Statistics in Context

The holistic statistics agency

True And False Discoveries: How To Tell Them Apart

By Tommaso Dorigo | July 22nd 2014

Claim	Claimed Significance				Verified or Spurious
Top quark evidence	3				True
Top quark observation			5		True
CDF bby signal		4			False
CDF superjets				6	False
Single top observation			5		True
HERA pentaquark				6	False
ALEPH 4-jets		4			False
LHC Higgs evidence	3				True
LHC Higgs observation			5		True
OPERA v>c neutrinos				6	False
CDF Wjj bump		4			False

Sigmas vs prob
1: 0.16
2: 0.023
3: 0.0013
4: 3.2 e-5
5: 2.9 e-7
6: 9.9 e-10

Do you see it now ? Only odd-significance claims turned out to be true, while all even-significance ones ended up in the dust bin!! I guess that does not bode very well for the 6-sigma BICEP observation of tensor modes in the cosmic microwave background...

Unconditional Quantum Teleportation

A. Furusawa, J. L. Sørensen, S. L. Braunstein, C. A. Fuchs, H. J. Kimble,* E. S. Polzik

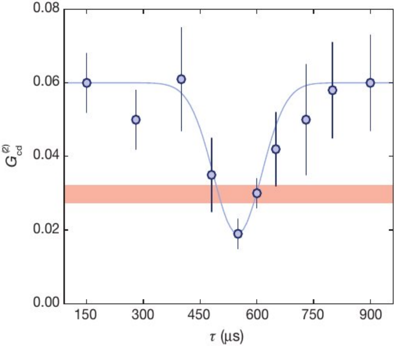
Quantum teleportation of optical coherent states was demonstrated experimentally using squeezed-state entanglement. The quantum nature of the achieved teleportation was verified by the experimentally determined fidelity $F^{exp} = 0.58 \pm 0.02$, which describes the match between input and output states. A fidelity greater than 0.5 is not possible for coherent states without the use of entanglement. This is the first realization of unconditional quantum teleportation where every state entering the device is actually teleported.

Science v282 p706 (1998)

Atomic Hong–Ou–Mandel experiment

R. Lopes[1], A. Imanaliev[1], A. Aspect[1], M. Cheneau[1], D. Boiron[1] & C. I. Westbrook[1]

Two-particle interference is a fundamental feature of quantum mechanics, and is even less intuitive than wave–particle duality for a single particle. In this duality, classical concepts—wave or particle—are still referred to, and interference happens in ordinary space-time. On the other hand, two-particle interference takes place in a mathematical space that has no classical counterpart. Entanglement lies at the heart of this interference, as it does in the fundamental tests of quantum mechanics involving the violation of Bell's inequalities[1–4]. The Hong, Ou and Mandel experiment[5] is a conceptually simpler situation, in which the interference between two-photon amplitudes also leads to behaviour impossible to describe using a simple classical model. Here we report the realization of the Hong, Ou and Mandel experiment using atoms instead of photons. We create a source that emits pairs of atoms, and cause one atom of each pair to enter one of the two input channels of a beam-splitter, and the other atom to enter the other input channel. When the atoms are spatially overlapped so that the two inputs are indistinguishable, the atoms always emerge together in one of the output channels. This result opens the way to testing Bell's inequalities involving mechanical observables of massive particles, such as momentum, using methods inspired by quantum optics[6,7], and to testing theories of the quantum-to-classical transition[8–11]. Our work also demonstrates a new way to benchmark non-classical atom sources[12,13] that may be of interest for quantum information processing[14] and quantum simulation[15].



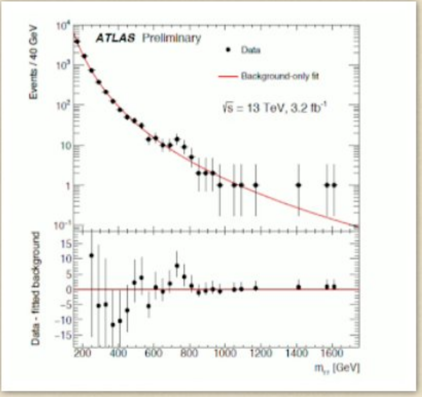
to the 68% confidence interval. The fitted value of the background correlation is 0.060(5) and the measured visibility is $V = 0.65(7)$. It is two standard deviations beyond the classical-to-quantum threshold represented by the red shaded area, at half the background correlation value. Each data point was obtained

Nature v520 p66 (2015)

Resonaances blog post Dec. 15 2015:

A new boson at 750 GeV?

ATLAS and CMS presented today a summary of the first LHC results obtained from proton collisions with 13 TeV center-of-mass energy. The most exciting news was of course the 3.6 sigma bump at 750 GeV in the ATLAS diphoton spectrum, roughly coinciding with a 2.6 sigma excess in CMS. When there's an experimental hint of new physics signal there is always this set of questions we must ask:



~~0. WTF ?~~

0. Do we understand the background?

1. What is the statistical significance of the signal?

2. Is the signal consistent with other data sets?

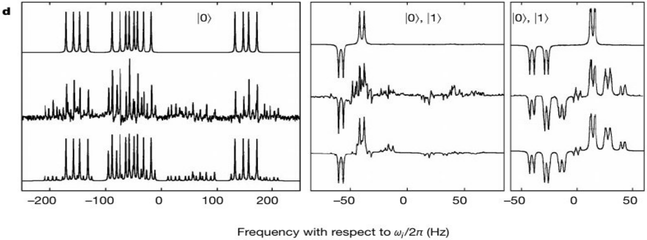
3. Is there a theoretical framework to describe it?

4. Does it fit in a bigger scheme of new physics?

Experimental realization of Shor's quantum factoring algorithm using nuclear magnetic resonance

Lieven M. K. Vandersypen*†, Matthias Steffen*†, Gregory Breyta*, Costantino S. Yannoni*, Mark H. Sherwood* & Isaac L. Chuang*†

proved elusive[8–10]. Here we report an implementation of the simplest instance of Shor's algorithm: factorization of $N = 15$ (whose prime factors are 3 and 5). We use seven spin-1/2 nuclei in a molecule as quantum bits[11,12], which can be manipulated with room temperature liquid-state nuclear magnetic resonance techniques. This method of using nuclei to store quantum informa-



NOT on spin 7. **c**, Output spectra of the easy case of Shor's algorithm ($a = 11$). The top traces are the ideally expected spectra, the middle traces are the experimental data, and the bottom traces are simulations which incorporate decoherence effects (see text). Each trace was rescaled separately. **d**, Similar set of spectra as in **c**, but for the difficult case ($a = 7$).

Nature v414 p883 (2001)

GW170104: Observation of a 50-Solar-Mass Binary Black Hole Coalescence at Redshift 0.2

B. P. Abbott *et al.**
(LIGO Scientific and Virgo Collaboration)

The inferred component black hole masses are $31.2^{+8.4}_{-6.0} M_\odot$ and $19.4^{+5.3}_{-5.9} M_\odot$ (at the 90% credible level).

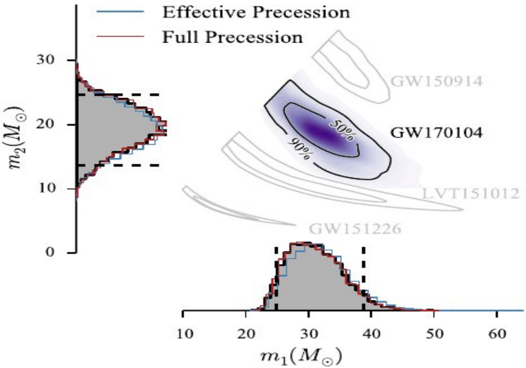


FIG. 2. Posterior probability density for the source-frame masses m_1 and m_2 (with $m_1 \geq m_2$). The one-dimensional distributions include the posteriors for the two waveform models, and their average (black). The dashed lines mark the 90% credible interval for the average posterior. The two-dimensional plot shows the contours of the 50% and 90% credible regions plotted over a color-coded posterior density function. For comparison, we also show the two-dimensional contours for the previous events [5].

PRL v118 #221101 (2017)

Bell violation using entangled photons without the fair-sampling assumption

Marissa Giustina[1,2]*, Alexandra Mech[1,2]*, Sven Ramelow[1,2]*, Bernhard Wittmann[1,2]*, Johannes Kofler[1,3], Jörn Beyer[4], Adriana Lita[5], Brice Calkins[5], Thomas Gerrits[5], Sae Woo Nam[5], Rupert Ursin[1] & Anton Zeilinger[1,2]

After recording for a total of 300 s per setting we divided our data into 10-s blocks and calculated the standard deviation of the resulting 30 different J values. This yielded $\sigma = 1{,}837$ for our aggregate J value of $J = -126{,}715$, a 69-σ violation (see Fig. 3). Note that this calculation does not assume Poisson counting statistics or any error propagation rules. We estimate the number of produced pairs to $N = 24.2 \times 10^6$ per applied setting, yielding a normalized violation of $J/N = -0.00524$ (± 0.00008).

Nature v497 p227 (2013)

Loophole-free Bell inequality violation using electron spins separated by 1.3 kilometres

B. Hensen[1,2], H. Bernien[1,2]†, A. E. Dréau[1,2], A. Reiserer[1,2], N. Kalb[1,2], M. S. Blok[1,2], J. Ruitenberg[1,2], R. F. L. Vermeulen[1,2], R. N. Schouten[1,2], C. Abellán[3], W. Amaya[3], V. Pruneri[3,4], M. W. Mitchell[3,4], M. Markham[5], D. J. Twitchen[5], D. Elkouss[1], S. Wehner[1], T. H. Taminiau[1,2] & R. Hanson[1,2]

ensure the required locality conditions[13]. We performed 245 trials that tested the CHSH–Bell inequality[20] $S \leq 2$ and found $S = 2.42 \pm 0.20$ (where S quantifies the correlation between measurement outcomes). A null-hypothesis test yields a probability of at most $P = 0.039$ that a local-realist model for space-like separated sites could produce data with a violation at least as large as we observe, even when allowing for memory[16,21] in the devices.

NV center in diamond

Nature v526 p682 (2015)

Scalable multiparticle entanglement of trapped ions

H. Häffner[1,3], W. Hänsel[1], C. F. Roos[1,3], J. Benhelm[1,3], D. Chek-al-kar[1], M. Chwalla[1], T. Körber[1,3], U. D. Rapol[1,3], M. Riebe[1], P. O. Schmidt[1], C. Becher[1]†, O. Gühne[3], W. Dür[2,3] & R. Blatt[1,3]

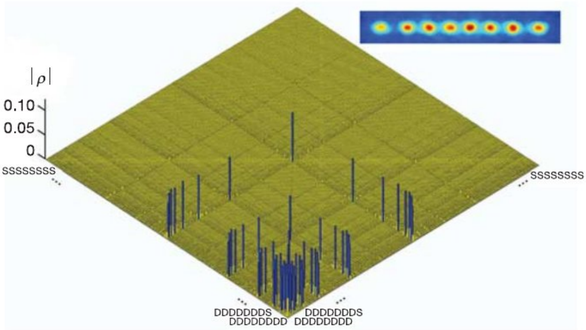


Figure 1 | Absolute values, $|\rho|$, of the reconstructed density matrix of a $|W_8\rangle$ state as obtained from quantum state tomography.

Table 2 | Entanglement properties of ρ_N

Property	$N = 3$	$N = 8$
F	0.824	0.722 (1)
$\mathrm{tr}(\tilde{\mathcal{W}}_N \rho_N)$	−0.532	−0.029 (8)
$\min(C_{kl})$	0.724	0.536 (8)
$\bar{C}$	0.776	0.633 (3)
$\min(C'_{kl})$	0.294	0.022 (3)
$\bar{C}'$	0.366	0.073 (1)

Nature v438 p643 (2005)