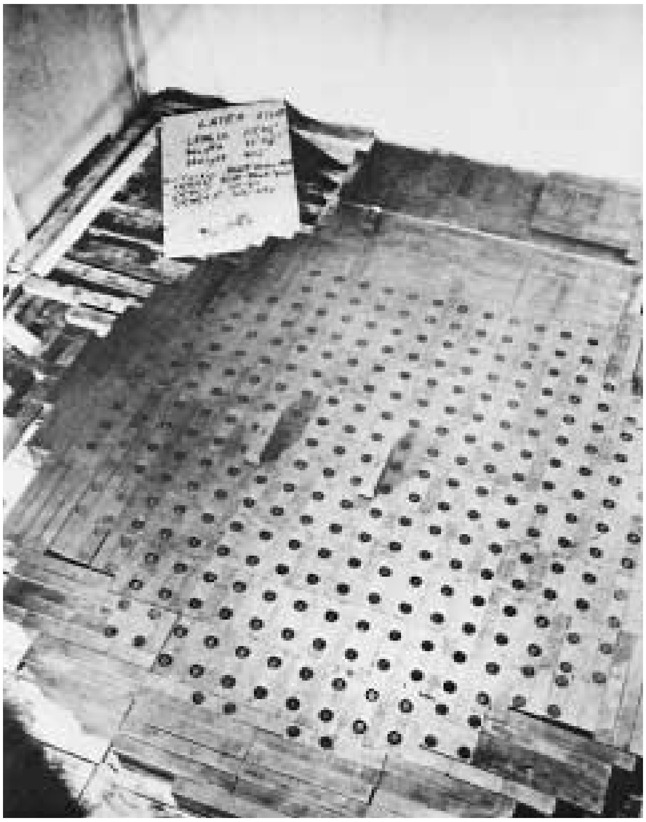
So you have all of this excitement about a particle being a wave, not only a wave can be a particle, because the photoelectric effect (how E is equal to $h\nu$—how a certain frequency can hit a metal, for example, and eject an electron, and that the E was equal to $h\nu$, the energy of the electron minus the contact potential of the metal).

So, there was that, and then there was the Franck and Hertz experiment, which had been done in Germany. I got to work on that as a pastime, where you had the mercury vapor, and here is an electrode—here is a cathode emitting electrons—and the electron is being accelerated, and it falls through this electric field, which is rather uniform. It gains energy linearly, and when it gets up to a certain voltage, there are two things you notice: There is a sudden drop in the current collected; there is also a light emitted. And that light is the beautiful resonance line, the 2,537 line of mercury (2,537 angstroms or .2537 microns). It is a very intense line. You ought to look it up in your spectrographic table, and you will see how intense it is—about 20,000.

And, that immediately showed, you've connected that frequency with the energy that the electron had, and it very quickly showed E equals $h\nu$—it happened there, too. So you had a pretty good, a fairly good determination of the Planck constant. And all along, this is what's been going on, as we—this is the great excitement—because it took so long building equipment, that I ended up building and designing a cyclotron, a 50-inch cyclotron. It weighed about 50 tons, altogether. And [laughs] putting that together—it was the first, really designed cyclotron, and then I did my doctoral piece on electron diffraction, at a very low energy—at 50 electron volts, at the most—from electric circuits, to show the structure of electric circuits, which I found. I found the structure of molecules that way.

University of Chicago Physical Chemistry Professor William Draper Harkins and his wife, holding the Moons' first child, Mary Elizabeth. They were her godparents.

Well then, of course, there had been exciting things going on. We had the War, in which we had the Manhattan Project, when we discovered—after we had this cyclotron—we discovered that it was a good source of neutrons, of course.



Argonne National Laboratory

The first U.S. "reactor," the atomic pile at the University of Chicago, produced a nuclear chain reaction on Dec. 2, 1942. A circular pattern of graphite bricks were stacked up in layers. Moon solved the problem of contamination that permitted the bricks to function as a moderator.

Because, if you have a proton with an electron, it becomes a neutron. But a deuteron is a proton and another proton with an electron condensed on it. So it has a mass of 2, instead of 1. But the charged part is left behind, and the neutron goes on, when it hits material media.[1]

And this was a way of testing the graphite and other things.[2] For making a reactor, there were only three things which were available. One was beryllium. It's a beautiful metal, but we didn't know anything about the metallurgy of it. No one had produced the metal. It's very strong and shiny—but we didn't have enough of that. So, then the other thing was heavy water [Water in which the ordinary light hydrogen is replaced with deuterons—heavy hydrogen]. And we didn't have enough of that. We had some, but not enough. And so the next thing was [graphite]—Chicago was a great steel-producing center. (It *was.* But you know, it's already in the past now. They shut down the Southworks and some of the steel works.) But anyway, the very fact they were making these graphites—they were about 4 feet long and about 4 inches square, and they were rounded at the corners. We tested this graphite. And we used the cyclotron to do it, because, we'd build a pile of the graphite samples we would get, and see how long a neutron would last in that pile, what its life would be.

And that was—to our surprise—finding that very pure carbon was obtained from the *center.* That when they fused the graphite, after they'd pressed the graphite together, and then passed a current through it to fuse it, in a rather huge pile of it, that you had almost pure carbon, I would say very close to pure carbon, in the center; all of the impurities had diffused outwards. And that's what we used for the moderator in our reactor. This was built on the squash court [under the football field]—they had to stop playing squash [laughs] so we could build our reactor. It was a cubical design. We built it with the graphite on the outside, which supported it, actually, something like a football—I suppose it was very *à propos,* since it was part of the football field [laughter].

The graphite was supported all the way round. If OSHA [the Occupational Safety and Health Administration] had been around I don't think we'd ever got the thing made, because we had to cut these round corners off, and we did it by using an end-mill on the graphite, so we all came out pretty black. And I'm sure if they knew what we were doing they would have shut us down, if they had existed then.

The Beginning of Fission

Anyway, the pile was built, and the reactor went on Dec. 1, 1942. Now, it seems like I'm getting more on the history of things, but I just wanted to give a taste of how exciting it was. I will say that Aristide von Grösse went over to Germany and talked to Otto Hahn and Leo Strassman, and they were the ones [to discover fission]. . . . And he [von Grösse] brought the message back. And the Physical Chemistry Department where I was doing all my work, now, my nuclear work—we had several meetings over what to do. So we checked out some of the things, and found it really was so, that fission was really taking place, when the neutrons bombarded uranium.

The physicists had all decided never to tell anybody about it. But as soon as that happened, they [the government] gave the $2 billion for the Manhattan Project, as it was called then. But, I do want to emphasize that, on the whole, we always talked about the spiritual and moral implications of nuclear energy—whether we were ready for it; whether people could take it. We would produce more energy, about 5 million times as much energy per gram of fuel as by combustion. So, that was always a question. And we talked about that all throughout the Project.

And we did *share* ideas. That's important, in the whole development of anything, the sharing of ideas with one another. We shared three times a week, much against what the Army wanted us to do—General Groves [head of the Manhattan Project], I mean. But, it meant sharing, letting everybody share, regardless of age, or sex, or religion, or race, or anything. And that was very good. You'd be surprised where some of the great ideas came from—they just had to be developed. They came from some of the youngsters!

So, that's the way we went, and, as you know, we did things in parallel. That's another factor. We started building Oak Ridge, and started building Los Alamos, and started building Hanford, Washington, all together. We didn't put them in series ("If this happens, then we'll do this, and then we'll do that.") We did it all together. And it worked very well.

I will say that when the pile got going, it shut down and wouldn't start up again [for three days]. And that turned out to

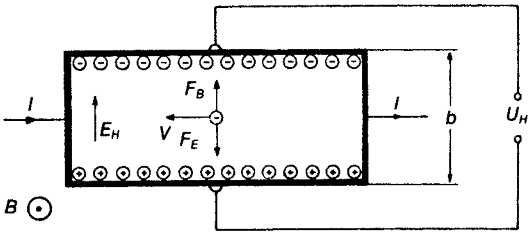


Figure 1
SCHEMATIC REPRESENTATION OF THE HALL EFFECT
Given a conductor through which the current I *is flowing, and a magnetic field* B *perpendicular to the direction of the current and the plane of the current-carrying transistor, the Hall effect describes the deflection of the charged particles sideways, also known as the Lorentz force,* F_B*. The particles will collect on the edge parallel to the electron velocity (when no magnetic field is present) and move from the opposite edge of the transistor.*

This charge separation leads to the buildup of an electrical field E_H *(the Hall field). As soon as the resulting force* F_E *compensates for the Lorentz force, an undeflected current continues to flow. A potential difference* U_H *is created between these two edges.*

be an isotope that had a very high capture cross-section [for neutrons]. It had a half-life of about three days, so it stayed shut down for three days, and then it started up [laughter]. So we learned a lot things that we didn't know about nature.

The von Klitzing Experiments

So, I'll just jump up to things that led up to what we're going to talk about in the structure of this nucleus. And that is, we had a paper by some Germans, [see p. 21] who had looked at the superconductivity—well really we shouldn't call it superconductivity this time, anyway—they were looking at the conductivity in a very thin piece of material which had a couple of electrodes on it, just to keep the current constant [Figure 1]. *I* [the current] was constant here. The magnetic field, *B,* was in this direction. Then, I'll draw this in three dimensions, an isometric projection. Then, electrons come over. The electron is bent by the magnetic field, and will make a circle. The electron is coming along, and as soon as it enters the field, it will make a circle. And this will cause a charge potential over here. Of course, as you create a magnetic field, it [the graph of the potential] goes from the straight, and then gradually it bends over more, until finally you reach a plateau.

But anyway, it was this particular experiment—of course, all of this was done at liquid hydrogen temperatures to keep it cool and to prevent the vibration of the particles in the semiconductor, which is a silicon semiconductor. So the current was constant. The *I* coming in is constant. It was kept constant by these electrodes here [see Figure 1]. And, then what is measured is the current divided by the voltages generated over here.

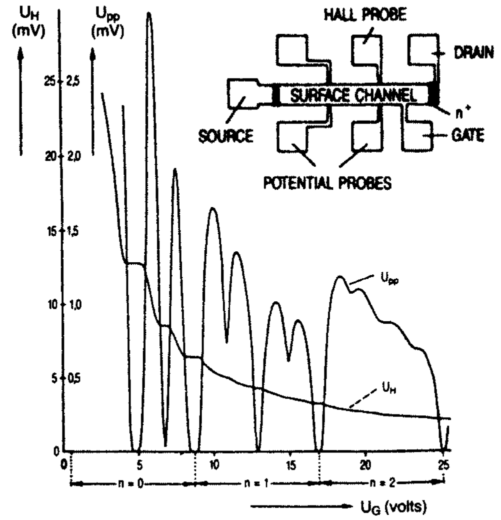


Figure 2
KLITZING'S EXPERIMENTAL CURVE
This is what the grid voltage U_G *versus the Hall voltage* U_H *actually looks like, according to Klitzing's experiment. The plateaus in the Hall voltage can be seen clearly.* U_{pp} *is the longitudinal voltage, which becomes zero when the plateaus appear. Klitzing first published these results in 1980 in* Physical Review Letters*.*

Well, what this began to show, was, as we plotted the current *I* as a function of *B,* the magnetic field, the magnetic induction. Let's not look at the current so much as the voltage in this case, that's generated across. The current is going this way, but the voltage is perpendicular. So, it comes along, and then finally there's a little plateau here [Figure 2]. Then it creates a little more, and there's another plateau. The plateaus get a little wider. Finally another one. It gets a fairly large one up here, and then, there doesn't seem to be any more. So, five distinct plateaus.

And, you begin to look at this, and *wonder* about it. And [laughs], you say, "Well, this must be because it seems the higher the field goes, no more plateaus seem to occur." Well, this happens because the electron spins. It spins around its axis. This is the electron [draws a curved arrow to indicate spin]. But then there is something more that happens. Not only are the electrons spinning, but this may be a north and a south pole, relative to the current. This is a current rotating, you see; the electron is a charge.

So, actually, you've got another plateau; it should occur up here. So, what, to give you the parameter, is the resistance? Well, you all know Ohm's law don't you? Most of you learn it this way: [*I* = *E/R*]. So, if you want the resistance, you just say *R* is equal to *E* over *I.* So, you see, you can measure the current, and this is the direction of the voltage this way, and this will be the resistance in this material medium. So, the last plateau occurs at about 12,812 ohms. We'll use an omega for an Ohm sign.

And then you begin to wonder, "Well, what's this plateau?" [Figure 2] And you find that that's . . . well, let me say that these electrons, now, they seem to like each other very well. And so one will spin in the opposite direction. This will be the South Pole, up here. So, the electrons seem to like to go around in pairs, in solid state, and this [plateau] happens to be one [electron] pair. And [when] you calculate this; this turns out to be just half that, which means two pairs. So this is about around 6,406 ohms, something like that. And then down here, this is three pairs—just half of the previous, which would be roughly 3,203 ohms. And so on, with four pairs, and you get down to five pairs down here. And that's about where it seems to stop.

Then you begin to wonder, "What are we really measuring here?" And [laughs], that turns out to be very exciting. It's von Klitzing that did this work. We reported it in both the journals . . . *Fusion,* and the *International Journal of Fusion Energy.*

Anyway, starting with these pairs, then you begin to wonder how many pairs could you go to? Well, you find, if you look at it, that you might even go up to 68 pairs plus one. You know what that would be?

Someone in audience: 137. It's the fine structure.

The Impedance of Free Space

Moon: So that's the way ideas tend to grow, and then it becomes very exciting. And so then you begin to wonder: "Well, why these pairs, and why does this happen?" Particularly since, if you remember, the velocity of light times the magnetic permeability of free space is the impedance of free space. Now there is something very interesting about the impedance of free space. If there's nothing there, you can't dissipate, can you? [If there's] nothing to hit, the energy just keeps there. So this is what we call the reactive component. It's reactive because it does not dissipate. And this equals 376-plus ohms.

And then we have the other part. Now the other part comes from any of these equations. You've got to to look into the equations for the fine structure constant, and you see they always involve the ratio 1/137. And actually, I think Bohr originally looked upon it as a ratio of the velocity. He made some calculations, and found that the velocity of the electron in the first Bohr orbit—that is the first orbit that an electron has around the nucleus of a hydrogen atom (of a proton, in other words)—that the velocity of the electron in that . . . you multiply that by 137, and you get the velocity of light.

So that was kind of exciting. And that sort of stuck in my mind for several years. So, immediately you begin thinking: Well, what we're looking at here [in von Klitzing's experiment], this value [the first plateau] is the impedance in material media like the semiconductor. So that seemed to indicate that these are the dissipative resistances. And, as a result of that, you begin to see something new.

Now, let me give you the real equation here. Because there are so many. I can give you an equation here which may help, a bit. I want to give you a simple one. This is the equation which generally is used here. If we want alpha, which is the fine structure constant—the inverse of it really: Now, you notice you have $\mu_0 c$, divided by 2. (Now you begin to wonder: Why the 2?). And then the other part of it is just *e*-squared (the charge of the electron) over Planck's constant, times the velocity of light:

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

Now what's curious about it, is there are pairs here. And so when you get this ratio, this turns out to be 1/137. So, you have the impedance of free space coming in, which is non-dissipative, and you have this [impedance in material media], which is dissipative. And so, after going through all the various calculations. . . . (You know, recently we've developed so many things in semiconductors—it just happened in the last two or three years—that we've gotten to the very. . . . In fact, I won't put down the equation that the Bureau of Standards uses, because they wanted to get the closest thing to determining alpha. But that was done in order to get the most precise determination of alpha; that is, the fine structure constant, that have ever been made. And now we even have better ways, as we are going more into superconductors. In a superconductor, this term will be very low—it will be like free space. (In a superconductor, there is no place for them to lose energy.)

Space, and Time, Must Be Quantized!

This then—in fact, it was early one morning—I began to say that, as a result of this, that there must be structure in space. And that space must be quantized! So that's what all these experiments do [laughs]—it starts way back, and many ideas will grow on you all, on everyone here, I'm sure.

Ideas will grow, and you will come to something like this, and then you will begin to wonder. So it was early one morning, about four o'clock in the morning . . . as I reflected on the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Chuck Stevens (left) with Dr. Moon at Moon's 75th birthday party; Louise Howard is at center.

idea of de Broglie on the quantum potential. The quantum potential says that if there is a slit somewhere, and a photon is coming up to it from some direction—or a particle—that particle knows that slit's there! That's what the *second solution of the quantum mechanical equation shows!* Now isn't that strange? [laughter] It doesn't have eyes. And so, that was probably the reason it was rejected in 1927 at the Solvay Congress. De Broglie had closed his books, as I told you earlier.

Anyway, this quantum potential now comes *to be a real thing.* David Bohm is publishing quite a bit on it. And, it simply means—and, this is one interpretation of it—that we have two kinds of time, and [laughs] the secret is that we should have quantization of time for this quantum potential to work. And, in the quantization of time, you would have time move along in *chronos,*—we have *chronos.* That's the time we know, the time you have when you turn on your radio station. *Chronos* [writes word on blackboard], that's man's time. Then there is the other one, *kairos,* which is God's time. These are Greek words. This is God's time. And this is man's time—*Chronos.* Does your alarm clock go off in the morning? And you've got to meet somebody at such and such a time [laughs].

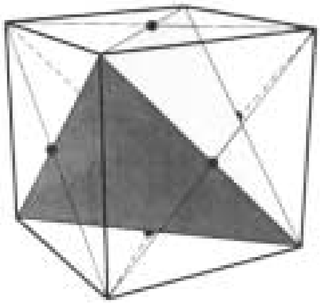


Figure 3
TETRAHEDRON INSCRIBED IN A CUBE
Four diagonally opposite vertices of the cube form the vertices of the tetrahedron. The midpoints of the six edges of the tetrahedron fall at the center of the cubic faces.

But, anyway, this seemed to be where *chronos* and *kairos* could come in. I don't know how to draw this, because ordinary time will go along like this, as a linear function, and the time is increasing. But then, if time stops, if there was a gap, would we know it? There could be gaps in time right now, and since we're going by *chronos* we wouldn't know it, would we?

But anyway, if you have those periods like this, you have gaps. In other words, you have both the quantization of space—that seems so clear—[draws something] and one is space, and the other is quantization of time. And this is *kairos* and this is *chronos*—I mean, you have two times here, *chronos* time and *kairos* time.

But what happens here in *kairos*? Well, what is the velocity of transmission of information? You know, in biological systems you are taught how this tells that thing what to do. We have people telling others what to do. But, what about *kairos?* This is a very important point.

Question from Fletcher James: Are you saying there would be infinite velocity of transmission, or . . .?

Moon: Right—or instantaneous transmission. That's right! So if you had instantaneous transmission—I can't say how long it lasts. But, anyway everything stops for, maybe it's a microsecond, maybe it's a femtosecond, or something. I don't know.

But, anyway, instantaneous transmission doesn't require much time does it? [laughter]

So, this means that every particle knows about every other particle in the universe which is exactly de Broglie's idea, and, David Bohm's, who rediscovered it. They worked together on this general idea, up until de Broglie died, early last year, I believe just in the last year.

Anyway, this seems to fit that kind of detail, that we do have a means whereby each and every one of us must, to some extent, must be aware of everything else in the universe. Of course, we may be aware of it, but we may not comprehend it. That's another thing [laughter].

So, at any rate, this is the situation, I think, in which we live, in which there is a knowledge of what is happening in the universe, even though 155,000 light years away, we had a super nova. And to think that the light coming from it, and the radiation coming from it, would keep together for 155,000 light years. That's quite a distance. Just think how difficult it is to keep together, even if you are walking with somebody, even walking a block [much laughter]. But, here these waves are keeping together. And there seem to be some neutrinos coming along. And the neutrino is a particle. It seems to get here. A few of them did, at least there were seven, I think, at the latest count [laughter].

Quantizing Space with the Platonic Solids

So: The quantization of space and time! That just struck like a bolt of lightning. Then, the next thing that struck was: Well, if space is going to be quantized, it should be quantized with the highest degree of symmetry. And so that immediately said, well, those are the Platonic solids.

And [laughs], so I was pondering over that until the Sun came up. So, I went out to eat at the Summit Hill. And, who should come in to eat, but Chuck [Stevens]. So we had quite a talk about it. It seemed very obvious how these solids should fit. You start out with the tetrahedron. And the tetrahedron fits into the cube. Two tetrahedra fit into a cube.

The tetrahedron has this kind of symmetry, doesn't it? It has two vertices here, and two here. And they are at right angles to each other. So if you put a tetrahedron across this way and one this way [with their edges] perpendicular, the four corners of the tetrahedron would be here [on the four corners of a cube, Figure 3].

But, now we would violate one of the things—the tetrahedron being a very special thing, we allow the two tetrahedra to intersect, so that one is across this way, and one across this way, so that the cube is made up of two tetrahedra. [See Figure 3.]

Anyway, the first tetrahedron just has one particle on it. Now, sometimes it gets a neutron, and that's deuterium, or it may get two neutrons, which is tritium. But they don't have to be at the vertices. They can be on the—well, scattered about—because the neutron has no charge. So then, when two protons are in place, then, of course, you have helium.

Now, I want to say, that with helium—this structure we've known for a long time—. . . among all the elements, there is a periodicity of four. And, if you look at various things—Larry [Hecht] got excited about this. We had just gotten a bunch of books over from the University of Maryland library. And he was excited about it, so he went into the extranuclear phenomena, which describes the *field* that is created by the shape of the nucleus. And you [Larry] have written a paper on that—such things as nuclear volume, ionization potentials, relative abundance, things of this sort, are the things that Larry wrote about. Did I miss any? . . .

Larry Hecht: . . . That covers it [laughter].

Moon: . . . And he did a very good job, and then started building models, too [laughs]. He built a lot of other models.

Philip Ulanowsky/EIRNS

Larry Hecht teaching a class on the Moon model in December 1992.

But anyway, the thing is, that you start with the tetrahedron, and then the cube. [Begins to assemble the Moon model, showing first the cube]. This cube, with a proton at each corner. . . . Now, there are two things about this, and that is this—these two things are, just: one proton (this is the exclusion principle for face centers)—one and only one. This is an exclusion principle. The protons are on the vertices. Now, we're not worrying about the neutron. We're not worrying about the neutron, because it can go [anywhere] . . . since it has no force on it, really, other than gravitational, it can find places in the structure. So, just imagine a cube now. You know what element this is, now, with four protons up here, and four protons up here? I might say, one thing that suggested that, is if you just made a simple table. There are a lot of exciting things. I don't know how much you want to know about these things, but let me just put that down here. I think most of you know this [draws the following table]:

	Faces	Vertices	Edges
Tetrahedron	4	4	6
Cube	6	8	12
Octahedron	8	6	12
Icosahedron	20	12	30
Dodecahedron	12	20	30

You can do these all yourself. You all know this. I'll just put down the face, the vertex, and the edges. And this is always intriguing. The cube is 6, 8, and 12. Then, the octahedron is 8, 6, and 12. This divides the two [points to separation between octahedron and icosahedron in chart]. Then the icosahedron becomes 20, 12, and 30. Now you know what the next one will be. The dodecahedron is 12, 20, and 30. So you have two sets here, where they exchange, and so that means you can put one inside the other without much trouble. And then, you get several relationships. But the one you probably all know is this one: which is the vertices minus the edges, plus the faces. You know what that equals, don't you? $V - E + F = 2$.

Yes, it's 2; its always 2, for any of these.

But then, there are others—I don't know whether I should go into it—but, you can also write each of these out separately, Because, let me put down that you can denote this by a *p* and a *q* [draws the following table]:

	p	q
Tetrahedron	3	3
Cube	4	3
Octahedron	3	4
Icosahedron	3	5
Dodecahedron	5	3

Now, what is a tetrahedron? It's a (3,3). Now, you can tell me what this means, when I get through. This one [the cube] is a (4,3). These are just numbers to designate it, and from these you can do some very interesting things. And this is a (3,4). Then we have a (3,5) and a (5,3). And, you see what's happening here?

Well, what do we have meeting here [points to first column]? These [*p*] represent simply the number of edges on the faces of any one of these. Here there are 3; here there are 5. In the cube you have 4 edges. These are triangles. Here you see that three of them are triangles [points to the *p* column]; one is a square; and this one is a pentagon.

And these [points to *q* column] are the number of them meeting in a point. There are 3 meeting in a point for the tetrahedron and the cube. And for the octahedron, there are 4; and the icosahedron there will be 5 meeting in a point; and in the dodecahedron, there will be 3.

Now, wait a minute, I've got this backwards. What have I done here? This isn't right, is it?

Comment from class: No, it's right.

Moon: Let me make sure of this. So that, then out of this, if you use the *p*'s and *q*'s—I'll just put down one, because I don't think I should go anymore into this. But the number of vertices can be calculated from this number that you assigned, which simply has to do with what the face is, and the number meeting in a point, in the vertex. And so the vertex will be four times *p.* And then you have this denominator for all of these: 2*p* plus 2*q* minus *pq.* [$V = 4p/(2p + 2q - pq)$] So, that'll give you the number of vertices—see if I'm right. Take any one of them. Anyway, you can do this with the edges, and also for the faces. But I don't think I'll go into that anymore; the time is getting short.

Elaborating the Model

But, now let's take a little time, and look further at the model. We've gotten up to this [points to octahedron on chart.] So, you know that the cube will go inside, without any trouble. Because, the number of vertices here—well I'll take this out. [He shows a model of the Platonic solids constructed to the proper relative dimensions of the Moon nucleus. The faces are made from discarded aluminum printing plates, held together with metallic adhesive tape].

You see the cube is nestled there; you see, it nestles very nicely. You can move it around. It's got the cube so the vertices are at the center of these faces. [Class members experiment with model.]

And, while you're doing that, I'll put down here something that has to do with the dimensions. These were all based on the dodecahedron. (I'll just use a *D* for that.) We used 100 millimeters. George Hamann was very useful in constructing these models. You can cut them out by the gross, can't you, George [laughs]? He took the waste, you see. You know what this is? You know where this came from, don't you?

George Hamann answers: The printing company.

Moon: They threw 'em away, so George caught them, and made these models. Well, we started out with the dodecahedron having 4, and then the sequence is that as you go down to the cube, that the ratio of these two, the dodecahedron over the cube (this is the ratio of the edge)—I use *E* here, meaning edge. And the best ratio seemed to be, after you begin to figure out all this, the best ratio turned to be the divine ratio. So this is, you all know: 1 plus the square root of 5 over 2 [$1 + \sqrt{5}/2$]. That's the divine ratio, which you know is 1.618, and so on.

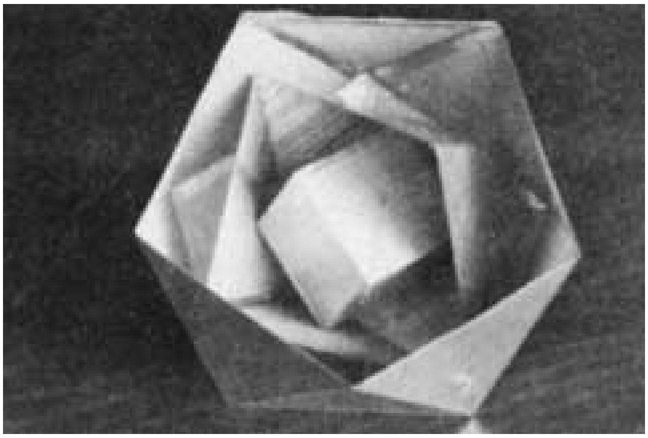
So, this then gave us—I'm going to write down here [puts table on board]—these are the edges [writes in 100 millimeters for the dodecahedron].

	Edge length (mm)
Dodecahedron	100
Icosahedron	117.1069
Octahedron	131.1048
Cube	61.8033

Then we have 117 (George, you can check me on this; George and I had quite a—we got lucky with this one). This is 117.1069 millimeters. That's for the icosahedron. . . . And then for the octahedron, we came with an edge of 131. Now, notice these edges are going up; the lengths are going up: 131 and .1048. (Can you vouch for it, George? How far can you vouch for it?)

George Hamann: I'll vouch for it to the .10.

Moon: George vouches for it to there [points to second decimal place]. Then the cube turns out to be 61.8033 millimeters.



A "Moon model" made by George Hamann from discarded aluminum printing plates.

So, now the ratio, as I say, is this [points to divine ratio]. And they all fit together well. The idea, with the exclusion principle which you have here, with one proton per face center, we now have a structure, which I think I can put together here. Have you got the rest of that model? [Takes model.] This goes inside. You see, now we have the octahedron. Here's where we have the fun. It's figuring out the best symmetry you can have with the octahedron inside the icosahedron. I have the faces off the icosahedron. You see the holes here [points to holes in the centers of six of the icosahedral faces]. This can be nested in here [places octahedron in icosahedron]. And, you can see it has quite a bit of wobble—in fact if you put it in that way, you can't see anything above the top, can you?

But we're dealing with a very peculiar element in this transition. You look at the properties—you might want to try this, moving it around in here, from its place. But the properties are varying very rapidly. [Class members experiment with the placement of octahedron in icosahedron.]

Question from class: What element is that?

Moon: Well, what do we have? We have 8; we just add them up here. This is where we start. There, the cube is 8, and here 6 [from the octahedral vertices] is 14, and now what's the next element? It's element 15, and what element is that?

Class comment: Phosphorus.

Moon: Yes, and phosphorus is so important in living things, too. But it also is one of those things we've got to check to make sure, because all of these things are locked up in the building. [He is referring to the forced bankruptcy of the Fusion Energy Foundation and two other associations connected with Lyndon LaRouche.] But Chuck had his old copy out. But it has a valence of 3, 5, and minus 3. That's the valence of phosphorus.

So, you see, there's another factor that was brought out in this particular design.

Larry Hecht: Do you mean the variable valence?

Moon: Yes, the variable. . . .

Fletcher James: . . . Dr. Moon, I have a fundamental question about what you are doing in filling in the these solids. Are you proposing a structure in which you actually have, quantized within space, a fixed structure, and you have points, particles which are located at rigid fixed intervals from each other within the structure?

Moon: No. You have singularities—singularities in space, particle singularities. . . .

Fletcher James: But at fixed, constant distances from each other? Or are you proposing that this is occurring in a phase space, and that there is a topological equivalence between this nesting?

Moon: Well, no, this is actual space, so there should be a topological *equivalent* to it. But, this is, these singularities in space may have nothing in them. But they're just a place where these particles can go.

So that when you've gotten beyond this [the icosahedron], we have half of the dodecahedron here [Figure 4], and this whole thing [cube-octahedron-icosahedron] can be placed in here, and of course this [the half dodecahedron] will fit exactly on the icosahedron—the icosahedron will fit in here—since there is a one-to-one correspondence in all the faces and all. And this [the other half of the dodecahedron] goes over the top.

Now you know where we are—what element? Do you know what element this is? It has nice symmetry, doesn't it? You know what element? This is palladium. This is element 46. Some of the astronomers seem to think that is one of the building blocks in the universe.

Well, now once you've got this, then how do you go on up in the periodic table? Well, this is the way you do it.

Maybe I should take this one, and build on this one. [Takes the completed dodecahedron with cube-octahedron-icosahedron inside]. So, you begin building particles out here, here, here. You extend from the one face of the dodecahedron, 10 vertices of a second dodecahedron, which will have a face in common with the first dodecahedron.

So that's 10, and now we're at element 56. And then, if you look at the periodic table, you've gone up 10, and now you've got to start building all over, the cube. So you start again [points to inside of the second half-dodecahedron], and you'd be building the cube, and the octahedron. [Builds the second cube and octahedron with the model.] So here we have 14—8 and 6 are the 14, and they're built up in here. Now, what do these 14 represent? There's 10 [points to the vertices of the half-dodecahedron]. You see, our rare earths begin with element 57. So, we start with 46, and we're going up to lanthanum. And there are 14, sometimes they are listed as 15, depending on whether you include lanthanum or not. And this then will represent the filling of the rare earths within [points to the octahedron with cube nested inside].

Then the rare earths will end, say, at 71. And then from 71, we now have the (well, I forgot to put this other [points to icosahedron]—I'm sorry). . . .

Larry Hecht: . . . No, that's right; that comes next.

Moon:. . .It comes *now,* but it has to go inside here—See now, the problem is you've got to see how elements are synthesized by protons passing through—there's a proton flux in the universe, the cosmic rays in outer space. But this is going to build up the elements and they've got to find a parking place [laughter]. And the protons find their parking place at what would correspond to the vertices. And then the neutrons, which are also out there, we're not going to worry about them, because they have no charge and they can be most any place. We will begin to worry about them later on.

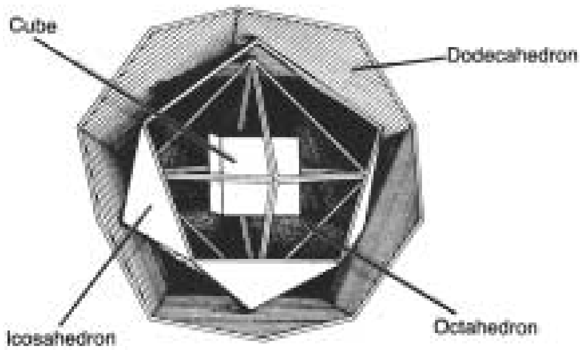


Figure 4
THE MOON MODEL OF THE NUCLEUS
A nesting of four of the five Platonic solids, starting with the cube, then octahedron, then icosahedron, inside a dodecahedron complete the first shell. The 46 vertices of the nested figure represent palladium, atomic number 46. To go beyond palladium, an identical dodecahedron is joined to the first one at a face.

But this builds up the rare earths, and then from here—is this the right one?—yes, we'll put this cover on here [puts in icosahedron and laughs]. This goes on top of this [places remaining half of dodecahedron on top to close the structure, Figure 5(a)]. And here we are. Now, you know what element you're at?

Radon! Did someone say that? Radon, a noble gas.

Now then, where do we go from here? How do we get another proton in. Every face here is filled with a proton, at the center, and the vertices have protons on them. Where do we go from here?

Hecht: Some of them know, but they won't say [laughter].

Moon: How about this? Turning up like this [he opens the two dodecahedra, using a common edge as if it were a hinge, Figure 5(b)]. Now you see what we have? We have one proton here, one proton here, but there are two vertices coming down, you see [points to the "hinge"]. In other words, we have only one there, but now it can fold out like this on an edge. Now the one proton that shared these two points [the vertices which were closed together but now are opened up] may stay with this, or it may stay with that [points to the two now-separated dodecahedra]. And the same thing over here.

Now, what element is it that follows radon? It's an element that doesn't exist in nature. And it doesn't exist, because it doesn't live very long: francium. We have made it in nuclear reactors by bombarding elements with neutrons. But then, you see, you have this situation happening, and two more will go in. Then, as we develop this, then we get to—uranium will be like this—one vertex [holds up model with the two dodecahedral pieces connected at only one vertex]. But, we can't violate the one proton per vertex that this would be. So the one proton goes inside, and the other goes inside here. [He indicates the one vertex displacing inside the other.]

Can you picture that? One proton in like that, and it makes a sort of hook like this [demonstrates two fingers hooked within one another]. Have you got the idea? And now what we have is something that's ready for fission. See? This thing is not very stable. It's only held in this point. So if you try to put more neutrons in there, it's going to fissh [laughter]. It's going to break apart. Now it won't break apart exactly in half, because it depends on where these other protons are going to go in the shuffle. But, that describes the beginning of fission; that can take place because we can now join two of these building blocks of the universe together at a corner.

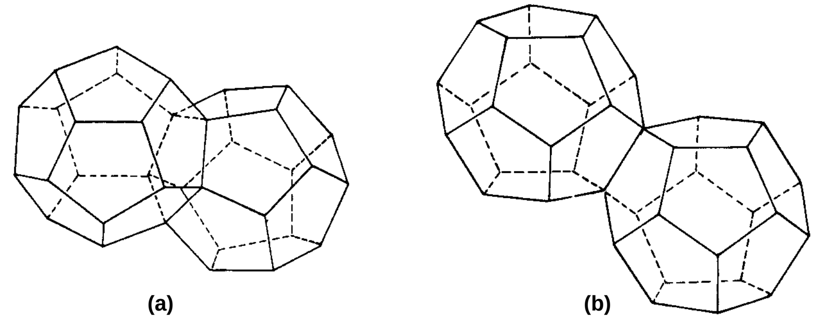


Figure 5
THE TWINNED DODECAHEDRA AND FISSION
(a) To go beyond radon, the twin dodecahedra open up, using a common edge as if it were a hinge (b). To create 91-protactinium, the hinge is broken at one end. When the position where two protons join is slightly displaced, it creates the instability which permits fission (92-uranium).

Chuck Stevens: Would you say the phosphorus is like a register shift, or like an asteroid belt?

Moon: It could be. It comes at that place [laughs]. It comes at that place, all right.

But this will give a distribution. You know, the distribution of the elements that are formed from the fission is like this [shows a curve with valley]. None of them are exactly a half, apparently, or at least we don't find many there. . . .

Now, just one more little thing, and that is: Supposing this assembly here, uranium. . . . You know that if you put three more neutrons in, and you know what happens there, don't you? You get uranium-238. But now, try to put another one in. And the neutrons don't like so many newcomers [laughter]. They won't allow it to come, to be part of it. So the thing that happens is, it gives off an electron. So that now goes to the next element, which is the next one to our most valuable element for fission—I guess most of you know that's plutonium. What's the one that comes before plutonium? You know your planets, don't you?

Voice in class: Neptunium.

Moon: Neptunium, yes. So, you have neptunium, and then it breaks down again, and you go to plutonium. So that's the way plutonium happens to be made, just by getting too many protons in. So there's a proton-neutron balance.

Well then, I just want—how am I doing, should I stop here? I had just one thing to talk about. Maybe it would be of importance in the nucleus, and that is the . . . magic numbers. Maria Goeppert-Mayer named them the magic numbers. Have you ever heard of them?

Larry Hecht: Well, I just realized it's 11 o'clock. Maybe we should pick that up in the next class. It's probably a good place to stop.

Moon: Well, I will say just—it's the only thing I will say—these magic numbers [laughter] fit the model! [more laughter, and applause]

[*The discussion continued after the class, but the audio tape picks up in mid-sentence.*]

Chuck Stevens: . . .the icosahedron. Did you at all think about this thing of the ratio of the golden section?

Moon: Yes, oh yes. That was the thing. We could change the dimension to that different one. But it also turns out—unfortunately, I don't have the calculations, because they're over in the Fusion Energy office. . . .

Stevens: . . . confiscated. . . .

Moon: . . . Yes. . . .

Question: The way I understand this is not so much structures, per se, but something like the experiments we were doing with soap bubbles, with the least action principle, where. . . .

Moon: Oh, least action, right. . .

Questioner continues: . . .where you get what appears to be a structure within the wire. But it's not like a physical kind of structure, per se. In other words that's how these things form—how the protons are added on?

Moon: Right. That's how the protons are added on. They can go in the center here. But this is just a means of showing it. . . .

Questioner continues: Right, right. When you're building up past the 46, and start going to the rare earth elements—when you have the cube and then the icosahedron, do you have significant elements at those points, just like, with the cube, what is it, oxygen, when you have the cube?

Moon: Yes. Once it's built up to this—that's 10. You see that takes us from 46 to 56. Then you see, with 57 we begin to see that these are the rare earths here, which begin at 57. And you see, that's exactly what we have. We have 10 and we're at 57, so now we begin to build up the rare earths, which are the 14. This part goes in here [places cube-octahedron combination inside second half-dodecahedron], which has 14. And these are the rare earths, which seem to have—in other words, what is happening here is that the shape of the electric field around this is elongated and somewhat different, and there's still a bit of unfilled spaces here. So that the first set of rare earths are given by this. You see, you've got to remember, we're building from the outside in, not from the inside out, like you did originally.

Larry Hecht: You know, I had a zany idea, while you were talking. What if . . . well, the first time through, we were having this problem of trying to decide what the size of this should be. Could it actually be different the first time through than the second time through? In the first 46 you've got phosphorus, but you don't have that rare earth phenomenon. . . .

Moon: No. . . .

Hecht: . . . Maybe the icosahedron would be one way the first time through—it would go in there one way the first time through, tighter or something—and maybe the second one is different, so the thing is not perfectly balanced. Maybe that helps account for the way it fissions."

Moon: It may well do that, because, in the fission of uranium, you'll see that the peak is off to the side of half the value—around 46—on either side of it. They go up like this [shows valley curve] . . .

Hecht: Oh, they peak on both sides?

Moon: . . .They peak on both sides.

Hecht: There isn't one point at which it's. . . .

Moon: No. It peaks on both sides. So you can see that uranium has quite a shake-up. And that's the result of trying to add another neutron. That's uranium-235, that is. Of course, -233 fisshes also. That we get from thorium, and that's what the Candu reactor uses—they use thorium going in one way, and uranium going the other way. They use heavy water as the moderator. This is the reactor used in Canada, and in India.

Mel Klenetsky: Will this show up in any kind of way—I mean is there any way to measure this? You have spectrographs to analyze things, but obviously it's not fine enough to pick up something like the energy flows. But it seems to me that this kind of configuration would yield some kind of an energy flux that you would be able to measure in some kind of way. . . .

Moon: Well, that's why . . . we're going to talk about the factors because of magic numbers and we're reaching the point where. . .

Klenetsky: . . .Because the whole thing we were talking about in inertial confinement, in terms of, if you're beaming, if you're taking certain beams in—you and I were discussing this a long time ago—there's a certain way you can match up these beams, certain angles, which are going to give you more of an optimal impact than others. . . .

Moon: Right.

Klenetsky: . . . And it seems to me that this structure lends itself to giving more insight into that.

Moon: Well, maybe, polarization is becoming very important, which we know it is—polarization of the magnetic field, for example, Yes, well, and then these magic numbers change the nuclear properties by a factor as small as you want. It's very sensitive to that. And then Larry's paper shows how this nuclear charge is affected by the—you went into that in your paper, didn't you?

Larry Hecht: . . . Yes—

Moon: . . .Nuclear volume, and things of this sort. In other words, the extranuclear electrons are really showing what's inside. Although it's not nearly as remarkable as the magic numbers are, which show how *nuclear processes* work—though they're both showing it. . .

Klenetsky: The thing I think that we should be able to do is refine this, to get a much better reading of the molecular structure at the microscopic level, which you don't have. I mean, the basic way that we're dealing with the fusion reaction is fairly primitive at this point. A lot of energy, and you're just squooshing things together, and you're just trying to jumble things up, you know, in a very arbitrary kind of way; and the point is that if you have a sense of the geometry, this should give us a much better way of approaching this, a much more sophisticated way.

Moon: Yes, and I think too, that when you use this to bombard uranium on uranium—then, there's a certain energy which goes into it, and this fine structure property comes in very beautifully. Because there's a paper written, and you don't know what the answer is to it—but when this hits another uranium, then it goes to element 184 [see p. 24]. Well, they tried all combinations, as you go from 180 to 188, I believe. But the thing is that this energy is divided—1/137 of the bombarding energy, as we show here [points to blackboard][3]—you see, this is the impedance of free space, which is reactive, which means . . . it's non-dissipative. And, therefore, calls for the conclusion that therefore this energy cannot be used for *binding.* And it's only this part that can. So, therefore, when they come up, there's immediately established around it, a first Bohr orbit, a virtual, first Bohr orbit.

Now, what can it do? There's nothing there, but there has to be something there. So, a positron-electron pair is produced, and the positron is thrown out. But the energy that throws it out is this [points to blackboard]—and that turns out to be—it's just the right fraction of the bombarding energy, they showed. So, this is the reactive energy, and that goes into an electron that goes off, and it's . . .

Hecht: . . .The first bracket, the first parentheses [Zmc^2]? That goes off?—

Moon: Yes, the first parentheses. . . . That energy goes off. . .

Hecht: . . .The second part is what can be used for binding? I couldn't see what you were pointing to.

Moon: Yes. So that's 1/137 of the energy. That's what we're talking about.

Hecht: e^2/hc?

Moon: Yes, that's the 1/137 of the energy that has to be reactive. And so that can carry the electron on it. Maybe that's the way it was meant. I don't know. Maybe that's part of the idea of the fine structure constant.

So all the elements they've made by this, all of which add up to something between 180 to 188. They find that the electron comes out—it's the same fraction of the bombarding energy, about 300,000 volts. Isn't that interesting? And that this gives the result, directly.

Hecht: So that is the Darmstadt . . .

Yes, the Darmstadt experiment. . . right.

Notes

1. If you accelerated deuterons in the cyclotron (a deuteron is a "heavy" isotope of hydrogen whose nucleus contains one proton and one neutron—the neutron is really a proton with an electron condensed on it—as opposed to ordinary, "light" hydrogen, whose nucleus contains just a single proton), you find that the charged part of the nucleus, the proton, is left behind when the accelerated deuteron beam passes through a material target. Thus, only neutrons emerge from the material target. [Charles Stevens]

2. In particular, how neutrons interacted with the carbon nuclei in graphite. This was most crucial for the development and realization of the first nuclear pile, the first nuclear reactor, which was built at the University of Chicago.

   At the time of the Manhattan Project there were only three things available for making a nuclear reactor (for containing the neutrons produced by uranium fission so that more neutron-induced fission reactions could be generated. [Charles Stevens]

3. The missing equation probably is:

$E = (Zmc^2)(2\pi e^2/hc)$. Cf. Erich H. Bagge, "Low Energy Positrons in Pair Creation," p. 24. [Laurence Hecht]