III. Mathematics Is Not Science

A Fusion-Driver Crash Program: Upshifting the Human Species

The following class was presented by Megan Beets, a leader of the LaRouche Science Team, to an audience in the New York metropolitan area on April 15, 2017.[1]

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Lyndon LaRouche in Berlin, 2002.

My name is Megan Beets. I'd like to welcome all of you to the tenth in our series of classes on LaRouche's Physical Economics. I'd like to begin with what I think is a familiar idea to those of you who have been attending this class series, which is our theme for today: that is that the creative human mind is an absolutely unique form of existence in the universe. This mind, this process of creative thought, distinguishes human beings as a type of living being, which is not only a living being, and it sets us absolutely apart from and above all other forms of life. Human beings can consciously and willfully think and invent in such a way that we're able to more and more comprehend the process which organizes the physical universe around us, and to participate in and contribute to the ongoing upward development of that universe.

Now, this was recognized by all of the greatest thinkers in history, just to reference a few: Johannes Kepler, Plato, V.I. Vernadsky, Einstein, Bach, Beethoven; and especially Lyndon LaRouche, who made his own discoveries in the science of physical economics, basing those discoveries on exactly this unique power of the creative human mind and the creative human imagination. This LaRouche defined as the science of Physical Economy, as a science and study of the upward progress of mankind and the promotion of the upward progress of mankind. Mr. LaRouche himself has made fundamental contributions to the understanding of that process.

I would like to address this theme using a very specific example that LaRouche calls for, in the fourth law of his "Four New Laws to Save the U.S.A. Now."

This fourth law is titled, "Adopt a Fusion-Driver 'Crash Program,'" and it begins, *"The essential distinction of man from all lower forms of life, hence, in practice, is that it presents the means for the perfection of the specifically affirmative aims and needs of human individual and social life. Therefore: the subject of man in the process of creation, as an affirmative identification of an affirmative statement of an absolute state of nature, is a permitted form of expression."*

Now, Mr. LaRouche follows that up, his Four Laws, with this statement:

"The knowable measure, in principle, of the difference between man and all among the lower forms of life, is found in what has been usefully regarded as the naturally upward evolution of the human species, in contrast to all other known categories of living species. The standard of measurement of these compared relationships, is that mankind is enabled to evolve upward, and that categorically, by those voluntarily noëtic powers of the human individual will."

Now that is the most important concept in economics. As people know who watched the April 1st presentation that was given by Ben Deniston, he referred to

1. A video of this class is available here.

the increasing rate of energy-flux density in the biosphere over the course of the evolution of life, and he referenced the idea, or the fact, that mammals, as a type of animal life, demonstrate a higher energy-flux density than reptiles, and reptiles over amphibians, and so forth, such that the increase in metabolic action and the increase of action per lifetime of mammalian species is a category above lower forms of life.

But now what about human? If people think about human metabolism, what we metabolize via our bodies is not all that impressive, compared to other forms of life. Most of human metabolism is external. Most of it is via technology, via society. For example, we metabolize *tremendous* amounts of steel, of coal, of copper, of zinc. And the per capita metabolism of these substances is *enormous*, incomparable with any other form of life.

The most important fact about human metabolism and human energy-flux density is that, yes, it's superior to mammals just as mammals are superior to reptiles, but it's not fixed. We can willfully upshift our interaction with the physical universe and revolutionize it. This happens with the introduction of a new discovery of principle, something generated by the human mind, which gives us power in and over the physical universe, to do things we simply could not do before. Our relationship to the physical universe is completely transformed in a way which is exactly comparable to a difference in species, a categorical difference in species. So if you think about human species five hundred or one thousand years ago, and you think about how you might describe the human species in a biological textbook and list the average lifespan of a human being, you list where we're able to live, you list the average population density, the kinds of resources we utilize, the kinds of structures we build, if you made that list for human beings of five hundred years, it would be completely different than the list or the description you would make of the human species today.

Making that kind of shift intentionally, is what the fusion driver crash program that Mr. LaRouche calls for is about. With the mastery of fusion we will realize full control over the atomic nucleus, something which has been a potential at our fingertips for over half a century. We will move mankind, finally, and fully, into the atomic age. Meaning this: Meaning that our relationship to matter will be transformed from a mode of a simple redistribution and recombination of elements, as it is today, and will move into a mode of the creation of elements, of the generation of elements.

Now, we already do this today on limited scale. With fusion, we will be enabled to do this on a large scale to the point that this will characterize the human species.

Understanding and Mastering Physical Processes

Now, a few things before going further. I know most people have seen little cartoons of atoms in their science textbooks, of little balls surrounded by other little balls. The universe is not composed of particles. There's no such thing as tiny, hard little balls which somehow interact with all of the tiny particles around them, and all of their little interactions somehow add up to a coherent, creative universe, which contains life and human creative thought. *That's not how it exists*.

Matter is as little composed of tiny particles, as music is composed of notes, or as poetry is made up of words. What we think of as words, or notes, or particles, are merely singularities within a particular geometry, which is the manifestation of a principle of action.

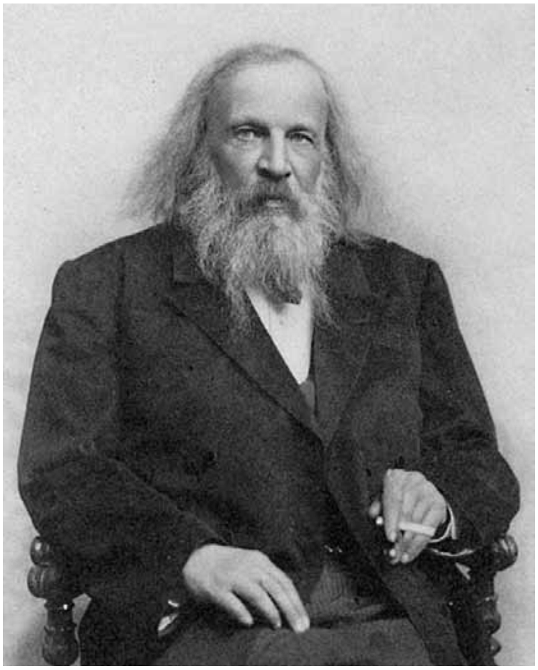
I want to give what I think is an example on a slightly simpler level but I think it gets at the point, and I think this might even be an example that was given by Mendeleyev, though I wouldn't vouch for that. Take a chemical compound which you know well: Water. Now, everyone learned that water is composed of hydrogen and oxygen. Now, hydrogen and oxygen are colorless, odorless, highly flammable gases. Right? What about the characteristics of hydrogen and oxygen when they come together, to become liquid water, which is the most essential thing for life? There's nothing characteristic in the parts that can predict the characteristics of the chemical compound that they create together. So, hydrogen, in the context of a water molecule, is completely different than hydrogen in its free form.

Now, it's important to make that statement, and not just because I know people, myself included, have these science textbook cartoons in their heads, but also because this is the way that people like Antoine Lavoisier and Dmitri Mendeleyev thought. Lavoisier and Mendeleyev bookended the roughly hundred-year development of modern chemistry. Lavoisier lived at the end of the 18th century [1734-1794], and he isolated as chemical elements, oxygen, nitrogen, for the first time, carbon, hydrogen, and so on, and determined that these were differentiated chemical elements which could not be made more simple. And he did this based on experimentation on their characteristics of action. There could be whole other classes on Lavoisier's work; Lavoisier founded modern chemistry.

Mendeleyev lived in the middle to end of the 19th century [1843-1907], and Mendeleyev discovered the unique harmonic ordering of the entire set of chemical elements that Lavoisier had first begun to discover. You all are probably familiar with this, the Periodic Table of Elements.

Mendeleyev's harmonic ordering of the periodic table was able to predict both the existence, but also the characteristics of chemical elements that hadn't even been discovered yet. Mendeleyev's first periodic table was proposed in 1871.

Almost immediately, within the last three decades of the 19th century, the completed discovery of the domain of chemistry by Mendeleyev, opened up into the discoveries of the nuclear age. In the decades of the 1880s and 1890s, you had the work of people such as Wilhelm Roentgen, Henri Becquerel, Paul Villard, Pierre and Marie Curie—and many others—whose work led to the discovery of the electron, the discovery of the proton, the discovery of the nucleus, of X-rays, the discovery of gamma rays; the discovery of radioactivity.



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Dmitri Mendeleyev, frontispiece from Fundamentals of Chemistry *(1897).*

These initial discoveries began to unlock a completely new domain of the nucleus and the powers associated with the nucleus. This was a complete revolution in science. This also formed the background and the context for the work of people such as Albert Einstein, including Einstein's idea that a very small amount of matter was equivalent to a very, very large amount of energy. This intrusion of the nucleus, including all of its bits and parts, completely challenged and overturned the previously held assumptions of the chemical era, for example, the law of the conservation of mass and the law of the conservation of energy.

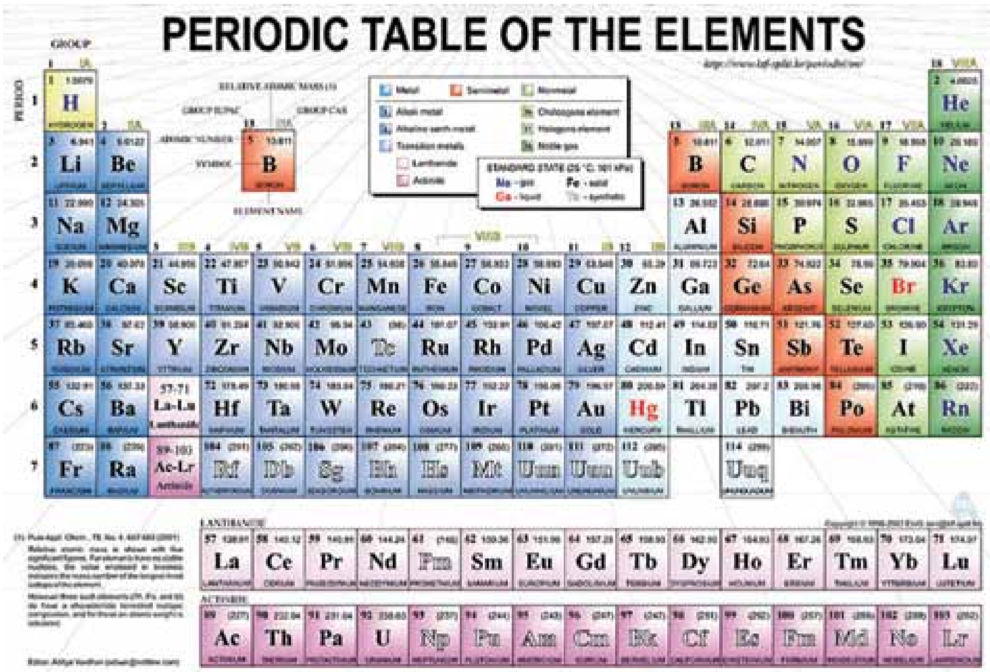
To give a quick illustration or example of that: If you take a water molecule and you split it into its constituent parts of hydrogen and oxygen, the mass of the hydrogen and the oxygen add up together to equal the mass of the water molecule. However, if you take a nucleus, such as uranium and you split that, the pieces that you end up with, if you added them back together, their mass is *less* than the mass of the original nucleus. Where did the mass go?

It was the phenomenon of radioactive decay observed by Becquerel, that challenged the idea of the conservation of energy. It seemed as if energy was coming out of nowhere.

So, this was a completely revolutionary period in human thought, and by the turn of the 20th century, you had the emergence of a completely new domain that nobody had ever imagined before, and which was completely invisible from the domain of chemistry, and chemical reactions.

By the early 1930s, you had the work of James Chadwick, who discovered the neutron. You also had in 1934, the first artificial radioactivity, and with this, came the idea that perhaps human beings can intentionally transmute elements. Perhaps human beings can change one chemical element into another. So if we go to the Periodic Table, you see on the top right the N and the O, standing for nitrogen and oxygen. In 1919, which is a little bit earlier than this, you would have the first intentional transmutation of nitrogen into oxygen, demonstrating that the Periodic Table was not a set of fixed categories, but it was actually a much looser domain that we could begin to move around in; we could begin to change one thing into another, and exert a certain amount of freedom over matter.

Work went on in the early 1930s, into the middle of the 1930s with transmutations, where scientists Otto Hahn, Fritz Strassmann, and Lise Meitner were bombarding elements with neutrons, trying to induce transmutations. In the bombardment of uranium, something very interesting happened. The expectation was that bombardment of uranium with neutrons would create an element one or two steps up on the Periodic Table. The problem was, that didn't happen. The bombard-



Wikimedia Commons/user:Kabirhridoy

ment of uranium generated products that were much, much further back on the Periodic Table, about half of the atomic weight of uranium.

This was the first emergence of fission: Fission power, or the phenomenon of fission. Most people's association with fission, if they have one, is of nuclear power plants; fission power to produce electricity, where we intentionally create nuclear chain reactions in uranium fuel, which generates a tremendous amount of neutrons, a tremendous amount of heat, and we use that to boil water, turn turbines, and create tremendous amounts of electricity.

Fission Power and Physical Economy

Now, this is an incredibly important use of the fission process. The energy locked up in the nucleus is more than a million times the energy in the chemical bonds. Think about that—something that is a million times more energetic than the previously used fuel. To put it another way, it takes 2.7 million pounds of coal to equal the potential energy in 1 pound of uranium. This is a complete revolution.

Imagine the needs of a population of 7.5 *billion* people, people whom we intend to uplift to a modern standard of living: the electricity requirements of these populations are overwhelming. The idea that we could supply those needs with a small amount of uranium, rather than millions of tons of coal or oil toted around the world every year, is incredible. And that's why most nations in the middle of the 20th century were running for nuclear power—and they would have had it, except that it was shut down by a British operation, which was deployed in the form of the environmentalist movement; it was deployed in the form of globalization, and globalist economics; and it was deployed in the form of coups to overthrow the leaders of nations who wanted this kind of development.

This sabotage has led to a condition where, today, only 31 out of roughly 200 nations on the planet use nuclear power. We have to increase this very quickly.

Electrical power is an incredibly important use of fission, but fission is not just an energy source. Put much more precisely, fission, or fission reactors, are atom producers, atom factories. And before I give a couple of examples of what I mean by that, I need to refer to an aspect of the Periodic Table which I skipped over a moment ago, which is this: In around 1910, in experiments that were being done on the decay of uranium, the natural radioactivity of uranium, it was discovered that in the process of giving off gamma rays and other particles, uranium is naturally transformed into different elements of lower atomic number.

So this was being studied in 1910, and it was identified that during that process of the decay of uranium, this yielded elements which were chemically identical with other elements of the Periodic Table, meaning that we started with uranium, then at some point we ended up with something that behaved chemically just like another element on the Periodic Table. It would enter into chemical compounds the same way; if it was mixed with that element you couldn't separate it chemically by any means. *However, it had very, very different physical and radioactive properties*. For example, the ionizing energy, the amount of energy it would take to ionize that element, was different than its chemical twin. The magnetic characteristics were different than its chemical twin; its half-life was different from its chemical twin. The half-life is the amount of time it would take for half of a sample of that element to decay, to go through a radioactive decay.

Why? There was nothing in the domain of chemistry that could explain this. So, it was in 1910, I believe it was Frederick Soddy who named chemical twins "isotopes," coming from the Greek to mean "same place," as in, they are in the same place on the chemical Periodic Table, although they exhibit different properties. There are two different types of oxygen. There are three different types of carbon, all of which are chemically identical, but different in other ways.

This added a completely new dimensionality to what we had perceived to be the chemical elements in the past. A few years later, it was confirmed that the isotopes of a single element had different atomic weights, and today we have over 3,000 known isotopes most of which are manmade, and we regularly use 200 of them in human economics.

Here's an example I want to give, which some of you may probably be familiar with—the term "medical isotope." A medical isotope is something that we use for medical imaging and diagnosis. People who have had MRIs, you drink a little potion that has a medical isotope in it which is able to respond to a magnetic field. We use these things in medical diagnosis, medical treatments, cancer therapies and so forth.

Medical isotopes are just one product of a fission reactor. These things are produced inside fission reactors. Other kinds of isotopes that we can produce in fission reactors and other associated nuclear technologies, have very interesting properties which I don't have time to go into today, but to give quick examples: Carbon has a few different isotopes, and all diamonds that are found in nature are made of a mixture of these isotopes of carbon. However, if we create artificial diamonds which are only of one isotope or the other, they actually have different properties. One, either carbon-13 or carbon-12, I forget which is which, but one of these diamonds is much stronger and its more thermally conductive than the other. You have a similar case with silicon, and probably most of the elements of the Periodic Table.

Another example: the metal steel which is doped with certain isotopes to create a stronger metal than the original. The other thing I'll refer to, although we don't have time to go into it today, is that life, living bodies, living organisms, are extremely selective of their isotopes. We find higher concentrations of certain isotopes inside of a living body, than in the environment around it; an example is carbon-14 which is the radioactive isotope of carbon. It's more concentrated in living forms, than in the air around us. Vernadsky began a whole study of this, and much more needs to take place.

The point is that with our initial control over the atomic nucleus, as exhibited with the kinds of experiments that led to fission power, we began to have this finely tuned freedom over matter. We need to complete that: We need to have full control over the Periodic Table and over the nucleus.

Fusion: Challenging All of Our Assumptions

I'm going to skip ahead to fusion. It was clear very, very early on, that the energy which could be attained by the fusion of chemical elements was many times greater, up to one hundred times greater than the fission of elements. If we think about fission again, for a moment, as opposed to transmutation, where we move through the Periodic Table step by step, with fission we move through the Periodic Table by great leaps, and this involved the release of a great amount of power. With fusion, we also move through the Periodic Table by leaps, but instead of going from heavier elements to lighter, we go from lighter elements to heavier. We put lighter elements together to create a new, heavier element, and this involves the release of much more power.

Fission and fusion—put that way—seem to be the inverse of each other: One is moving up, and one is moving down. But as we know from music, the inverse is never the simple inverse. There are always much different, or almost always, different implications in the inversion than meets the idea. This is the case with fusion. We have had control over fission for some time now. What's called the first "nuclear pile," was created in 1942 in Chicago as part of the Manhattan Project. We've had a fusion bomb, which is an uncontrolled form of fusion, since 1952. But we still don't have full control over causing fusion to happen.

So I'll say a few things about fusion: Fusion is not a terrestrial idea. Fusion, as far as we think, has been occurring inside of—and powering—stars for billions and billions of years, including our own Sun. This is why people may have heard the quest for fusion referred to as "bringing a star to Earth."

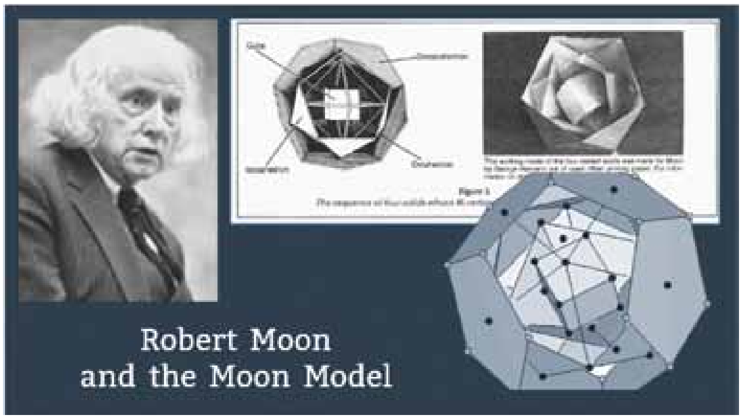
Most of the experimental work in fusion that's being done today, deals with plasmas. Plasmas are usually defined in a somewhat academic way, as a “charged ionized gas.” So, a gas which has been heated or affected to the point that the electrons are stripped off the atoms, and you have a soup of electrons floating around with a soup of positively charged nuclei. There’s a problem with this kind of thinking, which I’ll get to in a moment.

Plasmas are very fascinating, very interesting manifestations of matter. Plasmas are also, just like fusion, not terrestrial: Plasmas occur in solar processes, and plasmas occur in galactic processes. Roughly 90-95 percent, maybe more, of the matter in the known Universe, is in the form of a plasma.

Human beings are babies in terms of our understanding of the behavior of plasmas, and this has been shown abundantly in fusion research, in the failure of plasmas to behave as we think they should. If you think like a reductionist, you will take the formulae for the interaction of charged particles and try to predict the behavior of a plasma, and every model that’s been created using those methods, adding in another factor, another factor, another factor—every model has failed.

Plasmas have shown us that they have extremely unique properties, properties which are completely opposed to the formulae for an ideal gas system. They have exhibited the behaviors of self-organization, of concentration, rather than an homogeneous distribution.

Another anomalous behavior of plasma is something which is actually used to great advantage in most fusion experiments today, which is something called “H-mode.” H-mode refers to “high confinement mode.” This is an example of a tokamak, a particular type of a fusion machine. Inside of a tokamak, while the gas inside is being heated as more and more thermal energy is being deposited inside the gas, the plasma begins to go through states of turbulence. Now, I don’t know if anyone has experienced tuning a piano, or tuning two violin strings into unison, or any other harmonic interval: As you tune these strings, as the strings being to become closer and closer in tune, you begin to get a phenomenon called “acoustical beats” which are a certain turbulence in the harmonics. And as the strings come closer and closer into harmony, the rate of the acoustical beats speeds up, the turbulence speeds up, until the strings are perfectly in tune, and then you get a beautiful resonance. H-mode in a plasma is a somewhat similar phenomenon: As the thermal energy is deposited into the plasma, you get increasing resonance turbulence inside of the plasma until you reach a certain point, where suddenly—the turbulence stops. And the plasma is actually more stable, more easy to contain than it was before.



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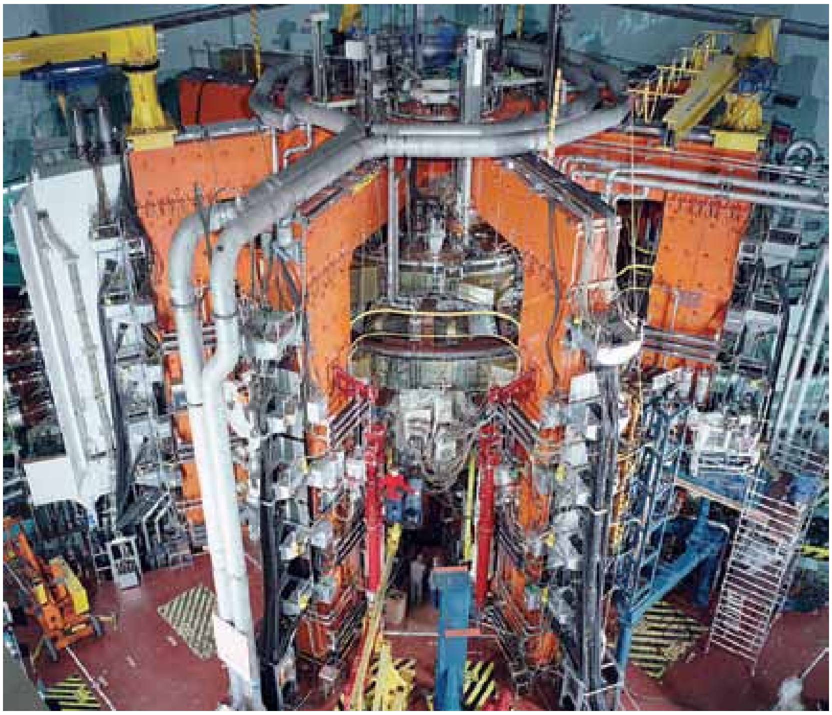
Now, nobody exactly knows why this happens, and when it was first discovered, I believe by Hans Bethe, this was a huge item of controversy.

I say these things to make the point that this state of matter which is associated with this newer advanced power of the nucleus, of fusion, is something which is defying all of our assumptions and challenging us at every turn, and this should point out to us that our assumptions about the nucleus are not right. There is something that we are missing, or more likely, there is something that we are blocking on, involved in this principle.

Just to reference another collaborator of ours, Dr. Robert Moon, who as a great friend of Lyndon LaRouche and helped to found the Fusion Energy Foundation—Robert Moon was part of the Manhattan Project and a student of William Draper Harkins. Dr. Moon insisted that the entire approach to the atomic nucleus was wrong, that the nucleus was not identical to the cartoons in your science text with a cluster of randomly situated protons and neutrons somehow held together by the “strong force.” He said this is entirely wrong. Dr. Moon thought very much along the lines of Johannes Kepler, that the parts do not add up to the whole. He said that, just as Kepler proposed and proved that the planetary orbits are singularities within a harmonically and geometrically organized system, that the protons and neutrons within the nucleus are singularities within a geometrically and harmonically organized space which we call “the nucleus.”

The Promise of Fusion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The Joint European Torus magnetic fusion experiment in 1991.

Despite the challenges that we have run into in the attempt to control fusion, to create controlled fusion, and I will say that these efforts of fusion science have always been quite international, with robust international cooperation and progress; despite the challenges to our efforts, in the course of this research, human beings have done some incredible things: We have created densities of matter which are one hundred times the density of the Sun; we have created temperatures in the hundreds of millions to billions of degrees, hundreds of times hotter than the core of the Sun. These are temperatures which will vaporize any material.

We have also, therefore, built ways to contain these plasmas at these temperatures with magnets, and along the way, we have driven the development of super-conducting magnets.

We have created pulses of energy which are on the scale of quadrillionths of a second, which is faster than the rate at which chemical reactions occur.

We have driven forward precision machining, precision science and engineering to keep up with the requirements of this, and we have developed some of the most incredible lasers in the world, one of which I'll talk about in a moment.

So, take that short list and think back for a moment to how I opened this discussion on the characteristics of the human species, and consider that short list of things as an answer to the question of your biological textbooks of "what does the human species do?" Well, with fusion, this is what we do.

A "Tokamak" is derived from the Russian word for "torus," and it's the toroidal shaped fusion machine which contains the plasma at temperatures of hundreds of millions of degrees with a magnetic field. And here's a similar, beautiful picture of the superconducting tokamak in Korea, named the KSTAR.

But the tokamak is not the only idea of how we will make fusion occur. This is a very incredible and beautiful fusion machine that was just completed and tested in Germany, called the Wendelstein 7-X, which is a type of fusion machine called a stellarator, where "stellar" comes from star. And this is actually a design of a machine that originated here in New Jersey at the Princeton Plasma Physics Lab. The PPPL has an incredible stellarator that they've designed, they've built, and it's sitting in parts in one of their rooms, because we don't have the money to put it together! I'll leave that there.

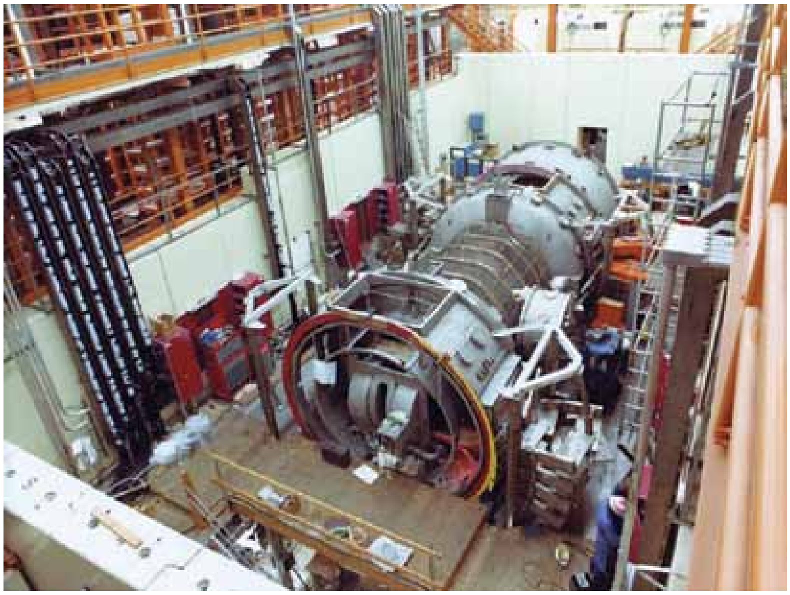
In the stellarator the copper parts are the magnetic coils, but these coils have a very, very complex twisted geometry. So the magnetic fields that these coils create is not a simple toroidal shape; it's a very complex twisted shape. That's another idea.

Another idea that we pioneered here in the United States in the 1980s, and could have been successful, except the funding was cut, is something called the "mirror machine." Instead of a closed torus, it's a linear geometry that has gigantic magnets at the ends to contain the fusion plasma.

We can not here discuss all the approaches to fusion, but I wanted to give you a little bit of a sense of an idea. There are also many interesting experiments going on with approaches to using the self-organizing characteristics of the plasma, like those filaments that I showed you, or those vortex rings. There are ideas of rather than trying to fight to contain the plasma, why don't we use the natural characteristics of the plasma itself to try to create fusion? I didn't show pictures of any of those experiments, but those are also going on and need to receive much more funding.

Let me discuss a few of the applications. Though we have not yet achieved fusion, we can already use some of what's been developed so far and foresee some of what we will be able to do with the full control over fusion power. I'm going to go through a few of them:

First is chemical processing. I don't know if anybody here is an expert in chemical production, but today the typical chemical factory uses a tremendous amount of heat to break down chemicals or create chemical reactions, uses working fluids to "leach" chemicals out of ores, dissolve an ore in this thing and leach what you want out of it; it uses electricity and so forth. With fusion reactors, it will be possible to divert some of that very high temperature plasma to a special section of the fusion reactor, where we can use it to process chemicals much more powerfully and efficiently than we do today. We could do things, for example, as take a fusion plasma into a special section, put some isotopes into it, and cause a tremendous amount of gamma radiation or ultraviolet radiation to be produced within the plasma, we could use that to do things like sanitize water on a mass scale, speed up the rate of chemical reactions, catalyze chemical reactions.


Flickr/Lawrence Livermore National Laboratory

Tandem Mirror Experiment (the TMX) at the Lawrence Livermore National Laboratory in 1979.

We could use the tremendous amount of cheap electricity created in fusion plants to make electrolysis a very cheap process. And these kinds of things could make possible the mass and very efficient production of heavy chemicals, methanol, ozone, and many others.

Another application of fusion is something called the "fusion torch," and this is something that was designed by two Americans named Bernard Eastlund and William Gough in the late 1960s who imagined, again, a special region of a fusion reactor where we divert the plasma into this special region, which is now at the temperature of tens of millions of degrees. Any material which is placed within that plasma is immediately vaporized, broken down into its constituent elements.

This completely revolutionizes the idea of "mining": Any material we take from a landfill, any random piece of rock, ore, that's dumped into the fusion torch, is immediately broken down into its constituent elements which can then be taken off into a separation process to create deposits of iron, deposits of carbon, of silicon, and so forth, which are mined from landfills, from plots of what were previously considered very poor ore and so forth. This will revolutionize our relationship to acquiring raw materials.

There is also something which I'm very excited about that was developed in the 1990s at the Lawrence Livermore Laboratory, which is working on creating fusion with lasers. This is the petawatt laser. The petawatt laser is a laser which can deliver a quadrillion watts of energy: for people who don't have a sense of scale of how much a quadrillion watts is, that's 1200 times the entire U.S. energy grid. So the petawatt laser can deliver a quadrillion watts in a pulse that lasts less than a trillionth of a second. That's faster than the rate at which chemical reactions occur, it's powerful enough to accelerate electrons to nearly the speed of light, meaning that they can transmute elements and change, in effect, the nuclei of elements; it also means they're accelerated so fast that they experience relativistic effects, such as their mass increasing.

The petawatt laser can also be used to machine, and I think this is incredibly beautiful. Laser machining is already orders of magnitude more precise than metal on metal machining; and now you look at the potentials of something like the petawatt laser and you imagine the kinds of precision we could get for the needs of space travel and so on.

The other thing that could be possible with the petawatt laser is surgery, because the petawatt laser can vaporize a single cell without disturbing any cells around it.

The Extra-Terrestrial Imperative

Another important application of fusion is space travel: moving mankind out into the Solar system. This is one design of a fusion rocket coming out of scientists, I think at the University of Washington in Seattle. Why is this important? Many, many people have recognized that it's ridiculous to say that we're going to put people on a rocket and spend nine months getting to Mars, let alone anywhere beyond it—completely impossible! With, first fission and then fusion rockets, it will be feasible to achieve what Mr. LaRouche called for back in the 1980s, which is a constant 1-gravity acceleration travel to Mars and into the Solar system.

So the design is that you have the very small fusion reactor at the business end of this rocket, and the products of it are accelerated out the back and that becomes the thrust of the rockets. This would make feasible the idea that we could travel to places like Mars with a constant 1-g acceleration. If you tried to do that with chemical rockets, Jason, I think, calculated that you would have to carry chemical propellant equal to the weight of Saturn. [laughter]

This promises to open up the development of the Moon, Mars, the moons of Jupiter, the moons of Saturn. The idea of time was completely changed by the building of the railroads, where it used to take 3-4 days, two weeks, six weeks to get from New York City to certain places in the country. Suddenly, with the building of the railroads, you could do that in *one day*. It's very similar with the idea of nuclear rockets. Things that are completely out of our reach, six or nine months away, a trip that would severely damage the human body; suddenly time is compressed and they're put in the realm of weeks.

I'll just end with an important application of fusion which is—electricity. I referenced the needs of the developing world in the last century, when fission power first became available. Consider the needs of the world today, consider the industrial needs, consider the level of electricity consumption if we bring seven or ten or twenty billion people up to a modern standard of living, and the full industrialized economy with fusion power plants which that implies.

This is important for Earth, it's important for space as well.

Let me say something about space. It was recognized by Krafft Ehricke and many others, that civilization on the Moon or anywhere else out in the Solar system could only be powered by nuclear power. So the idea of continuing the development of life off of the Earth, and beginning to colonize these other places in the Solar system, is only achievable with the kinds of energy densities and consistency that you can get from nuclear power.

But also on Earth! I will end with two quotes from two leaders in both fission and fusion research in the 1950s. The first is the head of the Indian Atomic Energy Commission Homi J. Bhabha, who chaired the first ever international conference on fusion, in Geneva, Switzerland, in 1955. And he said:

"I venture to predict that a method will be found for liberating fusion energy in a controlled manner within the next two decades. When that happens, the energy problems of the world will have been solved forever, for the fuel will be as plentiful as the heavy hydrogen in the oceans."

And then by Lewis Strauss, who was the head of the U.S. Atomic Energy Commission. This was from 1954:

"Our children will enjoy in their homes electrical energy too cheap to meter.... It is not too much to expect that our children will know of great periodic regional famines in the world only as matters of history, will travel effortlessly over the seas and under them, and through the air with a minimum of danger and at great speeds, and will experience a lifespan far longer than ours, as disease yields and man comes to understand what causes him to age."

That's the potential! I think it is beautiful that, in the 1950s, somebody felt this great sense of the transformation of mankind, that this was not just some new energy source to stick in your backyard or something, but this really was a complete transformation of the entire species, that there was something of great importance going on.

This presentation was by no means comprehensive, but hopefully it has given you a hint as to why Mr. LaRouche has called for a fusion-driver crash program. We are in the position to completely upshift the human species into a new era, *but it is something that has to be willed*. It does not happen automatically; this is something that has to happen as an intended effect of our economic and science and cultural activity.