THE QUARK

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Are Warp Drives Possible?

By Dash Collier

One of mankind's great dreams has always been to touch the stars, unfortunately this dream has proven difficult to realize. Massive amounts of resources and capital are required to send even small objects into orbit around the Earth. If our dreams of one day settling other planets are to be realized, we must overcome several massive physical challenges. The biggest of these is relativity, Einstein's theory tells us that there is a limit to the velocity that a particle can carry. This speed, referred to as c, is equivalent to the speed of light and other massless particles. The equations of relativity tell us that to exceed this limit would result in paradoxical results such as covering a distance in a negative amount of time. Results like this is physics often indicate to us that the conditions that we have put into our equation cannot be physically realized.

The cosmos exists on the scale of lightyears, any meaningful contact with humans in other solar systems would require that we could quickly traverse the space between solar systems. Unfortunately, our ability to move between stars is constrained by the fact that even the nearest solar systems are several light years. Unfortunately, the speed of light is not something that can be easily worked around, the universe seems intent on ensuring that energy and matter cannot propagate any faster than the speed of light. Meanwhile our galaxy spans tens of thousands of light years. How can we possibly expect to colonize our galaxy or maintain a cohesive human civilization without the ability to swiftly exchange information and resources across cosmic distances? Many solutions involve building massive ships that generations of people will live on for thousands of years before settling into other worlds. Other proposals involve fanciful ideas of cryogenics. None of these ideas are remotely realistic for the time being, and likely they will remain that way for centuries.

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About The Quark

The Quark is a monthly newsletter produced by the Public Relations Committee of the Texas Tech chapter of the Society of Physics Students (SPS). Our goal is to help new students become more familiar with the Physics Department and provide returning students more insight on aspects of the department they might not have been aware about.

If you have any questions about The Quark or SPS, you can email our Public Relations Officer Sabrina DeBreau at sdebreau@ttu.edu .

Although it is no less fantastic than other proposals, the most enticing solution to this problem by far has been the proposal of warp drives. Relativity posits that spacetime is not a mere mathematical abstraction from which we can create a coordinate system and measure distances. Spacetime is something that expands, contracts, and bends. It also happens that if the geometry of spacetime isn't flat then it's possible to work around the speed of light. One way to think about this is the idea of traversing less total distance due to the warping of spacetime. Based on this idea physicists began to investigate the idea of "warp drives" specifically they investigated whether or not it was possible to create a spacetime geometry that permitted "superluminal travel."

In order to find a spacetime geometry that would permit faster than light travel physicists initially looked for solutions to Einstein's field equations with an appropriate spacetime velocity. The downside to this approach was that they then had to work backwards to figure out what physical conditions permitted such a spacetime geometry. As it turned out things didn't look good for the possibility of a physical warp drive, the initial conditions required negative energy, something that likely does not and cannot exist. It also required more energy than what existed in the observable universe. In a sense, the Alcubierre drive would have to be powered with magic, which isn't something physicists have access to at the time of writing.

Recently Physicists have reexamined the possibility of physical warp drives. Primarily, they looked for spacetime geometries that could permit superluminal travel without requiring vast quantities of negative energy. A 2020 paper by Erik Lentz suggests that it is possible to use a complex distribution of plasma to create spacetime curvature that would permit superluminal travel. The biggest advantage to this hypothetical construct is that energy is positive everywhere. This solves by far the biggest problem facing warp drives by proposing an already known form of matter that could produce a "warp bubble." The other major benefit to this is that while the Alcubierre drive requires a quantity of negative energy exceeding the total energy in the observable universe, Lentz's proposal requires a mass energy equivalent to about a tenth of that of the sun. By no means is this a small or even realistically acquirable amount of energy, none the less, just as the energy requirements of the Alcubierre drive where gradually reduced by new studies over the years, it also possible that new versions of Lentz's proposal will be found that reduce the required energy by potentially several orders of magnitude. If an equivalent can be discovered that requires less energy this will also solve an additional problem facing the proposed warp drive. That being that the energy densities necessary to create such a drive would result in the formation of black holes.

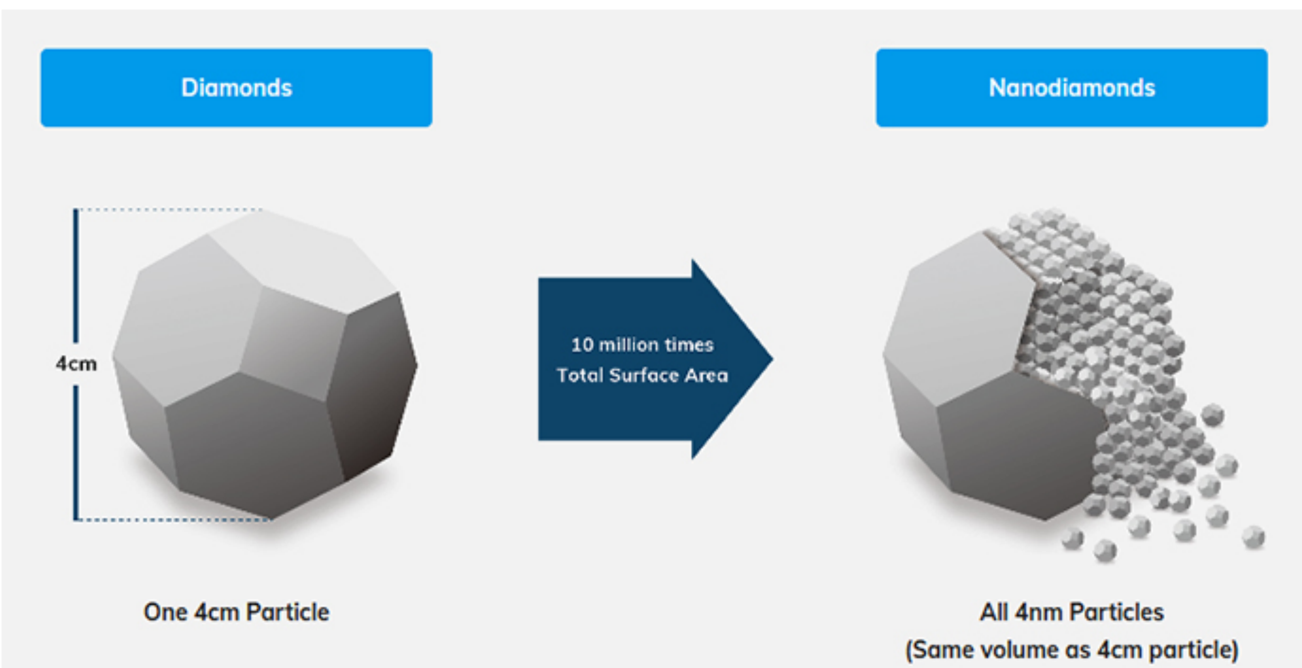
Of course, there are still many theoretical issues with Lentz's proposal. For example, many physicists contend that a warp drive does not actually avoid violations of causality that would be caused were an object made of ordinary matter capable of accelerating beyond the speed of light. Additionally, there have been no studies on how such an object would be accelerated, while a warp bubble can exist at superluminal velocities it remains to be seen if one can be formed and then induced to achieve a superluminal velocity.

Warp drives are quite fascinating from a social perspective, many people want them to be possible for no reason other than to avoid the potential reality that humanity will never be able to expand to the stars in a meaningful way. At the same time, for physicists the implications of superluminal travel are worrying, if it is possible to propel something at superluminal speeds without violating causality or creating black holes then it would potentially upend much of what we thought we knew about modern physics.

Physicists generally have more pressing concerns than investigating the possibility of superluminal travel requiring a small solar system's worth of energy. That said as human beings there is something inherently disappointing of knowing that there very well could exist hard limits on the extent to which humanity can expand its reach. While traveling between stars might seem entirely impossible, maybe several millennia away at best, I would like to acknowledge the disappointment the forward thinking people of newtons time must have felt when he calculated the escape velocity of the earth at a time when the fastest a human could possibly travel was limited to the speed of the fastest race horse, and the highest he could travel was limited by how much weight the walls of a building could support. At the time it would have been impossible to imagine the advances in communication technology, new types of fuel, the invention of rocket science, and many other innovations that ultimately permitted space travel. Perhaps humanity has discovered hard limits to what we are technologically capable of, perhaps our society as it currently exists isn't structurally equipped to sustain the levels of innovation needed to travel the stars, or perhaps history will repeat itself and, in a few centuries, people will laugh at those who believed the study of warp drives to be mere science fiction, only time will tell.

Nanodiamonds: A Scientist's Best Friend

By Mikaela D'Onofrio-Cantu



What are Nanodiamonds?

If you have ever heard the term "Diamonds are a girl's best friend," a sentiment from Leo Robin, lyricist of the song from which it originated, you are most likely picturing big stones set in fancy jewelry. The truth is, however, that diamonds are a scientist's best friend. Particularly, nanodiamonds or NDs. Nanodiamonds are diamonds so small, that they require the use of nanometers to be measured. They have low toxicity compared to other nanomaterials, which makes them one of the most biocompatible nanoparticles known. They also are highly fluorescent and therefore very visible. Nanodiamonds are also able to be modified, allowing them to make connections with other substances. There are multiple ways to make nanodiamonds, each using a combination of heat and force. These ways include the Detonation Technique, High-Pressure High-Temperature, Laser Ablation, as well as a few other methods. Recently, scientists have even used the last method to create nanodiamonds from something we have an abundance of: Plastic water bottles!

How Nanodiamonds are Made

The Detonation Technique

This method uses explosions to make nanodiamonds. The extreme heat and pressure in the shockwaves made by the explosions force the original substance, graphite, to transform the structure from its own into a diamond. This technique is far from perfect though, as traces of other substances have been known to attach to the surface of the nanodiamonds, causing them to be both impure and toxic.

High-Pressure High-Temperature

This is a popular method for both high-quality, marketable diamonds and nanodiamonds. Using this method, graphite and a metal catalyst are put under pressures ranging from 5-6 gigapascals and temperatures between 1300° and 1500° Celsius which changes the structure of the graphite. This method is less likely than the detonation method to have many metallic imperfections, making nanodiamonds produced safer for biological use.

Laser Ablation

Through laser ablation, a laser is focused on liquefied graphite powder in a medium, such as ethanol, changing the structure of the carbon atoms within through a process called bombardment. The nanodiamonds must then be purified for use. However, a new source for the making of nanodiamonds has been discovered. Researchers have found that by focusing a laser on the plastic of a water bottle, nanodiamonds can be formed. This is because the plastic used to package water, food, and other substances contains PET, or polyethylene terephthalate, a material that, under intense pressure and extreme temperature, changes its structure. PET contains Hydrogen, Oxygen, and Carbon, and when the laser is focused on the plastic, the oxygen atoms leave, often taking the hydrogen atoms with them.

The Practical Uses of Nanodiamonds

Nanomedicine

Nanodiamonds have many properties that make them useful to nanomedicine. Because of their low toxicity, fluorescence, and biocompatibility, nanodiamonds can be used in bioimaging, biosensing, drug delivery, and heat therapy. Most nanomaterials are too toxic to be of any use inside living organisms; they would be more harmful than helpful. Nanodiamonds, however, are composed of Carbon, an element already present in most living things, so they can safely be used. For example, nanodiamonds can be modified to be chemically or physically attached to different drugs. Using their fluorescence, researchers can watch as a drug is distributed throughout a patient through bioimaging. Another example of nanodiamonds in medicine is heat therapy, specifically in its use to eradicate tumors. Most nanomaterials that can get as cold as needed are too toxic to use, but nanodiamonds seem to be a promising replacement.

Physics and Engineering

Nanodiamonds also have applications in physics. After being introduced to dopants, chemicals that introduce impurities in matter to change certain properties of a substance, nanodiamonds can be used in sustainable nuclear waste batteries and room temperature superconductors. Nanodiamond Batteries have been introduced as a solution to both the nuclear waste crisis and the growing need for electricity across the globe. Nuclear power plants power many cities in the world but create a lot of waste that costs billions to store away from citizens. Nanodiamonds when introduced to certain dopants could collect the radiated electrons and use them as a sustainable power source, as the half-lives of the electrons would keep the battery working for the life of the device it is powering. Superconductors are matter with zero electrical resistance and no magnetic flux fields. These are typically found in matter at extremely cold temperatures. However, the nanodiamond, after being introduced to dopants, may be a viable room-temperature superconductor. Doped nanodiamonds could power maglev trains and even entire power grids without the need for cryogenic temperatures.

More Than a Shiny Rock

Nanodiamonds are extremely adaptable to different uses, in both the medical world and in physics. They can help create new technology and update old ones sustainably and safely. Nanodiamonds could be the change in power grids, bioimagery, and howe way tumors are treated. One thing is for sure: with nanodiamonds paving the way, the future looks a lot brighter than before.

Student Spotlight: Karina Kimani-Stewart

By John Lawhon

Karina Kimani-Stewart is a third-year physics major and the president of Woman in Physics. Karina has been involved with Women in Physics for two years, this being her first as an officer.

Woman in Physics or WIP is a student organization that focuses on professional development for women in physics although as Karina mentions, it is not required to be a Woman or even to be a physics major to join WIP. Karina goes on to say "WIP is a place for you to grow as an aspiring physicist, to build a community with others, to hear other perspectives, and learn what it means to be a woman in physics." WIP has provided a growing environment for about 40 members to this date although it has only been around since January 2018. Karina plans to grow this number and hopes to introduce many people to WIP. When asked how she first got involved she replied, "I first got involved in WIP when I met the previous president Linka who was very enthusiastic about WIP. She showed me all of these incredible opportunities, the great community and friendship that she found in WIP and so I fed off of that, joined, and little by little I got more involved and here we are today!" Clearly, WIP is an organization that once it has found you, you will find a home in it. When asked what her goals are as president of WIP Karina stated "I want to see WIP grow not only in numbers but in quality, I want to see WIP become a community that other Women in Physics can rely on to always be there for them. I want WIP to be a place for people to feel welcomed. I want WIP to be a place where you know you will only grow, and you will only thrive by being a part of it." Karina also plans to host more workshops, panels, and trips in the future. WIP benefits members of underrepresented communities such as women and people of color in science. "We've gotten more involved and plan to do more outreach this coming semester in the Lubbock community. STEM night is coming up and we're excited to be participating in that, a lot of our members are a part of the Astronight volunteer group, and we're currently working to get Women in Stem in student housing involved too." WIP will also be hosting a soldering workshop, a python workshop, and hosting speeches from grad students on their experience being a woman in physics in grad school. The next WIP meeting date is not yet set but Karina mentioned: "we are looking to have a special guest so if you are interested keep an eye on your email because you do not want to miss the special guest we will have."

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