

LIFE & WELLBEING SCIENCE

What is Quantum?

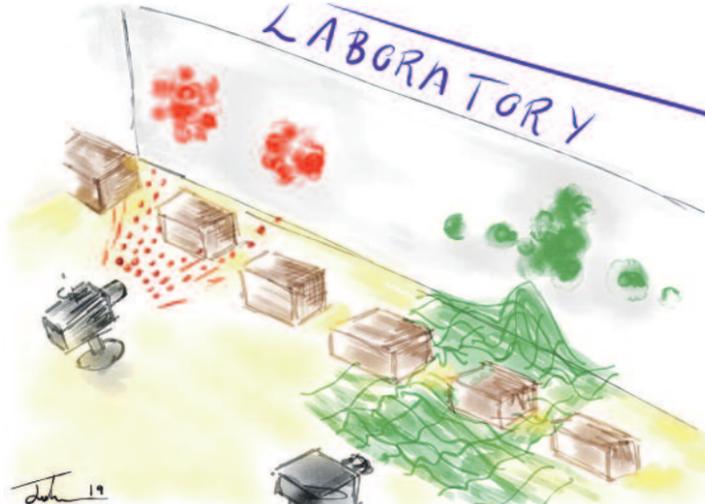


JAKE XUEREB

From toothpaste to washing machines, the word quantum invades our gaze on a daily basis. Is there anything to this word besides being a marketing tool? Well I would like to think so, but I study physics so maybe I am biased. Are these people justified in calling toothpaste quantum? Let us think through this and by the end you can decide for yourself!

In your head the word "Quantum" should at the very least evoke images of Einstein, Physics and maybe a cat. If this is what you thought then great because we can begin here.

Quantum mechanics is a particular area within the landscape of Physics; the study of how nature works at its most fundamental. The game we play in Physics is to think hard about something and then try to develop some sort of equation which can accurately guess how this thing is going to look like just by knowing where it starts.



In red we see paintballs shot through two holes which as we expect form two splotches. In green molecules are shot through two holes and behave like waves forming a surprising pattern of different sized splotches.
CREDIT: JAKE XUEREB

In the realm of quantum mechanics this is not the case! When objects are extremely small like a Buckminsterfullerene atom which is around a million times smaller than the width of a single strand of hair, these objects do not behave deterministically. We will try and understand this with an example. Buckminsterfullerene molecules look like footballs so let us try and shoot them through two slits and for comparison's sake

shoot paintballs at two similar holes. We will have a situation as I have sketched out above where of course nothing is to scale.

The paintballs behave as we expect them, forming big splashes through the holes. The same cannot be said for the buckyballs that land behind the barrier! The only way we can explain this is if we remember that quantum objects do not behave deterministically but rather probabilistically like proba-

bility waves! This wave behavior is known as superposition. Investigating the maths, we learn that each buckyball will have had an equal probability of going through either hole. In some sense having been divided and passing through the two holes at once.

This is what it means to be quantum! To be so small that the things which we know to be definite, like our position, stop being definite and allow these weird things to happen.

Returning to our question, toothpaste certainly does not behave quantumly. If I throw it at two holes, it will not split between them. But, like everything else, its behavior emerges from being made of a gargantuan number of quantum objects, molecules. Alone they are quantum but together interact so much that they lose these properties like superposition. This being said, I ultimately think that it should be ok for a toothpaste brand to claim that its toothpaste is quantum... so long as they provide a brief description of quantum mechanics on the back of the box. What do you think?

Jake Xuereb is a third year BSc Mathematics and Physics student, pursuing a thesis on the thermodynamics of quantum computation.

MYTH DEBUNKED

Why is the sky blue?

JAKE XUEREB

Having asked this question many times to children and adults alike I can tell you that the most common answers I get are "well because it reflects the colour of the sea obviously!" or my favourite "God made it that way". Whether the big man or woman up stairs made it that way or not, we can certainly understand the mechanism which results in the sky being blue.

Firstly, where do colours come from? Our favorite object related to colour is of course the rainbow which shows us that light coming from the Sun can be split into a spectrum when it intersects a rain droplet. At night when there are no colours. Everything is dark and there is no light. So colour comes from light.

Light is an electromagnetic wave and accepting this we realise that colours are nothing more than electromagnetic waves oscillating at different frequencies, possessing different amounts of energy. Ok, but why is the sky blue? Why do we go from white light, which contains all the colours to just one colour?

The atmosphere, is a collection of a number of gases which we breathe. They are what form up the air above our heads and so the sky. All things are made of smaller constituents, molecules, and gases are no different. When a beam of light hits one of these objects, by sheer chance, like a plane crashing into a mountain, its energy changes. We call this scattering, in particular Rayleigh Scattering after Lord Rayleigh who discovered this. Earlier we said that when the energy of light changes so does its colour and there you have it!

When light is moving through the atmosphere it scatters off of particles and molecules in the atmosphere, changing its energy and so frequency and colour. It just so happens that the energy light possesses most after Rayleigh Scattering is seen by our eyes as blue.

This same mechanism leads to the beautiful colours of the sunset and sunrise but I will leave this puzzle for you to find out!

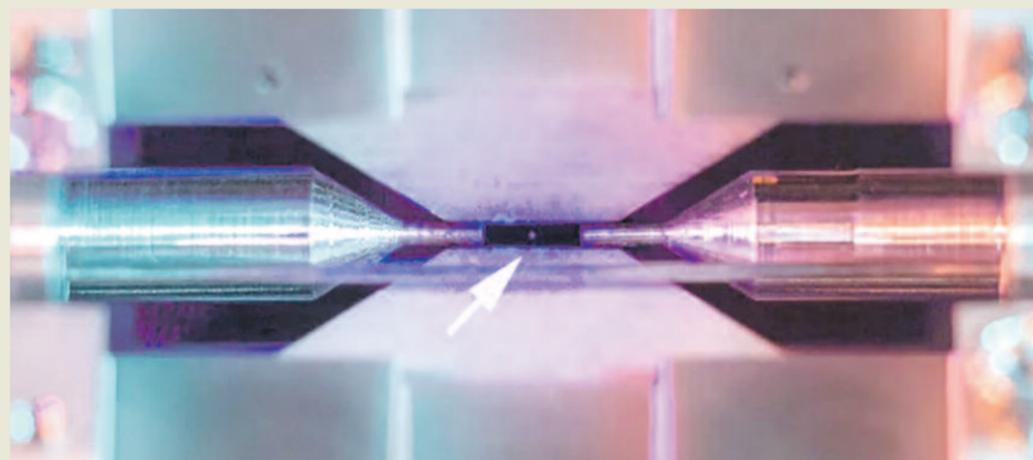
CONTRIBUTORS

EDWARD DUCA
JEAN-PAUL EBEJER
PETER BORG
DANIELLE MARTINE
FARRUGIA
JOSEF BORG
CLAUDIA BORG

E-MAIL

SCI-SUNDAY@UM.EDU.MT

PHOTO OF THE WEEK



Look closely at the centre of this image and you will see a single atom. This astonishing image was created by David Nadlinger at the University of Oxford, UK, who set out to capture an atom that could be seen with the naked eye – a world first. In the centre of the picture, a small bright dot is visible – a single positively-charged strontium atom which is held nearly motionless by electric fields emanating from the metal electrodes surrounding it. When illuminated by a laser of the right blue-violet color, the atom absorbs and re-emits light particles sufficiently quickly for an ordinary camera to capture it in a long exposure photograph. It is wonderful what one can accomplish on a quiet Sunday morning in the lab. PHOTO: DAVID NADLINGER/UNIVERSITY OF OXFORD

DID YOU KNOW?

- The word 'nice' is derived from the Latin 'nescius', meaning ignorant.
- Thomas Edison patented 1093 inventions in his life. From 1869 to 1910, he applied for a patent on average once every eleven days.
- In 1951, Dr. William L. Davidson invented a golf ball that supposedly couldn't be lost: it had small quantities of radioactive materials inside so that 'if you carry a portable Geiger counter, you can locate it even in dense woods'.
- Hexapus (English) - an octopus with six legs, and only two have ever been found. One was caught by an American family on holiday in Greece, who accidentally cooked and ate it before they realised.
- 4% of Canada's landmass is home to two-thirds of its population.

For more trivia see: www.um.edu.mt/think

SOUND BITES

• There are over 500,000 plant species in the world today. They all evolved from a common ancestor. How this leap in biodiversity happened is still unclear. In the upcoming issue of Nature, an international team of researchers, including scientists from Martin Luther University Halle-Wittenberg, presents the results of a unique project on the evolution of plants. Using genetic data from 1,147 species the team created the most comprehensive evolutionary tree for green plants to date.

[HTTPS://WWW.SCIENCEDAILY.COM/RELEASES/2019/10/191023132249.HTM](https://www.sciencedaily.com/releases/2019/10/191023132249.htm)

• A controversial theory that suggests an extraterrestrial body crashing to Earth almost 13,000 years ago caused the extinction of many large animals and a probable population decline in early humans is gaining traction from research sites around the world. The Younger Dryas Impact Hypothesis, controversial from the time it was presented in 2007, proposes that an asteroid or comet hit the Earth about 12,800 years ago causing a period of extreme cooling that contributed to extinctions of more than 35 species of megafauna including giant sloths, sabre-tooth cats, mastodons and mammoths. It also coincides with a serious decline in early human populations such as the Clovis culture and is believed to have caused massive wildfires that could have blocked sunlight, causing an "impact winter"

near the end of the Pleistocene Epoch. In a new study published this week in Scientific Reports, a publication of Nature, UofSC archaeologist Christopher Moore and 16 colleagues present further evidence of a cosmic impact based on research done at White Pond near Elgin, South Carolina. The study builds on similar findings of platinum spikes – an element associated with cosmic objects like asteroids or comets – in North America, Europe, western Asia and recently in Chile and South Africa.

[HTTPS://WWW.SCIENCEDAILY.COM/RELEASES/2019/10/191025110314.HTM](https://www.sciencedaily.com/releases/2019/10/191025110314.htm)

For more soundbites listen to Radio Mocha every Saturday at 7.30pm on Radju Malta and the following Monday at 9pm on Radju Malta 2 <https://www.fb.com/RadioMochaMalta/>