Quark Fusion – Pop and Fizzle
Excerpts from November-December 2017

Excerpt from "Fusion breakthrough explained: What are quarks again?"

Charlie Wood, Christian Science Monitor, December 11, 2017

"Quark fusion" may sound like "Star Trek" technobabble, but a recently confirmed particle could be the result of this process – an explosive reshuffling of some of nature's smallest constituents.

Q: What are quarks again?

You're looking at quarks right now. Magazines, screens, and air are made of atoms, and atoms are largely made of protons and neutrons – which are the most familiar examples of the three-quark bundles that physicists call baryons. Quarks come in six varieties: up, down, strange, charm, top, and bottom. Up and down quarks form protons and neutrons, while the unstable and much heavier strange, charm, top, and bottom quarks tend to transform into lighter particles fractions of a second after being created.

Excerpt from "'Quark Fusion' Produces Eight Times More Energy Than Nuclear Fusion"

Dom Galeon, Futurism, November 6, 2017

To reduce the emissions fueling climate change and develop more efficient ways of generating energy, while focusing on the bottom line, governments and private institutions all over the world have been turning to renewable energy. And while solar and wind energy advance and become more widely accepted, scientists continue to explore the possibility of stabilizing nuclear fusion as a truly renewable energy source that far outperforms current options.

But what if there's an even better source of energy that's also potentially less volatile than nuclear fusion? This possibility is what researchers from Tel Aviv University and the University of Chicago proposed in a new study published in the journal *Nature*.

This new source of energy, according to researchers Marek Karliner and Jonathan Rosner, comes from the fusion of subatomic particles known as quarks. These particles are usually produced as a result of colliding atoms that move at high speeds within the Large Hadron Collider (LHC), where these component parts split from their parent atoms. It doesn't stop there, however, as these disassociated quarks also tend to collide with one another and fuse into particles called baryons.

It is this fusion of quarks that Karliner and Rosner focused on, as they found that this fusion is capable of producing energy even greater than what's produced in hydrogen fusion. In particular, they studied how fused quarks configure into what's called a doubly-charmed baryon. Fusing quarks require 130 MeV to become doubly-charmed baryons, which, in turn, releases energy that's 12 MeV more energy. Turning their calculations to heavier bottom quarks, which need 230 MeV to fuse, they found that a resulting baryon could produce approximately 138 MeV of net energy – about eight times more than what hydrogen fusion releases.

Excerpt from "Particle Physics Discovery: Fusing Heavy Quarks Can Produce 10 Times More Energy Than Nuclear Fusion"

Allan Adamson, Tech Times, November 7, 2017

Melting elementary particles such as quarks can produce amounts of energy so massive it is equivalent to 10 times that of nuclear fusion, researchers have reported.

Quarks

Quarks are the most basic building blocks of matter. The protons and neutrons that make up matter are composed of quarks. Unlike protons and electrons, which have charges of +1 and -1, however, quarks have fractional electric charge. Quarks that are joined together form composite particles called hadrons. Quarks come in six flavors namely: up, down, top, bottom, strange, and charm.

Fusion Of Quarks Can Produce Massive Amount Of Energy

In a new study, researchers showed that two bottom quarks could theoretically fuse together in a powerful flash that can result in massive amount of energy that can spill out into the universe.

The fusion of two bottom quarks will produce 138 megaelectronvolts (MeV), which is eight times more powerful than individual nuclear fusion events inside a hydrogen bomb.

Is There Reason To Worry About Threats From A Quark Bomb?

Researchers, however, said that this kind of quark fusion could not be used to make a powerful quark bomb.

Excerpt from "Physicists Just Discovered Such an Explosive Type of Fusion They Almost Hid The Results"

Mike McCrae, Science Alert, November 3, 2017

A pair of physicists discovered a new kind of fusion that occurs between quarks – and they were so concerned with its power they almost didn't publish the results.

It could have been the dawning of a new subatomic age. But as they've explored the idea they've discovered there are limits to its potential that we can be both disappointed by and thankful for all at once.

The discovery of this highly energetic form of fusion between quarks comes with limits that make it an unlikely candidate for any kind of fuel source of the future. But it also means we won't see it become the next generation of nuclear weapon.

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Karliner and Letzter calculated the fusing of the charm quarks in the recent LHC discovery would release 12 megaelectron volts. Not bad for two itty-bitty particles.

But if we were using another pair of heavy quarks? Bottom quarks, for example? That becomes an astonishing 138 megaelectron volts.

We'd like to imagine this caused the physicists to tap wildly at their calculator screens.

Given such impressive energy output, our first reaction would be jubilation at a new way to produce copious amounts of energy from a small handful of materials. Followed by images of mushroom clouds.

But, as it turns out, neither will happen.

Excerpt from "No, Melting Quarks Will Never Work As An Energy Source"

Ethan Siegel, Forbes Magazine, November 8, 2017

When it comes to the ultimate dream of clean, efficient, and prolific energy sources, it's hard to do better than the secrets held within the interior of an atom. While conventional energy sources rely on chemical-based energy and the atomic/molecular transitions of electrons, nuclear energy is far more efficient. For the same amount of mass, a single atomic nucleus, either when split (for an atom like uranium) or fused together (in the case of hydrogen) can give off up to a million times the amount of energy of a combustion reaction. Recently, "melting quarks" have been discovered to be up to ten times more energy-efficient than fusion reactions. But while fusion and fission both hold tremendous potential for revolutionizing the world's energy, melting quarks will never work. Here's the science of why.

The way nuclear fusion works is by taking stable, bound states of quarks (like protons, neutrons, and composite nuclei) and bringing them together under high-energy, high-density conditions. When you overcome the electrostatic force and get these charged nuclei close enough, their quantum wave functions begin to overlap, meaning there's a finite probability that they'll fuse into a heavier, more stable nucleus. When this occurs, a significant amount of energy is released: about 0.7% of the rest mass energy of the initial reactants. Via Einstein's most famous equation, $\mathbf{E = mc^2}$, that mass gets converted into energy, the ultimate goal of a fusion reaction.

But normal nuclear bound states, even the unstable ones, are made up of up and down quarks only, including the proton, the neutron, and every element on the periodic table. There are a myriad of other possibilities, however, since there are four other types of quark known: strange, charm, bottom, and top. We've even made bound state analogies to the proton and neutron with strange, charm, and bottom quarks inside. If we can fuse protons, neutrons, and other bound quark states together, perhaps we can fuse these strange, charm, and bottom "baryons" together as well. (A baryon is any combination of three quarks, bound together.)

Even though they only exist for fractions of a second, we can perform detailed calculations and simulations with these particles. We can learn exactly how they'll behave, given that we understand the laws of physics. And in a new study, scientists Marek Karliner and Jonathan L. Rosner have demonstrated that an unprecedentedly efficient "melting quark" reaction is possible.

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Your mind might immediately race to unprecedented applications. "This could revolutionize our energy needs," you might think. "This could be the most efficient weapon of all time," the military-minded part of you says. But the truth is that these are just pipe dreams, never to be realized with any sort of practical application in the physical Universe.

Why not, you ask?

Because these particles are too unstable, and the amount of energy required to make them is far, far greater than the amount of energy you'd get out.

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But it cost you over 100% to make these particles in the first place! They're also incredibly unstable, meaning they'll decay to lighter particles on incredibly short timescales: a nanosecond or less. And, finally, when they do decay, you get 100% of your energy back, in the form of new particles and their kinetic energies. In other words, you don't get any net energy out; you simply get out what you put in, but in a lot of different, hard-to-harness ways.

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It's still an incredibly important find to learn – even via simulation – how these bound-quark systems bind together and interact with one another. It's important to understand how binding energy works, how much energy is liberated, and what form it takes when various unstable particles react. These steps forward are an integral part of nuclear and particle physics. But melting quarks will never work as an energy source or a weapons source, as the increased efficiency over traditional nuclear fusion at these high, unstable energies is far surpassed by the 100% efficiency of matter-antimatter annihilation. If you can make particles where melting quarks is a possibility, you can also create antimatter: the most energy-efficient source in the Universe. But for cheap, abundant, clean energy, nuclear fusion, not melting quarks, is the wave of the future.