

Gravity, Antimatter, and Quantization: The (Possible) Need for Higher Dimensions

If extra dimensions of space or time exist, their existence could solve several open problems in physics. All versions of string theory, though incomplete, predict the existence of additional dimensions—besides the three dimensions of space and one dimension of time that we normally associate with reality—to try to solve these open problems. A major problem is that according to certain conservation principles, there should be no matter at all in the universe. If the universe had followed known conservation principles [explain], then right after the Big Bang occurred in our standard four dimensions of space-time, neutrons, antineutrons, and other particle pairs would have been created in *exactly* equal numbers and then annihilated each other immediately thereafter. Instead, somehow there was an excess of neutrons over anti-neutrons of about one part per billion. The extra neutrons soon decayed and eventually, through nucleosynthesis, formed hydrogen and deuterium atoms, along with small quantities of other elements. If the extra dimensions proposed by string theory exist, they may have provided alternative mechanisms for particles to interact and for a matter-antimatter imbalance to have been created. In other words, it is easier to explain this excess of matter if additional dimensions exist.

Another problem that seems to necessitate additional dimensions is the apparent “weakness” of gravity in comparison with the other fundamental forces, especially electromagnetism. For instance, the electromagnetic force between two protons, which is repulsive due to their positive charge, is 36 orders of magnitude (a trillion trillion trillion times) stronger than the gravitational attraction between them, as a consequence of their tiny masses.

One way of explaining this is that somehow the gravity “leaks” into additional dimensions, and is effectively diluted.¹

The conflict between *general relativity* and *quantum mechanics* is a main motivation for the search for extra dimensions and the formulation of string theories. A fundamental incompatibility stems from the fact that general relativity describes gravitational dynamics among massive objects like stars, planets, and galaxies on the large-scale and along continuous space-time. Quantum mechanics, on the other hand, focuses on discrete, small-scale interactions, particularly among particles at the atomic and subatomic levels. As an example of the problem, in quantum theory, an electron that orbits a proton can only have certain discrete values of angular momentum. There is a certain minimum angular momentum it can have, or it can have exactly twice that or three times that, but not for example 1.6 times that minimum angular momentum. This discrete quantization of angular momentum should also apply to a tiny particle orbiting a tiny mass, but general relativity allows for *any* value of angular momentum for a gravitational orbit, not just integral multiples of the minimum possible angular momentum (which is denoted “h-bar,” approximately 10^{-34} joule seconds). Attempts to make general relativity compatible with quantum mechanics have so far led to “infinities” in energy densities unless extra dimensions are added to the mix.

Quantum mechanics and general relativity also deal with different forces. While general relativity describes gravity, which is the result of spacetime curvature (and not technically a field

¹ The “weakness” of gravity itself is somewhat of a misinterpretation. In fact, if two *fundamental* units of mass, known as Planck units, are held a distance apart from each other, their gravitational attraction would actually be a little over 130 times *stronger* than the electrostatic repulsion of two protons the same distance apart. This ratio is known as the *fine structure constant*. We think of gravity being weak compared to other forces because the known elementary particles weigh much less than the Planck mass of 2.2×10^{-8} kg. There are some experiments attempting to verify whether additional dimensions exist. One type of verification would be the detection of new, much heavier elementary particles. Obviously, heavier particles are more strongly attracted to each other by gravity, which would make gravity seem “less weak”.

or force), quantum mechanics describes three fundamental forces: 1) the *strong force* that prevents atomic quantum mechanics nuclei from flying apart in spite of the strong electrostatic repulsion between protons, 2) the *weak force*, which is responsible for radioactive decay, and 3) the familiar *electromagnetic* force (which incidentally has been unified with the weak force in *electroweak theory*). All of these forces are produced by *fields* that are **divided into separate units** (quantized) with force-carrying particles. For instance, the particles that carry energy via the electromagnetic field can be described as either a wave (like a radio broadcast) or a particle (like a photon). Gravity is an outlier, though. Gravitation essentially acts like a field, and any alterations in that field configuration propagate through space via gravitational waves (which have been detected), but these waves cannot be described by any type of discrete particles—at least not within the theory of general relativity. Gravitational waves are emitted whenever a mass is accelerated in such a way that the curvature of space around it is changed. For example, if you give a planet a push with a rocket, the planet will emit gravitational waves, but only while the push is being applied. (These waves will be very weak in any realistic scenario and will carry only a little energy away from the planet-rocket system.) Similarly, a perfectly-symmetrical sphere will not emit gravitational waves if it is just spinning. But, it *will* emit gravitational waves if its surface is bumpy or irregular, and then the resulting gravitational waves will slowly bleed away the rotational energy.

In order to quantize general relativity, a particle (the graviton) must be associated with these gravitational waves. If gravitons can be characterized and if the gravitational field can be quantized in the same way the other forces have been, then we could predict how gravity works in the microscopic scale (the quantum mechanical realm). Although gravitons are difficult to justify in regular four-dimensional spacetime, it becomes much easier to justify and characterize

them if extra dimensions are present. This is where things get a bit spooky, because gravitons may be able to exit our universe in the direction of a higher dimension...

According to several versions of string theory, three of the fundamental forces (but not gravity) are trapped in our four-dimensional space time: XYZT (where “T” is time). Gravity, on the other hand, is not completely trapped, and may be allowed to “leak” into a higher dimension(s). To detect hypothetical gravitons, which should travel at the speed of light and carry energy proportional to their frequency of oscillation like photons, experiments with particle accelerators have been conducted. These gravitons might be able to escape into the direction of a higher dimension and thus completely depart from our four-dimensional spacetime, which would not conserve energy and momentum. To verify the existence of gravitons exiting our spacetime, experimenters have looked for missing energy or missing momentum after high energy collisions—even though it would be very difficult to detect gravitons in this way if they exist. Although experiments performed by the European Council for Nuclear Research (CERN) have yet to detect any evidence of the existence of gravitons in this way, the existence of a higher-dimensional spacetime remains a theoretical possibility.

In theories with extra dimensions, how would the *disappearing-graviton act* be performed? Suppose there is an additional space-like dimension, in addition to X, Y and Z—a dimension we’ll call Q. According to these theories, all of the forces of nature (besides gravity) are confined to a very thin segment (probably smaller than the diameter of a proton) of dimension Q. All of the particles of matter exist within this Q-direction-thin membrane or *brane* of the XYZQT spacetime. This is like a drop of pond water tightly squeezed between two microscope slides. The microbes inside are constrained to exist in the thin space between the slides. The Q direction is only apparent to an external observer, such as someone looking down

at the slide through a microscope lens. From the microbes' perspective, though, motion is only allowed in two dimensions, and the space is so tightly squeezed in the other direction that the microbes are unable to jump over each other. Instead, they must swim *around* each other.

However, vibrations *can* travel through the thin, top microscope slide, and these vibrations are analogous to distortions in spacetime—perhaps from gravitons—that can travel from the Q direction into our thin slice of spacetime. Vibrations originating from a higher dimensional spacetime could create light, heat or even electrically conductive plasma of any arbitrary shape and any arbitrary motion within our spacetime.²

The Dark Matter Alternative

The whole allure of this multi-dimensional effect, however, is the scary concept that maybe someone or something could reach through solid matter, without leaving a hole, and interfere with our world. Although a long shot, it turns out that may be possible without going to extra dimensions. Perplexingly, the distribution of visible matter and why galaxies don't just fly apart cannot be explained unless there is actually much more matter in the universe than can be seen. To account for these inconsistencies, physicists have suggested that perhaps the current theory of gravity is inaccurate at very long distances, but the presence of dark matter has been hypothesized as another alternative. If dark matter exists, it outweighs regular matter by something like 5:1, and it would explain why the distribution of visible matter (atoms) in the

² All versions of string theory contain extra dimensions besides the three dimensions of space and one dimension of time that we normally associate with reality. The extra dimensions are required so that all of the elementary particles known to exist can be represented as vibrations of a string-like entity, but these vibrations are in tiny extra directions in space other than XYZ. These tiny extra directions (spatial dimensions) are not particularly usable in the macroscopic world, because they wrap around themselves like little loops and are probably much smaller than the diameter of a proton. However, some of these extra space dimensions might not be wrapped in loops, but have characteristics similar to the familiar XYZ space dimensions.

universe is as observed. To explain why dark matter is invisible and can only be detected by its gravity, it has been assumed that dark matter either doesn't interact with regular matter or interacts only very weakly, instead passing right through any regular matter that it encounters.

If dark matter exists, then this question remains: Can dark matter interact with *itself*, or at least weakly interact with regular matter other than through gravity? Recent studies of dwarf galaxies suggest that dark matter may indeed at least be able to interact with itself, perhaps using something like the strong force that holds atomic nuclei together, and maybe other forces. Interactions with these forces might even make dark matter become solid or perhaps liquid (i.e., not solid, but at least incompressible)—instead of the more likely form of dark matter, which is essentially a gas. Also, dark matter may not consist of just one, but instead a whole family of particles, and there's some evidence that some of those particles can radiate energy, which would mean that some dark matter particles or structures might be able to interact with regular matter in other ways besides merely exerting a gravitational pull. Since some dark matter particles or structures would interact very weakly, if at all, with regular matter, they could reach into any solid with little or no resistance as though they were reaching in from "another dimension."

We can speculate about how a "magic" invisible, regular-matter robotic device that harnesses dark matter to reach into solid objects might work. Dark matter is by definition invisible, and the parts of this magic robot that are made of *regular* matter might be covered in an active optical invisibility outer layer for concealment. The robot's arms may be composed of solid weakly-interacting dark matter structures that have been corralled and shaped by a regular matter framework (or holder) that connects to the weakly-interacting dark matter appendages. Perhaps one of the types of dark matter particles could interact just enough with the ordinary-matter robot to be ~solidly connected to its "shoulders," and this weakly-interacting dark matter

would be ~solidly connected to the non-interacting dark matter arm structures. Traveling even farther down this fanciful rabbit hole, perhaps a reaction could be set up so that the non-interacting dark matter arms had fingers that could turn into interacting dark matter after they reach through a solid object. Of course, this is all super-speculative and would require very advanced technology, but this possibility hasn't been entirely ruled out yet. An extremely advanced civilization may have harvested a toolbox of tricks that have been selected both from known and currently unknown physics, and perhaps spooky effects like this may be in that toolbox. [condense]

Of course there's an "easy" way for "other dimensions" to reach into our world. It's called cheating. Remember the glass microscope slide? What if our world is just a simulation and the real universe, including us, has more dimensions than we are led to experience? In the Simulation chapter, we will discuss an extremely unethical experiment that could be done in our real XYZT world: it is possible to raise a baby into adulthood believing that there is no Z dimension.

As we venture into more and more speculative ideas, some paranormal investigators also reference "other dimensions" to try to explain the nature of UFOs, as well as a wide spectrum of paranormal phenomena. A curious observation that has been made about UFOs is that they are repeatedly encountered in the same locations and are sometimes seen together with cryptids (e.g., Bigfoot, Mothman), ghosts, and various dark entities in hotspots such as the Skinwalker Ranch. Naturally, features of these hotspots have been scrutinized to identify the attractive factor, and some have surmised that the attractor (or generator) is intense collections of electromagnetic (EM) energy. High concentrations of EM energy are said to create energy vortexes or portals—portals that allow entities to cross over into our spacetime from other dimensions. Popular claims

are often made that quartz crystal and geological fault lines attract or emit large amounts of EM energy, which leads to various paranormal effects (or perhaps even direct psychological effects).

These ideas are discussed in more detail in the Cryptids chapter.

Cuts from this chapter:

Neither of the conceptions of string theory—that our world is a subset of a higher-dimensional universe or that there is a parallel, similar universe in close proximity to ours—are well-defined or readily verifiable. They do win points, though, for offering unique and intriguing explanations for UFO sightings that have captured the imagination of many people and have inspired new ideas and research in UFO investigation and beyond. If there is another XYZT spacetime (another brane) that is only separated from us by a small distance in an additional dimension, the natural laws there could conceivably be similar to the laws here, and that brane could harbor intelligent beings. These beings could use some kind of advanced technology to reach out to nearby branes, like ours, and could be intentionally tinkering with us. These beings could even be native to our own spacetime, using technology to manipulate an additional dimension, perhaps via gravitons. In contrast, if influence into our spacetime is coming directly from a higher dimensional spacetime, who knows what physical laws would apply and whether anything like intelligent beings could exist in that larger spacetime? In the various forms of string theory, quantum effects could flow from our spacetime to that larger spacetime, causing

changes which then flow back to us. If that's the case, then the "intelligence" is *ours*, perhaps through a quantum observer effect.

In any event, there's a very slight possibility that the **first tier** UFO cases could be caused by high frequency vibrations coming from "another dimension." These vibrations in the air could create illuminated floating objects, and even short circuit various electrical equipment, regardless of whether that equipment is contained in an impenetrable enclosure. As we've seen, it's also possible that the reach-through-solids trick can be done with dark matter, without fancy other dimensions being involved. Research into the potential properties of quantum gravity and dark matter is ongoing.