FERMITECH

Searching for Phenomena in Physics that May Serve as Bases for a Femtometer Scale Technology

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A Little History

In the winter of 1990/1991, I was spending two months in Boston, staying at an MIT "frat"(ernity) with a very young (16 years old) colleague of mine, working on a Connection Machine (CM5) trying to evolve 3D cellular fission rules to grow a 3D embryo. During those bitterly cold months, there happened to be a meeting one evening of the MIT Nanotech Club that I thought would be interesting to attend, so I did. The meeting featured a telephone hook up "Q and A session" with Erik Drexler (in California), generally consisted to be the "father of nanotech". I asked him whether he thought a "femtotech" might one day be possible. He pooh-poohed the idea, which struck me as odd, since he was so critical of those conservatives who pooh-poohed his vision of a nanotech (i.e. molecular scale engineering) with objections such as "The Heisenberg Uncertainty Principle forbids it", or "Thermal noise would destroy the accurate positioning of atoms", etc. Drexler persisted nevertheless, wrote his famous text in 1992, and now nanotech is a thriving research field with progress being made every month.

Half a decade later, I was visiting the Santa Fe Institute in New Mexico, and got an opportunity to ask Murray Gellmann, the SFI resident genius (and father of the quark, the eightfold way, charm, strangeness, the omega minus, etc) “Can you think of any phenomenon in physics that might be used as the basis for a femtotech?” He hadn’t really thought about the question, but managed to say that he had had a business meeting one time to consider the possible industrial applications of the neutral kaon particles.

So, it should be clear from the above two instances, that the question “What comes after nanotech?” has been on my mind for over 2 decades. If fermitech is not possible, then sooner or later, humanity (or post humanity) will start running up against the confines of nanotech and start itching to move down to the fermiscale. Now that nanotech is well launched, perhaps the time is now ripe to start thinking about “what’s next?”, i.e. about the possibility of a fermitech.

A decade and a half later, i.e. now, I find myself in my early 60s, ARCing (i.e. After Retirement Careering, which I describe as “wage free careering in the third third of life”) and returning (after working 20 years on artificial brains) to my old love of mathematical physics, studying intensively PhD level pure math and mathematical physics, with the view of writing several books on math/physics topics, such as “Topological Quantum Computing” and “Fermitech”. I am now actively hunting down phenomena in physics at the femtometer scale that might serve as substrates to allow computation and engineering at that tiny scale.

Since a femtometer (a.k.a. a “Fermi”) is 10^{-15} of a meter, to find such phenomena implies that one should be hunting at the nuclear, nucleon, and elementary particle levels. Hence one should be studying nuclear physics, elementary particles physics, QCD (quantum chromo dynamics), etc. I spend my afternoons in my favorite (beautiful) park, and my nights in my apartment, studying the following subjects in pure math, and theoretical physics, partly because of a deep inherent love of these topics, as well as being motivated to use this knowledge to try to find bases for a fermitech.

In pure math, I’m studying :- finite groups, abstract algebra, Lie theory, general topology, algebraic topology, geometric algebra, smooth manifolds, complex manifolds, representation theory, ring theory, Galois theory, knot theory, quantum groups, low dimensional topology, etc.

In theoretical physics, I’m studying :- quantum mechanics, quantum field theory, nuclear physics, elementary particle physics, quantum electrodynamics (QED), quantum chromodynamics (QCD), special and general relativity, gauge theory, supersymmetry (SUSY), superstring theory, M-theory, brane theory, conformal field theory (CFT), topological quantum field theory (TQFT), topological quantum computing (TQC), etc.

At the top end of both subjects, low dimensional topology and gauge theory have merged, thanks to the genius of Ed Witten, today's Einstein, and the only physicist ever to have won the coveted Fields Medal for mathematics. I call this math-physics merge "mathics".

So, I have my plate full, undertaking an ambitious program of study and keeping an idea note book on my desk, that I'm constantly jotting ideas into.

But, I'm only one person. My good friend Ben Goertzel and I email each other almost daily, so inevitably I was reporting on my studies to him, and got him interested in the topic. He started googling the key word "femtotech" and started his own paper chase that he reports on in a separate essay, twin to this one. It soon became clear to me that two heads are better than one, especially when it's Ben Goertzel's head that contains a world class brain. The same logic leads us both to open up the question to the general scientific public, to see what N heads can come up with.

Since it is likely that most of the readers of this e-zine have a computer science background, there may not be many readers who have a strong math-physics background, so if you are a CS type reader, can you please pass on this article to your math-physics friends and ask them if they have any suggestions as to possible fermi-scale phenomena that might serve as a basis for a future fermitech. If so, I and Ben would be most grateful and interested to receive ideas from you. Our emails are at the top, just below the title.

Details

Before launching into some initial tentative suggestions for fermiscale phenomena that may serve as bases for a fermitech, let me make a comment about “picotech”. Why did I jump from nanotech to fermitech? What happened to 10^{-12} meter (picometer) scale technology? The obvious answer is that nature does not provide us with anything that exists at the picometer scale (unless one assembles such large fermiscale structures that they reach the picoscale). A typical atom has dimensions of about 10^{-10} meters (i.e. angstroms). The nucleus and nucleon is about one hundred thousand times smaller (i.e. “a fly in a cathedral”), i.e. 10^{-15} meter, or “Fermi”. So nature simply does not provide any “building block” at the picometer scale. Hence we are forced to jump down by a factor of a million from the nano scale to the Fermi scale.

If ever a fermitech comes into being, it will be a trillion trillion times more “performant” than nanotech, for the following obvious reason. In terms of component density, a fermiteched block of nucleons or quarks would be a million cubed times denser than a nanoteched block. Since the fermiteched components are a million times closer to each other than the nanoteched components, signals between them, traveling at the speed of light, would arrive a million times faster. The total performance per second of a unit volume of fermiteched matter would thus be a million^3 times a million = a million^4 = a trillion trillion = 10^{24}.

I haven't even started thinking yet about possible applications of such a vast increase in capability of fermitech over nanotech, especially if quantum computers can be built to be robust against noise, by storing bits in topological quantum fields (topological quantum computing (TQC)).

On the desktop of my laptop, I keep a file called "BookPlans" which contains the titles of about a dozen books that I would like to write in the (hopefully) 30+ years left in my (ARCing) life. One of those is titled "Fermitech", with the same subtitle as this article. I have even written up a very tentative book plan, with chapter headings, where each chapter is concerned with a fermiscale phenomenon that just might serve as a basis for a fermitech. I list here these phenomena, and leave it to readers to use Wikipedia to learn about each topic. Please be conscious that this list is very tentative, just my "first pass" guess. I'm hoping after a few years of intensive study of math-physics, I will be able to create a much better list, thanks also to suggestions coming from readers of this article.

Here is the list :-

Nuclear Molecules, Quark-Gluon Plasma, Strangelets, Kaons, Surface of Neutron Stars, QCD (Quantum Chromo Dynamics), Quarkonia, Mini Black Holes, Halo Nuclei, Neutron Starlets, Bose Einstein Condensation of Squarks, etc

Presumably, if one is to create, for example, computers at the fermiscale, one would need to assemble large numbers of quarks or nucleons into a stable structure. Ordinary nuclei consist of protons and neutrons, but there is a limit to their size for stability reasons. The range of the strong force is only a few nucleon diameters, so one needs proportionately more neutrons per proton to counter the cumulating electric repulsion that has unlimited range. Once one reaches 92 protons (Uranium), the nucleus is almost unstable, because the cumulative electric repulsion is close to overcoming the strong force, which is only about 100 times stronger than the electric repulsion of the protons.

I've noticed that once one looks upon the many phenomena of nuclear physics, and QCD, one begins to see things in a new light, and starts to ask questions that may not have been asked before. For example, would it be possible to assemble structures that consisted of only neutrons? A single neutron will soon decay into a proton, an electron and an anti neutrino, but neutron stars seem to be stable, containing huge numbers of neutrons, (a massive neutron only nucleus, kilometers across). Could one build somehow a mini (or Fermi) neutron star consisting only of neutrons?

The above is highly speculative, and probably quite amateurish and wrong, but it illustrates the kind of novel thinking that is required if ever a fermitech is to come into being. It is easy to shoot down aunt sallies. It is a lot more difficult to actually find some physics loop hole that would actually allow a Fermitech. There is an interesting historical analogy that may be instructive. Ever since the phenomenon of radioactivity was discovered over a century ago, physicists knew there was enormous energy contained inside the nucleus. This led many people to ask whether one day it might be possible to tap into such energy on an industrial scale. Even as late as the early 1930s, the great Rutherford, the father of the nucleus (it's his term) thought the idea of industrial scale nuclear energy was "moonshine" (i.e. ridiculous). However, the Hungarian-American Jewish nuclear physicist, Leo Szilard was skeptical and felt there just had to be a way to tap into that enormous nuclear energy, if only he could be ingenious enough to find a way. Well, he did, in 1933, the year after the neutron was discovered, and the same year Hitler came to power in the world's dominant scientific country, i.e. Germany. Szilard's century-changing idea was to shoot a neutron (with no charge, hence would not be deflected by the charge of the nucleus) into a nucleus that was almost unstable, i.e. uranium. The penetrating neutron might make the nucleus unstable, which would split into two half nuclei with less neutrons, hence 2 to 3 neutrons would be shot out at the moment of the split, the "fissioning". These neutrons could then fission other uranium nuclei. The total mass of the two half nuclei, plus outgoing neutrons would be less than the uranium nucleus plus incoming neutron. The missing mass, via Einstein's famous $E=mc^2$ formula, would lead to the outgoing particles having great energy. Szilard's "chain reaction" idea allowed him to calculate that a football sized lump of uranium could release enough energy to vaporize a whole city. He was not only the first to dream up the idea of how to tap into the energy of the nucleus at an industrial (i.e. military) scale, but he was also the first to realize that Hitler might be the first to get the bomb.

So, readers are asked to take heart. Don't be put off by objections to the idea of a fermitech. If we don't go actively searching for fermiscale phenomena that might serve as a basis for a fermitech, then we will be much less likely to find one. Szilard succeeded by being cynical and brilliant. Perhaps one of you may do the same for fermitech. Who knows, one of the applications of fermitech might be a fermibomb, releasing orders of magnitude more energy than the fission and fusion nuclear bombs of the 1940s and 1950s, that would be capable of destroying not just cities, but whole counties. (I just thought of this fermibomb idea now, writing this paragraph).

The twin essay to this one is written by Ben Goertzel, my good friend, who is more technically minded than I am. I'm more on the visionary/political side, and Ben is more on the analytical details side. So, before I sign off, please email us if you are a physicist or you know someone who is, who has suggestions as to how to create a fermitech. Perhaps we can list the suggestions after this article, with readers responding to earlier suggestions, in a large scale brain storming across the planet. Such is the power of the internet.

By way of a footnote – if fermitech (10^{-15} m) is possible, what about an attotech? (10^{-18} m), a zeptotech? (10^{-21} m), a yoctotech? (10^{-24} m), …, a plancktech? (10^{-35} m) Since the smaller components are, the faster they can signal to each other, one comes to the jaw dropping conclusion, that there may be whole civilizations inside elementary particles, and that that may be the reason why we don't see signs of advanced civilizations in the cosmos, thus answering Fermi's famous question "Where are they?" (i.e. all the advanced civilizations in space who are billions of years older than the human species). Just maybe, we humans are built with such civilizations in all our constituent elementary particles. Perhaps these "particle civilizations" communicate with each other via "quantum mechanical entanglement", i.e. zero-signal-time action-at-a-distance. Maybe advanced civilizations are all around us, inside us, but are too small for us to see or even be aware of.