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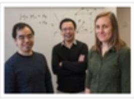
16.3k 

U.S. and European physicists searching for an explanation for high-temperature superconductivity were surprised when their theoretical model pointed to the existence of a never-before-seen material in a different realm of physics: topological quantum materials news.rice.edu

vor 8 Tagen by DoremusJessup

561 Kommentare Weitersagen Speichern Ausblenden melden

Top 200 Kommentare zeige 500

sortiert nach: beste (vorgeschlagen)

[–] **RadiatedCrystal** 1963 Punkte vor 8 Tagen

ELI5 "Topological Quantum Materials"?

Permalink embed Speichern melden antworten

[–] **Ihavefourspades** 3348 Punkte vor 8 Tagen*

These are materials with "topologically protected quantum states." These are quantum states that are protected due to the geometry of the material or potentials they are in. There's not an easy to way explain this intuitively - quantum mechanics is inherently counterintuitive and is only widely accepted because

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1. Directly link to published peer-reviewed research articles or a brief media summary
2. No summaries of summaries, re-hosted press releases, reviews or popular reposts (over 100 upvotes)
3. Research must be less than 6 months old
4. No sensationalized titles, all titles must include the model where applicable
5. No blogspam, images, videos, infographics
6. All submissions must be flaired and contain a link to the published article, either in the submission link or as a standalone comment.

nearly a century of careful and incredibly precise experiments align with its predictions - but I can try to give an example that hits the major idea here.

As a greatly simplified example, one of these topological materials involve the momentum and spin of an electron. The protected state is the spin of the electron. The electron is either spin up, spin down, or a quantum superposition of the two possibilities. It's like a bit in a computer that equals 0 or 1, but also could be either a 0 or 1 depending how you look at it. You can control how often it's either a 0 or a 1 both by how you measure it and by controlling it with outside energy sources, like microwave or optical photons.

What's important for practical purposes is that you can reliably prepare the electron spin and have it maintain that prepared state as long as possible. However, the spin by itself is subject to influence from magnetic and electric fields in the environment and a variety of other more complicated effects due to living inside of a crystal.

But now, what if we could tie the spin of the electron to its momentum? More specifically, there are states on the edge of this topological material where the electron will travel counterclockwise and spin up or clockwise and spin down. So now, for the spin to flip, the momentum of the electron has to change as well. This means it's much more difficult for the electron's quantum state (the spin) to be changed by the environment randomly, but easy for us to change it intentionally.

This is a very simple example that glosses over a lot of details and a physicist who studies these would have a lot of qualms with it, but it captures the essence of what is happening in these topological systems. We are coupling something important for quantum computing (like a spin) to other degrees of freedom in the system (like momentum) in order to greatly reduce the chance of random errors in a quantum computer. It's pretty neat stuff.

Permalink embed Speichern Übergeordnet melden antworten

[–] **solips_sonder** 2119 Punkte vor 8 Tagen

Okay, now explain like I'm 5.

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[–] **Ihavefourspades** 1758 Punkte vor 8 Tagen*

Imagine you spin a top. Assuming the top doesn't stay in one spot, the point will prefer to move either clockwise or counterclockwise based on how it's physically spinning. The only way to change the top's spin is to A) let the air and table slow it down (environmental effects), B) the top falls over (decoherence), or C) manually spin it the other way (coherently drive an electron spin). All of these involve changing the way the top is spinning in addition to its momentum, which is what we're aiming for.

Now, imagine the top isn't physically spinning and instead is a magnetic dipole, the top spins both ways at the same time until you measure it, how often it spins in each direction on repeated measurements depends not only how it starts spinning but how you decide to look at the spinning, there's magnetic and electric fields as well as strain and other tops' spins affecting the way the top you care about spins, and the top isn't actually physically spinning but refers in essence to a magnetic dipole moment that points either up or down in arbitrary axis that you or may not be able to control depending on the crystal the top is in, and none of the tops here are tops but actually electrons and nuclei in atoms in a crystal lattice, except the electrons aren't really bound to a single nucleus but allowed to roam freely around the edges of the crystal, and you may or may not understand this example of an extremely simplified topological quantum material.

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[+] ***Comment removed*** *vor 8 Tagen (131 Kinder)*

[+] ***Comment removed*** *vor 8 Tagen (4 Kinder)*

[–] **SatansSenseOfHumor** 25 Punkte vor 7 Tagen*

Wait wait wait wait wait...

The electrons can LEAVE their "assigned" atom, and just kind of move in and out of the valence shells of neighboring atoms?!

So what happens when the atom loses an/the electron? Is it immediately replaced by a neighboring atoms electron?

Are the nuclei essentially latticed together, smothered in a sea of roaming electrons!??

I'm losing my (very simple) mind here!!

Permalink embed Speichern Übergeordnet melden antworten

[–] **Ihavefourspades** 120 Punkte vor 7 Tagen

The process you've described is what happens when electrons live in the conduction band. For metals, this band is populated with electrons. For insulators, it's not. For semiconductors, the valence band is completely occupied, but the amount of energy needed to reach the conduction is relatively small compared to an insulator, so very few electrons become thermally excited into the conduction band.

In order to populate the conduction band, you can dope a material with an element that has more electrons than can be bonded to the host material. For instance, in a pure silicon crystal, the silicon atoms each bond to four nearest neighbors, sharing one of its four valence electrons with each neighbor. Phosphorus has five electrons, so if you replace a silicon atom with a phosphorus, the four surrounding silicon atoms take an electron but there is one left over. This one goes into the conduction band.

So the nuclei are kept intact with the core electrons that do not participate in bonding, are bonded with other nuclei due to sharing electrons with their neighbors to form a lattice, and the extra electrons are free to roam about the crystal.

To complicate things further, instead of doping with phosphorus, you can dope with boron, which has three valence electrons. That means one of the silicon atoms can't form a bond because there is a hole where there should be an electron. In this case, electrons move around to keep filling in the hole. However, it's hard to keep track of these billions of billions of electrons moving around, so we just pay attention to where the hole is moving. So that's where the notion of holes come from. These freely travel around the crystal in the valence band and have a positive charge, although they are not truly a physical particle in the sense that you could pick a single one out of a crystal.

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[–] **zzz0404** 31 Punkte vor 7 Tagen

Thanks for the effort you're putting into replying

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Mehr Kommentare laden (2 Antworten)

[–] **desync_** 7 Punkte vor 7 Tagen

> Are the nuclei essentially latticed together, smothered in a sea of roaming electrons!??

Yes, basically. That's the sort of "classical" way of looking at it, I guess - that is, if you think of electrons as being actual, tangible objects. That picture works on a qualitative level but what's really happening is the valence orbitals of the nuclei in the crystal lattice overlapping to form the 'bands' that Ihavefourspades talked in much greater detail about.

In a sense the atom doesn't "lose" the electron, but just says to every other atom in the crystal: "Hey, you can have a bit of this too!".

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[–] **chefhanabal** 5 Punkte vor 7 Tagen

(Please mind these are really simplified for 101 style classes)In my classes for materials and chem, they describe metals has having an electon sea, where there isn't a real distinction between "who's" electron. This helps visualize when we take circuits and try to picture the flow as pipes with water, in that the electrons are flowing throu your wire. This is the really simple way of talking about the conduciton band IHaveFourSpades is talking about.

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Mehr Kommentare laden (2 Antworten)

[–] **BearTail98** 68 Punkte vor 7 Tagen

For those still confused, you can’t explain this in any easier way than this. It is pretty hard to wrap your head around

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[–] **farmtownsuit** 44 Punkte vor 7 Tagen

All I got from this is that I am not a smart man.

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[–] **teronna** 51 Punkte vor 7 Tagen

Don't think like that. This stuff is unintuitive. Even the people that understand it, understand it at a mathematical level, not intuitively. At some point, once you study this kind of stuff enough, you stop thinking in terms of analogies to everyday things, and start thinking purely in terms of the formulas and the relationships between them.

Something similar is true in math. We simply can't visualize high-dimensional spaces (and in many areas of math, you can often work in spaces with hundreds or thousands of dimensions - like neural networks). Many people just assume they're not "smart" enough to understand them.

In reality, even the guys who work with it aren't understanding it the way you think they are. We just learned from experience to abandon real-life analogies when convenient and fall back on the formulas simply through experience. There's a great interview with Feynman about electromagnetism that covers the same point.

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Mehr Kommentare laden (2 Antworten)

[–] **Siriss85** 9 Punkte vor 7 Tagen

You are, you just need to have it explained in a way you get it!

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[–] **BedtimeWithTheBear** 5 Punkte vor 7 Tagen

What I got from it is that traditionally it's easy (easy being a relative term) to change any one property of a subatomic particle. This new theoretical discovery means that it should be possible to tether, or couple one property with another such that in order to change property A, you also need to change property B.

Using the existing example of quantum computing, the vanishingly unlikely event of property A changing due to some random interaction introduces errors into the environment and presumably decreases overall stability of the device.

If we could take advantage of this new theory's prediction, we'd be able to take that vanishingly small likelihood of error, and make it - and I'm going to get technical here, I'm afraid - super duper vanishingly small.

Something like this is almost certainly going to have really exciting undreamed of potential applications, if we manage, as a species, to last long enough to play with it.

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[–] **AEtherSurfer** 4 Punkte vor 7 Tagen

Realize that gravity was never "explained" to you, but you were able to learn to walk, run, and jump.

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[–] **OldIlluminati** 3 Punkte vor 7 Tagen

I agree with teronna

The world's greatest minds thought Einstein was a hack when he started talking about Relativity, and Einstein thought the world's greatest minds were hacks when they started talking about quantum mechanics

Different levels of understanding are revealed to us at different times and whether or not you understand something right now is not indicative of your intellectual potential

If there was a, 'Godfather of Quantum Mechanics', it was arguably Richard Feynman (the Fantastic Mr. Feynman). He famously said, "anyone who is not shocked by quantum theory has not understood it". Or Neils Bohr (one of the hacks Einstein disagreed with) said, "if you think you can talk about quantum mechanics without getting dizzy, you haven't understood the first thing about it"

For a layman (I studied QM at uni) the important thing to remember is the word, OBSERVABLES. We have precious little clue about the how and why, but we can observe stuff and see what happens. When you watch TV or use your digital device it's doubtful you know very much if anything at all about how it truly works but that's OK - if you can observe it and use it then you have the same understanding as the best quantum physicist. What is happening in this experiment is that the researchers have changed the channel on the TV and are observing what they see. Their genius is knowing about many TV channels and which buttons to press on the remote control to get there

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Mehr Kommentare laden (2 Antworten)

[–] **Cronyx** 5 Punkte vor 7 Tagen

I'm still not entirely clear on what electrons *are*. Are they physical, can you touch them, or are they point abstractions of fields that don't exist in any one place nor have definable shapes or volume, etc.

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[–] **Lumpiestgenie00** 9 Punkte vor 7 Tagen

Well first you must understand the mass and size of an electron. It's so small that it does not make sense to talk about "touch" in regards to it. At length scales like that, it's more appropriate to talk about how it interacts with other things and how it can be detected. In that vein, it exhibits both particle and wave like behavior and exists as a wavefunction spread in space, like a probability density cloud. Idk it gets hard to explain, but you certainly can't touch it I'm the classical sense

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Mehr Kommentare laden (1 Antwort)

Mehr Kommentare laden (4 Antworten)

[–] **seattleandrew** 29 Punkte vor 8 Tagen

> except the electrons aren't really bound to a single electron but allowed to roam freely around the edges of the crystal

Shouldn't this say "bound to a single atom"? As in the electrons freely move from one atom in the crystal to the next.

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[–] **Ihavefourspades** 26 Punkte vor 8 Tagen

Yep, fixed.

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[–] **gentlemandinosaur** 5 Punkte vor 7 Tagen

I was under the impression that it's not the act of observation but the method of observation that causes the variance.

As in the equipment needed to observe are what actually interfere.

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[–] **cheevocabra** 2 Punkte vor 7 Tagen

Yeah, that's how I've always understood it as well. The only way we have of observing quantum objects involves stuff like hitting them with photons or manipulating electrons, which would obviously influence the things that we're trying to observe.

It's kind of like you have a Magic 8-Ball sitting upside down on a table and you want to know which side is facing up. The only way to know is to pick it up and look at what it reads. Until you do that it is in a quantum superposition of all possible outcomes and every time you try to take a reading your answer changes. I could be incorrect in my understanding though, I'm only a chemist not a quantum physicist haha.

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Mehr Kommentare laden (1 Antwort)

[–] **Picklebeer** 3 Punkte vor 7 Tagen

Now explain like I'm five, please

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[–] **ShallowSleip** 2 Punkte vor 7 Tagen

Okay, now explain like I'm five.

Permalink embed Speichern Übergeordnet melden antworten

Mehr Kommentare laden (28 Antworten)

[+] ***Comment removed*** *vor 8 Tagen* (22 Kinder)*

[–] **Tymalic** 10 Punkte vor 8 Tagen*

I'll give it a try. So there are materials that function on a quantum level. We can take what is essentially a mechanical advantage and apply that to micro technology or quantum computing. With these protected states, it provides what is essentially another tool to engineer with. Obviously, there's a ton more to this, but it's an ELI5

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[–] **MarvinLazer** 3 Punkte vor 8 Tagen

What do you mean by "function?" Do they just do weird things when you look at them on quantum scales?

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[–] **Ihavefourspades** 12 Punkte vor 8 Tagen

When they say "materials that function on a quantum level", they are specifically referring to devices whose physical dimensions are small enough that the effects from the individual atomic particles become important. These are confinement effects, one of the few terms in physics that actually means what it seems it means. At these atomic scales (up to a few hundred nanometers) energy levels are a complicated mess of quasi-continuous bands and discrete states and allow for extremely precise control over things like atomic motion, light emission, and light absorption. These simple things are what give rise to pretty much all of our cutting-edge technology in the past decade or so.

If you're not too intimidated by math, the simplest example of a confinement effect is the particle in a box. It's the first worked example taught in an undergraduate physics course and is the foundation of understanding all the weird stuff that comes out of quantum mechanics. Other important examples are the hydrogen atom energy levels and wavefunctions and 2D electron gas materials similar to graphene.

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[–] **Clausewitz1996** 3 Punkte vor 8 Tagen

> If you're not too intimidated by math, the simplest example of a confinement effect is the particle in a box.

I saw the first line of math and got scared. Now I am reminded of my own stupidity.

Thanks a bunch.

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[–] **kaitelweiss** 2 Punkte vor 8 Tagen

What is meant by a “protected” state?

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[–] **Ihavefourspades** 7 Punkte vor 8 Tagen

These are states that can only change if one or more other states also change simultaneously. The protected state and it's "protectors" usually rely on fundamentally different physical processes, meaning it's highly unlikely for them to both happen randomly at the same time compared to how often they happen on their own. However, we can easily make these things happen at the same time if we want to, allowing us to control the protected state really well.

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Mehr Kommentare laden (2 Antworten)

[–] 137thNemesis 2 Punkte vor 8 Tagen

You have an electromagnetic corkscrew. Sort of.

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Mehr Kommentare laden (14 Antworten)

[–] fuckedbymath 23 Punkte vor 8 Tagen

Great explanation.. you should be a teacher.

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[–] Ihavefourspades 32 Punkte vor 8 Tagen

This is actually the example that most professors familiar with the field use. Not sure where it originally came from, but I've heard it from my thesis advisor and a couple other professors in the department.

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[–] Matasa89 3 Punkte vor 7 Tagen

Hah, I knew it! You're not just some nerd!

Spill, which university or state department do you research at?

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[–] Ihavefourspades 7 Punkte vor 7 Tagen

I'll just say it's a university and leave it at that.

Permalink embed Speichern Übergeordnet melden antworten

[–] Matasa89 3 Punkte vor 7 Tagen

So secretive, doc. What are you trying to hide...

Good information though, hopefully this will laid the groundworks for future room-temperature superconductor... or at least something easier to use.

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[–] Dlrlcktd 5 Punkte vor 8 Tagen

Is it an edge in the classical sense? Like how metals form an oxide layer on their edge? Or is this some quantum Mumbo jumbo where "edge" means something else?

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[–] Ihavefourspades 16 Punkte vor 8 Tagen

In my example I'm referring to an honest-to-God physical edge. It comes from the fact that the energy bands in the solid have to somehow transition to the allowed energy states outside of the solid in some way that jives with the equations that govern this transition.

But in other topological materials, it doesn't have to refer to a physical edge state at all. It can refer to any number of far more complicated things involving some wacky particle stuff.

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Mehr Kommentare laden (1 Antwort)

[–] **DiogenesCane** 3 Punkte vor 8 Tagen

Why didn’t you talk about topology at all in your answer? Its the first word in the name. Is its name a misnomer?

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[–] **Ihavefourspades** 10 Punkte vor 8 Tagen*

Explaining that goes off into the weeds and “intuitive” explanations there would just confuse the main consequence of these materials and why they are exciting.

The topology comes into the nitty-gritty details of the energy band structure of the solid, where the allowed transitions depend on rules and equations that come from a topological treatment of the band structure. It’s purely mathematical and the typical explanations of donuts and holes that you hear with topology don’t make intuitive sense in this context.

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[–] **[deleted]** 6 Punkte vor 8 Tagen*

Topology is used in a really abstract way here, way up the mathematical machinery. The reason why it's significant is that topology used to be very rarely used in quantum physics. One of the researchers just came up with the idea of using it for a particular material, and it worked really well.

I've been explained that in the intuitive sense, topology (number of holes -> so essentially, states that are completely discrete because there are no "half-holes") here has - very vaguely - to do with the discreteness of some of the properties of topological materials. I'm not far enough into either QM or topology that I could completely understand this, but the pop science poster I saw explained it this way.

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Mehr Kommentare laden (1 Antwort)

[+] ***Comment removed*** *vor 8 Tagen (1 Kind)*

[–] **unfair_bastard** 2 Punkte vor 8 Tagen

What do you mean by protected in this context?

Permalink embed Speichern Übergeordnet melden antworten

[–] **Ihavefourspades** 8 Punkte vor 8 Tagen

By protected states I mean states that can only change if one or more other states also change simultaneously. The protected state and it's "protectors" usually rely on fundamentally different physical processes, meaning it's highly unlikely for them to both happen randomly at the same time compared to how often they happen on their own. However, we can easily make these things happen at the same time if we want to, allowing us to control the protected state really well.

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[–] **dontcareaboutreallif** 2 Punkte vor 7 Tagen

Anywhere I can read about this from a topologists viewpoint? I'm doing a PhD in algebraic topology but have little background in physics.

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[–] **Ihavefourspades** 3 Punkte vor 7 Tagen

This is a succinct review of the physics behind a certain class of these materials. Physicists wrote it, however. I don't know of any good written perspectives from a topologist, sorry. This actually isn't my field, I look at defects in solids.

https://arxiv.org/pdf/1509.02295.pdf

This one is more math-y, to the point where it goes way beyond what I'm familiar with. Still mathematical physics, though.

https://arxiv.org/pdf/1607.04013.pdf

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Mehr Kommentare laden (2 Antworten)

[–] **Killerhurtz** 2 Punkte vor 7 Tagen

If I'm interpreting this correctly, then this must have MAJOR implications for quantum computing (among other things), am I wrong?

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[–] **Ihavefourspades** 3 Punkte vor 7 Tagen

Yes, it's massive. These types of materials are ideal candidates for quantum memories.

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Mehr Kommentare laden (1 Antwort)

[–] **singham** 2 Punkte vor 7 Tagen

I want a Vsauce or Verisatium video on this topic. Neat stuff that you have explained. This restores my faith in humanity exploiting the nature's law further for our progress. I thought that ending of Moore's law is the end of the rapid progress we have had till now. But this changes that. Thanks!!!

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Mehr Kommentare laden (44 Antworten)

[–] **roundedge** 25 Punkte vor 8 Tagen

Suppose you had a very long hose that someone had not put away, and it was wound around your house in a complicated way. You know that if you were to grab the end of the hose and start coiling it up, you would have to walk fully around your house a particular number of times depending on how the hose was wound around the house. But by looking at any single side of the house it is impossible to tell what that number is. Maybe the hose doubles back on itself somewhere on another side of the house that you can't see. You have to look at every single side of the house in order to decide how many times you will have to walk around the house to coil up the hose. So the information about the number of windings is hidden from you.

Now if you remember Schrodinger's cat you will know that quantum mechanics says that things can be in superpositions of completely distinct states, like a cat being in a superposition of alive and dead, and that the superposition collapses only when you get information about which of those distinct things is the case.

So imagine your hose was not just a regular hose, but a Schrodinger's hose, and it was in a superposition of the number of windings. If you were to look at any single side of the house certain winding numbers would look exactly the same to you, so if they were in a superposition, you would not collapse it, since you would get no information about the winding number. Only by looking at every single side of the house do you discover which winding it is, and do you collapse the superposition. This is a topologically ordered quantum system. The number of times a hose winds around a house is a topological property, because nothing you do locally to the hose will change or reveals its winding number, you have to do something about the WHOLE arrangement of the hose.

Topological quantum materials are materials that have something analogous going on with their constituent parts, like its electrons for example. Interactions between the material and the rest of the world are usually local. If neighbourhood kids kept trying to un-wind your hose by just running up to one side of the house and pulling and tugging at it they would not succeed. They need to all coordinate on all sides to unwind the hose, and they just aren't that smart. Similarly, nature isn't coordinated enough to collapse certain kinds of superpositions in a topological quantum material, so the superpositions are protected. This makes topological quantum materials very good candidates for qubits!

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[–] **learunxday** 3 Punkte vor 8 Tagen

so what is the trick of making these topological ordered quantum system?

How can the spin of one electron be dependent on an assemble of other electrons?

Permalink embed Speichern Übergeordnet melden antworten

[–] **roundedge** 7 Punkte vor 7 Tagen

The trick to making the systems topologically ordered is to have their natural state be a superposition of states that are locally indistinguishable, but globally distinct.

It doesn't necessarily have to relate to the spin of the electron. Maybe an easier case to consider is the number of electrons in the system. In particular the evenness or oddness of the number of electrons. The only way to tell if the number of electrons in a system is even or odd is to count every last one of them. So no local measurements can tell you. However under most circumstances the number of electrons is fluctuating as it interacts, and so the evenness or oddness of the system is not preserved. But if you were to somehow ensure that electrons could only move in and out of the system in pairs, then the evenness or oddness of the system would be preserved and it would have the potential to exhibit topological order. If I understand correctly, this is pretty much what is going on when people talk about "Majorana Fermions" on nano-wires.

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[–] **easyfeel** 4 Punkte vor 7 Tagen

Imagine ripples on a pond and how they create patterns on the surface of the water. The bigger waves are the atomic particles. What these guys found is a way of bending the pond so that you can have new types of waves.

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Mehr Kommentare laden (17 Antworten)

[–] **hughnibley** 117 Punkte vor 8 Tagen

This looks really exciting, but I must admit to being a complete lay-person where this is concerned.

Any physicists who wouldn't mind weighing in on the significance of this?

Permalink embed Speichern melden antworten

[–] **Tymalic** 215 Punkte vor 8 Tagen*

The applied significance of this could be a material capable of room temperature (high heat) super conductance or perhaps a material that doesn't require a near absolute zero temperature. What a super conductor is, is a material that conducts with no resistance, thus there is no loss (mostly thermal), without this loss it frees up a ton of engineering hurtle that I cannot even begin to explain, but for the layman super conductors are used for things like magnetic trains, nuclear power plants, and as far as my field goes- there's a ton of applications for Josephson Junction based circuits (these are devices that can be used to measure things to a great deal of percision like SQUIDs which are used for sensing magnetic fields).

So having a room temperature super conductor could lead to massive miniaturization, perhaps even more complex single atom transistors, and so many more things. With miniatuization comes the capability for more complexity, in general. This could be the next big step for technology since the transistor.

Edit: SQUIDs not SQUIBs

Permalink embed Speichern Übergeordnet melden antworten

[–] **MrIncognitoFace** 127 Punkte vor 8 Tagen

This could also lead to consumer grade quantum computers, because it would make having quantum computers without a cryostat feasible. Not only this, but as stated by Tymalic, sensor technology would be advanced significantly. For example, MRI scanners could be miniaturized to a fraction of their current size, because most of the MRI scanner is insulation to cool the electromagnetic coil within to superconducting temperatures. This would revolutionise the health industry. The energy industry would be overturned as well. A room temperature superconductor could be used in power lines, eliminating virtually all power losses. If scientists find a room temperature superconductor, it will change the world more than the invention of the transistor did.

Permalink embed Speichern Übergeordnet melden antworten

[–] **AFlyingMexican5** 20 Punkte vor 8 Tagen

What are the chances of something like this?

Permalink embed Speichern Übergeordnet melden antworten

[–] **aboba_** 68 Punkte vor 8 Tagen

We don't know if it's possible, but at the same time, we don't know it's not possible either.

Permalink embed Speichern Übergeordnet melden antworten

[–] **Nekzar** 43 Punkte vor 7 Tagen

That sounds like superpostition!

Permalink embed Speichern Übergeordnet melden antworten

[–] **n3rv** 3 Punkte vor 7 Tagen

If I was a betting man, I'd put my money on possible.

All the out shit that has come out of science fiction, makes me feel like it's a good bet.

Permalink embed Speichern Übergeordnet melden antworten

Mehr Kommentare laden (2 Antworten)

[–] **zweifaltspinsel** 3 Punkte vor 7 Tagen

If such supeconductors exist, their cost are also important, when we talk about widespread applications. But it is going to be a game changer nonetheless.

Permalink embed Speichern Übergeordnet melden antworten

[–] **WerewereTheWerewolf** 3 Punkte vor 7 Tagen

Cost would decrease with economies of scale - unless there is some fundamental physical reason against it. What do you mean?

Permalink embed Speichern Übergeordnet melden antworten

[–] **zweifaltspinsel** 3 Punkte vor 7 Tagen

> unless there is some fundamental physical reason against it. What do you mean?

There could be either a bottle neck in production - i.e. a necessary step in production that cannot be easily scaled - or certain elements/compounds are scarce - i.e. if we needed elements such as indium etc.

I guess in that case, using these supeconductors for landlines could still be too expensive.

Permalink embed Speichern Übergeordnet melden antworten

[–] **WerewereTheWerewolf** 3 Punkte vor 7 Tagen

Yeah, I suppose thats true. But if you look at the history of production in general those bottlenecks usually get worked out over time. Since we are talking about currently novel physics then I think your argument has some merit, but of course there have been novel physics in past that were though to be impossible to scale and that turned out to be not the case. I'm not trying to argue that you are incorrect, you raise good points.

Permalink embed Speichern Übergeordnet melden antworten

[–] **zweifaltspinsel** 3 Punkte vor 7 Tagen

No problem! It just reminded me a little bit of those 1950s ads, where they dreamed of having nuclear powered cars and motor cycles.

Still exciting stuff.

Permalink embed Speichern Übergeordnet melden antworten

[–] **Nanemae** 7 Punkte vor 8 Tagen

Wait, is that what the cooling effect is for, preventing an accidental change in momentum? If that's true, then dang this is a big possibility.

Permalink embed Speichern Übergeordnet melden antworten

[–] **Blue_Pie_Ninja** 6 Punkte vor 7 Tagen

I assumed the cooling was to make it work and not melt everything around it

Permalink embed Speichern Übergeordnet melden antworten

[–] **_riotingpacifist** 10 Punkte vor 7 Tagen

Both are the same thing, an accidental change in momentum, would heat the atoms involved up.

A super conductor is **just** a material capable of having fields which gently guide electrons rather than "guide" them "dodgem style"

Permalink embed Speichern Übergeordnet melden antworten

[–] **daftqunt** 3 Punkte vor 7 Tagen

The cooling is to make it work because it needs to be Dang cold. It doesn't generate much heat.

Permalink embed Speichern Übergeordnet melden antworten

Mehr Kommentare laden (1 Antwort)

Mehr Kommentare laden (23 Antworten)

[–] **Neko-sama** MS | Systems Architecting and Engineering 15 Punkte vor 8 Tagen

One of the biggest applications for room temperature superconductors is to eliminate loss on transmission lines. A significant portion of energy is lost when "moving" (AC current doesn't so much as move as wiggle really fast back and forth) current from places where power plants are (less populated, undesirable land) to where people actually live. This also opens up putting large solar farms in deserts and transferring the energy to cities. It's currently not really economical viable or really feasible to build a massive solar farm in the Sahara where the sun typically cloud free and power all of Europe off it (mainly due to line losses). Room temperature superconductors make that all possible. (provided they can be made cheaply enough). Just because something is technically possible doesn't mean it's economical possible, but that's a different issue than what's presented here.

Permalink embed Speichern Übergeordnet melden antworten

[–] **luckyme888** 2 Punkte vor 7 Tagen*

I thought long range lines are DC cables? With high enough voltage you have relatively little power loss over long distances?

Since there has not really been a need for such long range lines, most are AC, but with solar you see increasingly (especially in China) DC lines being built.

The largest cost would still be material. Not to speak of having a thousand km line of this complicated material in a AC line would not be cheap either.

https://en.wikipedia.org/wiki/Ultra-high-voltage_electricity_transmission_in_China

Permalink embed Speichern Übergeordnet melden antworten

[–] **Tymalic** 10 Punkte vor 8 Tagen

For clarification on SQUIDs...tons of things produce magnetic fields, those fields can decay overtime and have different aspects based on what is producing said field... So like a cow or your own brain. Just for the sake of encouraging interest (something I think modern science education fails to do). If these circuits are made compact enough with ample power handling, they could be used to produce incredible sensors that aren't just accurate, but detailed. Imagine Star Trek sensors, they can scan for lifeforms, run a scanner over someone's body and give an instant diagnosis, or the most realistic application would be cheaper hyper quality control testing devices which is not as sexy, but definitely the most beneficial as it could effect the cost of everything else and ultimately lead to more advanced and high quality consumer products.

Permalink embed Speichern Übergeordnet melden antworten

[–] **foxmetropolis** 9 Punkte vor 7 Tagen

And yet again, here we would see a pure deep theoretical science yield a practical, world-changing result.

For anybody reading, this is why pure science grants are important. If you only fund leads that seem likely to benefit industry, you hamstring yourself. Pure science takes time to pay off, but having a strong understanding reality's underpinnings slowly builds up our ability to do more and more amazing things

Permalink embed Speichern Übergeordnet melden antworten

[–] **ThePnusMytier** 6 Punkte vor 7 Tagen*

This would be a bigger paradigm shift than the invention of the laser and its tie to the semiconductor... bringing in the digital age and the complete shift in how we process data and interact with the world. Their initial discovery couldn't have possibly predicted the broad reaching impact they would have, and their ubiquity in such a huge diversity of applications, but initially they were just found through theoretical science. Obviously agreeing with you here, but I just want people to see how immense the magnitude of something like this could be

Permalink embed Speichern Übergeordnet melden antworten

[–] **foxmetropolis** 2 Punkte vor 7 Tagen*

Absolutely. You simply never know when an abstract scientific field will suddenly change your day to day life. Another great example: the gps systems your cell phone uses right now. Your phone gps enables your phone to do everything from give you travel directions, to tagging your selfie locations, to finding your closest nearby singles on tinder/grindr - and *that* gps network *requires* Einstein’s relativity equations to function properly, to account for time dilation for satellites.

Here’s a theoretical, mathematical, abstract physics theory that at the time of its inception would have been considered useless, totally inapplicable to day-to-day life. And yet now, thanks to Einstein’s contribution to modern tech, you will almost never be lost.

Permalink embed Speichern Übergeordnet melden antworten

[+] ***Comment removed*** *vor 8 Tagen (5 Kinder)*

Mehr Kommentare laden (9 Antworten)

[–] **MaxThrustage** Grad Student| Physics 28 Punkte vor 8 Tagen

To add to /u/Tymalic's answer: it's not *just* about applications. A lot of physics is done just because we want to understand the world around us. High-temperature superconductivity was discovered in the 80s, and since then no one has able to fully explain why (the standard model of superconductivity predicts that they should not be superconducting at those temperature).

In trying to understand this huge mystery, the scientists in the article have potentially discovered a whole new type of material - not a superconductor, but something else with some of the same properties. Finding out exactly what matter can and can't do can be exciting and interesting from a fundamental point of view - similar to scientists finding new cosmological phenomena or new species of animal. Maybe not *useful*, but interesting.

Of course, discovering new kinds of materials has the added benefit that it may *also* be useful. A group I'm involved with is looking for new materials for low-energy electronic transport - we hope to be able to build low-loss circuits that could be used in computers (which currently consume 10% of the world's electricity). Other groups are looking for new materials that may be used for quantum information, for transforming and processing light, for use as sensors... but we never know what a material may be useful for until we explore and understand it.

Permalink embed Speichern Übergeordnet melden antworten

[–] **olive_tree94** 8 Punkte vor 8 Tagen

I would say that the application is always important, but it's impossible to tell now. This might lay the ground for the inventions of the 21th century. There are many cases where scientistist/mathematicians were just playing around and discovered something that ended up being huge much later on. Electricity was just an intellectual curiosity for millennia before the late 19th century saw the rapid advancement of electrical engineering. Euler created graph theory (a huge field in Computer Science) when he tried to solve the Bridges of Königsberg problem just for fun.

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[–] **MaxThrustage** Grad Student| Physics 8 Punkte vor 7 Tagen

I get what you're saying, but I don't really agree. The applications are often there, but they're not always the *point* of the research, and the research is still valuable even if it is never useful. Graph theory may happen to be useful, but even if no one ever bothered to find an application it would still be worthwhile, because it has given us some of the most beautiful and ingenious proofs in mathematics. There are plenty of pieces of maths and science that as of yet have no practical application, and some of them may never get a practical application, but that's almost besides the point.

(But, of course, we do need to worry about practical applications as well. Science is expensive, and it would be nice if we could justify that expense with more than just curiosity and good vibes.)

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Mehr Kommentare laden (3 Antworten)

[–] **theRealRedherring** 136 Punkte vor 8 Tagen

In a new study due this week in the Early Edition of the Proceedings of the National Academy of Sciences (PNAS), Rice University theoretical physicist Qimiao Si and colleagues at the Rice Center for Quantum Materials in Houston and the Vienna University of Technology in Austria make predictions that could help experimental physicists create what the authors have coined a “Weyl-Kondo semimetal,” a quantum material with an assorted collection of properties seen in disparate materials like topological insulators, heavy fermion metals and high-temperature superconductors.

All these materials fall under the heading of “quantum materials,” ceramics, layered composites and other materials whose electromagnetic behavior cannot be explained by classical physics. In the words of noted science writer Philip Ball, quantum materials are those in which “the quantum aspects assert themselves tenaciously, and the only way to fully understand how the material behaves is to keep the quantum in view.”

These quirky behaviors arise only at very cold temperatures, where they cannot be masked by the overwhelming forces of thermal energy. The most celebrated quantum materials are the high-temperature superconductors discovered in the 1980s, so named for their ability to conduct electrical current without resistance at temperatures well above those of traditional superconductors. Another classic example is the heavy fermion materials discovered in the late 1970s. In these, electrons appear to be effectively hundreds of times more massive than normal and, equally unusual, the effective electron mass seems to vary strongly as temperature changes.

Permalink embed Speichern melden antworten

[–] **sunnysider** 29 Punkte vor 8 Tagen

Ceramics?

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[–] **Ihavefourspades** 53 Punkte vor 8 Tagen

Pretty much every high-temperature superconductor that’s being researched is a ceramic material, usually cuprates or iridates.

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[–] **potpourris** 1 12 Punkte vor 8 Tagen

high-temperature superconductors operate at what temperatures?

Permalink embed Speichern Übergeordnet melden antworten

[–] **Ihavefourspades** 35 Punkte vor 8 Tagen

The current record holder seems to be sulfur hydridge at 190 K (-83 C, -117 F, but this is at extremely high temperatures and sulfur hydride is a pain to work with safely.

Cuprates are much safer to work and hold the #2 spot at [133 K (-140 C, -220 F)[http://www.sciencedirect.com/science/article/pii/037596019491026X] at ambient pressures.

As a point of comparison, liquid nitrogen is 77K and dry ice is 194K. Liquid helium, which is used to reach temperatures for "conventional" superconductivity, is 4K. However, 4K is still not low enough, and dilution fridges are used to bring the temperature down to a few tens of milli-Kelvin, where most easily fabricated superconductors actually become superconducting.

Ideally we want one that operates at room-temperature, but that's a ways off. We have candidates, but they're currently being studied.

Permalink embed Speichern Übergeordnet melden antworten

[–] **barsoap** 18 Punkte vor 7 Tagen

Ideally we want some that operate at up to what 500C or such. Then we can build water-cooled fusion reactors.

Permalink embed Speichern Übergeordnet melden antworten

Mehr Kommentare laden (2 Antworten)

[–] **Kellyanne_Conman** 4 Punkte vor 7 Tagen

So, what you're talking about is the critical temperature (Tc) of the superconductor. This is the temperature at which superconductivity fails when it isn't subjected to zero field and zero current. This is NOT the temperature at which superconductors "operate." They operate in a space that's defined by 3 things, and the relations between them: the critical current, the critical temperature, and the critical field. The difference between some high and low superconductors can be seen here. Note that they can superconduct at higher temperatures, sure, but they also can maintain their state at much higher fields as well... Some in the community have even argued that they are better termed "high field superconductors."

The most widely used superconductors are low temp superconductors (NbTi and Nb3Sn). Their critical temperatures are ~10 K and ~18 K respectively, but they operate at 4.2 K (the temperature of liquid He) because their critical currents at higher temperatures are very low, and not useful... The colder, the better... this means higher currents and fields.

I work in applied superconductivity, and we deal mainly with magnet tech. We like high currents and fields, so we operate at low temperatures... That means 4.2 K. YBCO, Bi-2223, and Bi-2212, the three most widely used (or most promising) HTS cuprate materials generally operate at 4.2 K. Bi-2212 and Bi-2223, even at 77 K, are almost useless even though their Tcs are > 90 K because their critical currents drop off significantly at temperatures above ~30 K. YBCO is really the only superconductor that can feasibly operate at 77 K (the temperature of liquid N2).

TL;DR Superconductors *do not* **operate** at their critical temperatures. That's just the highest temperature where superconductivity can feasibly exist. At these high temps, even "high temp superconductors" aren't all that useful.

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Mehr Kommentare laden (2 Antworten)

[–] **theRealRedherring** 16 Punkte vor 8 Tagen

I was surprised also... apparently ceramics have quantum properties.

Permalink embed Speichern Übergeordnet melden antworten

[–] **CosineDanger** 52 Punkte vor 8 Tagen

Everything has quantum properties. This just has new and different quantum properties.

Permalink embed Speichern Übergeordnet melden antworten

[–] **theRealRedherring** 4 Punkte vor 8 Tagen

good point but I was refering to the point of the article that says

> materials whose electromagnetic behavior cannot be explained by classical physics

I was surprised that ceramics was included. figuring ceramics as molecules and not elements. I'm not saying I'm a physicist here, just that it is stranger than normal for me. I'm curious if others know more about it.

Permalink embed Speichern Übergeordnet melden antworten

[–] **MaxThrustage** Grad Student| Physics 13 Punkte vor 8 Tagen

Being more elemental isn't going to make something more quantum. Most of the high-Tc superconductors are actually quite complex in their structure.

But, if the definition is just "materials whose electromagnetic behavior cannot be explained by classical physics" you should include basically all solids.

Permalink embed Speichern Übergeordnet melden antworten

[–] **daniel_h_r** 2 Punkte vor 7 Tagen

You can make semiclassical models to explain roughly the properties of any common material. For this quantum materials this is impossible. You can make models, but then need take quantum mechanics from start to work.

Permalink embed Speichern Übergeordnet melden antworten

[–] **CosineDanger** 24 Punkte vor 8 Tagen

I really don't like how the article worded that. Your screen is probably based on LEDs which rely on a (quantum) bandgap. Same with solar panels, and really most things if you take them apart and look at them closely enough.

Basically "electromagnetic behavior which cannot be explained by classical physics" is a crock of shit. This is bad science journalism.

Permalink embed Speichern Übergeordnet melden antworten

Mehr Kommentare laden (2 Antworten)

[+] ***Comment removed*** *vor 8 Tagen (2 Kinder)*

Mehr Kommentare laden (2 Antworten)

[–] **_ahnomatopia_** 16 Punkte vor 8 Tagen

Does anyone (including the authors) know what this new material could be used for? I read the article, but I definitely missed a lot.

Permalink embed Speichern melden antworten

[–] **MrIncognitoFace** 41 Punkte vor 8 Tagen*

New types of quantum computers, and possibly nanotechnology. Oh yeah, and lossless power transfer.

Permalink embed Speichern Übergeordnet melden antworten

[–] **expendablethoughts** 7 Punkte vor 7 Tagen

But would lossless power transfer actually be useful when you need an extremely expensive material to do it with?

In Québec, we use aluminum wires to bring the power from hydroelectric power plants up North to big cities, bring it up to hundreds of thousands of volts with low amperage, and then transform it to lower voltage with higher amperage. We use the fourth best conducting metal as it's cheaper than gold, silver and copper and doesn't corrode, or at least not as easily.

So I guess my question is, would a superconductor corrode? Would the material degrade in any way the way metals do when they transfer electrons for a very long period of time? Could this be done for cheap?

And wouldn't simply doing a dual connection with a say, -15° superconductor for the winter (that still conducts alright past that point, although a little less perfectly, I presume?) and another metal for the summer? Winter is when we use more electricity here, so it would make sense that the system be better in the winter at least.

Or is that all just for proof of concept and very specific applications, ie replacing gold in electronics?

Permalink embed Speichern Übergeordnet melden antworten

[–] **tuctrohs** 3 Punkte vor 7 Tagen

> We use the fourth best conducting metal as it's cheaper than gold, silver and copper and doesn't corrode, or at least not as easily.

Cheaper than all three.

Corrodes more than gold, but less than copper and silver.

And, importantly, it's a lot lighter than the others, which matters if you want to hang it overhead. A steel core is also used to help make that possible, as pure aluminum isn't very strong.

But in any case, I think long-distance overhead power transmission lines would not be the first places it would be used. For example, it would get used in transformers, and in power distribution in congested areas (e.g. underground in cities) where there are more space constraints.

Permalink embed Speichern Übergeordnet melden antworten

[–] **expendablethoughts** 3 Punkte vor 7 Tagen

Yes, gold doesn't corrode, my bad lol

Permalink embed Speichern Übergeordnet melden antworten

Mehr Kommentare laden (1 Antwort)

[–] **MrIncognitoFace** 2 Punkte vor 7 Tagen

Yes. Spot on. Not only this, but I presume that this could be used in communications as well, as there would be no to little signal loss. Correct me if I am wrong though.

Permalink embed Speichern Übergeordnet melden antworten

[–] **MrIncognitoFace** 3 Punkte vor 7 Tagen

I understand what you're saying, and yes, in reality a room temperature superconductor would probably not be used in transmission lines. But they could be used in power substations and in transformers, making them safer due to much less energy loss to heat, along with making them extraordinarily efficient. Transportation could be revolutionized, because room temperature superconductors could be used in Maglev trains and be used to make AC and DC motors much more powerful.

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[+] ***Comment removed*** *vor 8 Tagen (1 Kind)*

Mehr Kommentare laden (3 Antworten)

Mehr Kommentare laden (2 Antworten)

[–] **SnowyNW** 26 Punkte vor 8 Tagen

Its articles like these that make me feel like a kid just learning about things like the universe again.

Permalink embed Speichern melden antworten

[–] **litritium** 15 Punkte vor 7 Tagen

I am just happy when i read about succesful US-European science teamwork. That's where the future is at. More collaboration between our amazing scientists.

Permalink embed Speichern Übergeordnet melden antworten

[–] **busetgadapet** 11 Punkte vor 8 Tagen

what a good timing after pentagon revealed that they found material not known to scientist

Permalink embed Speichern melden antworten

[–] **lotus_bubo** 8 Punkte vor 7 Tagen

Wait what? I searched for this to dismiss it and found an oddly high number of moderately reliable articles talking about it.

There's a lot left out of the story here. How did they get from, "here's a video of a weird jet incident," to, "oh yeah we have some material of unknown origin lol."

Permalink embed Speichern Übergeordnet melden antworten

[–] **busetgadapet** 2 Punkte vor 7 Tagen

exactly what I thought as well, that's escalated way too quickly

Permalink embed Speichern Übergeordnet melden antworten

Mehr Kommentare laden (1 Antwort)

[+] ***Comment removed*** *vor 8 Tagen* (7 Kinder)*

[–] **CompMolNeuro** Grad Student|Neurobiology 4 Punkte vor 8 Tagen

Could we have an engineering perspective eli5? Are they trying to say that this material could be vastly superior in electromagnetic conductive properties?

Permalink embed Speichern melden antworten

[–] **tuctrohs** 3 Punkte vor 7 Tagen

I gather that this is a step forward in understanding the science of superconductors which could enable future advances in practical materials. I think it's way to early to say whether those would have engineering applications.

Permalink embed Speichern Übergeordnet melden antworten

[–] **c0gsw3ll** PhD | Chem Eng | Nanotechnology | The Mad Scientist Podcast 6 Punkte vor 7 Tagen

Did I completely misread this, or did they state that they found a spin state for the material where quantum particles went from having 1000x electron mass to zero?

Permalink embed Speichern melden antworten

[–] **omegashadow** 4 Punkte vor 7 Tagen

Quasi particles; a propagation that is modelled as a particle. The propagation is massless.

Permalink embed Speichern Übergeordnet melden antworten

Mehr Kommentare laden (1 Antwort)

[–] **Lokipi** 2 Punkte vor 7 Tagen

Quasi particle, not quantum particle. The terminology is super confusing I know. Essentially this material has a high degree of coupling and confinement for electrons which increases their mass while in that state.

So when this metastable state collapses we lose all the extra mass as the electrons cease being coupled and confined.

Permalink embed Speichern Übergeordnet melden antworten

[–] **Wulfyn_** 4 Punkte vor 7 Tagen

A few years ago I watched this TED talk about Quantum Locking, and being able to use a superconductor to levitate many times its own weight above a magnetic track. It worked because the quantum field was locked so it took more energy to overcome the locked state than the force of the weight was able to provide.

The downside was that they had to use liquid nitrogen to keep it cool enough to work (i.e. be a superconductor).

https://www.ted.com/talks/boaz_almog_levitates_a_superconductor#t-88041

Would the technology in this report be able to use high-temperature superconductors for this as well?

Permalink embed Speichern melden antworten

[–] **MaxThrustage** Grad Student| Physics 2 Punkte vor 7 Tagen

Liquid nitrogen *is* high-temperature when it comes to superconductors. This is as opposed to more conventional superconductors, which require liquid helium temperatures.

The article is not really talking about superconductivity, but rather a proposed new kind of material that could carry a current without any resistance. But to get quantum locking you need the Meissner effect (repelling magnetic fields) and vortex pinning, which to my knowledge you only get with superconductors.

Permalink embed Speichern Übergeordnet melden antworten

Mehr Kommentare laden (2 Antworten)

[–] **bearlolzzx** 5 Punkte vor 8 Tagen

interesting this has applications in computing for sure

Permalink embed Speichern melden antworten

[–] **MrLostAtSea** 5 Punkte vor 8 Tagen*

Topological quantum materials? Sounds similiar to the "surface tension" property of water.

Permalink embed Speichern melden antworten

Mehr Kommentare laden (1 Antwort)

[+] ***Comment removed*** *vor 7 Tagen (1 Kind)*

[–] **yokothespacewhale** 3 Punkte vor 7 Tagen

these guys look like they're about to

DISRUPT AN INDUSTRY

Permalink embed Speichern melden antworten

Mehr Kommentare laden (99 Antworten)