Forging Fusion: Physical, Chemical, and Nuclear

by Jason Ross

A video of this Jan. 13 presentation can be viewed at larouchepac.com/forging-fusion.

The only way mankind will exist in the future, is through the mastery of controlled nuclear fusion. But, the importance of fusion cannot be understood by enumerating its benefits or calculating its electrical potential (although it is immense): The new quality of human civilization it will allow, can only be adequately understood by looking at it in the long-term context of human development, from the physical world of the Stone Age, to the chemical world of the Bronze and Electrical Ages, to the nuclear world that we have only just ventured into.

By contrasting the stages of physical, chemical, and nuclear, we can understand the profound importance of developing a fusion platform, specifically one powered by the rare isotope helium-3, found naturally on the Moon, but not on Earth.

Let's start by going back a few thousand years.

Physical Changes

Ten thousand years before the present, in the Stone Age, our tools and technologies were material, physical. Many tools were made from rocks, which might be chipped into better shapes, such as for sharpening, and other materials used for construction and tools were those found around us, such as fiber, wood, bone, shells, mud, and stone. If someone considered what a rock was made out of, the answer would be "smaller rocks" and wood was made of "wood."

The characteristics of objects that were of value (besides food) were what we could call material or physical ones: strength, hardness, flexibility, durability, heaviness, size, and so on. The changes we could cause were, in large part, physical reshaping and cutting, as well as movement. The "simple machines" of antiquity—the lever, the screw, the wedge, and so on—are physical machines, which could transform one kind of

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Jason Ross: Thermonuclear fusion power "is not an option. It is the natural next stage of human evolution. . . ."

TABLE 1

PROPERTIES	PHYSICAL CHANGES	MACHINES
Hardness	Grinding	Hand-axe
Flexibility	Chipping	Mortar & Pestle
Color	Cutting	Screw
Density	Breaking	Wedge
Size	Bending	Inclined plane
Shape	Mixing	Lever
Sharpness	Heating	Pulley
Temperature		Windlass/Crank

motion into another. For example, lifting a weight could be made easier by using a system of pulleys. More rope is pulled with less effort, to lift a heavier weight a shorter distance. Or a heavy mass could be used to lift another by using a lever.

Table 1 includes characteristics of this physical world: the kinds of machines we had created, the characteristics of materials that we would consider, and the kinds of changes we could bring about.

Not included in this table is the application of fire, the use of which absolutely separated the human species, as a creative species, from all other forms of life (**Figure 1**). The first evidence for the use of fire goes back hundreds of thousands, or perhaps, a million or more years. With fire, man could cook new foods to make them edible and safer, harden rocks to make for sharper edges, fire clay and ceramics, increase the flexibility of wood by boiling, treat textiles to create fabrics. We could see and protect ourselves at night; we could clear land; we could bake.

After wood fire, the first change in our power over nature that was of a truly different type, was seen in the Bronze Age.

Chemical Changes

The Bronze Age, like the later Iron Age, took its name from advancements in making metals. Bronze is a combination of copper and tin, which requires a new kind of power over nature to create. Take malachite, a blue-green rock that was the primary source of copper in the Bronze Age. This rock, despite its unusual color, isn't so different, physically, from other rocks. It's not remarkable by its hardness, weight, durability, or ease in chipping apart to make sharp edges. Yet, when a new kind of fire is applied to it, something amazing happens.

FIGURE 1

The use of fire separates the human species from the animals.

This new type of fire is that of charcoal. Charcoal is made from wood by partially burning it without air, such as slowly burning it under a pile of dirt, as you see here (**Figure 2**). The resulting charcoal burns both hotter and cleaner than a wood fire, allowing for more convenient cooking than using wood, which creates a great deal of smoke. A charcoal fire has the ability to "cook" malachite, and turn this rock into a metal. Let's look at how modern-day researchers have recreated the process.

After grinding malachite with a stone, they dig a pit, start a fire in it, add charcoal, add the ground malachite, more charcoal, and a lid, and blow air into it with a bellows to keep the fire going. After some hours, the pit is

FIGURE 2

Creative Commons/Frank Behnsen

Creating charcoal by burning wood without air, under a covering of earth.

FIGURE 3

Courtesy of David Champan

Retrieving copper created from malachite which has been "burned" in a charcoal fire.

reopened, the malachite has disappeared, and copper metal has been formed (**Figure 3**).

This is an astonishing change, absolutely unlike any of the physical changes created before, and far more dramatic than the change that takes place when baking bread or cooking meat. The very nature and material of the rock has changed in an almost miraculous way! It's hard to imagine substances more different than rocks and metals. Metallurgy was the beginning, the first example, of what were later called chemical changes.

With the development of modern chemistry by Antoine Lavoisier and Dmitri Mendeleyev, the answer to the question, "What is a rock made of?" was totally different. No longer was a rock made of "rock." Now the chemical elements, the smallest "pieces" into which the rock could be broken, including these new kind of processes—these elements were being worked out. A rock was now made of silicon and oxygen, in the case of this rock, or copper and oxygen, in the case of this malachite. And these component parts (oxygen, silicon, and copper) had absolutely none of the physical properties used to describe the physical materials they formed.

For example, graphite, coal, and diamond are very different in hardness, color, density, almost in every imaginable way, yet these substances are all made entirely of the chemical element carbon. Carbon does not have color; it does not have density; it does not have hardness. Carbon has a susceptibility of entering into particular compounds with itself and other elements, making materials that do have physical properties. Yet, the properties specific to carbon itself are chemical, not physical. They relate to the kinds of compounds it forms, and the ease with which it does so, what ratios it combines with other elements in, and so on.

The first chemical *machine* was in metallurgy: The work of transforming rocks into metal was totally different than what could be done with physical machines, with cutting, grinding, pulling, scraping, banging, and heating. None of that can make copper. The charcoal fire was pulling the oxygen away from the metal in the rock, in effect undoing the process of rusting, which is the chemical combination of a metal with oxygen. We saw this earlier with the creation of copper from malachite. The form of processed iron ore you see here (**Figure 4**), called taconite, looks like balls of rust, which is essentially what it is. When it is smelted into iron, it is, in effect, *un-rusted chemically*, by removing the oxygen.

The Steam Engine

Around 1700, a powerful new chemical machine was developed and built: the steam engine, which used the potential of coal to change chemically (to burn), to produce motion. Now the power of a lump of coal was much greater than its ability to weigh down a lever or a pulley: It could be burned to heat water to produce steam to push pistons, as in a steam locomotive.

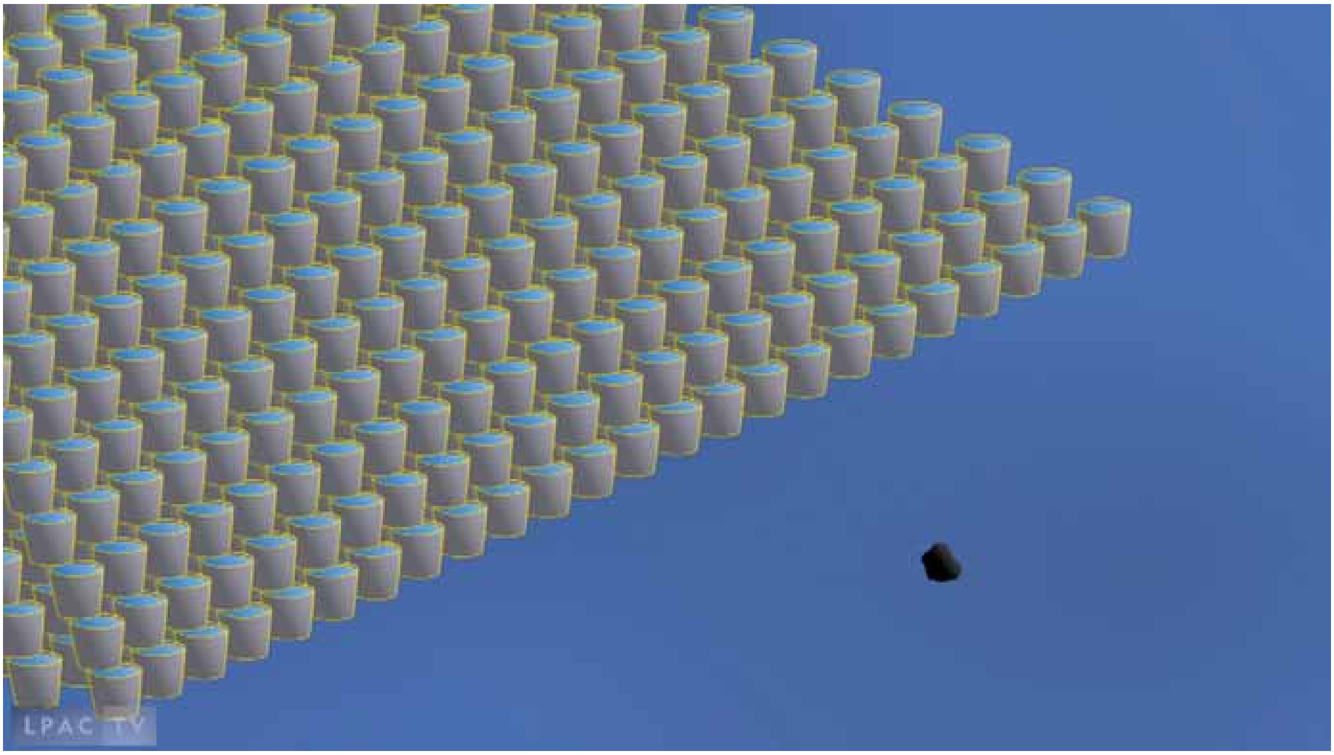
Let's compare the physical versus the chemical power of a lump of coal: In order to get the same energy as burning a given amount of coal, you'd need to have a hundred thousand to a million times as much water flowing through a hydroelectric dam (depend-

FIGURE 4

Creative Commons/Harvey Henkelmann

Taconite, a processed form of iron ore, looks like rust. Smelting taconite to produce iron is essentially "un-rusting" it.

FIGURE 5



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The chemical power in a mass of coal is equivalent to the physical power of up to a million times its mass in water, running through a hydroelectric dam.

TABLE 2

PROPERTIES	**CHEMICAL** CHANGES	MACHINES
Valence	Reactions	Metallurgy
Atomic mass	Dissociation	Steam engine
Enthalpy	Refining	Oil refinery
Ionization energy	Smelting	Fertilizer plant
Bonding	Electrolysis	TNT
Gibbs energy	Oxidation	Car engine

ing on the height of the dam) (**Figure 5**).

The coal is nearly a million times more powerful when burned chemically, than its weight is, were it to be used physically. This is the astonishing power of chemical machines!

A whole new vocabulary now existed.

Some of these new chemical attributes include valence, enthalpy, and atomic mass (**Table 2**). These terms, possibly unfamiliar, relate to the ability of elements to combine and in what ratios (valence), the heat released or consumed in such chemical changes (enthalpy), and the characteristic mass associated with a certain quantity of an element, determined by its interaction with other elements (atomic mass).

This was an entirely new domain of characteristics, and understanding it allowed us to create and understand a whole new domain of changes, including everything from soap to camera film, from cement to gunpowder, superglue and antifreeze, petroleum and plastics, new alloys, tougher steels. Recombining elements could create materials with totally different physical properties than previous compounds the elements entered into.

One particularly dramatic change was the chemical development of nitrogen fertilizers, which are responsible for the lives of a significant portion of the people currently living on the planet. That one discovery very directly changed the potential global population of the human species.

This world of chemical characteristics, processes, and changes, required a new vocabulary, and represented a higher level of power than the purely physical changes of the past, of the Stone Age.

FIGURE 6

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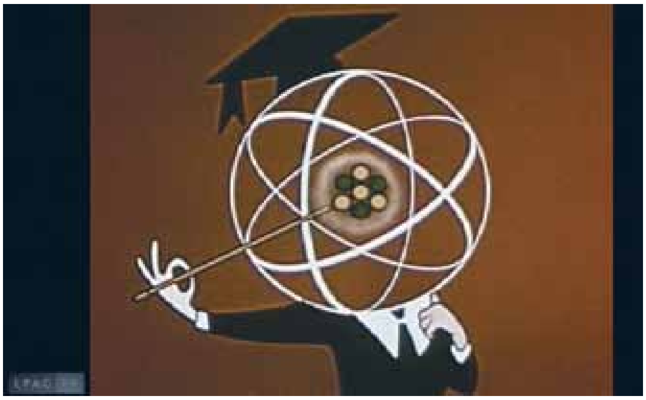
Carbon has chemical, rather than physical properties. Carbon in solid wood is still carbon when it is in the carbon dioxide gas produced by burning the wood.

FIGURE 7



The nucleus is understood as a collection of positive protons and neutral neutrons.

To get into the next form of action, nuclear, we'll talk a bit about atoms, which were a contentious development in the field of chemistry. Elements, and atoms in particular, were understood as the fundamental components of matter. Their combinations might change, but the constituent elements and atoms did not themselves change. Take this wood fire for example: Carbon in the wood combines with oxygen in air to form carbon dioxide gas. The carbon that was in the solid wood is still carbon when it is in carbon dioxide gas (**Figure 6**). Wood is not a gas, but carbon itself can be in a solid or gas. Carbon in one compound is still carbon when in another compound, and no techniques had ever been found that could change one element into another (although the alchemists had been trying for a long time to turn lead into gold!).

Atoms themselves are considered to be a heavy nucleus, containing positive protons and neutral neutrons, with a swarm or cloud of negative electrons swirling around it (**Figure 7**). Chemical reactions and changes are considered to be related to the interactions of these electron clouds around atoms, not the nucleus. Yet the nucleus determined what element the atom was! Understanding of the nucleus moved forward with—you guessed it—nuclear science.

We sometimes forget today that the word "nuclear" means "pertaining to the nucleus." You yourself are *very* nuclear: There are several thousand trillion *trillion* atoms in your body, and each one has a nucleus!

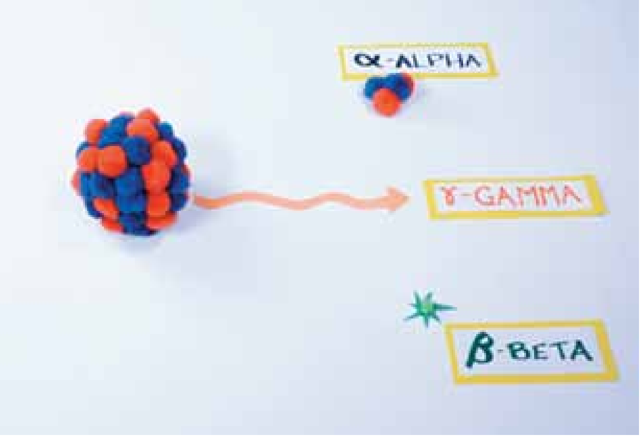
Nuclear Changes

Experiments with radiation, truly a fascinating subject, led to the hypothesis that the nuclei of atoms were themselves changing, and emitting various sorts of radiations as they did so. This was a new change. Physical changes to a rock still make pieces of rock, and chemical changes to a rock may pull apart the elements, but don't change them: The copper was already in malachite. Now, the nuclei, the type of atom, the element itself were actually changing!

Parts of the nucleus were energetically flying off. The most common changes were the nucleus emitting two protons and two neutrons (called an alpha particle), or a single electron (a beta particle), or a high-energy light-like ray (called a gamma emission) (**Figure 8**). The names come from alpha, beta, and gamma being the first three letters of the Greek alphabet.

The amount of energy that could be given off was

FIGURE 8



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The three main types of radioactive decay emissions are alpha, beta, and gamma emissions, taking their names from the first three letters of the Greek alphabet.

astonishing, and overthrew the "laws" of physics. A given mass of radium (a very radioactive element) emits as much energy over time as 500,000 times its mass in TNT! This is a tremendous amount of energy. Remember that coal has hundreds of thousands times more energy when burned chemically than when simply used as a physical weight. And now, a nuclear process is about a million times more powerful than a chemical one! So overall, there is about a *trillion* times more power in nuclear processes, than physical ones.

But radiation energy is typically released very slowly (it would take 1,600 years for a piece of radium to release half its energy—that's its *half-life*). This would mean that if you wanted to go off the grid, and power your house or apartment with radium, you would need several hundred pounds of radiating radium to make enough energy. Radiation is quite weak, and totally unsuitable as a large-scale power source (although radiation energy does power the Curiosity rover up on Mars). Radiation is not energetic; it's certainly not how nuclear power plants work—they're not based on radiation. If they were, they'd hardly make any electricity at all!

There's *another* kind of nuclear change we need to know about to understand this. It was discovered that some nuclei, instead of only emitting these puny radiations, also sometimes split in half, creating two new atoms of varying types, along with several neutrons, and a tremendous amount of power. This breaking apart of a nucleus is called *fission*, and it happens spontaneously in some kinds of nuclei. But what made nuclear power possible was the discovery that unlike normal radiation, which just occurs on its own in certain nuclei, fissions could be caused when the nucleus was stimulated by having a neutron smash into it. By arranging enough of these fissile (that means capable of stimulated fission)—enough of these fissile nuclei together, a chain-reaction process could be made, where one fission would cause other fissions with the neutrons it created, which would in turn make more fissions, and so on. This could release a great deal of energy very quickly, and be useful for power, unlike natural radiation, which basically makes rocks warm.

This power of fission is what happens inside current nuclear power plants, and except for a few very unusual geological formations, this fission *never* occurs in nature: it is a specifically human-created form of "fire"—it is *only made by us.*

TABLE 3

	NUCLEAR	
PROPERTIES	CHANGES	MACHINES
Isotope	Radioactive decay	Fission power plant
Half-life	Fission	PET scan
Decay type	Fusion	Radium watch dial
Cross-section	Isomeric transition	Nuclear explosive
Mass-defect		Fusion torch
		Food irradiation
		Proton beam treatment

Now, there is a whole new vocabulary to introduce (**Table 3**).

Nuclear vocabulary includes cross-section (how easy it is to cause a nucleus to react with another particle), decay type (alpha, beta, or gamma radiation), half-life (radioactive nuclei now have lives because they change on their own), and "isotope" (which means "same place," and names different varieties of the same element). Isotopes are in the same place on the Periodic Table, but they aren't exactly the same substance. For example, uranium mined on Earth is a combination of two kinds of uranium, called U-235 and U-238, which are chemically indistinct, and are both called "uranium" by a normal chemist (**Figure 9**). The isotope numbers 235 and 238 are the total number of protons and neutrons in the nucleus. All uranium has 92 protons, which is what makes it uranium, just like having 8 protons would make it oxygen.

U-235 has 143 neutrons along with those 92 protons, making a total 235, which is why it's called U-235. U-238 has 3 more; it has 146 neutrons, which, with the 92 protons, totals 238. This difference of 3 neutrons between 143 and 146 doesn't seem to mean much, chemically, unlike a difference in protons, which makes a different chemical element. A different number of neutrons makes a different nuclear isotope. But there is a major difference here: The U-235 is fissile, meaning it will fission—split apart—when struck by a neutron, and U-238 is not (**Figure 10**). This is why uranium "enrichment" is performed, to concentrate the U-235 needed for a power plant.

We still don't know why some isotopes undergo fission and others don't, or what the configuration or shape or nature of the nucleus is, with these different numbers of nucleons.

Examples of nuclear machines include nuclear

FIGURE 9

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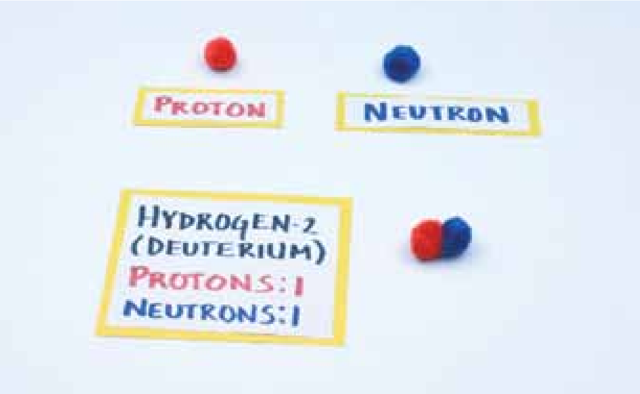
Two isotopes of uranium, uranium-235 and uranium-238 are chemically equivalent.

power plants, nuclear explosive devices (which, fine-tuned, could see application in excavation projects), medical scans that use special isotopes, and food irradiation to prevent disease and hunger and food waste from spoilage. The power of a rock of uranium can do much, much more than weigh down on a lever or be burned to produce heat (although you *can* burn uranium if you want to): It can undergo a nuclear change and release a million times more power than if it were burned chemically, and a *trillion* times more than if it were used physically as a weight, to push down on a grandfather clock to keep it running.

And that's only the part of its use that can be compared to lower levels of power, like making electricity: You can't perform a medical scan of your thyroid gland or look at broken bones with any number of rocks connected to pulleys, levers, and corkscrews, or with a gigantic pile of charcoal, or with a bunch of chemicals.

FIGURE 11



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Deuterium is an isotope of hydrogen, because, like normal hydrogen it has 1 proton. But is also has an extra neutron, giving it the name deuterium (like duet, it relates to the number 2).

FIGURE 10

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But these 2 isotopes are nuclearly quite different. Only uranium-235 can participate directly in fission. This is why it is concentrated ("enriched") for use in power plants.

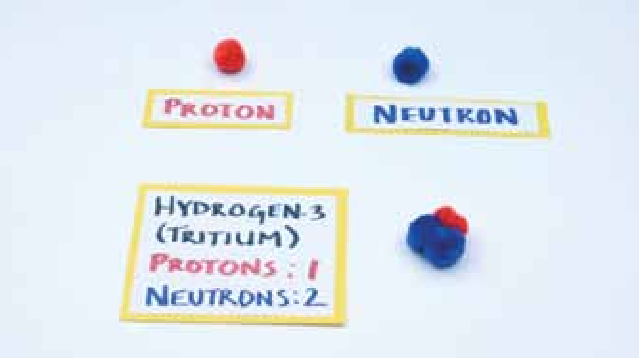
It's just a different kind of process.

Today's nuclear isn't the end of the story: Let's look at fusion.

Fusion

Fusion is the necessary technology and power platform for the future. Unlike fission, which is the breaking apart of large nuclei, fusion is the combining or joining (or fusing) of small nuclei. One example of a fusion reaction, the one most commonly studied today, is that between deuterium and tritium. Deuterium is an isotope of hydrogen. And all hydrogen nuclei have one proton, shown here in red (**Figure 11**). However, unlike most hydrogen, it also has a neutron, which we see here in dark blue. Since it has 2 nucleons, it has the name deuterium (from *deutero*, meaning two). Both normal hydrogen and deuterium can form water by combining with

FIGURE 12



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Tritium is another isotope of hydrogen. It has a total of 3 nucleons (1 proton and 2 neutrons). Deuterium-tritium fusion reactions are the most studied for power applications today.

oxygen: They are chemically identical. Tritium is also a kind of hydrogen, which has a total of 3 nucleons: 1 proton and 2 neutrons (**Figure 12**). When deuterium and tritium combine nuclearly (which is difficult to make happen, and we still do not fully understand the process), there are 2 protons and 3 neutrons, which result in helium (2 protons and 2 neutrons) and 1 extra neutron (**Figure 13**).

This is a nuclear characteristic. The chemical combination of 2 hydrogen atoms (including using deuterium or tritium) just makes hydrogen gas and a tiny bit of heat, but the nuclear fusion can produce a huge amount of power, a million times more! The magnitude of power made possible by fusion could eliminate the problem of droughts, by large-scale seawater desalination; it will eliminate resource shortages by making ore-processing tremendously easier, allowing even low-quality mineral deposits to be mined; and it holds the potential to eliminate any shortages of power for living, commerce, industry, and agriculture.

FIGURE 13

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The fusion products of combining deuterium and tritium are an alpha particle (2 protons and 2 neutrons) and an extra neutron. This neutron is problematic, because it cannot be controlled by magnetic or electric fields, and collides with the walls of the fusion apparatus, creating heat and damaging the material.

But there's a problem with this planned deuterium-tritium fusion. Similar to the way you can't use a magnet to pick up a piece of plastic, the neutrons made by deuterium-tritium fusion cannot be controlled by the magnetic or electric fields used in most fusion experiments.

Since the neutrons cannot be directed, they just shoot off uncontrollably in whatever direction, hitting the walls of the fusion device and getting hot. Now—and this is embarrassing for these fusion scientists—the current embarrassing plans for fusion power call for using that heat to boil water or heat a gas to spin a turbine, just like the steam power plants of the 1800s!

A much more powerful and useful reaction is between helium-3 and deuterium. Helium-3 has 2 protons, which makes it helium, and unlike normal helium (helium-4), this helium-3 has only 1 neutron, rather than 2 (**Figure 14**). Let's look at fusion between helium-3 and deuterium. If we count up our nucleons, we see that combining helium-3 with deuterium gives a total of 3 protons and 2 neutrons (**Figure 15**), producing a helium-4 (2 protons and 2 neutrons) and an extra proton (**Figure 16**).

FIGURE 14

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The best fuel for nuclear fusion: helium-3. Unlike helium-4 (the alpha particle which has 2 protons and 2 neutrons), the alpha particle, helium-3 has only 1 neutron.

FIGURE 15

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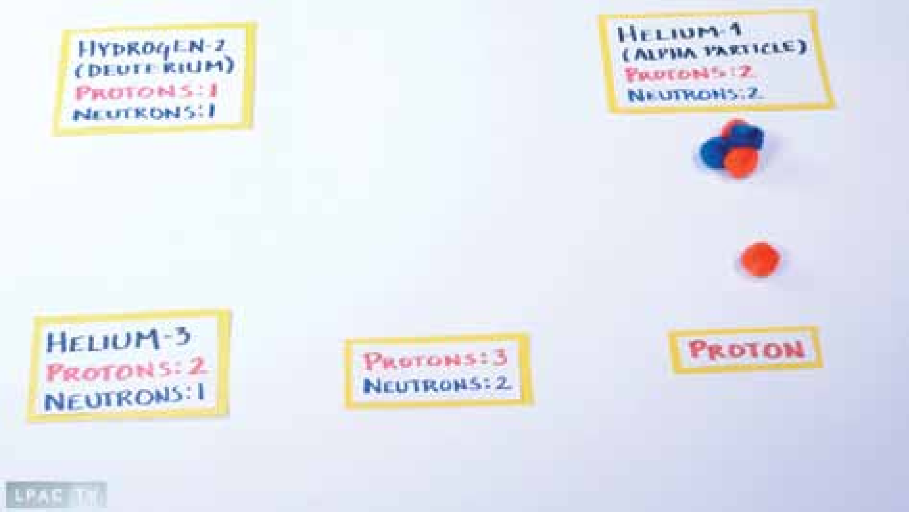
The fusion of helium-3 and deuterium gives 3 protons and 2 neutrons.

FIGURE 16



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The resulting products of fusion of helium-3 and deuterium: an alpha particle, and a proton, both charged. No longer must we use heat to make power!

Unlike the uncontrollable neutrons, these products are both charged, allowing something unique to take place. The entire reaction can be controlled by magnetism and electric fields, allowing us to go beyond the benefits of deuterium-tritium fusion: We could divert the products to directly make electricity, to create proton beams for transmutation, to create space rocket fusion thrust (needed for defense against asteroids), and many more properties we have yet to discover!

Helium-3 will allow us to *finally* stop using heat (a physical property) for power, and to truly work on the nuclear and electrical level. And acquiring helium-3 requires making a leap beyond our planet: There is very little helium-3 here on Earth, maybe a hundred pounds, but there are *millions of tons* on the Moon! China has expressed its intention to develop this resource, and the world should join this outlook.

Fusion: Not an 'Option'

To review: We've discussed different levels of activity and understanding: physical, chemical, nuclear, and fusion. The tables you see (**Tables 4 and 5**) show some of the language used for each level of understanding, which shows up in the questions of: What is matter made of? What changes can we create? What technologies are at our disposal? We've seen that as we move smaller on the scale of our action, from physical stone tools to chemical reactions to nuclear changes, we've moved larger on the scale of our power, from physical machines based on motion, to chemical ones based on combustion and transforming materials, to nuclear ones of incredible power and new capabilities. And in the nuclear world, a trillion times more powerful, we've seen why helium-3 fusion will be the first kind of "fire" not based on heat, as we move more fully beyond the world of physical characteristics.

Fusion is not an option; it is not a power source; it must not be delayed: It is the natural next stage of human evolution, and is being pursued by the BRICS nations, while being shut down and starved of funding in the U.S. If we are to join the new economic and political paradigm now blossoming around the world, under the current leadership of Brazil, Russia, India, China, and South Africa, we must embrace the creative identity of man, and make fusion, with the Moon-based fuel helium-3, a goal we are unwilling to postpone, one we intend to win.

TABLE 4

PROPERTIES

PHYSICAL	CHEMICAL	NUCLEAR
Hardness	Valence	Isotope
Flexibility	Atomic mass	Half-life
Color	Enthalpy	Decay type
Density	Ionization energy	Cross-section
Size	Bonding	Mass-defect
Shape	Gibbs energy	
Sharpness		
Temperature		

TABLE 5

MACHINES

PHYSICAL	CHEMICAL	NUCLEAR
Hand-axe	Metallurgy	Fission power plant
Mortar & Pestle	Steam engine	PET scan
Screw	Oil refinery	Radium watch dial
Wedge	Fertilizer plant	Nuclear explosive
Inclined plane	TNT	Fusion torch
Lever	Car engine	Food irradiation
Pulley		Proton beam treatment
Windlass/Crank		