the BIG BELL TEST

www.thebigbelltest.org

@TheBellsters

ICFO The Institute of Photonic Sciences
A member of BIST Barcelona Institute of Science and Technology

Generalitat de Catalunya

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ICREA

The Big Bell Test in a Nutshell

What is the BIG Bell Test?

It's a worldwide project that intends to carry out a set of quantum physics experiments in one day with the help of the maximum amount of people that will contribute to the initiative by behaving as randomly as possible (the platform is a video game).

When will it happen?

November 30th, 2016

Where will it take place?

In different scientific labs all around the world.

Who can contribute?

Anyone with a computer, smartphone or tablet, who would like to contribute to this unique experiment and who can contribute through the thebigbelltest.org by behaving as randomly as possible in a video game. Participants will be our special Bellsters.

What does a Bellster have to do?

The Bellsters are in charge of creating random sequences of bits, ones ( ) and zeros ( ), that will reach the labs and help the different scientific experimental groups around the world to control the experiments.

There are 2 ways for Bellsters to create their sequences of random bits:

1. The Quick Bell Test - in simple interface to generate zeros and ones as fast and randomly as you can.

2. The BIG Bell Quest- a gamified interface with 6 different levels of increasing difficulty.

Where will the bits go?

The unpredictable bits supplied by the Bellsters will be sent to laboratories around the world, where they will decide which measurement to make on a quantum particle. Some labs will use photons (particles of light), some will use atoms, some will use superconductors… In this way, the Bellsters contribute to many experiments at the same time.

Why a Bell Test?

Quantum physics is famous for its strange views about what we can or cannot know about reality. It predicts that small things can be in several places at the same time, as long as we do not look at them, and it is only when we decide to look that they randomly decide for a single position. Can we affect reality just by looking at it? Does the world have a form independently of us, the observers? Can a particle randomly decide how to behave, without any cause?

Questions like that, usually a matter of philosophical discussion, entered Physics at the beginning of the twentieth century. This scientific debate was initiated by Bohr, who accepted the strange predictions of quantum mechanics, and Einstein, who refused them.

Now, is it possible to scientifically prove or disprove either of these two positions? After all, how are we to be sure that something is really there before we look at it?

Believe it or not, in 1964 physicist John Bell from CERN came up with an experiment to solve these issues: The Bell Test. Bell put an end to the otherwise brilliant intellectual debate between Bohr's and Einstein's views. Since then, the Bell Test has been performed with several implementations, mostly attaining results in favor of the theory of quantum mechanics.

Why with people?

In order to be convincing, the Bell Test must be performed under strict conditions. One such condition is using unpredictable and independent input to decide which measurements to perform on quantum objects like atoms and photons. By being unpredictable, we can be sure that Nature is not adapting its answers to our questions.

The cutting-edge quantum physics experiments that will be carried out on November 30th will use the unpredictable input from the Bellsters, free human minds independent of each other, acting as randomly as they can, to choose the measurements made on quantum particles in the laboratories.

To succeed, this initiative needs the contribution of at least 30.000 people during that day, to generate at least 30.000 sequences of random bits.

Key Messages of the BBT

The key messages that the organizers of the initiative would like to transmit are the following.

- *It's a* **Worldwide Scientific Initiative**: *we want all the world to participate in this citizen science experiment.*
- **Powered by Human Randomness**: *the set of quantum experiments will be powered by the sequences of random bits created by humans.*
- *The project will* **Test the Laws of Quantum Physics**, *using unpredictability provided by independent human decisions*
- *The event will take place on one day:* **November 30th.** *During this day, people from around the world will be generating sequences of bits that will be sent to quantum physics experiments in different labs around the world.*
- **We need you!** *In order to consider it a success, the initiative needs the contribution of at least* 30.000 people *playing the videogame to generate* at least 30.000 sequences *of random bits. .*
- **Everyone can participate!** *It's a matter of willingness and commitment. You only need a* computer, tablet, *or* smartphone *and the internet to connect to the platform and generate random bits.*
- **Show how unpredictable you can be** *The sequences of bits that control the experiments are generated by the participants. You will control the experiments with your bits! You will be giving the input to the experiments!*

Social Networks

Twitter:

ICFO has created a new account dedicated exclusively to the BIG Bell Test initiative. The account **@TheBellsters** will post in English, Catalan and Spanish. The **@ICFOnians** account will also help disseminate the news and create engagement.

Main Account: **@TheBellsters**
Insitutional Support Account: **@ICFOnians**

hashtag **#BIGBellTest**

We encourage you to follow both accounts to receive updates on the event as well as facts that could be interesting to know about quantum physics.

Please use the hashtag **#BIGBellTest,** so we can be aware of questions and reactions of our followers and retweet when possible.

Facebook:

ICFO will use the insitutional facebook account to disseminate all the news and events as well as important information/facts regarding the initiative. In addition, the institution has also created a BCN facebook page, dedicated to post only local news and events occuring in Barcelona.

Institute's FB page: www.facebook.com/ICFOnians
Local Barcelona page: www.facebook.com/TheBellsters

The facebook page of **ICFOnians** will also be used for dissemination of the project at a national and international level.

The facebook page **The BIG Bell Test BCN** (community) was created by students which are helping us create an engaged community at local universities. They plan talks, debates, and events at the University. We recommend to create similar local facebook pages at your institutions as well to help disseminate the initiative.

For partners/collaborators: we will provide you with suggested content for your twitter as well as your facebook accounts. You may use this content as a guideline as well as create the content that is more adequate for your experiment or your institution.

The Scientific Partners

ICFO is coordinating this initiative and has teamed up with different institutions around the world, who will carry out different quantum physics experiments using these random bits as input parameters.

Logo	Institution	Web SM info	City
	CQC2T - Centre for Quantum Computation and Communication Technology *1. Griffith University* *2. Australian Research Council*	www.cqc2t.org/ @Griffith_Uni	Brisbane
	Departamento de Ingeniería Eléctrica *Universidad de Concepción de Chile* ***Department of Electrical Engineering - Linköping University*** *Universidad de Sevilla* ***Dipartimento di Fisica–Sapienza Università di Roma***	www.die.udec.cl/ @CEFOP_UdeC http://www.isy.liu.se/en/ @liu_university www.us.es/ http://personal.us.es/adan/home.htm @unisevilla http://www.uniroma1.it/ @SapienzaRoma	Concepción ***Linköping*** Sevilla Rome
	CAS - Center for excellence and Synergetic Innovation Center of Quantum Information and Quantum Physics **USTC** - *University of Science and Technology of China*	http://quantum.ustc.edu.cn/ @ustc	Shanghai
	EQUS - Center for Engineered Quantum Systems *1. University of Queensland* *2. Australian Research Council*	equs.org @ARC_EQuS	Brisbane
	ICFO - Institute of Photonic Sciences	www.icfo.eu @TheBellsters @ICFOnians	Barcelona
	IQOQI - Institute for Quantum Optics and Quantum Information *Austrian Academy of Sciences*	iqoqi.at/ @iqoqi @OeAW	Vienna
	Department für Physik Ludwig-Maximilians-Universität München	www.en.uni-muenchen.de @LMU_Muenchen	Munich

Logo	Institution	Web SM info	City
	LPMC Laboratoire de Physique de la Matière Condensée *1. Université Nice Sophia Antipolis* *2. CNRS*	http://lpmc.unice.fr @Univ_Nice	Nice
	QUDEV - Quantum Device Lab **ETH** Zurich	http://www.qudev.ethz.ch/ @qudev @ETH	Zurich
	División Óptica Cuántica, DEILAP-UNIDEF (**CITEDEF-CONICET**) Departamento de Física, FCEyN, Universidad de Buenos Aires (**UBA**)	http://exactas.uba.ar/ @UBAonline	Buenos Aires
	National Institute of Standards and Technology (**NIST**)	https://www.nist.gov/	Boulder

The BIG Bell Quest & The Quick Bell Test
How to contribute

In order to contribute to the experiment you can enter the The BIG Bell Test website and click on the Contribute tab. The game can be accessed through any platform: computers, tablets or/and mobile phones.

To play the game, you can either register by singing up and creating a username, or play as a guest.

NOTE: ***We encourage you to* REGISTER *if you would like to compete and have your score show up in the rankings. If you register, we will be able to use your data for statistical analysis.***

A Double Platform

There are two different ways of playing the game:

- The Quick Bell Test: a simple interface that allows you to enter your sequences of random bits in a very simple format.If you want your sequence to be used during the experiment, you must register otherwise your bits might be discarded.

- The BIG Bell Quest: a tailored game that consists of 6 different levels in which you need to type in sequences of 0s and 1s as fast as possible and trap atoms or beat the Oracle, who will try to predict your bit inputs. Difficulty increases with level.

NOTE: The more you play, the more points you earn and therefore, the more sequences of random bits you generate, which will be of utmost importance for the scientific experiments that will be taking place on November 30th.

Rankings

There are several ways that you can see your scored ranked in the lists. Either you can play against everyone in the world and your score will appear in the worldwide ranking if you make it to the top ten best scores, or you can create groups to play with your acquaintances.

How to create Groups

If you register to have your own profile, it is possible to create groups depending on the activities or events that you have in mind. This option has been included to help schools, institutes, companies create local competitions among their staff, students or members.

It is possible to create up to three different groups to compete with those you know, e.g. familiy, friends, city. Then, you can invite all of them to enter your group and compete against you and all its members by sending them the name of your group. Each group will have its own ranking, which appear in the ranking by groups list.

Collaborators

ICFO has also teamed up with different institutions and individuals around the world that have shown interest in the project and would like to help us spread the word. So far, our institutional collaborators are:

Logos	Institution	Social Media Info	City
eduCaixa	*Educational Platform of the "La Caixa" Foundation*	www.educaixa.com/ @educaixa	Barcelona
OSA | 100 The Optical Society Since 1916	The Optical Society of America - **OSA**	www.osa.org/ @OpticalSociety	Washington D.C.
ECOP European Centres for Outreach in Photonics	European Centres for Outreach in Photonics	http://ecopalliance.eu/ info@ecopalliance.eu	Barcelona
POLITECNICO MILANO 1863	Politecnico de Milano	http://www.polimi.it/en/ @polimi	Milan
INVESTIGACIÓN Y CIENCIA 40	*Investigacion y Ciencia - IyC*	http://www.investigacionyciencia.es/ @IyC_es	Barcelona
intef	*Instituto Nacional de Tecnologías Educativas y de Formación del Profesorado Ministerio de Educación, Cultura y Deporte*	http://educalab.es/intef @educalab http://www.mecd.gob.es/ @educaciongob	Madrid
Crea Ciència	*CreaCiència*	http://creaciencia.com/ @cienciadeldani	Barcelona
Big Van	*Big Van - Científicos sobre ruedas*	www.bigvanscience.com @_BigVan	Spain
TOPTICA PHOTONICS	*TOPTICA*	http://www.toptica.com/	Munich

	European Physics Society	www.epsyoungminds.org/ @epsyoungminds	Europe
	Real Sociedad Española de Física	https://rsef.es/ @RSEF_ESP	Madrid
	Institut de Cultura Ajuntament de Barcelona	http://www.barcelona.cat/ca/ @bcn_ajuntament	Barcelona

The ICFO Bellster team

At ICFO, we have a team of Bellsters that include not only researchers but also staff from the Knowledge and Technology Transfer Unit as well as the Communication unit working together to make this initiative possible.

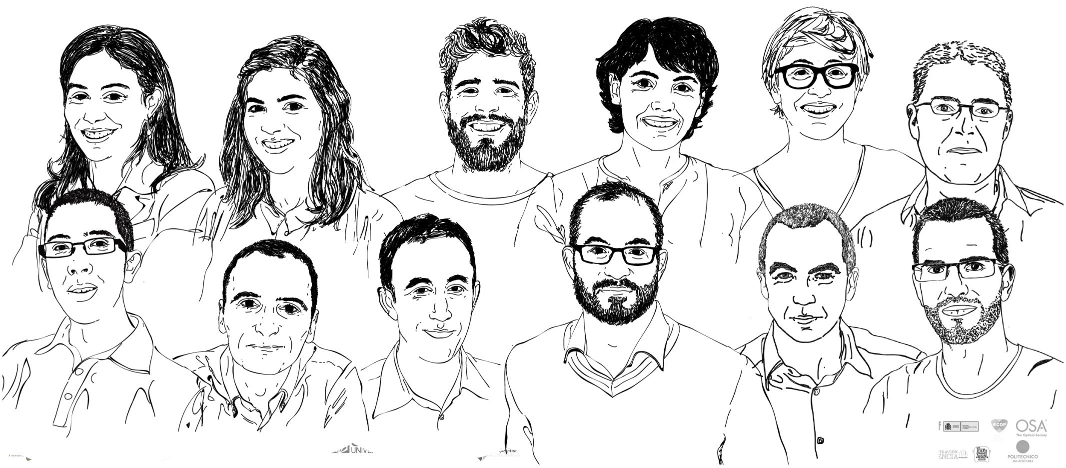
The Scientific Team includes:

ICREA Prof. at ICFO **Morgan Mitchell, Carlos Abellán,** *ICREA at ICFO Prof.* **Valerio Pruneri,** *ICREA at ICFO Prof.* **Antonio Acín,** *Dr.* **Jordi Tura,** *ICREA Prof. at ICFO* **Hugues de Riedmatten,** *Dr.* **Georg Heinze,** *and* **Pau Farrera.**

The Outreach, Management and Communications' team includes:

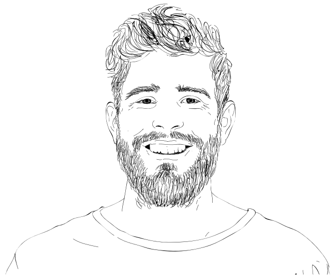
Dr. **Marta García Matos,** *Dr.* **Federica Beduini, María Martí,** *Dr.* **Silvia Carrasco,** *Dr.* **Alina Hirschmann** *and* **Brook Hardwick.**

The ICFO Bellster team welcomes any suggestions and comments that could help increase its reach and scope and thus accomplish having thousands of people generating random numbers and participating in the first quantum scientific experiment powered by human randomness.



Prof. Morgan W. Mitchell

"There are deep mysteries of physics that can only be studied by asking unpredictable questions of Nature. Humans making independent choices are very valuable, a unique way to ask unpredictable questions - no matter what secrets Nature might be hiding from us."



Carlos Abellán

"The most fascinating thing about the BIG Bell Test is that people and scientists play an equally important role for the success of the experiment. It's a unique opportunity for bringing frontier research in quantum physics closer to people."

Dr. Federica Beduini

"Thanks to the BIG Bell Test, I can finally share one my passions - quantum physics - with my family and friends, because you don't need to be a physicist to be a Bellster! Everyone can become one and be able to contribute to worldwide scientific experiments that will improve our knowledge of the quantum world!"

Dr. Marta García Matos

"Besides being at the very edge of physics, these experiments touch aslo fascinating topics in math (randomness), logic (the link between theories and models), the philosophy of knowledge and the philosophy of mind, interesting to anyone who ever wondered about the difference between the things we see, the things we know, and the things that do exist."

Prof. Antonio Acín

"Quantum correlations that do not have a classical analogue, because they violate a Bell inequality, is the most interesting aspect of quantum physics. By measuring quantum particles, we observe correlations that are impossible in our macroscopic world governed by Newtonian classical physics. Moreover, quantum correlations are not only fundamentally relevant, but also a resource for novel quantum information protocols. The present experiment tests them using human-generated randomness."

Dr. Silvia Carrasco

"The most amazing thing about quantum mechanics is that we still don't know what is the most amazing thing about it. The power of the experiment is that each and every participant will be physically affecting in real time an experiment happening thousands of km away!! The experiment will be different without each of us."

María Martí

"We are going to do something unique, unpredictable and beautiful, but most importantly, we are going to do it together."

Dr. Jordi Tura

"I am thrilled to see how good humans are at trying to be unpredictable. The BIG Bell Test offers us not only a way to involve a huge number of people in a scientific project, but also a chance to see how predictable we really are."

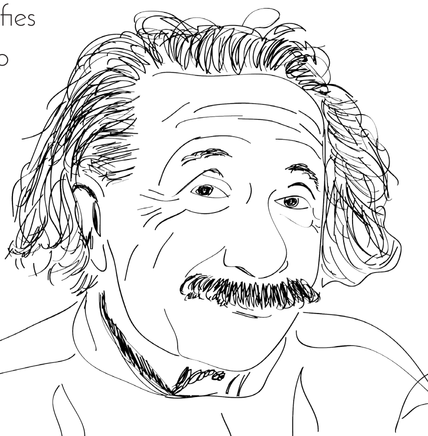
The meaning and history of the Bell Test

The BIG Bell Test (BBT) is a worldwide project to bring human unpredictability (randomness) to cutting-edge physics experiments. It may be surprising, but there are aspects of physical reality that can only be understood by asking unpredictable questions of nature. The most famous experiment of this kind is the Bell test, which seeks to catch quantum particles "talking" to each other and matching their answers to the questions asked. In the BBT, laboratories around the world (see map) will prepare entangled quantum particles: electrons, photons, atoms, and superconductors. Through the Internet, an army of participants, the Bellsters, will shower these particles with unpredictable, high-speed "questions" (measurements, in fact). Together, we will perform unique quantum physics experiments, including the first human-driven Bell test.

Einstein's objections

Albert Einstein was the most vocal opponent of Bohr's interpretation. In a several-year-long debate with his friend Bohr, Einstein articulated two principles he saw as fundamental: Realism says that objects have well-defined properties even when we are not looking at them and locality says that objects can only be influenced by causes in their immediate vicinity, not by "action at a distance." Locality is, among other things, important to Einstein's theory of relativity, in which time and space depend on the observer. In relativity, locality ensures that effects come after, and not before, their causes.

In 1935, Einstein and colleagues Podolsky and Rosen published a strong attack on Bohr's interpretation, now called the "EPR paradox." The paradox uses the mathematics of quantum mechanics to describe a pair of entangled particles in different locations. According to Bohr's interpretation, when one particle is measured, the other particle would change instantly, even though it might be very far from the first particle. Einstein considered this communication between the particles, which he called "spooky action at a distance," to be so implausible that it disproved Bohr's claims that measurement influences the world. The EPR article also suggested that quantum mechanics should be replaced by a more complete theory, one that specifies what happens also when we are not watching. Einstein did not, however, have such a theory to offer.



Bell's theorem: quantum mechanics is incompatible with local realism

In 1964, John Bell, a physicist at CERN, translated Einstein's philosophical positions of locality and realism into a precise mathematical description, now called "local realism." With this mathematical description, he proved that Einstein's local realistic world-view is incompatible with quantum mechanics. That means that there are experiments for which quantum mechanics gives one prediction, and any theory Einstein would have approved of gives a different prediction. Bell's work thus made it possible to test in the laboratory what had previously been a philosophical question.

Bell tests: does Nature agree with Einstein or with Bohr?

There remains the question of whether Nature itself agrees with Einstein or with Bohr. This requires an experiment, a Bell test. This experiment looks a lot like the EPR scenario: the experimenter produces a pair of entangled particles (entanglement means that their properties are strongly correlated; for example if one spins left, the other must spin left, too) and sends them to two separated measurement stations, traditionally called "Alice" and "Bob." Alice and Bob make simultaneous, unpredictable measurements on the particles. Quantum mechanics says that the measurement Alice makes will instantly influence Bob's particle, with the effect that the measurement results agree. In local realism, this influence cannot happen, and Bob and Alice's measurement results will often disagree. This agreement or disagreement, called correlation, is the signal that allows an experiment to decide about local realism.

2015 loophole-free Bell tests

In 2015 three extraordinarily advanced experiments, performed at TU Delft (the Netherlands), IQOQI Vienna (Austria), and NIST Boulder (USA) , resolved the few remaining problems (the so-called loopholes) in previous tests, including giving strong physical arguments for the unpredictability of their measurements.

They used physical random number generators provided by ICFO to turn unpredictable physical events like spontaneous emission (which Einstein also studied!) into measurement choices. The results were clear: they saw correlations too strong to come from local realism.

The New York Times summarized the situation: " Sorry, Einstein. Quantum Study Suggests 'Spooky Action' Is Real."

The BIG Bell Test of 2016

The BIG Bell Test (BBT) is a worldwide project to bring human randomness to cutting-edge quantum physics experiments. On November 30th, many people will contribute randomly chosen bits. These will be distributed in real-time to experimental groups around the world (see map) for use in quantum physics experiments, including the first Bell test(s) with human-generated randomness. In addition to testing fundamental physical principles like non-locality, human randomness is useful in important applications such as secure communications, and also as a "seed" for the generation of even more randomness.

Why a Bell test with people?

Bell test experiments must be performed under strict conditions in order to be convincing. One such condition is using unpredictable and independent input to decide which measurements to perform on quantum objects like atoms and photons. There are many ways to guarantee independence; the BIG Bell Test will use the Bellsters, free human minds independent of each other, to control the measurements on quantum particles through their decisions. Unlike electrons or protons or the Higgs boson, which are perfectly interchangeable particles that behave similarly under the same conditions, every human-being acts genuinely on his/her own, and this is very valuable for the Bell test requirements. The BIG Bell Test aims to show for the first time that human choices can contribute to fundamental science, and at the same time to perform a suite of never-before-attempted experiments.

Why so many people?

As in any scientific experiment, we want to be sure of the precision our result, to know that the effect we are observing is really a consequence of the properties of the physical world. A common way to reduce the uncertainty on the result of an experiment is to repeat it many times and then check if the results are statistically significant. It is like trying to know if a coin is biased or not: if we toss it just a couple of times we cannot be really sure, but as the number of tosses increases, we obtain a more and more precise estimation of how often we obtain tails against head.

Every random number that the Bellster community contributes with allows the scientists to perform another run of the experiment, and to reach a more precise result. Moreover, the more different individuals are participating, the more we are assuring the statistical independence that is so important for this kind of experiments. This is really the case to say: the more, the merrier!

How does it work?

The participants send their contributed bits through this website. There are two ways to participate: (1) using a plain interface in which you introduce zeros and ones as fast as you can, and (2) a video game interface. All those bits will be sent directly to the experiments, to choose the measurements. Each human-generated bit used in the experiment will thus be the result of a unique and conscious decision process.

The day of the experiment, ICFO will distribute in real time the human-generated randomness to many top-notch Bell tests (and related experiments) all around the world (see map). In parallel, we will also distribute random numbers from a physical random number generator designed and built at ICFO. A cloud-based server will collect all the random numbers and distribute them to the experimental teams via Internet. All the human-generated bits before and during the experiment will also be archived for later study.

What will happen in each lab?

The experimental teams will receive three streams of random bits: one real-time from participants, one real-time from ICFO's physical RNG, and one stream of archived bits entered earlier by participants.

Each experimental group will contribute by performing the most interesting experiment(s) they can with human-generated randomness.

Scientific Experiments of the Nodes

On the day of the experiment, the random number sequences created by the participants will be directed to the labs around the world control the following experiments:

Experiment 1

Lab: *IQOQI-Institute of Quantum Optics and Quantum Information / Österreichische Akademie der Wissenschaften. Wien.*

Team: *Rupert Ursin, Anton Zeilinger and Thomas Scheidl (PI)*

Description

Our setup will generate polarization entangled photon pairs in a maximally entangled state using a polarization Sagnac interferometer. The photons will be coupled into single mode optical fibers and guided to separate polarization analyzing modules, each of which features an electro optical modulator (EOM), a polarizing beam splitter and two single photon detectors. The random numbers provided via the cloud infrastructure of the Big Bell Test will be used in real-time to control the EOM, implementing polarization measurements in one of two complementary bases. The measurement bases will be chosen to allow for a test of the CHSH form of the Bell inequality.

Experiment 2

Lab: *Faculty of Physics Ludwig-Maximilian University of Munich*

Team: *Daniel Burchardt, Kai Redeker, Robert Garthoff, Norbert Ortegel, Wenjamin Rosenfeld (project leader) and Harald Weinfurter (PI)*

Description:

The experiment at the LMU in Munich employs spins of single trapped atoms to perform tests of Bell's inequality. By combining entanglement of atoms over a large distance (400 m) with fast and efficient measurements of the atomic spin states it fulfills all requirements for a conclusive loophole-free test of local realism.

Experiment 3

Lab: ***(Main Node)***

Departamento de Ingeniería Eléctrica, CEFOP-Centro de Óptica y Fotónica, Universidad de Concepción, Chile

(Support Nodes)

Departamento de Física Aplicada II, Universidad de Sevilla, Spain

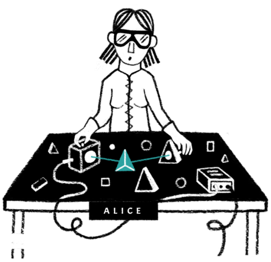
Institutionen för Systemteknik, Linköpings Universitet, Sverige

Dipartimento di Fisica–Sapienza Università di Roma, Italia

Team: ***Felipe Toledo, Pablo Gonzalez, Jean Cortés, Aldo Delgado, Gustavo Lima, Álvaro Alarcón, Jaime Cariñe, Miguel Figueroa, Adán Cabello, Jan-Åke Larsson, Paolo Mataloni, Álvaro Cuevas, Gonzalo Carvacho, Fabio Sciarrino and Guilherme B. Xavier (PI)***

Descritpion:

Many Bell tests have been performed using energy-time entanglement, which is well suited for long-distance propagation over optical fibers. The standard configuration adopted has an inherent built-in post-selection loophole, making it unsuitable to be used in "loophole-free" tests. Our group has managed to experimentally demonstrate an alternate geometrical configuration as a viable path to remove this loophole. Here we upgrade our previous experiments to allow external random inputs (human randomness) in Alice and Bob's measurements, and thus perform an automated Bell test. Our results have implications for device-independent quantum key distribution based on energy-time entanglement.



Experiment 4

***Lab:** CQC2T- Centre for Quantum Computation and Communication Technology, Griffith University / Australian Research Council , Brisbane*

Team: *Geoff Pryde (PI)*

Description:

Entanglement shared between two parties (Alice and Bob, say) is a useful resource for absolutely secure secret communication, networking quantum data, and performing certain precise measurements and timekeeping.

Therefore, it is very important to be able to verify that two parties really do share entanglement. That is, it is important to check that the experimental measurement results they obtain really come from a quantum effect and not from an adversary trying to trick them (to get the secret data), nor as a result of some imperfections in their techniques or apparatus.

There exist a number of techniques for looking at correlations (matched patterns) in experimental data to determine whether the signal really comes from entanglement. Of these, quantum steering is an interesting technique because it performs well in real-world situations where there are some experimental imperfections – it can distinguish between entanglement and other effects under useful conditions.

The aim of this experiment is to investigate how quantum steering works in conditions that mimic those that would be found in real-world applications. The idea is to find out how to tolerate significant experimental imperfections while still performing a test that guarantees that the results are explicable by entanglement alone.

The physical system we will use is entangled photon pairs, generated using our state-of-the-art entangled photon source and measured using very high efficiency detectors. We will combine several measurement protocols we have developed for making quantum steering tests robust, and test how the overall approach works under useful conditions. The quantum correlations will be carried by the polarization state of the entangled photons – the direction of oscillation of the light for one photon will be connected to that of the second photon.

The random numbers provided by participants will be used to control the settings of devices that measure the polarizations of the photons. One of the novelties compared with some other experiments in the BBT is that our technique requires a much larger number of different measurement settings, so each time a measurement is made, up to 8 bits of input data is required.

Experiment 5

Lab: ***CAS - Center for excellence and Synergetic Innovation Center of Quantum Information and Quantum Physics***

USTC - University of Science and Technology of China, Shanghai

Team: ***Yang Liu, Cheng Wu, Jian-Yu Guan, Xiongfeng Ma, Xiao Yuan, Lixing You, Zhen Wang, Qiang Zhang (PI) and Jian-Wei Pan (PI)***

Description:

It has been shown in theory that Bell inequality violations can be used to generate perfectly random bits with very strong guarantees, stronger than any other known method to make random bits. But a Bell test itself requires random bits as input, to choose the basis settings. This seems to create a "boostrapping problem", in which guaranteed randomness is required in order to produce guaranteed randomness. Human randomness may provide a solution. Because people have free will they are unpredictable, but we also know that they are not perfectly random; there are always some patterns in the things they choose to do. In our experiment we will use a different Bell inequality (not the usual CHSH inequality), one that has only a mild randomness requirement. We will then experimentally verify if there is a violation using randomness from human choices (free will). This will help us to test our Bell inequality and to close the randomness loophole with the help of human free will.

Experiment 6

Lab: ***LPMC Laboratoire de Physique de la Matière Condensée -***

Université Nice Sophia Antipolis / CNRS, Nice, France

Team: ***Florian Kaiser, Tommaso Lunghi and Sébastien Tanzilli (PI)***

Description:

Our experimental setup for the Big Bell test is shown in the figure. The scheme is based on a Sagnac interferometer and standard telecom fiber components. Both ensure a highly stable and reliable operation and should therefore lead to very pertinent results within the framework of the Big Bell Test. We note that our setup shows a few similarities with previous experiments reported by Lim et al., and we encourage the interested reader to refer to references [1–5].

To read the whole description of the experiment with reference included, please click on the following link: **LMPC experiment**

Experiment 7

Lab: ***EQuS – Arc Center of Excellence for Engineered Quantum Systems, University of Queensland, Brisbane***

Team: ***Marcelo Almeida, Geoffrey Gillett, Jacquiline Romero, Martin Ringbauer, Till Weinhold and Andrew White (PI)***

Description:

Our experiment will study quantum correlations in time. Quantum entanglement is usually thought of as a strong connection between two (or more) particles that are separated in space. Such entanglement can be revealed by Alice and Bob, who each measure one of these particles, in a Bell-inequality test. However, quantum correlations cannot only exist across space. Alice and Bob could also be separated in time, rather than space, and perform their measurements on the same quantum system at different times. Such an experiment can reveal so-called temporal entanglement, which is a much less well-known form of entanglement. In our experiment Alice and Bob will use human-generated random numbers to choose measurement settings for a Bell-inequality test for temporal quantum correlations. Studying temporal quantum correlations will help us to understand the structure and power of quantum correlations.

Experiment 8

Lab: ***Quantum Device Lab, Deparment of Physics, ETH Zurich, Zurich***

Team: ***Philipp Kurpiers, Johannes Heinsoo and Andreas Wallraff (PI)***

Description:

The Quantum Device Lab at ETH Zurich will contribute to the Big Bell Test (BBT) making use of a well-controlled quantum system based on superconducting circuits, combining linear oscillators, realized as coplanar waveguides, and non-linear oscillators implemented using Josephson junctions. The two lowest eigenstates of the non-linear oscillators form the basis states of the qubits with which the Bell test is performed. We entangle a pair of such qubits making use of their capacitive coupling to a common resonator acting as a quantum bus and perform qubit readout by probing the transmission of a coplanar waveguide resonator coupled to the qubits. The near quantum-limited readout scheme allows us to measure the computational states of the two qubits with high fidelity in each single shot using a Josephson parametric amplifier. We define the effective basis in which we perform the measurement by applying single qubit gates which are chosen by the randomness provided to us through the BBT project.

Experiment 9

Lab: ***ICFO - The Institute of Photonic Sciences, Barcelona***

Team: ***Georg Heinze, Pau Farrera and Hugues de Riedmatten (PI)***

Description:

Our experiment will test Bell correlations between two very different quantum objects: a single photon and a single collective spin-excitation (called a spin-wave) involving millions of atoms in a laser-cooled atomic cloud. We will generate entanglement probabilistically between a photonic time-bin qubit well suited for transmission in optical fibers and a spin-wave qubit stored in a quantum memory. After a controllable storage time, the spin-wave qubit will then be converted deterministically into another photonic time-bin qubit. Both photonic qubits will be analysed using optical interferometers. The random numbers provided by the public will be used to randomly choose the measurement bases by changing the phase of each interferometer using a piezoelectric device.

The BBT Agenda

June 20th: Launch of the website and twitter account

July-August-September: Selection of Ambassadors and Influencers for social media campaign to help spread the word.

September: preparation of promotional video + communication and outreach material for dissemination.

Begin with teaser campaign- dissemination campaign through all ICFO and partner channels as well as with the help of ambassadors and influencers.

October and November: social media campaign to gain followerrs and have people ready for Nov 30th.

1 week prior to 30 Nov: Runner-up campaign - through all possible channels and with the help of ambassadors and influencers.

30 November 2016: Day of the experiment. Create a "During event campaign" to show the participation of people all around the world.

Mid December: elaborate final report on the outcome of the project.

Contact Information

For inquiries concerning the outreach initatives, please contact:

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Join the Bellsters!
November 30, 2016

the BIG BELL TEST

@TheBellsters

Image courtesy of ICFO/Kaitos & Maria Pascual