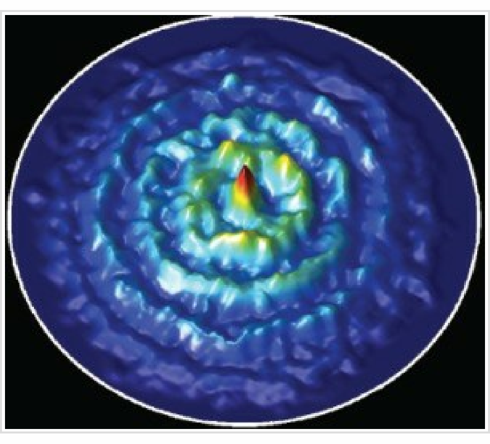
# Einstein's Intuition : quantum space theory



## Overview of quantum space theory



Quantum space theory is a pilot-wave theory [1] (similar to de Broglie's double solution theory, [2] the de Broglie-Bohm theory, [3] and Vigier's stochastic approach [4]) that mathematically reproduces the predictions of canonical quantum mechanics while maintaining a completely lucid and intuitively accessible ontology. The theory takes the vacuum to be a physical fluid with low viscosity (a superfluid), and captures the attributes of quantum mechanics and general relativity from the flow parameters of that fluid. This approach objectively demystifies wave-particle duality, eliminates state vector reduction, reveals the physical nature of the wave function, and exposes the geometric roots of Heisenberg uncertainty, quantum tunneling, non-locality, gravity, dark matter, and dark energy—making it a candidate theory of quantum gravity and a possible GUT.

In short, quantum space theory offers a more detailed picture of reality—conceptually exposing internal structure to the vacuum that gives rise to the emergent properties of quantum mechanics and general relativity. This deeper level geometry restores scientific realism and determinism—powerfully arguing that the smallest parts of the world exist objectively, in the same sense that the moon and rocks exist, whether or not we observe them, and that the subtle details of that reality can be captured by the human mind—a position held in common by Einstein, Planck, Schrödinger, de Broglie, Bohm, Vigier, Descartes, Heraclitus and more.

The idea is surprisingly simple—to reproduce the cornucopia of phenomena we find in Nature (those captured by quantum mechanics and general relativity) we model the vacuum as a superfluid—a dynamic fluid defined by the collective interactions between large numbers of quanta that shuffle about, colliding and careening off of each other, like the molecules in supercooled helium do. These vacuum quanta (pixels of space) are arranged in (and move about in) superspace. The positions and velocities of these quanta define a vector space (think Hilbert space, or state space, but apply these mathematical notions to a physically real arena in which the vacuum quanta reside—called superspace). At any given moment, the "state of space" or the "vacuum state" for a particular volume of space is defined by the instantaneous arrangements (positions, velocities, and rotations) of the vacuum quanta that make up that volume. That is, the vacuum state is defined by variables that exist in superspace—not in space.

Because the vacuum is a collection of many quanta, its large-scale structure—represented by the extended spatial dimensions $(x, y, z)$—only comes into focus as significant collections of quanta are considered. On macroscopic scales, that structure is approximately Euclidean (mimicking the flat continuous kind of space we all conceptually grew up with) only when and where the state of space captures an equilibrium distribution with no divergence or curl in its flow, and contains no density gradients. [5]

There are two classes of waves in the vacuum: solitons, and pressure waves. A soliton is a wave packet that remains localized (retains its shape, doesn't spread out). In other words, solitons are complex and non-dispersive, or what a mathematician would call "non-linear". By contrast, pressure waves (also called longitudinal waves) do spread out. They are simple and "linear".

There are two types of solitons: pulse phonons, and vortices. Pulse phonons (undulating pulse waves) propagate through the vacuum at the speed of light, similar to how sound waves pass through the medium of air at the speed of sound. The difference between pulse phonons in the vacuum and sound waves in air is that (1) due to Anderson localization (otherwise known as strong localization) pulse phonons stay localized as they propagate through the vacuum, and (2) they resonate, and therefore possess an internal frequency.

As a soliton (wave packet) advances, the randomly ordered fluid around it pushes back, collectively creating interferences that keep it from spreading out. [6] This dynamic interaction (between the soliton and the surrounding fluid) results in a redistribution of the medium—which can be described as a linear wave whose magnitude dissipates with distance from the core of the non-linear soliton wave. This surrounding wave is called a "pilot wave" because it guides and directs the path of the soliton it contains.

Every soliton connects to the surrounding medium via a pilot wave, but pilot waves can exist without solitons. Pulse phonons, along with their pilot wave counterparts, represent bosons (photons, gluons, etc.).

The other type of vacuum soliton is made up of waves that twist together to form stable quantized vortices, (whirling about on a closed loop path in whole wavelength multiples—matching phase with each loop). This stabilization condition leads to vortex quantization (allowing only very specific vortices). [7] These vortices can persist indefinitely, so long as they are not sufficiently perturbed. That is, once stable vortices form in a superfluid, they do not dissipate or spread out on their own. Incoming waves can transform an existing vortex to a different allowed vortex, so long as the distortive energy of those waves is equal to the difference between the two stable states. With sufficient disruption, vortices can also be canceled out—by colliding with vortices that are equal in magnitude but opposite in rotation, or by undergoing transformations that convert them into phonons.

Unlike pulse phonons, which pass right through each other upon incidence, quantized vortices, or sonons, [8] (think smoke rings) cannot freely pass through each other. Instead, they hydrodynamically push and pull on each other in ways that allow only certain stable configurations, giving rise to the Pauli exclusion principle. Vacuum vortices also connect to the rest of the medium via a pilot wave. Each unique vortex, along with its surrounding pilot wave, represents a fermion (an electron, quark, muon, etc.)

According to this picture, wave-particle duality is an implicit, non-excisable quality of reality because "particles" are localized vacuum waves (complex, non-linear distortions that are concentrated in a small region—solitons) surrounded by pilot waves that guide their motion. Both the particle and the pilot wave are physically and objectively real entities.

### Evolution of the idea

In 1867, William Thomson (also known as Lord Kelvin) proposed "one of the most beautiful ideas in the history of science," [9]—that atoms are vortices in the aether. [10] He recognized that if topologically distinct quantum vortices are naturally and reproducibly authored by the properties of the aether, then those vortices are perfect candidates for being the building blocks of the material world. [11]

When Hermann Helmholtz demonstrated that "vortices exert forces on one another, and those forces take a form reminiscent of the magnetic forces between wires carrying electric currents," [12] Thomson's passion for this proposal caught fire. Using Helmholtz's theorems, he demonstrated that a non-viscous medium does in fact only admit distinct types, or species, of vortices. And he showed that once these vortices form they can persist without end, and that they have a propensity to aggregate into a variety of quasi-stable arrangements. This convinced Thomson that vorticity is the key to explaining how the few types of fundamental matter particles—each existing in very large numbers of identical copies—arise in Nature.

Despite the elegance of Thomson's idea, the entire project was abandoned when the Michelson-Morley experiment ruled out the possibility that the luminiferous aether was actually there. Interpreting these vortices to critically depend on the aether (instead of allowing for some other medium to be the substrate that supports them) scientists dropped the idea altogether—unwittingly throwing the baby out with the bathwater.

In 1905, in response to the discovery that light exhibits wave-particle duality—that light behaves as a wave, even though it remains localized in space as it travels from a source to a detector—Einstein proposed that photons are point-like particles surrounded by a continuous wave phenomenon that guides their motions. [13] This proposal resurrected the core of Thomson's idea—framing it in a new mold (pilot-wave theory). [14]

In 1925 Louis de Broglie discovered that wave-particle duality also applies to particles with mass, [15] and became acutely interested in the pilot-wave ontology. Determined to further develop pilot wave theory, he added internal structure to Einstein's notion of particles, and suggested that particles are intersecting waves, like fluid vortices, made up of many interacting atoms/molecules of a sub-quantum medium. [16] Convinced that this idea was "the most natural proposal of all", de Broglie outlined its general structure, [17] and then began working on a second proposal—a mathematically simplified approximation of that idea, which treated particles as simple point-like entities surrounded by pilot waves. De Broglie presented this second proposal at the 1927 Solvay Physics Conference, where it was ridiculed to such a degree that he dropped the idea for decades.

Twenty-five years later, David Bohm rediscovered de Broglie's simplified approach, and (in collaboration with de Broglie) completed the formalism. The result was the de Broglie-Bohm theory, [18] "the fully deterministic interpretation of quantum mechanics that reproduces all of the predictions of standard quantum mechanics without introducing any stochastic element into the world or abandoning realism." [19] (Never heard of this before? Well most physicists haven't either. Read Why don't more physicists subscribe to pilot wave theory to find out why. [20])

### Quantum mechanics from pilot wave theory

Pilot wave theory fully (and deterministically) captures quantum mechanics, and it does so with elegance and ease. In fact, when we assume that particles (photons, electrons, etc.) are point-like entities that follow continuous and causally defined trajectories with well-defined positions $\xi(t)$, and that every particle is surrounded by a physically real wave field $\psi(\boldsymbol{r},t)$ that guides it, we only need three supplementary conditions to perfectly choreograph all of quantum mechanics. Those conditions are:

1. The wave $\psi(\boldsymbol{r},t)$ evolves according to the Schrödinger equation,
2. The probability distribution of an ensemble of particles described by the wave function $\psi$, is $P=|\psi|^2$, and
3. Particles are carried by their local "fluid" flow. In other words, the change of particle's position with respect to time is equal to the local stream velocity $d\xi(t)/dt=\boldsymbol{v}$, where $\boldsymbol{v}=\nabla S/m$, and the "velocity potential" $S$ is related to the phase $\varphi$ of $\psi$ by $S(\boldsymbol{r},t)=\hbar\varphi(\boldsymbol{r},t)$.

From here, obtaining a full hydrodynamic account of quantum mechanics is simply a matter of expressing the evolution of the system in terms of its fluid properties: the fluid density $\rho(\boldsymbol{r})$, the velocity potential $S$, and stream velocity $\boldsymbol{v}$.

The first step is to write down the Schrödinger equation in its hydrodynamic form: [21]

$$\psi=\sqrt{\rho}\,e^{\frac{iS}{\hbar}}$$

Then we express fluid conservation via the continuity equation, which states that any change in the amount of fluid in any volume must be equal to rate of change of fluid flowing into or out of the volume—no fluid magically appears or disappears:

$$\frac{\partial\rho}{\partial t}+div(\rho\frac{\nabla S}{m})=0$$

From this it follows (given that particles are carried by their guiding waves) that the path of any particle is determined by the evolution of the velocity potential $\partial S/\partial t$, which is:

$$\frac{\partial S}{\partial t} = -\frac{1}{2m}(\nabla S)^2 - V - Q$$

This evolution depends on both the classical potential $V$ and the "quantum potential" $Q$, where: [22]

$$Q = -\frac{\hbar^2}{2m}\frac{\nabla^2\sqrt{\rho}}{\sqrt{\rho}} = -\frac{\hbar^2}{4m}\left[\frac{\nabla^2\rho}{\rho} - \frac{1}{2}\left(\frac{\nabla\rho}{\rho}\right)^2\right]$$

That's it. We now have a hydrodynamic model that fully reproduces the behavior of quantum particles in terms of a potential flow.

Note that, from a classical or realist perspective, the assumptions held by this formalism are far less alarming than those maintained in canonical quantum mechanics (which regards the wave function to be an ontologically vague element of Nature, inserts an ad hoc time-asymmetric process into Nature—wave function collapse, abandons realism and determinism, etc.). Nevertheless, being based on an approximation of the more natural ontology, the auxiliary assumptions of this construction still cry out for a more complete understanding. So let's address them.

> Condition 1: The wave $\psi(\boldsymbol{r},t)$ evolves according to the Schrödinger equation.

Every physical medium has a wave equation that details how waves mechanically move through it. Under de Broglie's original assumption that pilot waves are mechanically supported by a physical sub-quantum medium, the idea that the pilot wave $\psi(\boldsymbol{r},t)$ evolves according to the Schrödinger equation is completely natural—so long as the fluid has the right properties (e.g. behaves like a superfluid). But the de Broglie-Bohm theory doesn't explicitly assume a physical medium. [23] As a consequence, it must tack on the assumption that the pilot wave (whatever it is a wave of) evolves (for some reason) according to the Schrödinger equation.

It's worth pointing out that the Schrödinger equation was originally derived to elucidate how photons move through the aether—the medium evoked to explain how light is mechanically transmitted. The aether was considered to be a "perfect fluid", which meant that it had zero viscosity. When the aether fell out of fashion the medium was dropped but the wave equation remained, leaving an open-ended question about what light was waving through.

When we fail to stipulate a physical medium, evolution according to the Schrödinger equation becomes a necessary additional (brute) assumption. With the physical medium in place (especially one with zero viscosity) the wave equation immediately and naturally follows as a descriptor of how waves mechanically move through that medium.

> Condition 2: The probability distribution of an ensemble of particles described by the wave function $\psi$, is $P = |\psi|^2$.

In order to establish that the equilibrium relation $P = |\psi|^2$ is a natural expectation for arbitrary quantum motion, Bohm and Vigier proposed a hydrodynamic model infused with a special kind of irregular fluctuations. [24] To explain those fluctuations, they pointed out that the equations governing the $\psi$ field could "have nonlinearities, unimportant at the level where the theory has thus far been successfully applied, but perhaps important in connection with processes involving very short distances. Such nonlinearities could produce, in addition to many other qualitatively new effects, the possibility of irregular turbulent motion." [25]

Bohm and Vigier went on to note that if photons and particles of matter have a granular substructure, analogous to the molecular structure underlying ordinary fluids, then the irregular fluctuations are merely random fluctuations about the mean (potential) flow of that fluid. They went on to prove that with these fluctuations present, an arbitrary probability density will always decay to $|\psi|^2$—its equilibrium state. This proof was extended to the Dirac equation and the many-particle problem. [26]

In short, in order to justify the equilibrium relation, Bohm and Vigier returned to de Broglie's original idea—that particles are intersecting (non-linear) waves in a sub-quantum fluid surrounded by a (linear) pilot wave. The substructure of that fluid, how its inner parts mix and move about, is naturally responsible for the fluctuations that create the equilibrium relation—in perfect analogy to how Brownian motion is caused by the collisions and rearranging of molecules in the fluid it is in.

Without assuming the physical existence of this sub-quantum fluid, the wave equation and the equilibrium relation are mysterious and unexpected conditions—additional brute assumptions. With the fluid, they naturally follow.

> Condition 3: The change of particle's position with respect to time is equal to the local stream velocity $d\xi(t)/dt = \boldsymbol{v}$, where $\boldsymbol{v} = \nabla S/m$, and the "velocity potential" $S$ is related to the phase $\varphi$ of $\psi$ by $S(\boldsymbol{r},t) = \hbar\varphi(\boldsymbol{r},t)$.

Relating the velocity potential $S$ to the phase $\varphi$ of $\psi$ by $S(\boldsymbol{r},t) = \hbar\varphi(\boldsymbol{r},t)$, means that the phases of both (the pulsing particle and the surrounding wave) coincide. This condition—that "the particle beats in phase and coherently with its pilot wave"—is known as de Broglie's "guiding" principle. It "ensures that the energy exchange (and thus coupling) between the particle and its pilot wave is most efficient," [27] and that the core of the particle is carried along with the linear wave $\psi$.

Given that what de Broglie really had in mind was that particles were intersecting waves in some fluid (pulsating non-linear waves), and that pilot waves were the linear extensions of those waves into the rest of the fluid, this condition may feel completely natural—automatically imported. But the simplified model doesn't have that advantage. That is, under the approximation that particles are point-like structureless entities, it becomes necessary to additionally assert that (for some reason) those particles possess a phase, which pulses in sync with the surrounding pilot wave. This condition secures that the velocity of the particle matches the local stream velocity of the fluid.

The moral of this story is that all of the auxiliary premises in the de Broglie-Bohm theory are necessitated by the model's omission of the sub-quantum fluid that is responsible for the effects it is capturing—by what it washes out by way of approximation. In other words, these assumptions are consequences of the fact that the de Broglie-Bohm theory is a mean-field approximation of the real dynamics. To more viscerally connect with the quantum world, to have a richer understanding of quantum phenomenon while minimizing the number of our auxiliary assumptions, we have to tell the story from the perspective of the more complete ontology—the one that mirrors what's actually going on in Nature—the one that de Broglie originally had in mind. [28] This is the aim of quantum space theory.


[1] Pilot-wave theories (also called nonlocal hidden-variable theories) are a family of realist interpretations of quantum mechanics that believe that the statistical nature of quantum mechanics is due to an ignorance of an underlying more fundamental real dynamics, and that microscopic particles follow real trajectories just like larger classical bodies do. Quantum space theory falls under the family of models categorized as vacuum-based pilot-wave theories. It logically overlaps with both stochastic electrodynamics and superfluid vacuum theory. For a modern review of pilot wave theories, see: John W. M. Bush, "Pilot-Wave Hydrodynamics". Annu. Rev. Fluid Mech. 2015. 47:269–92 (2015).
[2] Louis de Broglie, "Interpretation of quantum mechanics by the double solution theory". Annales de la Fondation, Volume 12, no. 4 (1987).
[3] David Bohm, "A Suggested Interpretation of the Quantum Theory in Terms of 'Hidden Variables' I". *Physical Review*. **85** (2): 166–179 (1952).
[4] Stanley Jeffers, "Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics" (2000).
[5] This echoes Dirac's sentiment that, "the perfect vacuum as an idealized state, not attainable in practice." The true vacuum is much richer than that trivial state and not "needs elaborate mathematics for its description." It acts like a fluid, or "an aether, subject to quantum mechanics and conforming to relativity…" Paul A. M. Dirac, *Nature* (London) 169, 702 (1952).
[6] If the vacuum were a composite of periodically arranged quanta, instead of being randomly arranged, then wave pulses passing through the vacuum would spread out (scatter and dilute). Randomness causes interference between multiple scattering paths to keep wave pulses completely localized. Anderson, P. W., "Absence of Diffusion in Certain Random Lattices". *Phys. Rev.* **109** (5): 1492–1505 (1958); Roati, Giacomo; et al., "Anderson localization of a non-interacting Bose-Einstein condensate". *Nature*. **453** (7197): 895–898 (2008).
[7] See: https://en.wikipedia.org/wiki/Quantum_vortex – Vortex-quantisation_in_a_superfluid
[8] Ross Anderson & Robert Brady, "Why quantum computing is hard—and quantum cryptography is not provably secure" (2013).
[9] Frank Wilczek. (December 29, 2011). Beautiful Losers: Kelvin's Vortex Atoms. NOVA: http://www.pbs.org/wgbh/nova/physics/blog/2011/12/beautiful-losers-kelvins-vortex-atoms/ Much of this section follows this article.
[10] Lord Kelvin (Sir William Thomson), On Vortex Atoms. Proceedings of the Royal Society of Edinburgh, Vol. VI, 1867, pp. 94-105. Reprinted in Phil. Mag. Vol. XXXIV, 1867, pp. 15-24.
[11] Thad Roberts, Einstein's Intuition: Visualizing Nature in Eleven Dimensions. (2016).
[12] Frank Wilczek. (2011, December 29). Beautiful Losers: Kelvin's Vortex Atoms. NOVA: http://www.pbs.org/wgbh/nova/physics/blog/2011/12/beautiful-losers-kelvins-vortex-atoms/ Much of this section follows this article.
[13] Albert Einstein, *Ann. Phys. (Leipzig)* **17**, 132. "Concerning an Heuristic Point of View Toward the Emission and Transformation of Light"(1905).
[14] Einstein eventually came to the viewpoint that "quantum statistics should be due to a real subquantal physical vacuum alive with fluctuations and randomness." Stanley Jeffers, "Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics" (2000).
[15] Louis de Broglie, *Ann. Phys. (Paris)* **3**, 22 (1925).
[16] Louis de Broglie, "Interpretation of quantum mechanics by the double solution theory". Annales de la Fondation, Volume 12, no. 4 (1987); Stanley Jeffers, "Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics" (2000).
[17] Louis de Broglie, "Interpretation of quantum mechanics by the double solution theory". Annales de la Fondation, Volume 12, no. 4 (1987).
[18] David Bohm, *Phys. Rev*. **85**, 166, 180 (1952).
[19] Stanley Jeffers, "Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics" (2000).
[20] https://www.quora.com/Why-dont-more-physicists-subscribe-to-pilot-wave-theory/answer/Thad-Roberts
[21] Erwin Madelung, *Physik* **40**, 332 (1926). See also: Madelung equations.
[22] is called the Laplace operator and it represents the divergence of the gradient. Note that equations (2) and (3) do not contain the actual location of the particle , which is required to produce an exact output. That is, in order to use this theory to make an exact prediction of where the particle will end up, we must specify exactly where it was at some point. The quantum potential represents how much vacuum mixing redirects the particle, an effect that becomes less intense as the mass of the particle (the distortion magnitude of the soliton) increases.
[23] Many physicists imagine a non-physical field supporting these wave dynamics instead of a physical fluid medium.
[24] David Bohm & Jean-Pierre Vigier, *Phys. Rev.* **96**, 208 (1954).
[25] Ibid.
[26] Stanley Jeffers, "Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics" (2000).
[27] Ibid.
[28] Louis de Broglie, *Une tentative d'interprétation causale et non-linéaire de la Mécanique Ondulatorie* (Gauthier-Villars, Paris), (1956).


**Ok, So where do we go from here?**

When we step back from the simplified assumptions of the de-Broglie Bohm model, returning to the full picture that de Broglie originally intended, how many other mysteries can we ontologically penetrate? Advocates of quantum space theory (qst) are exploring the full implications of this question and are attempting to finish a complete mathematical formulation of de Broglie's "most natural proposal". So far, the theory paints a multi-dimensional picture, that offers a visceral portrayal of a vacuum with more texture than previously imagined, controlled by deterministic dynamics. This rich vacuum geometry reveals the phenomena of quantum mechanics and general relativity as emergent—characteristics that supervene on spacetime's sub-structure.

Many of us working on this project are motivated by the desire to understand Nature's infinitely cascading structure and its dynamics—to grasp the complete laws of Nature and, in so doing, come to grips with our 'magnificent insignificance.' In the spirit of that investigation, we invite you to critically explore this new perspective and thank you for participating in this grand scientific quest.

Please note that we are acutely aware that this new theory might not turn out to accurately map Nature. So far, several testable predictions have fallen out of the theory, and any one of them could falsify it. This is part of the process of scientific investigation. Our desire to complete Einstein's task moves us to explore theories that are capable of making epistemic contributions. In general, such efforts should be focused (in response to the constraints we are under) toward those theories with the greatest ontological potential. As the candidate for the theory of quantum gravity that offers the most intuitive accessibility, and the greatest ontological clarity, quantum space theory is our pick for the theory most worthy of our efforts.

All professional and constructive reviews of this work are welcome. A book on this topic, written for a general science enthusiast audience can be found here. (If cost is a barrier please send us a message.) Contact us with questions, comments, or to join the research effort at ei at EinsteinsIntuition dot com.

**qst axioms:**

1. The hierarchical structure of the superfluid vacuum is self-similar, cascading as a perfect fractal. The familiar medium of *x, y, z* space is composed of a large number of "space atoms" called quanta that dynamically mix and interact. Those quanta are composed of a large number of sub-quanta and the sub-quanta are composed of sub-sub-quanta and so on, ad infinitum. Vacuum superfluidity constrains the possible states of the vacuum in accordance with energy conservation, de Broglie relations, and linearity. More generally it constrains the vacuum as an acoustic metric.
2. Time is uniquely defined at each location in space and evolves discretely (for each quantum) as the number of whole resonations each quantum undergoes. As a result, the acoustic metric inherits a Newtonian time parameter and therefore exhibits the important property of stable causality.
3. Energy (total geometric distortion) is conserved. Energy conservation means that all metric distortions (phonons, quantum vortices, etc.) are interchangeable from one kind to another, including the transference of metric distortions from one hierarchical level to another, like the quantum level to the sub-quantum level.

**What follows from those axioms:**

1. The wave equation (the non-linear Schrödinger equation, also known as the Gross-Pitaevskii equation) can be derived from first principles (see here, or here), from the assumption that the vacuum is a BEC whose state can be described by the wavefunction of the condensate.
2. Modeling the superfluid vacuum as an acoustic metric reproduces an analogue for general relativity's curved spacetime within low momenta regimes.
3. Mass generation is a consequence of the symmetry breaking that occurs when quantum vortices form in the vacuum condensate.
4. The total number of spacetime dimensions in our spatiotemporal map depends on the resolution we desire. (Are we only quantizing the fabric of *x, y, z*? Or are we also keeping track of the subquanta that those quanta are composed of? and so on.) For any arbitrary resolution, the number of dimensions is equal to $3^n + n$. A second order perspective ($n = 2$) quantizes the fabric of space one time, and a third order perspective quantizes the volumes of that fabric, and so on, ad infinitum.
5. Quantization restricts the range of spacetime curvature: the minimum state of curvature (zero curvature) can be represented by the ratio of a circle's circumference to its diameter in flat space (π), and the maximum state of curvature can be represented by the value of that ratio in maximally curved spacetime, a number that we will represent with the letter ж ("zhe").
6. The constants of Nature are derivatives of the geometry of spacetime: they are simple composites of π, ж, and the five Planck numbers.
7. When the quanta of space are maximally packed they do not experience time because they cannot independently or uniquely resonate.
8. Black holes are collections of quanta that are maximally packed—regions of maximum spatial density.
9. When two objects occupy regions of different quantum density, the object in the region of greater density will experience less time.
10. Because the quanta are ultimately composed of subquanta, all propagations through space necessarily transfer some energy from the quantum level (motion of the quanta) to the subquantum level (to the internal geometric arrangements and motions of the subquanta). Although this transference of energy is proportionally very small (being approximately equal to the energy multiplied by the ratio of the subquantum scale to the quantum scale) it is additive. Therefore, it can become significant over large scales—leading to what we now call red-shift.

**Some testable predictions:**

1. Although the superfluid vacuum is non-relativistic, small fluctuations in the superfluid background obey Lorentz symmetry. This means that for low momenta conditions the theory captures the expectations of general relativity, but at high energy and high momenta conditions the theory projects Newtonian expectations over relativistic ones. Therefore, the theory predicts that when massive objects are accelerated to near the speed of light they will exhibit effects that will contradict general relativity in favor of Newtonian projections.
2. When we place a circle of any (macroscopic) size in a region where the gradient of spacetime curvature is at a minimum (where there is zero change in curvature throughout the region) the ratio of its circumference to its diameter gives us a value of 3.141592653589… (π). Qst predicts that this ratio will decrease if the circle occupies a region with a nonzero gradient of spacetime curvature. Furthermore, it predicts that in regions where the gradient of spacetime curvature is at a maximum there will be a minimum possible value for this circumference to diameter ratio. More specifically, for all possible circles centered around a black hole (or approaching the quantum scale) the minimum circumference to diameter ratio will be equal to a minimum value of 0.0854245431(31) (ж). This means that, instead of being randomly ascribed, the constants of Nature are immediate consequences of the geometric character of spacetime. A quantized picture of spacetime requires a natural minimum unit of distance (the Planck length), a natural minimum unit of time (the Planck time), and maximum amounts of mass, charge, and temperature in reference to the minimum units of space and time (Planck mass, Planck charge, and Planck temperature). Furthermore, quantization dictates minimum and maximum limits for the gradient of spacetime curvature (π and ж). According to qst, the constants of Nature are composites of these seven numbers. It turns out that this claim holds when ж is equal to 0.0854245431(31).
3. The theory predicts that temperature dependent phase changes exist in space—regions where the average geometric connectivity of the quanta of space transition from one state to another. Furthermore, the theory predicts that because the background temperature of the universe is cooling (the average wavelength of the Cosmic Microwave Background Radiation is increasing), the fraction of space characterized by the denser geometric phase should become more prevalent with time.
4. The theory predicts that the average radii of dark matter haloes should decrease as the energy output of the host galaxy decreases. It predicts that by comparing contemporary haloes we should find that the average radii of these haloes should depend on the energy output of the host galaxy and that the further the background temperature of space drops below the temperature of the critical phase transition the smaller the average radii of dark matter haloes should be. It follows from this that the radii of local dark matter haloes should decrease in the future (with a dependence on its host galaxy's output).
5. The theory predicts that quantum tunneling should be less frequent in regions of greater curvature (regions with a greater density of space quanta).
6. The theory predicts that supersymmetric geometries are available only in axiomatic frameworks with a total number of dimensions equal to $3^n + n$, where n is an integer.
7. The theory leads us to expect that when the highest-energy gamma rays reach us from extremely distant supernova, they should be less red-shifted in proportion to the difference in time between the arrival of the gamma rays and the remaining wavelengths divided by the travel time of the longer wavelengths.

**Impact**

Up until now, our intuitions about the world have, for the most part, been imprisoned by the confines of four dimensions (three dimensions of space plus one dimension of time). Investigations of the mysteries effects we have observed in Nature have all started from this reference. As a consequence, we have tried to explain unexpected effects (like the Moon orbiting the Earth instead of just going *straight through space*) by inventing ad hoc "forces" that we have held responsible (in the non-explanatory sense) for those effects. This process has restricted our ontological access.

When we hold onto these traditional assumptions about space and time it becomes necessary to awkwardly superimpose equations for four forces on top of our preconceived axiomatic construction in order to retain predictability. The problem is that this method of regaining predictability robs us of the ability to explain those effects. Einstein interrupted this process by constructing a geometry that included the effects of gravity within his metric. Qst extends this approach by introducing an intuitive eleven-dimensional vacuum geometry (nine space dimensions and two time dimensions). So far this geometry appears to have the ability to contain Nature's strange characteristics (the effects traditionally assigned to the four forces). To more rigorously determine whether or not those geometric characteristics fully account for the effects we have observed, we are working to complete a full mathematical formalism of the axiomatic structure.

This picture gives us intuitive access to Nature's mysteries by transforming the arcana of general relativity and quantum mechanics into necessary conditions of Nature's geometric structure. Just how precisely qst maps all of Nature's characteristics is a matter of scientific investigation. Before that question is resolved we can be assured that, as an intuitively accessible deductive construction, the model has significant scientific value. (Note that we have known for quite some time that Nature does not actually map to Euclidean geometry, nevertheless, the deductive, axiomatic framework known as Euclidean geometry continues to be a very useful and practical tool).

The mere possibility that quantum space theory maps something new in the spectrum of Nature's colorful character makes it worth investigating. But the fact that it enables us to visualize eleven dimensions simultaneously, something that has never been done before, directly speaks to its contributory value to science. From this we gain the potential to expand our intuitive horizon beyond our inbuilt senses and begin to penetrate the geometric origins of Nature's mysteries: Heisenberg uncertainty, wave-particle duality, what the insides of black holes are like, the cause of the Big Bang, why the constants of Nature are what they are, dark matter, dark energy, etc.

With an intuitively accessible model big science is no longer beyond the horizon of human intellect. Whether or not the model of quantum space theory is eventually shown to map Nature with precision, it provides us value because once we are equipped with the eleven-dimensional geometry of a superfluid vacuum, the biggest questions in physics gain elegant and simple analogies that anyone can understand.

For more information check out this introduction video, or pick up your copy of 'Einstein's Intuition' by Thad Roberts.

**Why it is needed**

As Thad states in chapter one of *Einstein's Intuition*, we need to return to a place akin to where the young Einstein found himself, a place where the senses are allowed a deep connection to Nature, facilitating Einstein's envisionment of the properties of light and time. Thad goes on, "this … highlights a fundamental problem in the approach taken by modern physics. For the past several decades, theorists and mathematicians have been working on constructing a framework of Nature that is capable of mathematically combining the descriptions of general relativity and quantum mechanics under the same rubric. … But their efforts have been focused on organizing Nature's data into a self-consistent assembly—like the ones and zeros of a digital picture. The problem is that this inductive approach does not encourage, let alone require, the discovery of a conceptual portal."

"Even if physicists were one day to conclude that their assembly was mathematically correct, it would not actually increase our ability to truly comprehend Nature unless it was translated into some sort of picture. Therefore, since it is really the picture that we are after, maybe it is time for us to consider whether or not our efforts will bear more fruit under a different approach. Specifically, to maximize our chances of completing our goal of intuitively grasping Nature's complete form, maybe we should follow the lead of young Einstein and return to a deductive conceptual approach. Perhaps it is time for us to place our focus on constructing a richer map of physical reality."

But, how do we actually do this? We are told, over and over that it is impossible to visualize more than three spatial dimensions, yet today's leading theories routinely suggest, or even require, more than three spatial dimensions. Many people find the notion of additional dimensions absurd. They suggest that when other dimensions pop up in our equations they are just artifacts of our intricate mathematics of theoretical physics. They claim that those equations should not be taken as an indication of the "actual" existence of these extra dimensions. In opposition to this reaction quantum space theory holds these extra dimensions to be as real as the *x*, *y*, *z* and *t* dimensions we experience every day. Qst further elaborates a hierarchical structure to these extra dimensions that allows us to comprehend, and even visualize, the super and intra dimensions.

qst proposes that the vacuum is a superfluid, that space is literally quantized into discrete pieces (quanta), and its eleven-dimensional structure follows from that claim.

The notion that the vacuum is a superfluid (whose geometric structure is hierarchically quantized) gives us the ability to explain:

- The constants of Nature—as a consequence of vacuum geometry
- Force phenomena—in terms of allowed geometric distortions in the vacuum
- The wave equation—as a descriptor of how distortions translate though the vacuum
- Heisenberg uncertainty—as a manifestation of vacuum quantization and mixing
- Wave-particle duality—as a manifestation of the vacuum's fluid nature
- Dark matter—as a phase change in the vacuum
- Dark energy—as a transference of energy from the quanta to the sub-quanta
- The State Vector—as a blurred (ensemble) representation of the vacuum's possible state (given our ignorance of its exact state at any moment), and more.

Instead of resting on a set of impenetrable dialogue filled with complex and distracting jargon, the solutions proposed by quantum space theory are all intelligible. By examining the idea that the vacuum is a superfluid we gain intuitive, simultaneous access to more than four spacetime dimensions, which allows us to intuitively absorb details of Nature and intimately understand the mysteries of physics.

We invite you to participate in the task of steering science back towards its goal of obtaining ontological clarity, of acquiring intuitive pictures, deductive solutions, and accessible explanations for Nature's baffling effects. We invite you to read all about this model in the book Einstein's Intuition: Visualizing Nature in Eleven Dimensions. Open yourself to a change in perspective and escape the conceptual limitations of three dimensions of space and one dimension of time.

Contact us with questions, comments, or to join the research effort at ei at EinsteinsIntuition dot com.