Science AMA Series: We are quantum technology researchers from Switzerland. We'll be talking about quantum computers, quantum entanglement, quantum foundations, quantum dots, and other quantum stuff. AMA!

QSIT$_{R}esearchers^{1}andr/ScienceAMAs^{1}$

[1]Affiliation not available

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I apologize for coming to this as a programmer rather than a physicist, but I hope you can still answer some questions for me:

Do you think quantum computing will ever be available to consumers? If so, how far out is it? And based on how they work, what would be some of the implications of that?

I've also heard that quantum computers work quite differently than the ones we use today. Would we need to dramatically change the way we approach problems in programming in order to see the benefits of the new technology?

Muffinizer1

I've also heard that quantum computers work quite differently than the ones we use today. Would we need to dramatically change the way we approach problems in programming in order to see the benefits of the new technology?

I thought someone would ask something like this, so I just bashed out the following. Other people have done work on this and know more than I do, as you can see in Lidia's comment . But here are my insights.

A universal quantum computer would be universal, meaning it can do anything. It could run any program ever written. You'd just need a quantum compiler. So for something as non-quantum as "Hello World!", you'd just write it in your favourite programming language. The quantum compiler would then prepare as many qubits as you need bits to represent "Hello world!" in binary, and set them to be 0 or 1 as needed.

For a truly quantum program, the language would have to deal with two important issues: multiple bases and coherence.

The first means that you can ask a qubit whether it is 0 or 1, just as you can a bit. But you can also ask it if it + or -. These represent two possible ways that you can have a superposition of 0 and 1. + and -

are as different from each other as 0 and 1 are. So it makes just as much sense to do your computations with + and - as it does 0 and 1. A quantum computer can even use a mixture of the two. And there are infinitely many possible pairs of states just like 0 and 1, or + and 1.

One note on this. 0 and 1, and + and 1, are what's known as complementary bases. This means that knowing exactly what the qubit is doing with one, means you have no idea about the other. This is due to Hiesenberg's well known uncertainty principle. So you could have something like

if (x==0) {

do stuff

{

or something like

if (x==+) {

do stuff

{

but not

if ((x==0)&&(x==+)) {

do stuff

{

While we are on the subject of if statements, let's move on to coherence. If you have bits x and y in a normal computer, you can have something like

if (x==0) {

do stuff to y

{

This quite unambiguously means that the computer is to look at x, see if it is 0, and do stuff to y if so. But if the computer is quantum, and x and y are qubits, there's two ways to do this.

One is the same as the classical way: measure x, and either do something or nothing to y depending on the result. If x was initially in a superposition of 0 and 1, the measurement destroys it.

The other is to make x and y interact with each other, in a way that makes the stuff happen to y only if x is 0. If you do it right, and x was initially a superposition of 0 and 1, you'll end up with a more complicated superposition. It will be a superposition of x=0 and y with stuff done to it, and x=1 and y without stuff done. The two will end up entangled. And you don't get that in a normal computer.

So a quantum programming language will have to specify when you want your superpositions preserved, and when you want to measure them away.

- James

Edit: i cant spel

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Muffinizer1

You can already try out IBM's 5-qubit quantum processor. LdR

Thank you for doing this AMA, my question is in your expert opinion what do you think will be the biggest breakthrough in your field within the next 10 years? Thanks! ... Have a great day

sorebiceps

The discovery of a way of building a quantum computer with semiconductor devices which can be scaled up from a few qubits (as we have now) to many that can talk to each other without being too noisy.

Prof Warburton

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sorebiceps

Also: efficient, secure and cheap quantum cryptography devices. LdR

I've read that quantum computers will easily be able to break all modern encryption. Do you believe that a quantum-safe encryption algorithm will be created *before* quantum computers are capable and available?

gizram84

There's been a lot of research on post-quantum crypto. It's certainly possible. Lots of current cryto relies on some problems being too hard for computers (i.e., they take too long to run). Though quantum computers make some of those problems much easier to chew on, they still have their limits. So your secrets are safe with us.

James

What is your favourite book on introductory quantum information?

ttmp3

Nielsen and Chuang is, and will always be, my quantum Bible. Though it's starting to look its age.

- James

What is your favourite book on introductory quantum information?

ttmp3

Here go some resources I like (I might update this list). LdR

Books:

- Nielsen & Chuang
- Jeffrey Bub, Banana World: quantum mechanics for primates
- Schumacher & Westmoreland

Online lecture notes:

- John Preskill

Video series of lectures:

- Rob Spekkens, check out also other lecture series at PIRSA.

Is quantum x a career worth pursuing? What would the path be for different positions?

seanmerron

There are a lot of careers described as 'quantum x', from matheticians in their ivory towers to engineers up to their armpits in grease. But at the moment it typically needs a PhD, following a degree in physics, or sometimes maths or computer science, to work within our wide field of quantum teach. But there are other quantums than us.

James

How far away do you think that we are from Quantum Computers being in generic household items? (Like desktop PCs and phones and such.)

DiscoDeathmetal

Some QSIT colleagues of ours wrote this paper about quantum random number generation on a mobile phone. Not what you asked about, but it shows that our research isn't so far away from generic household items.

As for quantum computers, I can't see them becoming commonplace. The main tasks we'd use them for are scientific in nature. Like simulating chemisty and other tiny things that are too complicated for our current computers to chew on.

But they said that about normal computers, and look what happened! It all depends on whether a household application is found for quantum computers. Once that happens, someone will find a way to make one to sell to you.

- James

What's the simplest way you can explain quantum technology? And what are the likely sort term wins that we can expect from it?

Xaero13

There's lots of different strains of quantum tech, buthere's my attempt at explaining quantum computation.

James

Do you think it's possible the universe is a simulation, and if so, could quantum uncertainty be analogous to lazy computation in conventional programming? I.E. do all bits not get resolved unless something needs to know the outcome, in order to improve overall performance?

toastjam

Do you think it's possible the universe is a simulation

Certainly possible. It's also possible to think a lot about the philosophy of what is a simulation, and what is *real*

As for the rest, I can't say anything sensible now. I'll try to revisit later

James

Prof Daniel Loss and Dr Christoph Kloeffel, have Einstein-Bose condensates been verified to exist? Can we observe macroscopic quantum phenomena by analyzing them?

adeebchowdhury

Many thanks for asking. Remarkably, the answer to both questions is YES!

See for instance: https://en.wikipedia.org/wiki/Bose%E2%80%93Einstein_condensate#Gaseous

In fact, we also create Bose-Einstein condensates here in Basel (Treutlein group). A recent experiment is described here: https://www.unibas.ch/en/News-Events/News/Uni-Research/The-Atom-Without-Properties.html

Christoph

I have only a very limited understanding of quantum computing so please excuse me if this question makes no sense or is unanswerable for other reasons, but I am interested in the impact it might have in the political and social spheres.

One of the things forecast for this kind of computing is unbreakable encryption. Apart from standard research NDAs has your group come under any outside pressure to limit or direct the avenues and scope of your research?

ThatChap

I have never met anyone in the field who has felt that kind of pressure to limit the scope of their research. Some funding agencies sponsor research in specific directions (like cryptography), but all research at ETH Zurich is public, and you can see all of our papers on the arXiv, see for example here. LdR

I have one simple question. Is D-Wave Systems full of bunk? Because it claims to be a company that's *currently* selling quantum computers, and has been for at least a few years.

Cronyx

The D-Wave device is not, and was never intended to be, what we call a universal quantum computer. This would be a device that can run any program, and is what we usually mean when we talk of quantum computers. Instead it is a quantum annealer, which is a kind of computer but it solves only a limited set of (interesting and useful) minimization problems. It is certainly interesting and important work on quantum technology, though.

As a simple example of what D-Wave does, I'll refer you to this article about the building of St Paul's cathedral in London. They used the principle of Robert Hooke

as hangs the flexible line, so but inverted will stand the rigid arch

So if you want to know what shape to build an arch, just hang a rope between two points and flip that shape upside-down.

In this case, the rope is just naturally hanging in a way that minimizes its energy, given the constraints of being held at the two points. So it's solving a minimization problem and, by understanding the underlying physics, we can apply the solution of that problem to apparently unrelated things (like a cathedral)

This is what D-Wave does. It solves a lot more minimization problems, and they are very different to this, and it's a lot more complicated that a rope with a couple of posts. But I'd say the basic idea is the same.

James

To what extent do you believe quantum computing will replace conventional supercomputer clusters?

Armpitfluff

For problems that quantum computers can do more efficiently than standard ones, I believe they will replace them entirely. But there are problems that they are equally good at on paper. In reality, supercomputers will be much smaller and cheaper. So they will absolutely still be around.

James

I don't know a lot (pretty much nothing) about quantum computing. Back when news regarding D-wave quantum computers came out, there was a decent amount of lash back since their method was different from the traditional theory on how to approach creating a quantum computer, and they didn't make a "real quantum computer" or something.

Does your project work on a similar basis as theirs did, and if so will it encounter the same difficulties?

If it is different, what is different about your approach?

What do you intend to achieve with this current project?

Mephisto_fn

For the D-Wave part, see this.

Does your project work on a similar basis as theirs did, and if so will it encounter the same difficulties?

We are looking into universal quantum computers based on the circuit model. Very different aim, and very different architecture, as I hopefully explained in the reply linked above. Some of the same problems, but also some different ones.

What do you intend to achieve with this current project?

If you are asking about the Decodoku project, the aim is to find ways to do quantum error correction really well. That means solving puzzles. These are puzzles a normal computer can solve, so the quantum computer would need one bolted on the side. But we still need to tell it how to solve the puzzles. So I made the puzzles into apps, so you could all become quantum researchers and design your own algorithms.

James

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Does your project work on a similar basis as theirs did, and if so will it encounter the same difficulties?

If it is different, what is different about your approach?

What do you intend to achieve with this current project?

Mephisto_fn

The D-Wave devices are special purpose analog computers that solve certain problems using quantum effects. However so far no advantage over the best classical algorithms has been seen.

Prof Matthias Troyer

Professor Troyer is a colleague from ETH Zurich, who has done research on the capabilities of D-Wave. I contacted him specifically for the D-Wave question.

James

Completely ignorant on physics....is there a possibility of using a combination of quantum computing with biomechanics/nanotechnology to make advancements in disease/cancer research?

paladine1

One possible direction is to use quantum computers to simulate quantum systems (like molecules) efficiently, which could have applications in drug research. LdR

where does the word quantum come from? or what does it mean on its own, because it sounds pretty badass just put quantum in front of words and you have a new science quantum desks, quantum lamps, quantum toasted sandwiches

Total_Fish

It basically means an amount (like a quantum of solace). It comes from Latin, and is related to the word 'quantity'.

It started to get applied to physics when it was realized that some things, like the energy of an electron in an atom, can't vary continuously, but has to be one of a fixed set of amounts. And that lead to all the crazy stuff that quantum science has become.

James

Two questions: 1) From your research what is the most accurate type of error-checking and why? So using a separate (ancilla) qubit to verify the coding (such as IBM's system) qubits or using quantum annealing itself (such as D-Wave's system?) 2) And do you agree that a superconducting qubit-based chip is the best/most reliable path to a universal quantum computer with hundreds of thousands of qubits; or will the future universal quantum system be better as a hybrid? If not what is your opinion?

AA_2011

2) And do you agree that a superconducting qubit-based chip is the best/most reliable path to a universal quantum computer with hundreds of thousands of qubits; or will the future universal quantum system be better as a hybrid? If not what is your opinion?

The approach based on superconducting qubits is very interesting and much more advanced at present than spin qubits in semiconducting nanodevices.

This, however, does not mean that spin qubits are not interesting by themselves. On the contrary, in terms of size and speed, spin qubits in quantum dots are very small (10-100nm scale) and very fast (operation times in nano- or even subnanosecond regime), such that it is conceivable to put a billion spin qubits or so on a Si-based chip of one square cm size, with a clock speed of about 1GHz. These specs in speed and size are very similar to conventional chips in your computer. Also, in recent years a number of labs around the globe have made breakthroughs in realizing spin qubits in Si-based quantum dots, the material most chip industry uses and likes to work with. All this together is a strong driving force behind the research on spin qubits. Most of the progress so far has been achieved in GaAs or InAs based quantum dots, with 2 to 3 three qubits under control. This semiconductor material is the traditional workhorse material in research labs but not so much in industry (with notable exceptions, of course).

Finally, as a comparison, the size of a quantum chip containing a billion superconducting qubits or so, has been estimated to be the size of a soccer field, and also it would operate with a much lower clock speed than spin qubits. Both systems share the requirement of very low temperatures, and obviously the smaller system the easier this will be.

However, one should also point out the enormous challenges which lie ahead in 'wiring up' such a quantum chip, be it superconducting or spin qubits, at the moment there are only ideas how this might be possible. And so, much more research is needed before we can make more reliable predictions about the future quantum computer.

Concerning hybrids, this is an interesting question, and, yes, I think this is also a very useful direction to think about, with the goal to combine the 'best of both worlds'.

Prof Loss

Hey, thanks for this opportunity! My question involves Feynman's sum over histories interpretation of the double slit experiment. When he says that the photon takes *every single path* from Point A to Point B, what exactly does he mean? If the photon is travelling all the way across the universe and then coming back within such a brief time, does that violate the principle that the speed of light is the upper limit of velocity in our universe?

adeebchowdhury

This is indeed a very fascinating aspect of quantum mechanics, many thanks for your question.

I guess it is more suitable to consider an electron at first, because in contrast to photons they have a mass and it is probably easier to imagine them.

You may think of it as follows. All possible paths that the electron may take are weighted by some complex-valued factor, which is related to the action. The probability of finding the electron at a certain position is then obtained by summing over all paths and taking into account the aforementioned factors. For paths which are very unrealistic, the phase factors usually add up destructively, and so the associated probability goes to zero. Nevertheless, the different contributions may not cancel completely, and so a nonzero probability may remain. In the end, the electron will at a given time no longer be at exactly one position (as we may assume from our everyday-life experience), it will be at various positions at the same time. The probability distribution for the position of the electron corresponds to the absolute value squared of the so-called wave function, which obeys the Schrödinger equation (neglecting special relativity for now).

Your question about the speed limit in this description is also very interesting, here is my attempt to answer it. Let us assume that the electron starts at position A. Its probability distribution will then evolve in time according to the Schrödinger equation. On average (i.e., looking at the expectation values), the electron will pretty much behave as in a non-quantum calculation (see also the Ehrenfest theorem), so when you do not expect the speed of light to be exceeded in a classical and non-relativistic calculation, the probability of finding the electron in a position where the speed of light has been exceeded will also be (at least really close to) zero in a non-relativistic quantum mechanical calculation.

Special relativity is taken into account by moving from the Schrödinger equation to the Dirac equation. In this case, you will find that exceeding the speed of light is indeed impossible. This also holds for the photons that you initially asked for, which are massless.

I hope this was helpful.

Christoph

Will quantum entanglement lead to revolutionary means of communication across vast distances? If so, what's a realistic timeframe estimate?

Hidden__Troll

Two important applications:

- **Secure communication**, by using entanglement to create a secret key between two agents (which can then be used to encrypt a message).
- **Communication of quantum states** over long distances, via "quantum teleportation", a protocol that uses a pair of entangled qubits and two classical bits to transmit one qubit. (*Qubit*: two level quantum system, like the spin of an electron. *Teleportation* does not allow for faster-than-light communication, as you still need to transmit two classical bits; yes, it was named by Star Trek enthusiasts.)

Regarding the **time frame**: there is a thriving (and well funded) field of research into *quantum repeaters*, where the idea is to create a network (much like the physical structure behind the internet) to distribute entanglement over long distances, and enable those applications. The nodes of the network hold quantum states, such that neighbouring nodes are entangled. There are still a long way to go, as errors scale with the size of the network, and the community are working on efficient protocols and more reliable technology. To answer your question: it really depends on how much funding is invested in the field, but I expect it to be significant progress within the next decade.

LdR

How does one begin a career in quantum computing? Is a background is both computing and physics required? Will one or the other suffice?

Or, if you prefer, how would someone with an interest in being on the cutting edge of computational techniques get involved in you field? Thanks

sudo-shutdown

One or the other, or maths.

The typical route is a degree in physics, maths or comp sci (with the first being the most common) followed by a PhD in the field.

James

ELI5: Quantum Computers

TheBarnyardBen

First: ELI5 Normal Computers

Computers do maths. Even when you are browsing reddit, they are just doing maths.

To do complicated maths (like browsing Reddit) they break the problem down into lots of tiny bits of maths. Like "are these two bits the same or not", or "do I have at least one 1 with these two bits". These are problems that we can make transistors do for us. So with a shed load of transistors, we can do anything.

Some problems need a lot of transistors, though. Or them need us to use them many times. To solve these problems, we have to let our computers run the age of the universe. Which is a bit rubbish. One example is simulating quantum things.

Quantum computers break the problems down into different tiny bits of maths. It's not maths that a transistor can do, but it's maths that quantum particles can do. The number of these basic building blocks you need for to solve a problem is different than before, because the building blocks are different. So some problems that would take the age of the universe for a normal computer to chew on, no longer would. One example is simulating quantum things. Because quantum things are pretty good at being quantum things.

James

Do you have an opinion on the Copenhagen interpretation? Or Pilot-Wave (Bohmian) mechanics?

Despite me and my coworkers all being Ph.D. physicists, I have trouble convincing them that the wave function does indeed incorporate all possible information about an ensemble, and that the probabilities are not due to some failure to understand something. Is my point of view wrong, or over simplified?

Fermi_Dirac

My opinion on interpretations is mostly 'shut up and calculate', with the occasional bit of many worlds.

I think you are right about the wave function, but it is still a point of debate as far as I know. Perhaps you would be interested in this article.

James

Hi, thanks for doing this AMA. I wonder:

1. When will quantum computers become commercially available and will it benefit everyone or certain sectors.
2. How long would it take to convert and adjust our current systems to quantum.
3. This might be subjective but what do you think the impact is on our lives when this happens.

mistymountainz

I think that they will mainly be used for research, and won't directly imapct you or the computing infrastructure that much. But the research they enable will allow great strides to be made in many field, such as medicine. Which is obviously awesome for everyone.

Edit: 'tis I, James

I am a mechanical engineering student interested in getting involved in quantum computing. I don't care how, I just want to be involved in the research. Is there a place for mechE students in quantum computing fields yet? Or are we still a long way out from practical application that would necessitate a mechE?

Savasshole

There's definitely a role for electrical engineering in quantum computing – a quantum computer will only operate with a lot of sophisticated electrical engineering, for instance high frequency electronics. This need exists right now. Mechanical engineering? Not so sure about this!

Prof Warburton

I know that this is probably a pitiful, unworthy question compared to what's probably being asked.. But if you don't try...

Hey guys, I wanted to know.. What does it take to become a recognized physicist? I'm assuming yall weren't born into lab coats and quantum calculations, so how do you go from an "ordinary" life to working on expanding our knowledge of existence?

This is actually a very important question to me, as I have a friend who has a dream and a theory and is in college for what he believes will lead him into his field of choice,but he feels way in over his head and is scared that all his hard work will be for nothing. As someone who wants to help, but has no earthly knowledge of how, your response could be life changing. (... Uh, no pressure.)

Chaos_Archangel

The standard route is a masters level education in physics, a PhD in physics (and at this point you make a choice – theory or experiment), then a post-doc position. This is not for everyone of course. Physics is not an easy subject. It's also an old subject – making big breakthroughs is not trivial (and it probably never was). It seems to me there's not much risk attached to studying quantum physics – a research career is one option at the end of it, but there are many other options.

Prof Warburton

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Chaos_Archangel

Most of us went into physics and research because of curiosity and the desire to understand how Nature works. There is also an intrinsic beauty to physics and the math used to formulate the governing laws, like quantum mechanics, as developed by great minds about 100 years ago, with a continuing development, which seems to be endless, given the increasing complexity and novel features which emerge with every new insight we achieve when investigating systems of billions and billions of particles that constantly interact with each other. In our daily lives not much is predictable, but in physics you can make clear predictions which, moreover, can be tested by experiments. So, if your friend feels that 'fire' and has some talent in math then he will be rewarded if he pursues an education in physics. And then you go from there. Unfortunately, there is no clear cut career path which will make sure that you reach your goals or dreams. But it is worth a try.

Prof Loss

Thanks for this AMA. I watched a documentary that talked about quantum entanglement and its relation to parallel universes. I thought that idea was awesome but not really believable. Can you provide more information about this. Is there such a relation that has been proven in some way or just a theory to explain entanglement?

mistymountainz

The many worlds interpretation is the thing to look into. It might not be exactly like the parallel worlds you see in sci-fi.

It does have a lot of support, and I have trouble seeing how it is not true. That's whe I think about it, which admittedly isn't often. I am more of the 'shut up and calculate' school of quantum interpretations.

You might also be interested in some recent work by my QSIT collaborators. See Lidia's talk linked above for more info.

James

Thanks for doing this AMA! I've been reading a few articles about quantum entanglement and it seems rather fascinating. Recently physicists have managed to teleport a cloud of gasover half a metre. I'm no expert on quantum physics, so I've some questions regarding this:

1) The teleportation process is usually explained in terms of quantum entanglement using the spin of

particles (which can only be 1 of 2 possibilities). Is it possible to achieve entanglement of other binary properties such as electric charge? Is quantum entanglement only limited to binary properties?

2) The way I understand it is that, the actual atoms aren't transported, but rather the quantum information is copied. So does the original set of atoms still remain? What happens to it?

3) What are the major challenges in teleporting objects measuring ~1m across large distances, say ~1000 miles?

ZealousAngel

1) The teleportation process is usually explained in terms of quantum entanglement using the spin of particles (which can only be 1 of 2 possibilities). Is it possible to achieve entanglement of other binary properties such as electric charge? Is quantum entanglement only limited to binary properties?

Anything can be entangled. If you can imagine it being correlated, then it can be entangled. Entanglement is just a type of correlations. What makes it special is that the entangled particles are only entangled with each other, and so we have unprecidented control over it. Most correlated things are correlated with a bunch of other stuff too, like the air bumping into them and getting correlated in ways that we can never hope to see or control.

The way I understand it is that, the actual atoms aren't transported, but rather the quantum information is copied. So does the original set of atoms still remain? What happens to it?

In the classical protocol, two people (Alice and Bob) share a pair of entangled particles (one each). Then Bob has another particle whose information he wants to send to Alice. He does this by forcing his particles to become entangled, by measuring them in a way that the only possible outcomes are entangled states. The information then no longer has any space on Bob's side, so it pops out on Alice's end, it's like the state of Alice's particle, and the one Bob wanted to send, have swapped places.

I tried to explain it all in a blog post once.

3) What are the major challenges in teleporting objects measuring ~1m across large distances, say ~1000 miles?

The sheer number of particles in a 1m large object is huge, and we basically only know how to send them one by one. The distance is not the problem at all.

James

Hi I have two questions about quantum computers:

- can they be used to simulate the neurons in a brain so that we can have better AI?
- can they be used to simulate even larger quantum systems, for example a game world?

homestead_cyborg

can they be used to simulate the neurons in a brain so that we can have better AI?

In principle, but I'm not sure we need quantum for this.

can they be used to simulate even larger quantum systems, for example a game world?

The resources required to simulate all the particles in a macrosopic world would be huge. Maybe this is why Breath of the Wind is talking so long.

I would love to see the game that needs a quantum computer, though.

James

Dr. Bussières,

I'm a computer scientist and a grad student. I was speaking with one of my physics professors about quantum encryption, and one of the interesting ideas that came up was that it's fundamentally unbreakable (in my physics professor's mind). Would you agree with this? I understand the concept and why one might believe this to be the case, however I'm not 100% convinced. Do you have any thoughts on this topic, or could you provide some insight?

GeronimoHero

Indeed, the principle of quantum encryption is proven to be unbreakable. The challenge is to implement the encryption in the exact way the principle dictates. What has happened in the past is that some technical loopholes have been found. This prompted the quantum engineers to fix them. The current status is that the most obvious loopholes are believed to be fixed, and dealt with in a rigorous fashion (using analytical and experimental approaches). There is an active community of researchers (so-called quantum hackers) looking for other kinds of loopholes, and this community is working together with some companies selling commercial quantum encryption systems. Overall, it is a very healthy process for the quantum encryption business.

Felix Bussieres

Can entanglement be used for communication? I've heard conflicting ideas. More importantly, could it ever be used for faster-than-light communication?

willyolio

I think someone else could answer more thoroughly, but here's a quick response.

Entanglement can be used as part of communication protocols, and let us do things we can't do normally. But it can't be used directly, in that you can't wiggle one end so that the other can instantly feel it.

You cannot use entanglement for FTL communication. It is rather beautiful that non-relativistic quantum mechanics, which knows nothing of the speed of light, somehow still knows to obey it.

- James

Can entanglement be used for communication? I've heard conflicting ideas. More importantly, could it ever be used for faster-than-light communication?

willyolio

Quantum entanglement is really fascinating. It allows creating correlations between two objects that are distant enough to not be able to influence each other through all known physical influences (all travelling at the speed of light, or slower). Yet, the correlations we observe intuitively seem "too strong"... and it could be tempting to think these correlations arise because the particles somehow influence each other faster than the speed of light. However, invoking this faster-than-light influence is not necessary. The correlations are "strong" indeed, but not strong enough to all faster-than-light communication. It seems like quantum mechanics allows just the right amount of weirdness to allow "classically unintuitive" correlations to exist, yet without allowing faster-than-light communication.

Felix Bussieres

I'm an incoming college freshman, and I want to read up on quantum physics and start to learn the basics on my own. Can you suggest any reading material? I just have no idea where to start, and everything I find is either way too advanced, or is written for the general layman audience.

acoustic-electric

There's no substitute for getting hold of a decent text book on quantum mechanics and working your way through it! There are lots to choose from. The one by Sakurai has classic status!

Prof Warburton

My blog is better than a poke in the eye with a sharp stick. I hope.

James

What is your opinion regarding the idea that pilot waves are responsible for the results seen in the double slit experiment? Are the oil drop experiments a good way to prove the pilot wave hypothesis?

RespectMyAuthoriteh

I know of no experimental predictions for which the pilot wave interpretation differs from any other. It has all the same maths, by design.

Most of us don't actually spend to much time thinking about interpretations of quantum mechanics, though they are one of the things that seem to capture the popular imagination.

I think that our main aim should be to unify quantum mechanics with gravitation. That could provide many insights as to the correct interpretation. Or perhaps there isn't one alone that is correct, and its just our minds trying to see a story where there is only maths.

James

Dr James Wootton, I know that your specialty involve anyons, but I'd like to inquire about tachyons instead. If such particles exist, what implications does that have about relativity? How do tachyons "perceive" time? Why doesn't time dilation occur for them?

adeebchowdhury

I'm afraid that I am not well versed on tachyons. But thanks for the question.

James

How expensive is Quantum technology research? Is it something that I could practically do without the backing from Academic institutes, governments and other organisations i.e. at home?

Shirikatsu

In theoretical work maybe! But in experimental work it's going be very difficult doing useful things in your kitchen or garage! In my case, I have a lab full of lasers, sophisticated electronics, cryogenics and the like. I also need sophisticated semiconductors to work with – making these is an art in itself and definitely not something you can set up in your back-yard. That said, it's still essentially table-top physics – a skilled student can run the entire experiment. Yes, it costs something, but I would claim it comes at a fraction of the price of running a big facility like cern, even when one adds up the costs of all the labs in this field.

Prof Warburton

How expensive is Quantum technology research? Is it something that I could practically do without the backing from Academic institutes, governments and other organisations i.e. at home?

Shirikatsu

Is it something that I could practically do without the backing from Academic institutes, governments and other organisations i.e. at home?

That's what our project, Decodoku, is all about. It provides a way for anyone to do research in quantum error correction. You are not just making data for us, but actually researching yourself.

James

Inspired by the questions regarding encryption; how will quantum computing affect file compression?

kluvin

The Holevo bound basically limits us to storing no more than one bit in a qubit. The quantum notions of entropy, which serve as a compression rate, basically follow the non-quantum ones. So I don't see any way to affect file compression. But things such as superdense coding show that there are sometimes ways to cheat.

James

Have any Quantum scientist looked into the Mandela effect/Quantum effect if you have is there any findings?

jimjones615

Without any way to reproduce it in the lab, there's not much we can do. I think it's the kind of thing we need to let the physcologists and sociologists have a crack at first.

James

Where are we in establishing a link between quantum and "normal" physics ?

itarrow

Many thanks for your question.

Links between quantum physics and "normal" ("classical") physics are already well established. One example is the Ehrenfest theorem which, loosely speaking, says that the quantum mechanical description of a particle coincides with the classical description when one looks at the average behavior, i.e., the expectation values.

While quantum physics and classical physics go together very well, a big challenge of current research is to find a link between quantum physics and general relativity. Probably the most famous approach in this direction is string theory.

Christoph

How close are we to actual useful quantum computers?

KarlKastor

We currently have a handful of qubits. We would need many millions. Some groups are aiming to double their qubit number every year. So we might have a universal quantum computer by 2050.

James