

Kuantum bilgi bilimi ve teknolojileri

11. FF Semineri

19 Aralık 2012

feliztronot



KUANTUM
DÜŞÜNCE TEKNİĞİ

Fethon Efecinar'ın
KUANTUM SİÇRAMAS

SİSTEM YAYINCILIK

3. BASKI

İmkânsız diye bir şey yoktur!

**KUANTUM
DÜŞÜNCE
YÖNTEMİ**

James J. Mapes

Sandra Anne TAYLOR

Zenginliğe ve Başarıya Sağlıklı Yollar
**KUANTUM
BAŞARI**

21

**KUANTUM
DÜŞÜNCE TEKNİĞİ**

Yeni Bir Gerçeklik İncelemesi (Dijitalizasyon Süreci)

R. ŞANAL

ARITAN

14.
BASKI

**Kuantum
Yaşam Müjizesi
İçin 5 Adım**

Natalie R.

R. Şanal

**KUANTUM
SİÇRAMA**

Acıdan Mutluluğa, Yokluktan Bolluğa,
Hastalıktan Şifaya...

ARITAN



Klasik bilgi vs. kuantum bilgi

Kuantum şifreleme ve haberleşme

Kuantum simülasyon

Kuantum hafızalar ve kendi deneylerimiz

Klasik bilgi

EVET – HAYIR

Klasik bilgi

EVET – HAYIR

VAR – YOK

Klasik bilgi

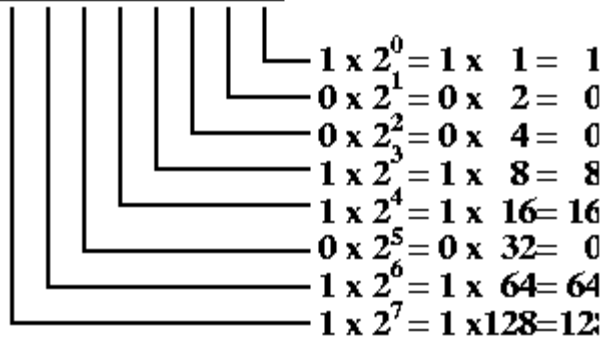
EVET – HAYIR

VAR – YOK

1 – 0

Klasik bilgi

1 1 0 1 1 0 0 1

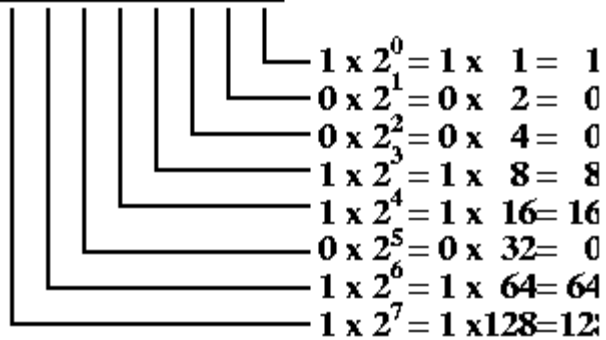


8 bit = 1 bayt (*byte*)

$$1 + 8 + 16 + 64 + 128 = 217$$

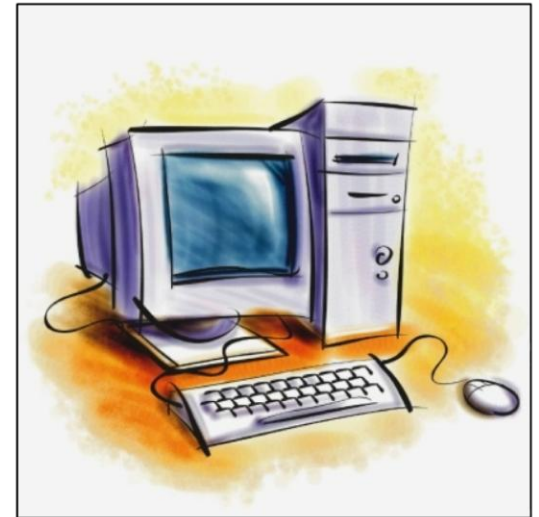
Klasik bilgi

1 1 0 1 1 0 0 1



$$1 + 8 + 16 + 64 + 128 = 217$$

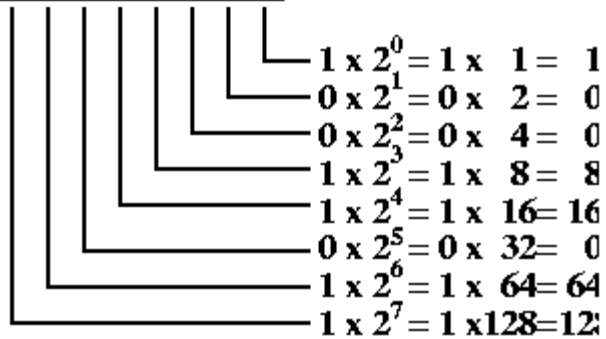
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Bilginin saklanması...

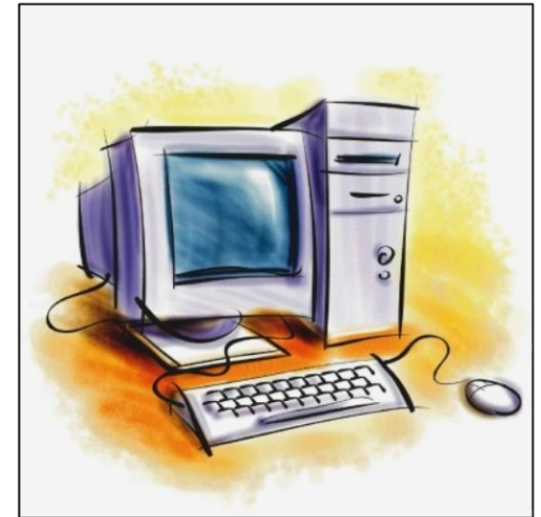
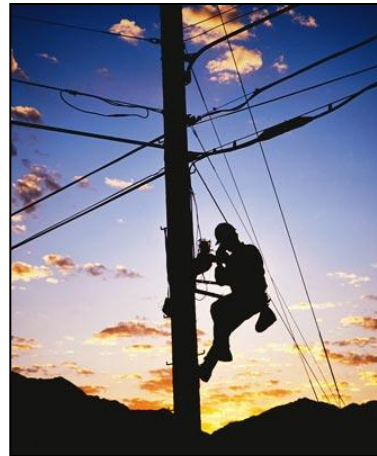
Klasik bilgi

1 1 0 1 1 0 0 1



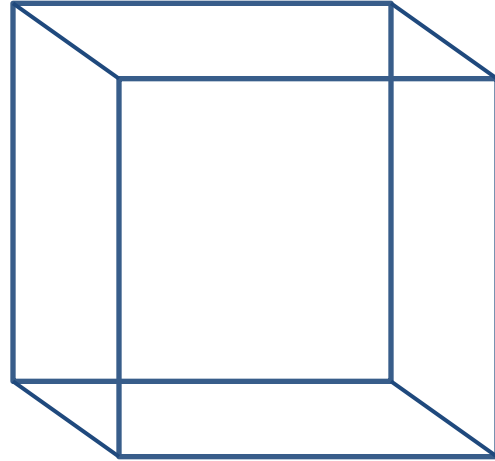
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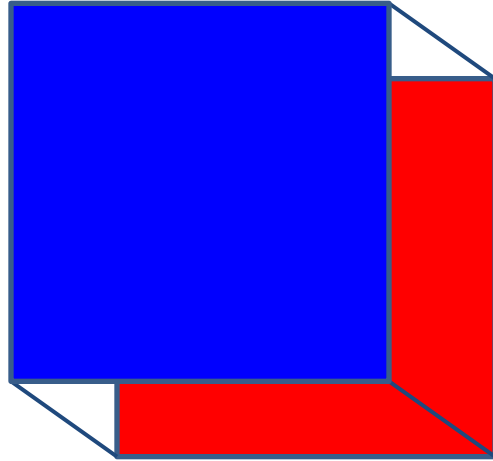
Bilginin **saklanması** ve **iletilmesi** gerekir.

Süperpozisyon

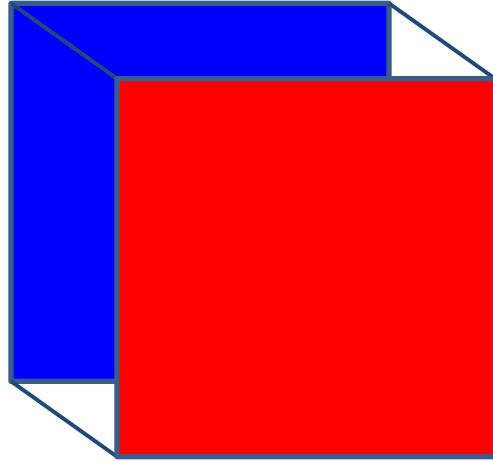


Hangi kübü görüyorsunuz?

Süperpozisyon



Süperpozisyon



Süperpozisyon

Aynı anda birden fazla duruma sahip olma.

Yapılan bir ölçüm üzerine sistemin o duruma “çökmesi”

Süperpozisyon

$|EVET\rangle + |HAYIR\rangle$

$|VAR\rangle + |YOK\rangle$

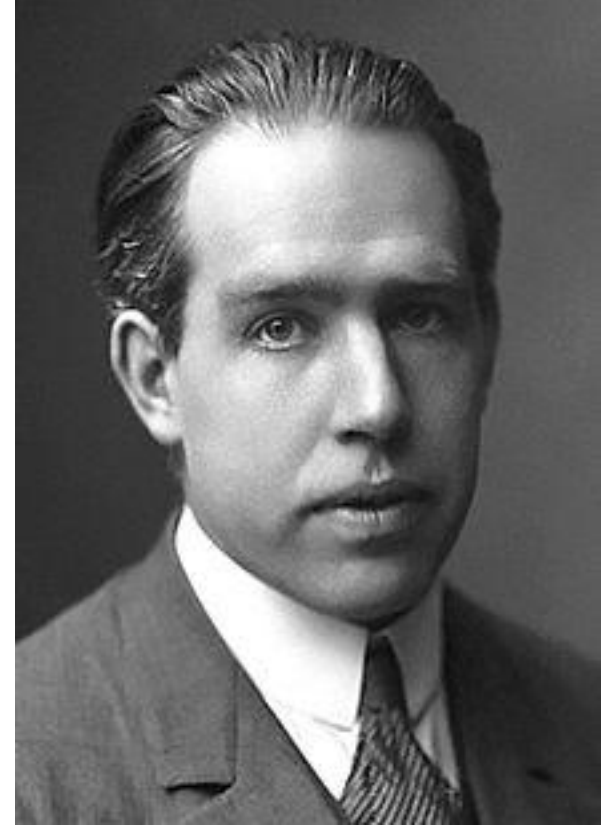
$|1\rangle + |0\rangle$

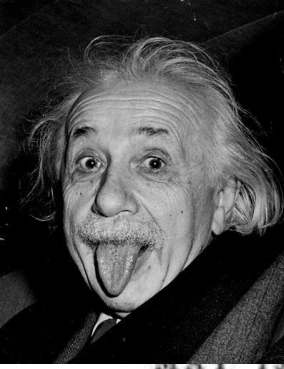
Süperpozisyon

Ölçüm yapılana kadar sistem aynı anda muhtemel bütün durumları taşır. Ölçüm yapıldığında sistem olası durumlardan birisine **belli bir olasıkla** “çöker” (*wavefunction collapse*)



Niels Bohr Enstitüsü, Kopenhag





Einstein'ın itirazı

MAY 1935

PHYSICAL REVIEW

VOLUME 47

Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?

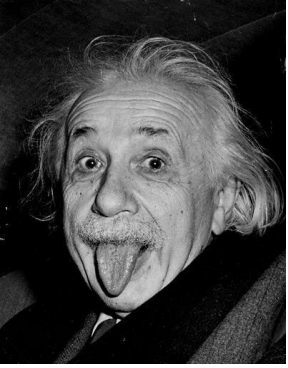
A. EINSTEIN, B. PODOLSKY AND N. ROSEN, *Institute for Advanced Study, Princeton, New Jersey*

(Received March 25, 1935)

In a complete theory there is an element corresponding to each element of reality. A sufficient condition for the reality of a physical quantity is the possibility of predicting it with certainty, without disturbing the system. In quantum mechanics in the case of two physical quantities described by non-commuting operators, the knowledge of one precludes the knowledge of the other. Then either (1) the description of reality given by the wave function in

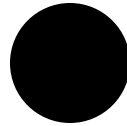
quantum mechanics is not complete or (2) these two quantities cannot have simultaneous reality. Consideration of the problem of making predictions concerning a system on the basis of measurements made on another system that had previously interacted with it leads to the result that if (1) is false then (2) is also false. One is thus led to conclude that the description of reality as given by a wave function is not complete.

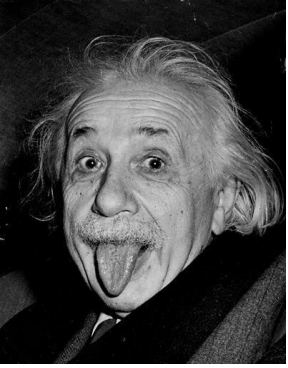
Birbiri ile alakalı iki parçacık (A, B) olsun. Birisi $|1\rangle$ ise diğeri $|0\rangle$ olsun. Ama ikisi de başlangıçta $|1\rangle + |0\rangle$ durumunda. Farzedelim ki A üzerinde ölçüm yaptık ve $|1\rangle$ bulduk. Bu durumda B'nin $|0\rangle$ olduğu sonucuna, **B üzerinde ölçüm yapmadan ulaşıyoruz.**



Einstein'ın itirazı

$$S = 0$$





Einstein'in itirazı



Kuantum dolanıklık

$$\Psi \approx |1\rangle_A |-1\rangle_B + |-1\rangle_A |1\rangle_B$$

$$\mathbf{A} = |1\rangle (|-1\rangle) \longleftrightarrow \mathbf{B} = |-1\rangle (|1\rangle)$$

(A $|1\rangle$ ise B $|-1\rangle$ demek, ve tersi)

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(A $|1\rangle$ ise B $|-1\rangle$ demek, ve tersi)

A ile B arasında çok uzak mesafeler olsa bile A üzerinde ölçüm yaparak B'nin hangi durumda olduğu bilgisini elde ederiz. B anında A üzerindeki ölçümden haberdar olup öğrendiğimiz duruma *çöker*.

“Spooky action at a distance”

Einstein

Kuantum dolanıklık

Meraklılar için:

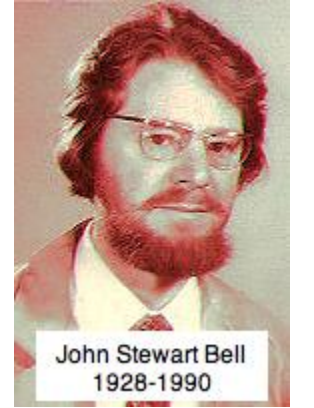
Gizli deęişkenler teorileri (*hidden variables* olarak geçen ve bu “anında etki”yi açıklayacağı düşünölmekteydi)

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Gizli deęişkenler teorileri (*hidden variables* olarak geen ve bu “anında etki”yi aıklayacağı düşünölmekteydi)

Bell teoremi: 1964’te CERN fizikisi **John Bell**’in ortaya attığı GD teorilerinin test edilebileceğini söyleyen teorem (deneyler de **Bell testleri** olarak biliniyor artık).

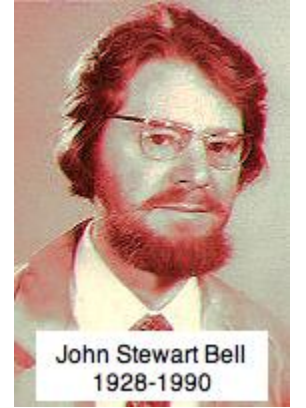


Kuantum dolanıklık

Meraklılar için:

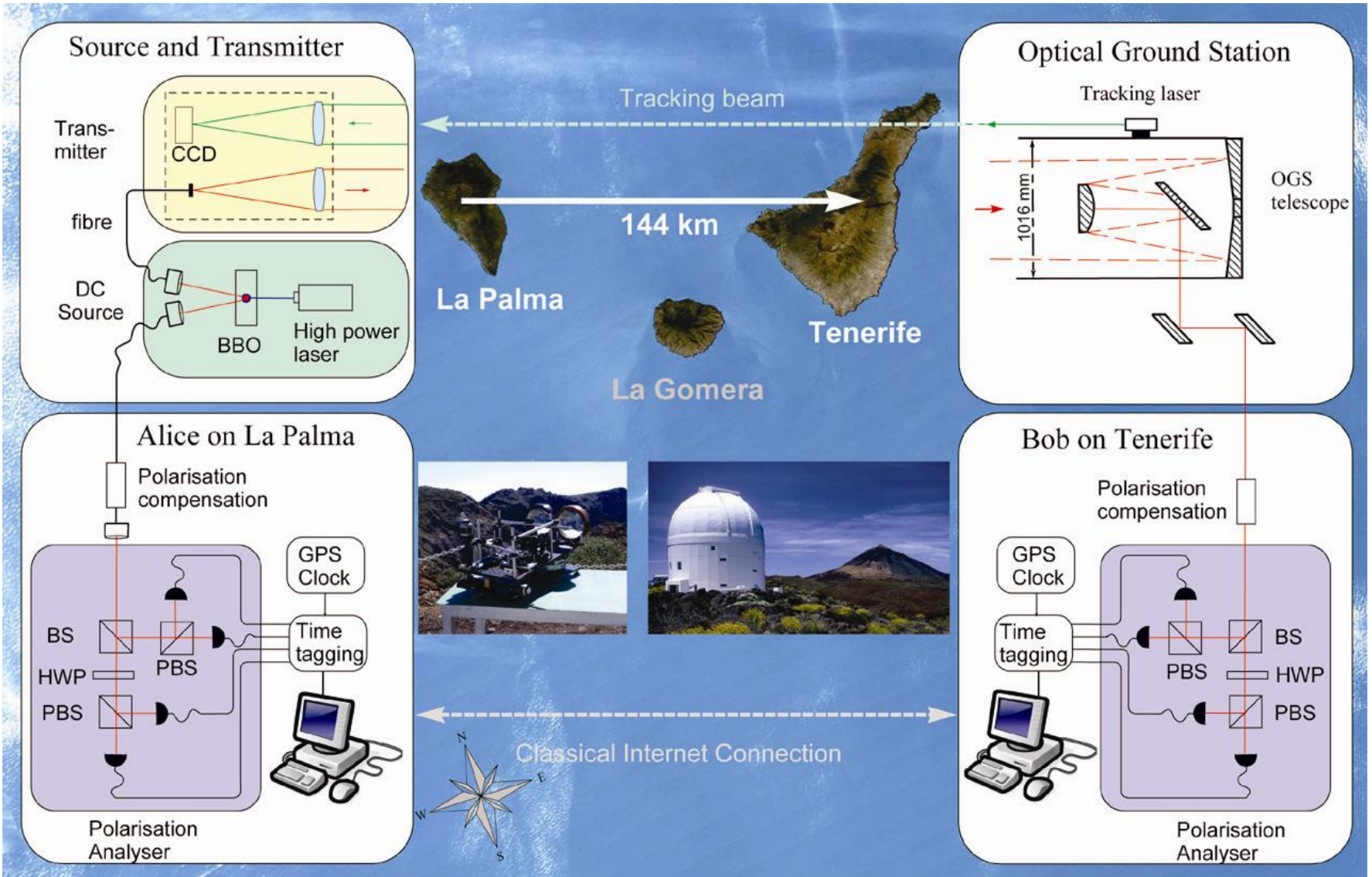
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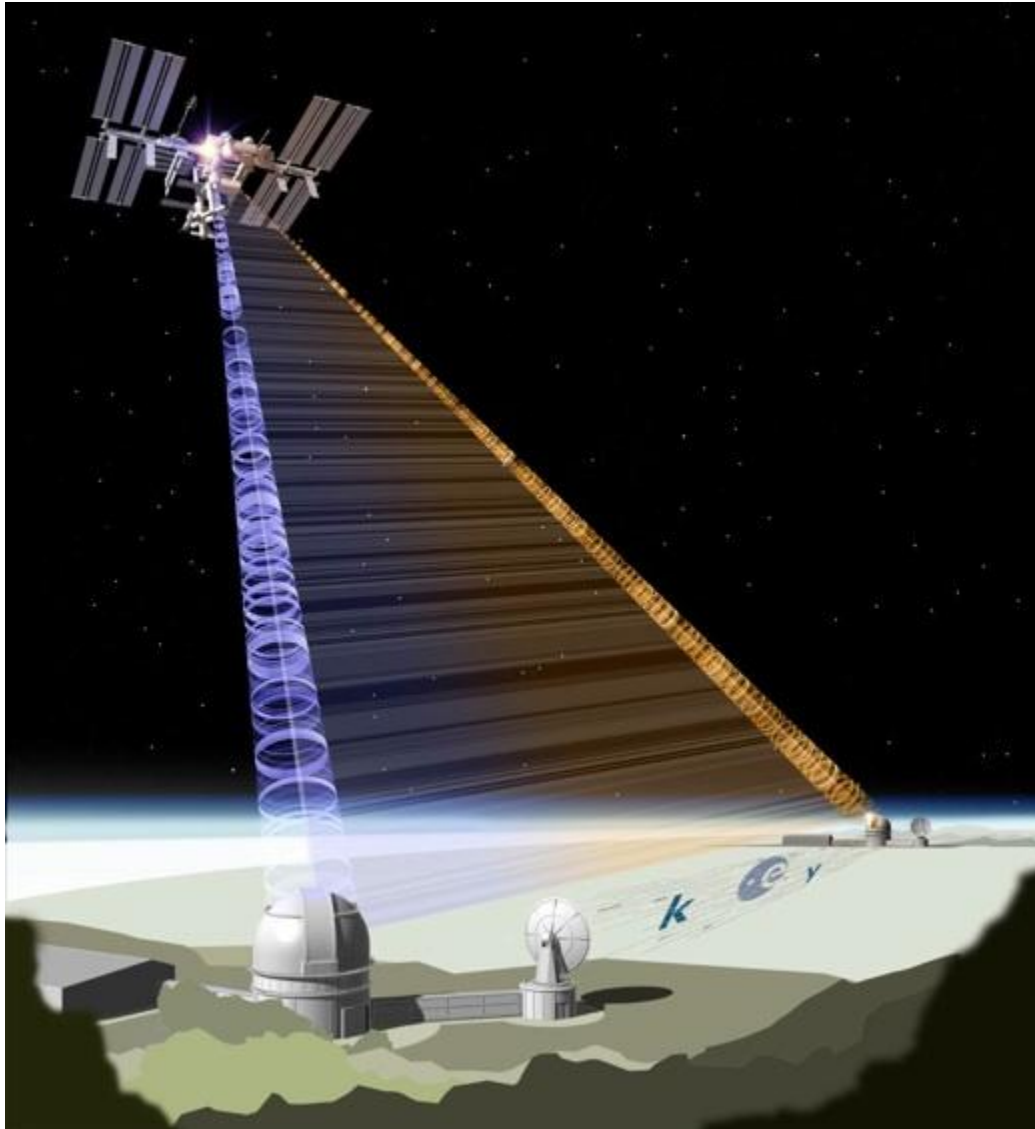
İlk deney: 1982’de Paris’te **Alain Aspect** tarafından yapıldı. Kuantum mekaniğinin doęru olduęu sonucunu verdi.

Rekor: 144 km



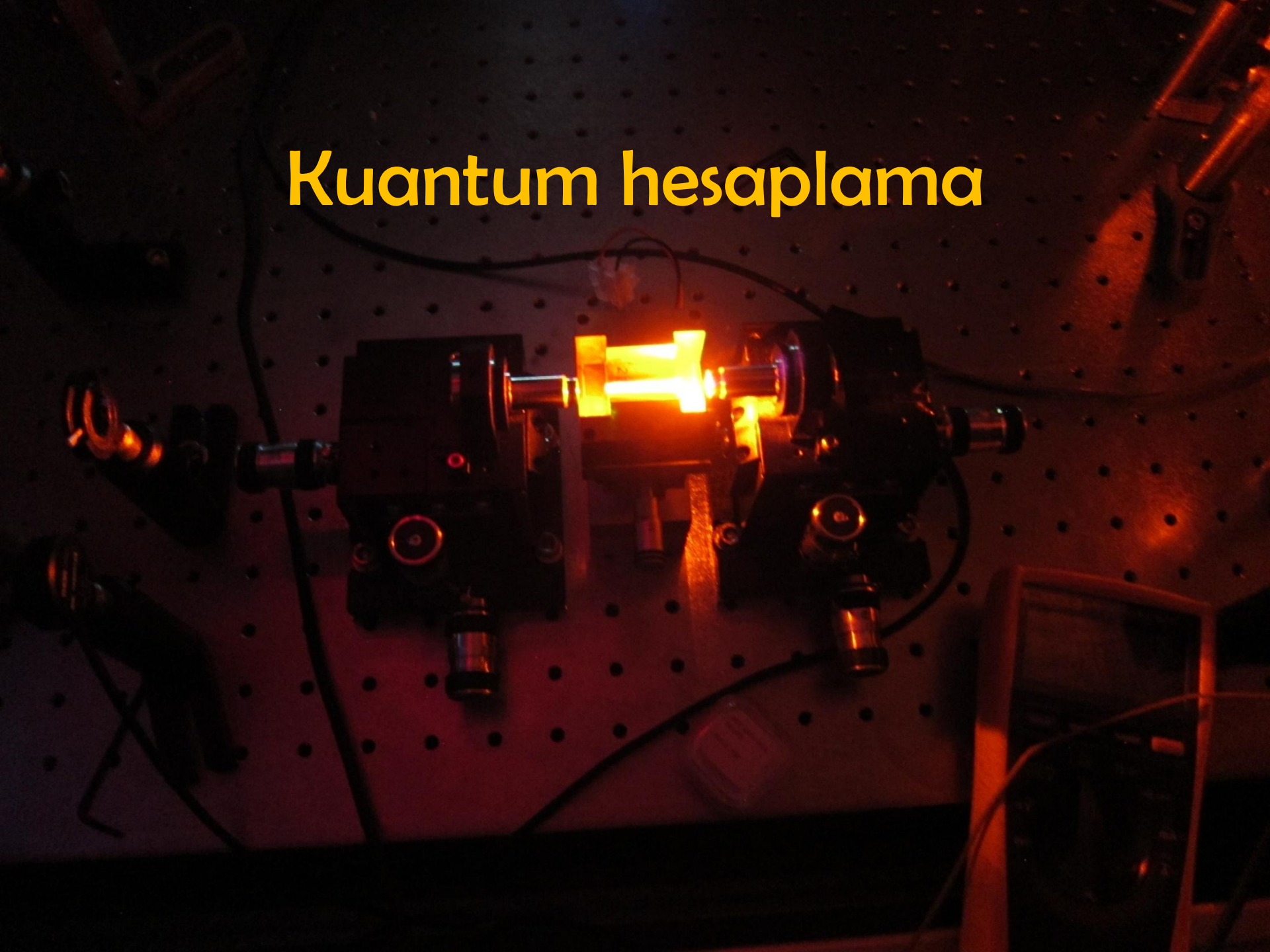
Rekor: 144 km





www.quantum.at/quest

Kuantum hesaplama



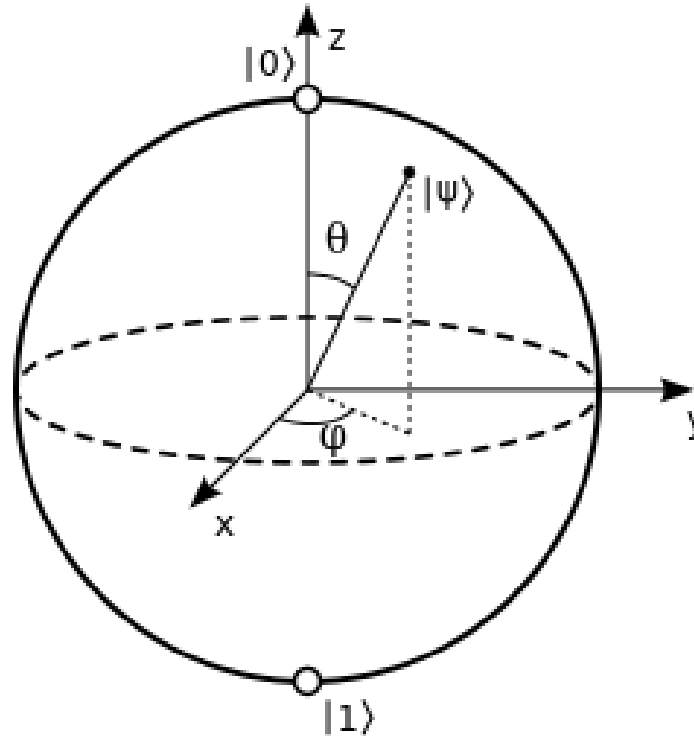
Kuantum bit – kubit

$$|1\rangle + |0\rangle$$

Kuantum hesaplama, gücünü kuantum süperpozisyon prensibinden alır

Kuantum bit – kubit

Meraklılar için:



Bloch küresi

Kuantum algoritmalar

Shor'un çarpanlarına ayırma (*factoring*) algoritması



Bir tamsayı N 'yi çarpanlarına çok hızlı bir şekilde ayırma algoritmasıdır.

Günümüz şifreleme sistemleri (RSA mesela) büyük sayıların faktörize edilmesine dayandığı için Shor algoritması bulunduğu anda çoğu şifre çok kısa sürede kırılabilir duruma gelecek.

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L=400 basamaklı bir sayı için:

$$O(e^{L^{1/3}}) \quad O(L^3)$$

Klasik: 10 milyar yıl Shor algoritması: 3 yıl

Kuantum algoritmalar

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Ana içeriği **kuantum fourier dönüşümü**

$$15 = 5 \times 3$$

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^{*†}

^{*} IBM Almaden Research Center, San Jose, California 95120, USA

[†] Solid State and Photonics Laboratory, Stanford University, Stanford, California 94305-4075, USA

The number of steps any classical computer requires in order to find the prime factors of an l -digit integer N increases exponentially with l , at least using algorithms known at present¹. Factoring large integers is therefore conjectured to be intractable classically, an observation underlying the security of widely used cryptographic codes^{1,2}. Quantum computers³, however, could factor integers in only polynomial time, using Shor's quantum factoring algorithm⁴⁻⁶. Although important for the study of quantum computers⁷, experimental demonstration of this algorithm has proved elusive⁸⁻¹⁰. 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

i	$\omega_i/2\pi$	$T_{1,i}$	$T_{2,i}$	J_{7i}	J_{6i}	J_{5i}	J_{4i}	J_{3i}	J_{2i}
1	-22052.0	5.0	1.3	-221.0	37.7	6.6	-114.3	14.5	25.16
2	489.5	13.7	1.8	18.6	-3.9	2.5	79.9	3.9	
3	25088.3	3.0	2.5	1.0	-13.5	41.6	12.9		
4	-4918.7	10.0	1.7	54.1	-5.7	2.1			
5	15186.6	2.8	1.8	19.4	59.5				
6	-4519.1	45.4	2.0	68.9					
7	4244.3	31.6	2.0						

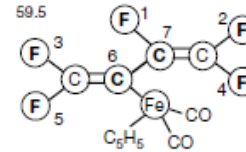


Figure 2 Structure and properties of the quantum computer molecule, a perfluorobutadienyl iron complex with the inner two carbons ¹³C-labelled. Based on the measured $J_{13C,19F}$ values, we concluded that the placement of the iron is as shown, different from that derived in ref. 29 from infrared spectroscopy. The table gives the $\omega_i/2\pi$ (in Hz) at 11.7 T, relative to a reference frequency of -470 MHz and -125 MHz for ¹⁹F and ¹³C respectively, the longitudinal (T_1 , inversion recovery) and transverse (T_2 ,

$$15 = 5 \times 3$$

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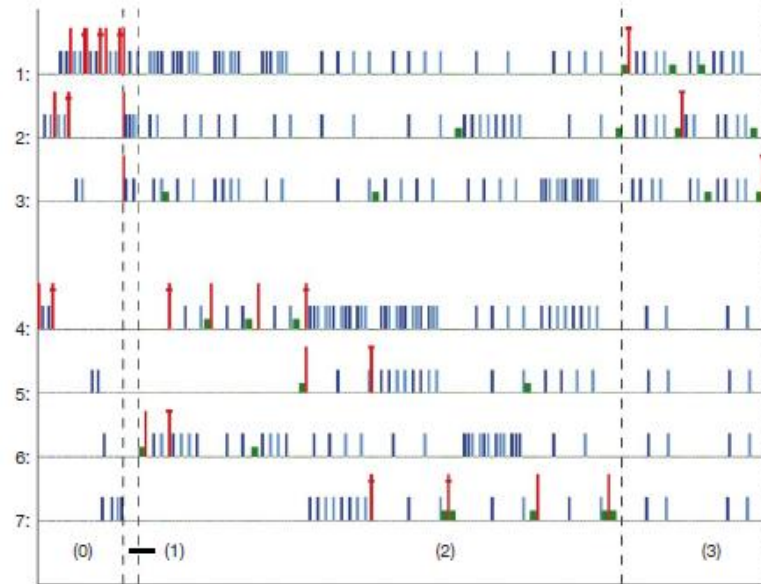
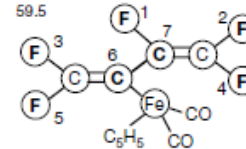


Figure 4 Pulse sequence for implementation of the quantum circuit of Fig. 1 for $a = 7$. The tall red lines represent 90° pulses selectively acting on one of the seven qubits (horizontal lines) about positive \hat{x} (no cross), negative \hat{x} (lower cross) and positive \hat{y} (top cross). Note how single 90° pulses correspond to Hadamard gates, and pairs of such pulses separated by delay times correspond to two-qubit gates. The smaller blue lines

denote 180° selective pulses used for refocusing³⁰ about positive (darker shade) and negative \hat{x} (lighter shade). Rotations about \hat{z} are denoted by smaller and thicker green rectangles, and were implemented with frame-rotations. Time delays are not drawn to scale. The vertical dashed black lines visually separate the steps of the algorithm; step (0) shows one of the 36 temporal averaging sequences.

$$21 = 7 \times 3$$

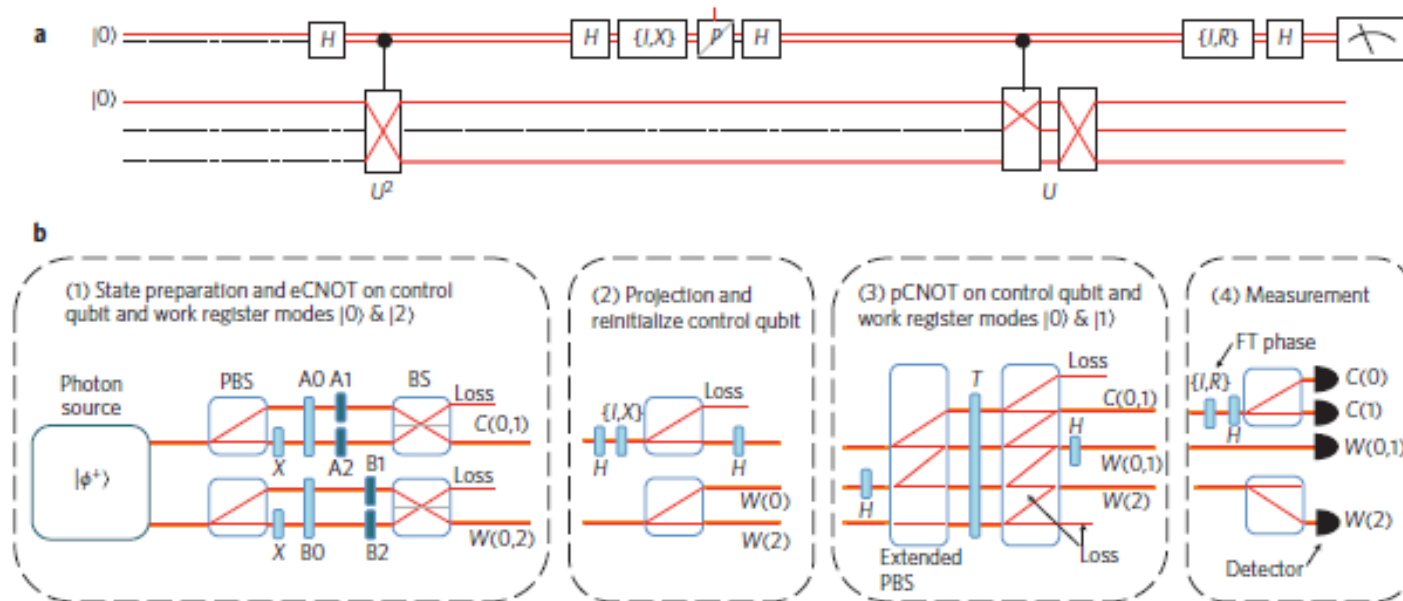
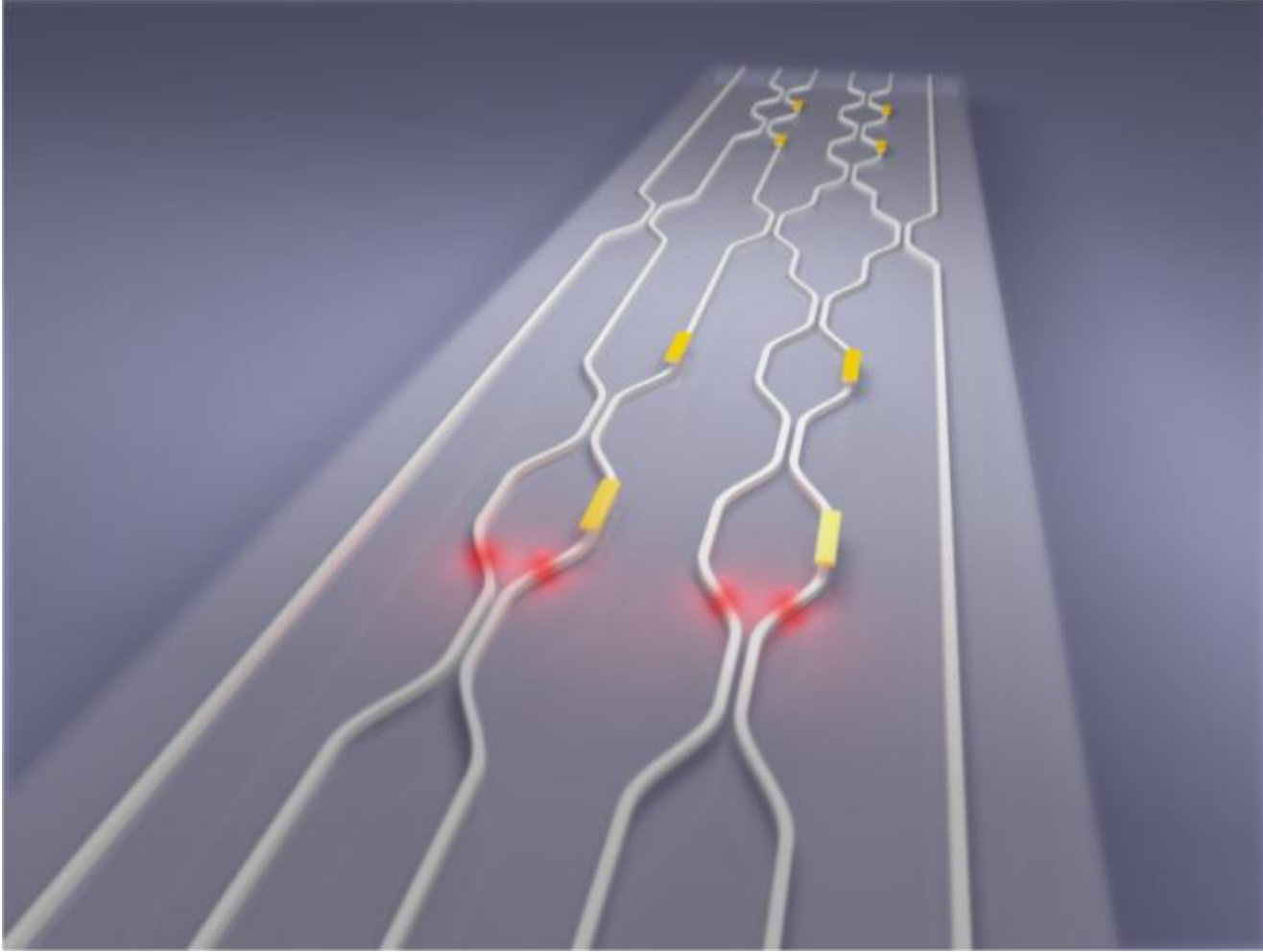


Figure 2 | Compiled iterative order-finding algorithm. **a**, Idealized compiled circuit diagram. The first controlled unitary is implemented as a CNOT acting on work modes 0 and 2; the final controlled unitary uses a CNOT on work modes 0 and 1 followed by an uncontrolled swap on work modes 0 and 2. P indicates a projection onto the computational 0, preceded by either a bit flip gate X , or the identity operation I . H denotes the Hadamard gate. The iterative Fourier transform (FT) includes the rotation $R = |H\rangle\langle H| - i|V\rangle\langle V|$ when the first projection is made onto the computational 1 state (see Supplementary Information for details). **b**, Schematic of the experimental circuit (see Methods for details).

Kuantum dalgakılavuzları

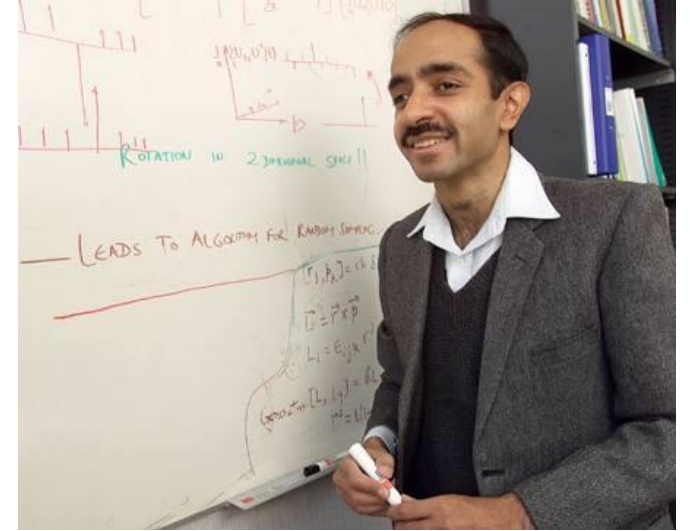


Çip tabanlı olduğu için prensipte ölçeklenebilir (*scalable*) bir sistem

Kuantum algoritmalar

Grover arama algoritması

Klasik olarak bir veritabanında istenen bir elemanı bulmak için elemanlara tek tek bakmak gerekir
– **arama süresi veritabanı boyu ile doğru orantılı - $O(N)$.**



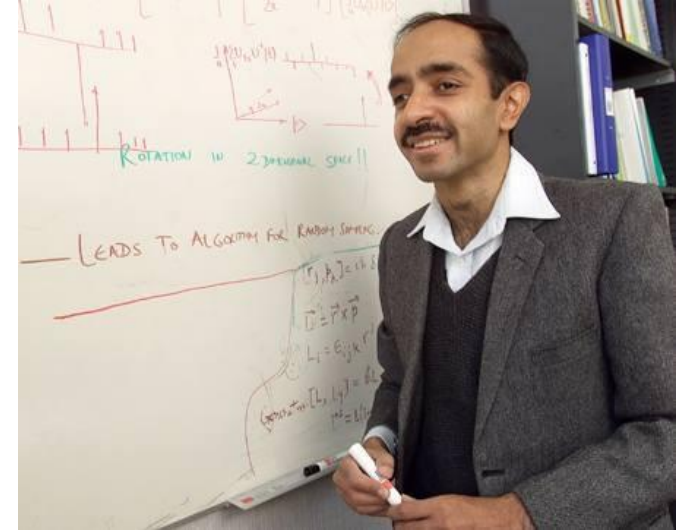
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GAM ise kubitlerden faydalanarak bu süreyi karekök mertebesine düşürebilmekte - $O(\sqrt{N})$

Klasik olarak 1 ay sürebilecek bir arama 27 dakikaya inebilecek.



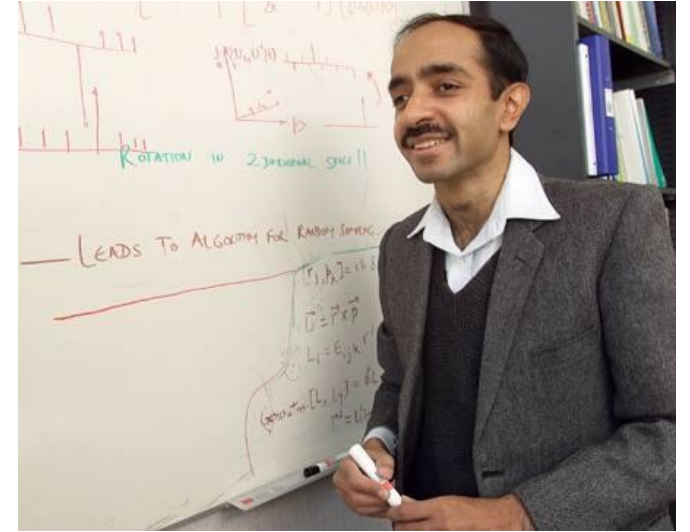
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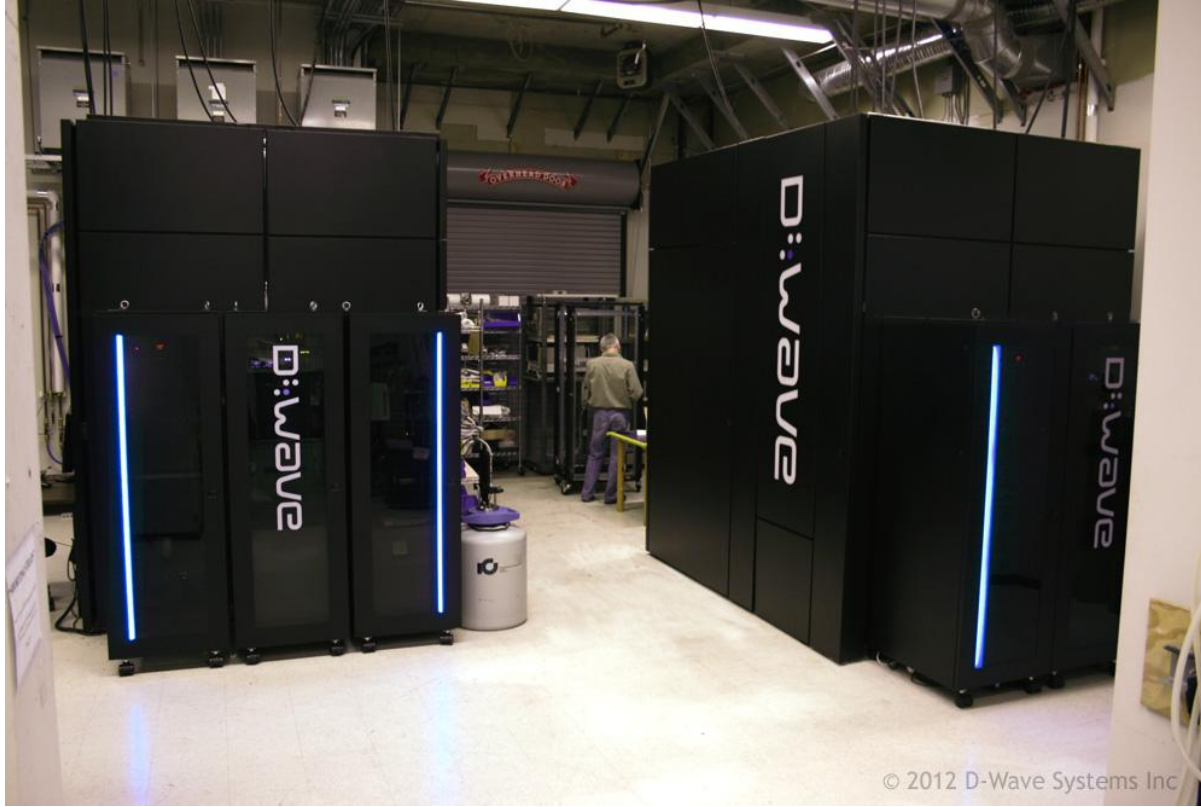
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D-Wave Őirketi



“*Quantum annealing*” tekniĐi ile kuantum hesaplama yaptıklarınđ iddia ediyorlar.

D-Wave Őirketi



“Quantum annealing” tekniĐi ile kuantum hesaplama yaptıklarını **iddia ediyorlar**.

Tanesini 10 milyon dolara satıyorlar. Lockheed Martin ilk müşterilerinden birisi.

Kuantum von Neumann mimarisi

Implementing the Quantum von Neumann Architecture with Superconducting Circuits

Matteo Mariantoni,^{1,4*} H. Wang,^{1†} T. Yamamoto,^{1,2} M. Neeley,^{1‡} Radoslaw C. Bialczak,¹ Y. Chen,¹ M. Lenander,¹ Erik Lucero,¹ A. D. O'Connell,¹ D. Sank,¹ M. Weides,^{1§} J. Wenner,¹ Y. Yin,¹ J. Zhao,¹ A. N. Korotkov,³ A. N. Cleland,^{1,4} John M. Martinis^{1,4*}

The von Neumann architecture for a classical computer comprises a central processing unit and a memory holding instructions and data. We demonstrate a quantum central processing unit that exchanges data with a quantum random-access memory integrated on a chip, with instructions stored on a classical computer. We test our quantum machine by executing codes that involve seven quantum elements: Two superconducting qubits coupled through a quantum bus, two quantum memories, and two zeroing registers. Two vital algorithms for quantum computing are demonstrated, the quantum Fourier transform, with 66% process fidelity, and the three-qubit Toffoli-class OR phase gate, with 98% phase fidelity. Our results, in combination especially with longer qubit coherence, illustrate a potentially viable approach to factoring numbers and implementing simple quantum error correction codes.

Kuantum von Neumann mimarisi

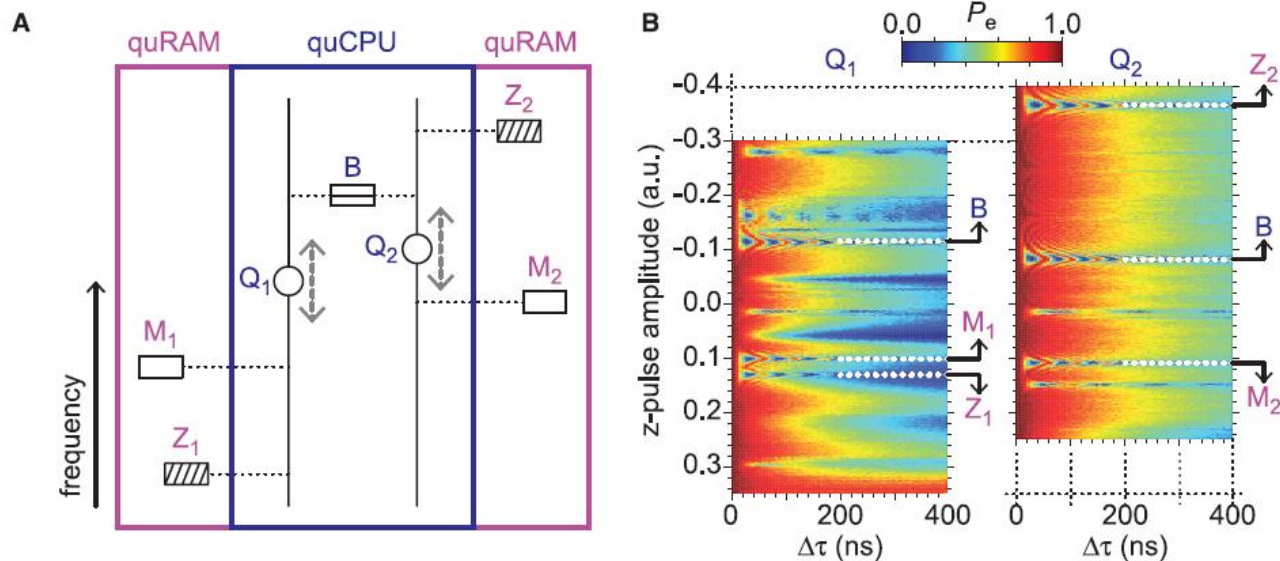


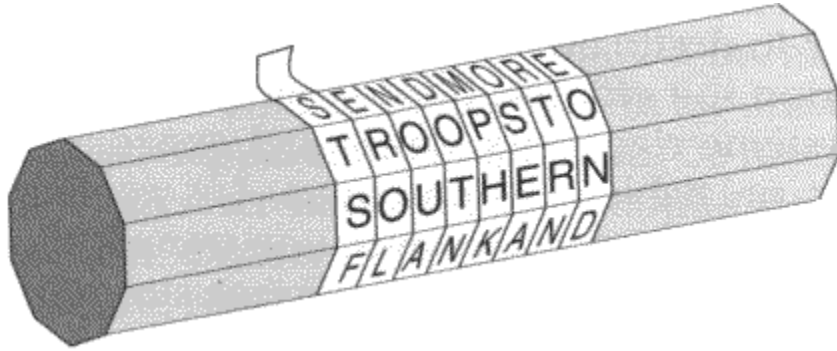
Fig. 1. The quantum von Neumann architecture. **(A)** The quCPU (blue box) includes two qubits Q_1 and Q_2 and the bus resonator B. The quRAM (magenta boxes) comprises two memories M_1 and M_2 and two zeroing registers Z_1 and Z_2 . The horizontal dotted lines indicate connections between computational elements. The vertical direction represents frequency, where the memory and zeroing registers are fixed in frequency, whereas the qubit transition frequencies can be tuned by z-pulses (gray dashed double arrows). **(B)** Swap spectroscopy (21) for Q_1 (left) and Q_2 (right): Qubit excited state $|e\rangle$ probability P_e (color scale) versus z-pulse amplitude (vertical axis) and delay time $\Delta\tau$ (horizontal axis), after exciting the qubit with a π -pulse. At zero z-pulse amplitude the qubits are at their idle points, where they have an energy relaxation time $T_{\text{rel}} \cong 400$ ns. A separate Ramsey experiment yields the qubits' dephasing time $T_{\text{deph}} \cong 200$ ns. By tuning the z-pulse amplitude, the qubit

transition frequencies f_{Q_1} and f_{Q_2} can be varied between $\cong 5.5$ and 8 GHz. For z-pulse amplitudes indicated by B and M_1 for Q_1 , and by B and M_2 for Q_2 , the chevron pattern of a qubit-resonator interaction is observed (21). The transition frequencies of B, M_1 , and M_2 are $f_B = 6.82$ GHz, $f_{M_1} = 6.29$ GHz, and $f_{M_2} = 6.34$ GHz, respectively. From the chevron oscillation, we obtain the qubit-resonator coupling strengths, which for both the resonator bus and the memories are $\cong 20$ MHz (splitting) for the $|g\rangle \leftrightarrow |e\rangle$ qubit transition, and $\approx \sqrt{2}$ faster for the $|e\rangle \leftrightarrow |f\rangle$ transition ($|g\rangle$, $|e\rangle$, and $|f\rangle$ are the three lowest qubit states) (22). For all resonators, $T_{\text{rel}} \cong 4$ μs . Swap spectroscopy also reveals that the qubits interact with several modes associated with spurious two-level systems. Two of them, Z_1 and Z_2 , are used as zeroing registers. Their transition frequencies are $f_{Z_1} = 6.08$ GHz and $f_{Z_2} = 7.51$ GHz, respectively, with coupling strength to the qubits of $\cong 17$ MHz.

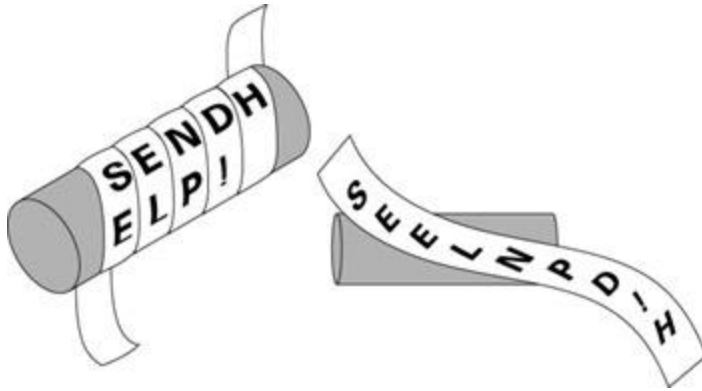
Kuantum haberleşme (kuantum anahtar dağıtımı)



Klasik şifreleme



Scytale – Sezar şifresi



Şifrelenmiş mesaj + anahtar

Klasik şifreleme

- 1 – Büyük sayıların çok zor faktörize edilebilmesi temelli.
- 2 – Public-key (*açık-anahtar*) dağıtımını sözkonusu

Kuantum anahtar dağıtımı

(Quantum key distribution - QKD)

- Fiber-optik iletişim hattında **tek foton**larla yapılır.
- Dolanıklık özelliğinin kullanılması şart değildir.
- Tek fotonlar kullanıldığı için araya bir casus girip bilgi çalmaya kalksa farkedilmesi çok kolay olacaktır.

Kuantum anahtar dağıtımı

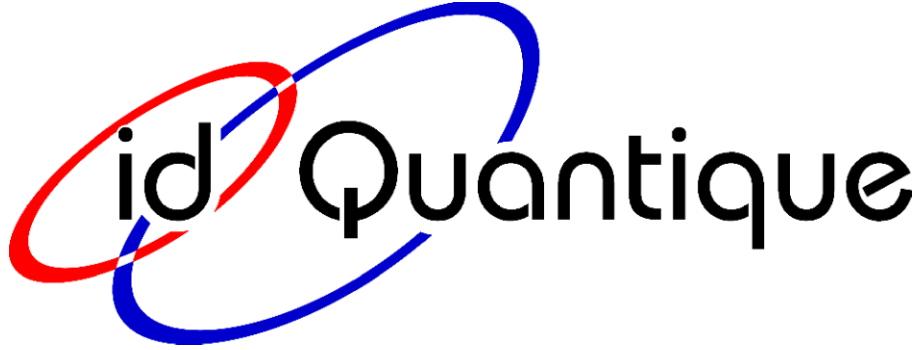
(Quantum key distribution - QKD)

- Fiber-optik iletişim hattında **tek foton**larla yapılır.
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- Tek fotonlar kullanıldığı için araya bir casus girip bilgi çalmaya kalksa farkedilmesi çok kolay olacaktır.

Alice's random bit	0	1	1	0	1	0	0	1
Alice's random sending basis	+	+	×	+	×	×	×	+
Photon polarization Alice sends	↑	→	↘	↑	↘	↗	↗	→
Bob's random measuring basis	+	×	×	×	+	×	+	+
Photon polarization Bob measures	↑	↗	↘	↗	→	↗	→	→
PUBLIC DISCUSSION OF BASIS								
Shared secret key	0		1			0		1

Kuantum anahtar dağıtımı

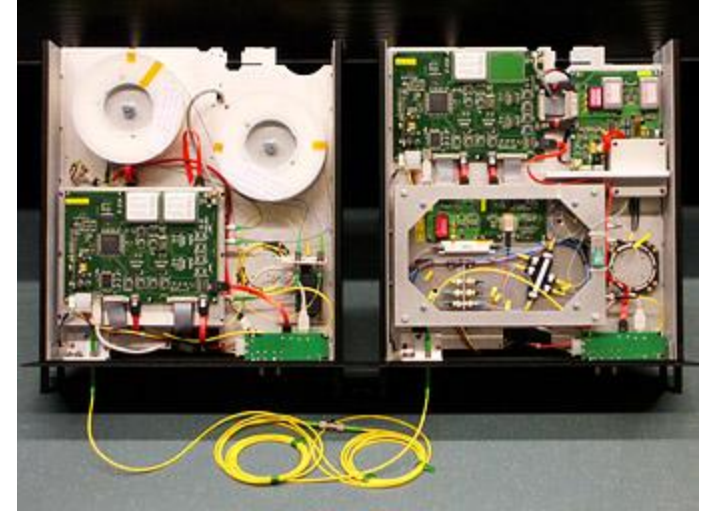
(Quantum key distribution - QKD)



2001'de İsviçre, Cenevre'de kuruldu.
2004'te ilk QKD cihazlarını piyasaya sürdü.

2007'de İsviçre yerel seçimlerinde
kullanıldı.

Benzer bir sistem 2004'te Viyana'da ilk
defa bir banka işlemi için kullanıldı.



Kuantum hacker



Vadim Makarov



Kuantum anahtar dağıtımı

(Quantum key distribution - QKD)

Fiber optik kablolardaki kayıp mesafe konusunda sınırlayıcı

10 GHz sinyal hızı 500 km'de 1 Hz'e düşmekte

10 milyar foton/saniye \rightarrow 1 foton/saniye

En uzun mesafeli QKD 100-200 km.

Kuantum anahtar dağıtımı

(Quantum key distribution - QKD)

Fiber optik kablolardaki kayıp mesafe konusunda sınırlayıcı

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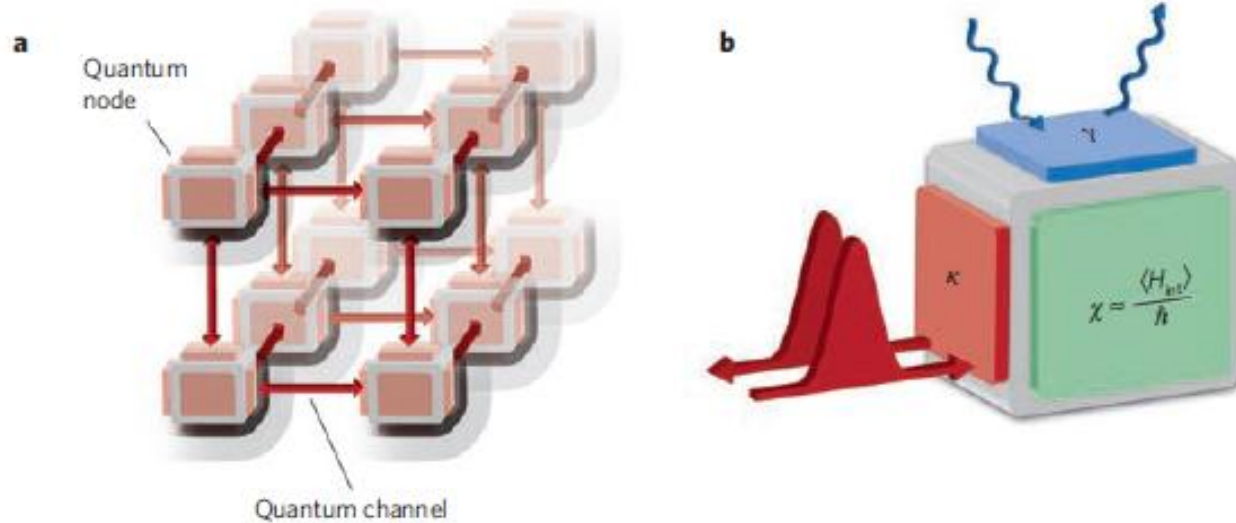
En uzun mesafeli QKD 100-200 km.

Çözüm: Kuantum ağlar

Kuantum ađ ve hafızaları



Quantum “*internet*”

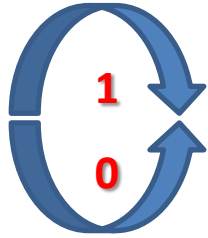


Kuantum *nod*lar

*Uçan kubit*ler ile *durağan kubit*ler arasında bir arayüz

Kuantum *nod*lar

*Uçan kubit*ler ile *durağan kubit*ler arasında bir arayüz



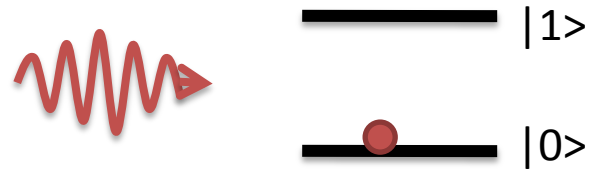
Örnek: Foton polarizasyonu



Örnek: Bir atomun elektronik seviyeleri

Kuantum *nod*lar

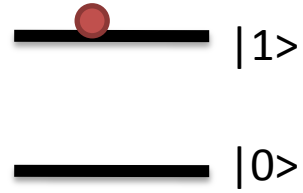
*Uçan kubit*ler ile *durağan kubit*ler arasında bir arayüz



Örnek: Bir atomun elektronik seviyeleri

Kuantum *nod*lar

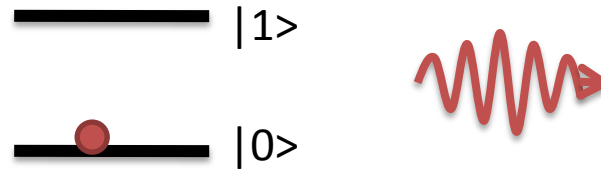
*Uçan kubit*ler ile *durağan kubit*ler arasında bir arayüz



Örnek: Bir atomun elektronik seviyeleri

Kuantum *nod*lar

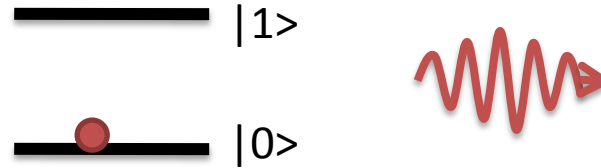
*Uçan kubit*ler ile *durağan kubit*ler arasında bir arayüz



Örnek: Bir atomun elektronik seviyeleri

Kuantum *nod*lar

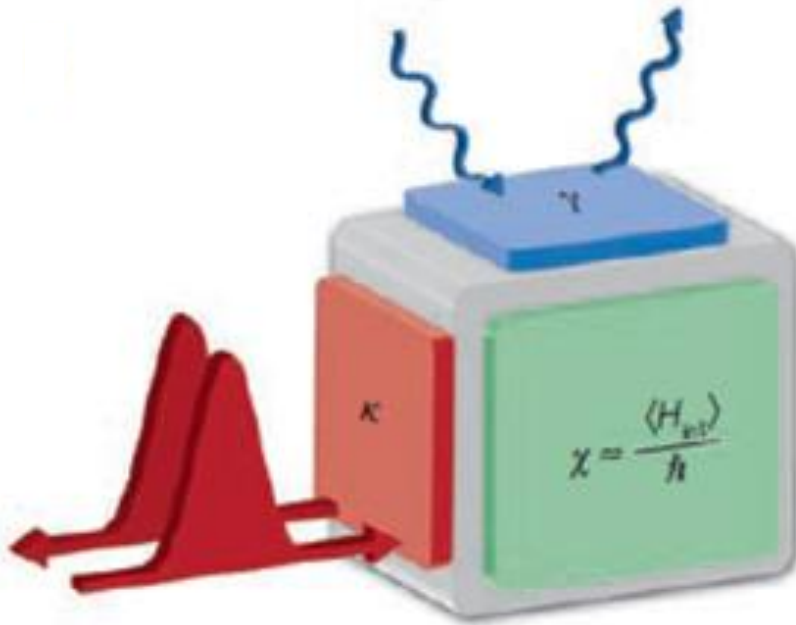
*Uçan kubit*ler ile *durağan kubit*ler arasında bir arayüz



Örnek: Bir atomun elektronik seviyeleri

Kuantum *nod*lar

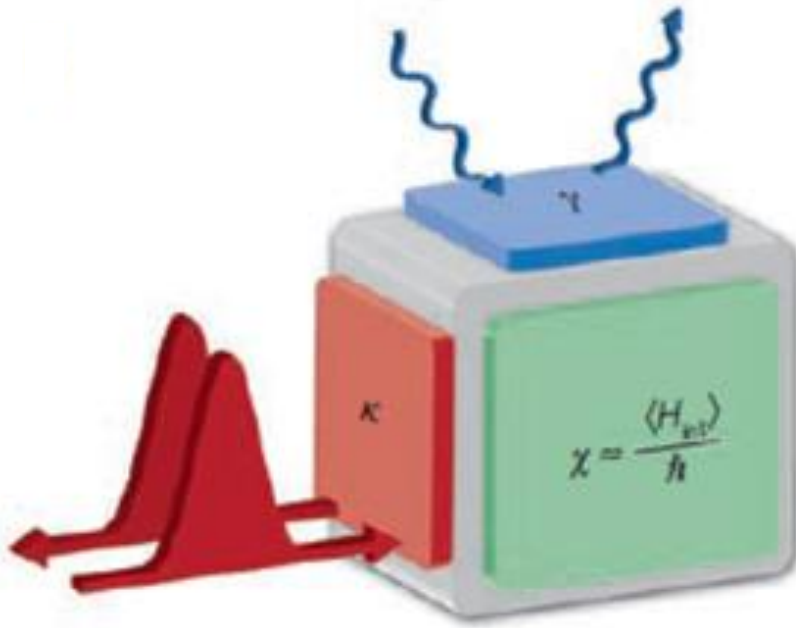
Gereklilikler:



Işıđı kuantum özellikleri ile birlikte saklamak ve geri alabilmek

Kuantum *nod*lar

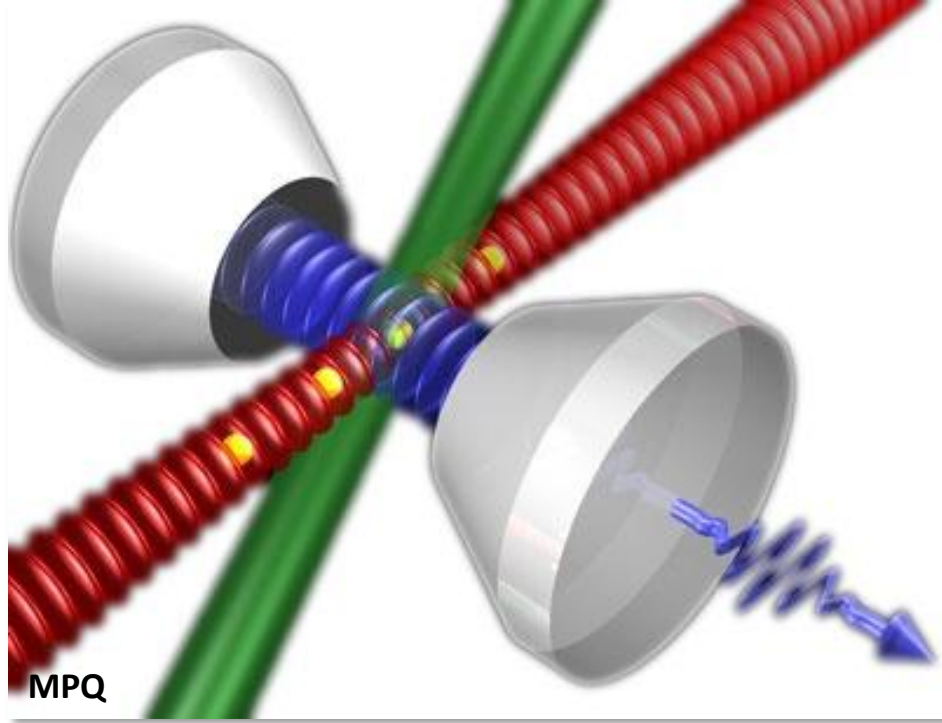
Gereklilikler:



Işıđı **kuantum özellikleri** ile birlikte saklamak ve geri alabilmek

- Verimlilik
- Saklama süresi
- Kuantum durumu koruma (*fidelity*)

Çeşitli kuantum hafızalar



İki ayna arasındaki tek atomlar
(Haroche, Kimble, Rempe...)

Manyeto-optik tuzaklama (magneto-optical trap - MOT)



The Nobel Prize in Physics 1997

Steven Chu, Claude Cohen-Tannoudji, William D. Phillips

The Nobel Prize in Physics 1997

Nobel Prize Award Ceremony

Steven Chu

Claude Cohen-Tannoudji

William D. Phillips



Steven Chu



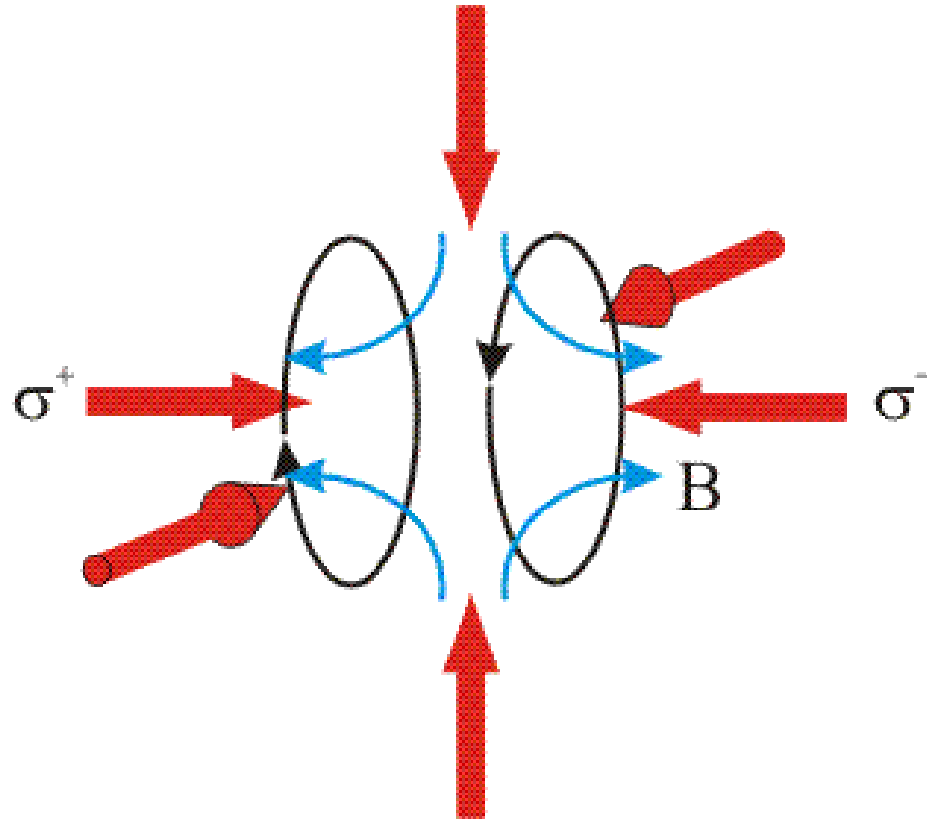
Claude Cohen-Tannoudji



William D. Phillips

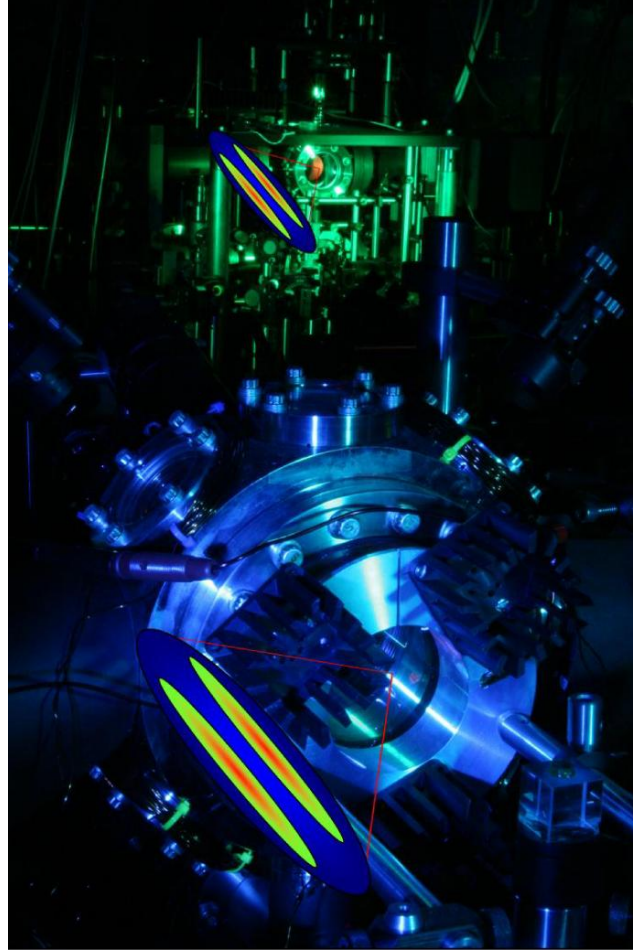
The Nobel Prize in Physics 1997 was awarded jointly to Steven Chu, Claude Cohen-Tannoudji and William D. Phillips *"for development of methods to cool and trap atoms with laser light"*.

Manyeto-optik tuzaklama (magneto-optical trap - MOT)



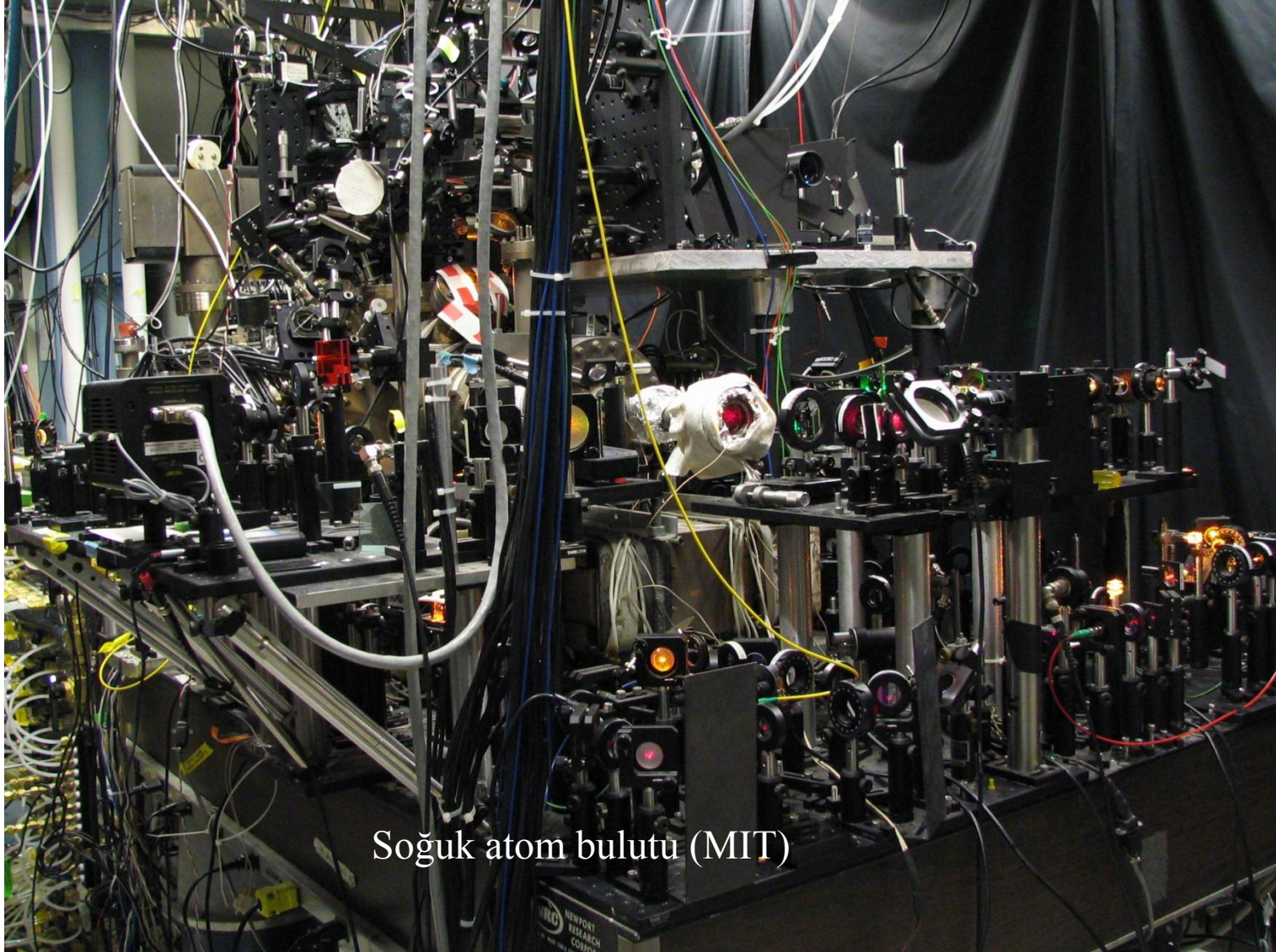
Soğuk atom kümeleri

Çeşitli kuantum hafızalar

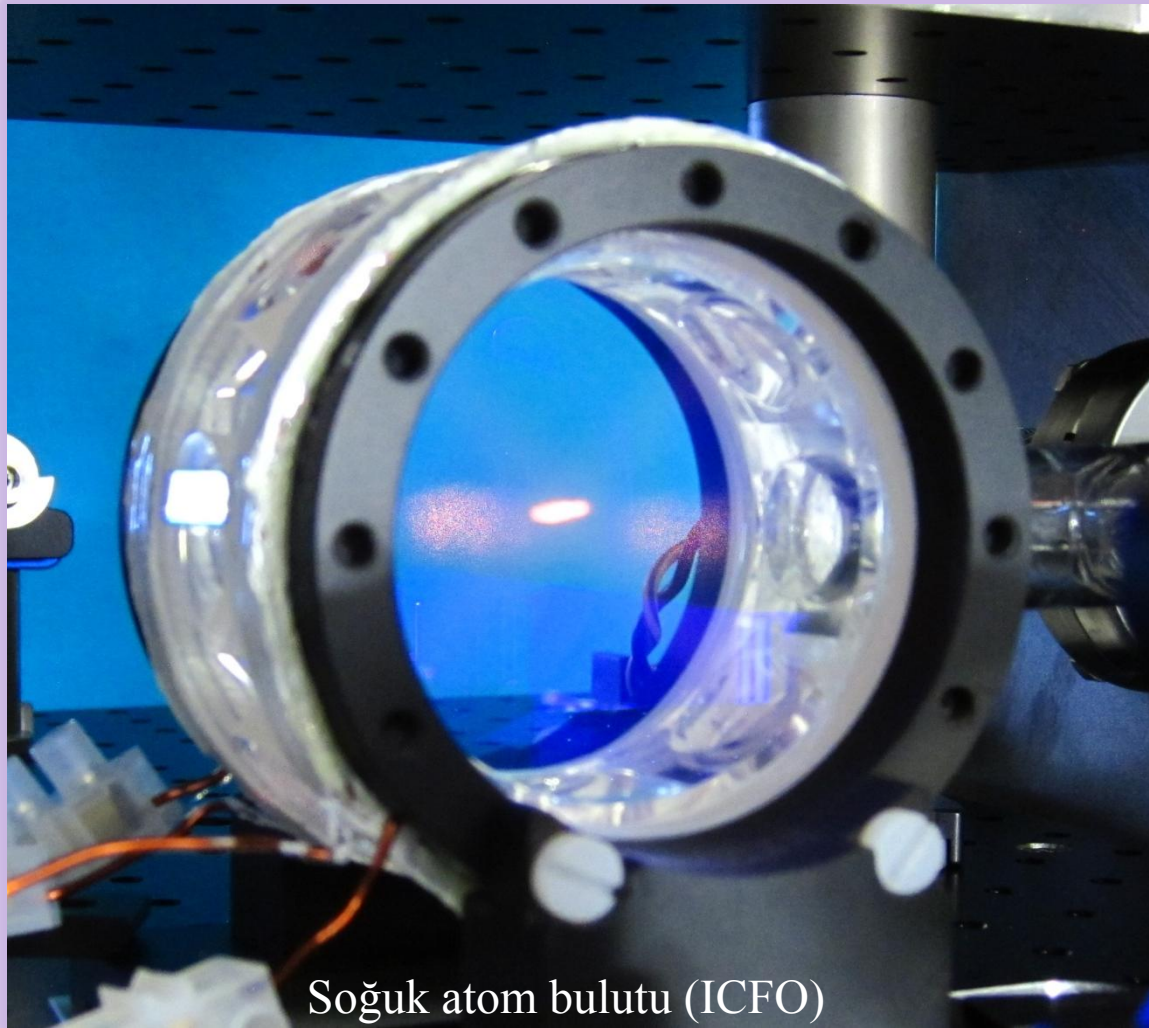


Soğuk atom bulutu (Caltech)

Çeşitli kuantum hafızalar

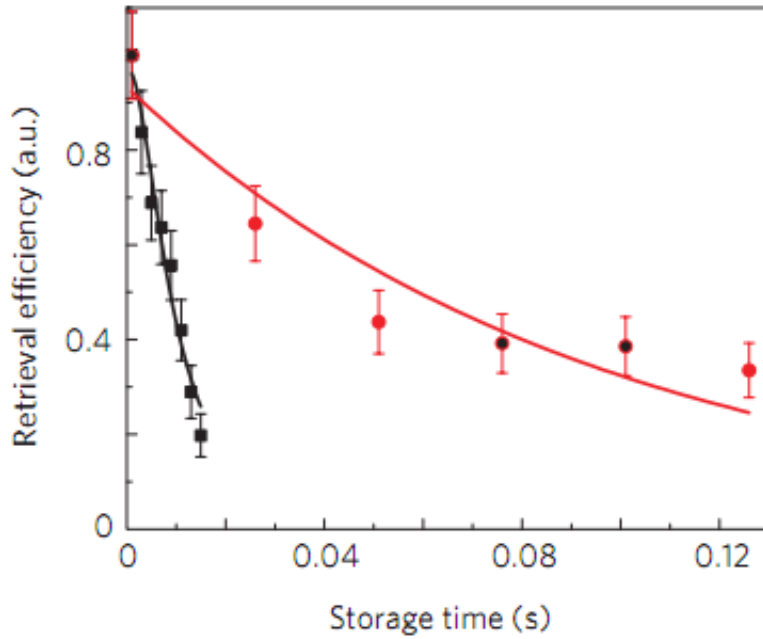
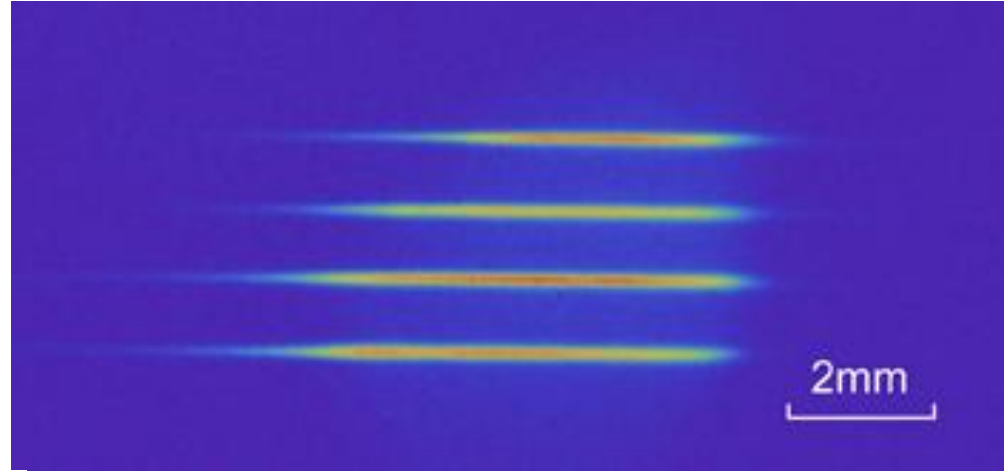


Soğuk atom bulutu (MIT)



Soğuk atom bulutu (ICFO)

Dört farklı atom bulutunun dolanıklığı
Nature **468**, 412-416 (2010)



En uzun tek-foton saklama deneyi
Nature Physics **6**, 894–899 (2010)

Tuzaklanmış iyonlar

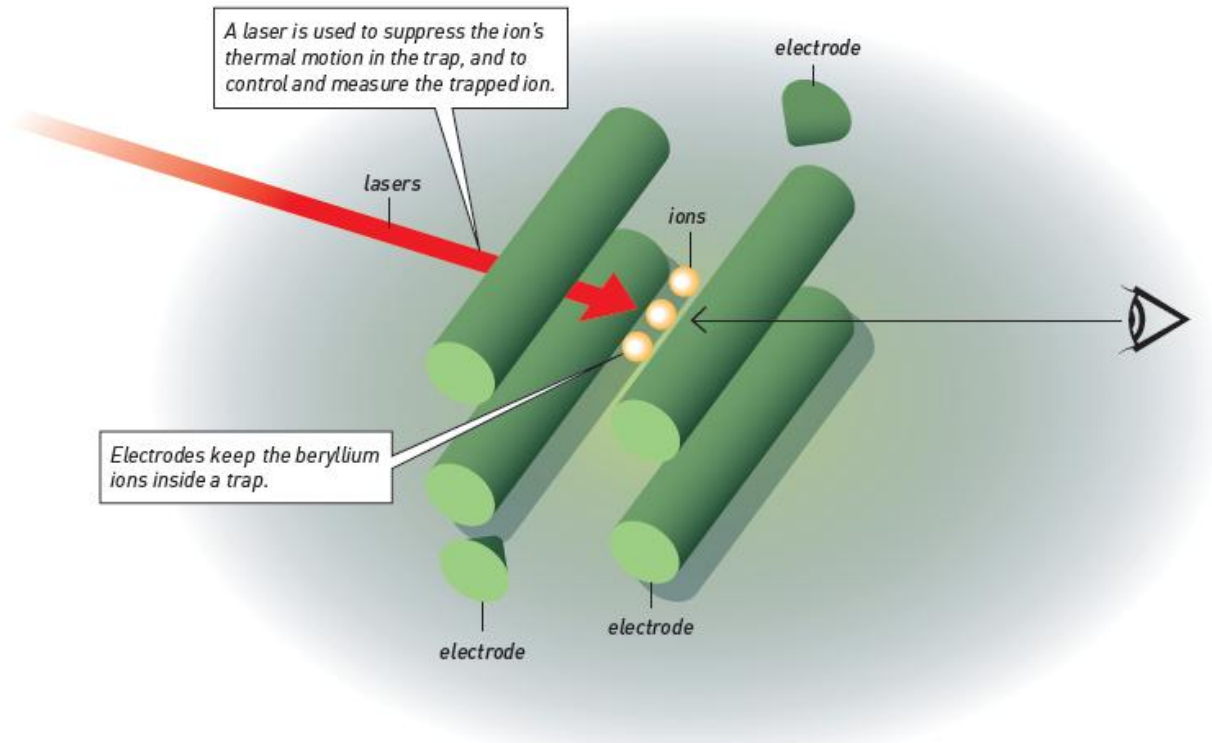
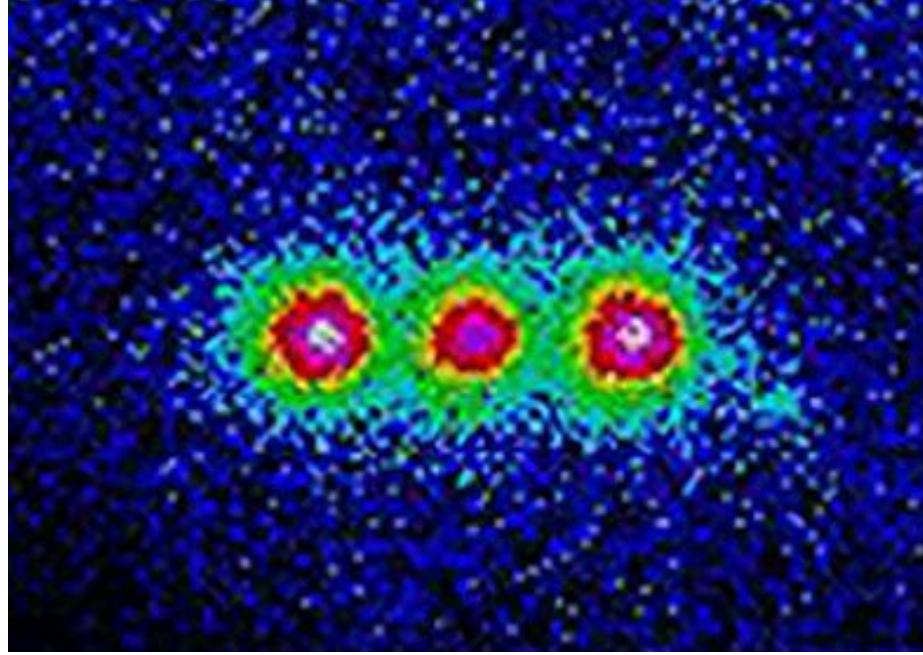


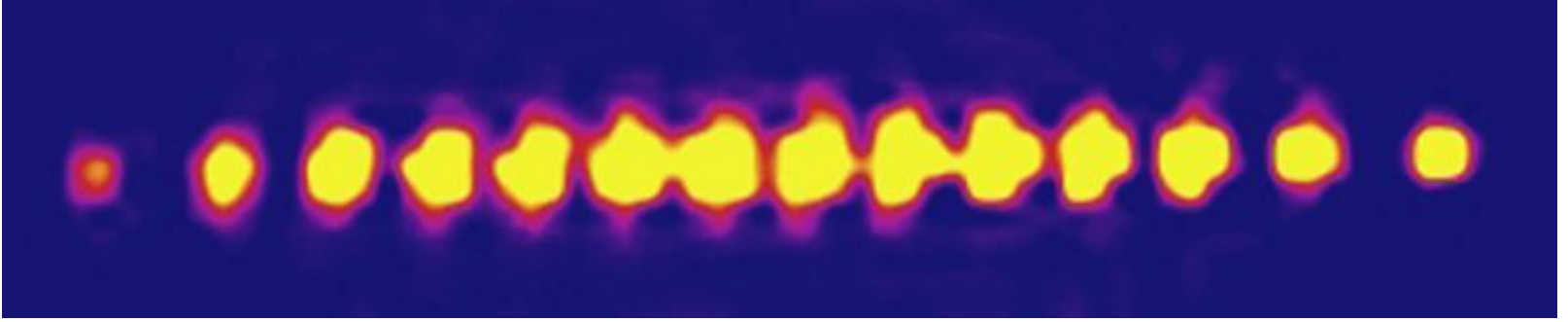
Figure 2. In David Wineland's laboratory in Boulder, Colorado, electrically charged atoms or ions are kept inside a trap by surrounding electric fields. One of the secrets behind Wineland's breakthrough is mastery of the art of using laser beams and creating laser pulses. A laser is used to put the ion in its lowest energy state and thus enabling the study of quantum phenomena with the trapped ion.

Tuzaklanmış iyonlar



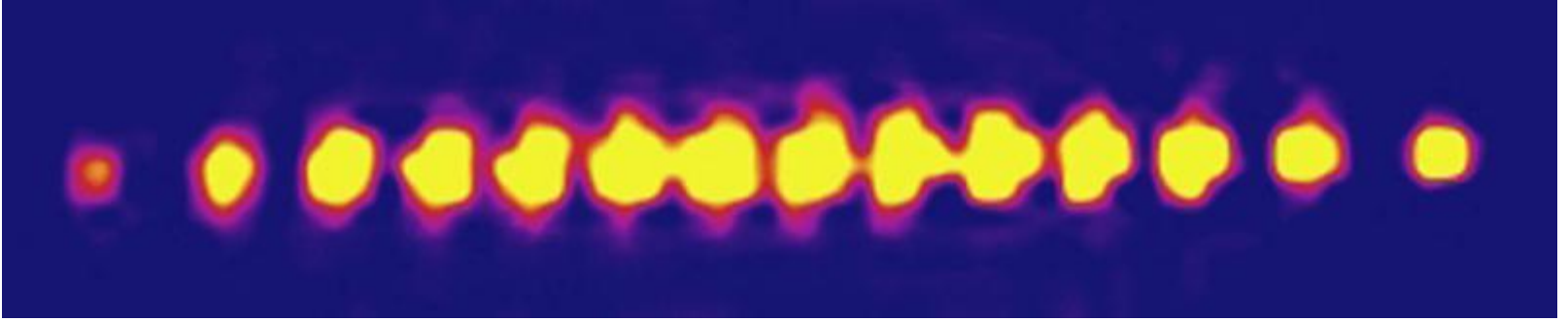
Yanyana tuzaklanmış 3 iyon (NIST)

Tuzaklanmış iyonlar



Dolanık hale getirilen 14 kalsiyum iyonu (Innsbruck Üniversitesi)

Tuzaklanmış iyonlar



Dolanık hale getirilen 14 kalsiyum iyonu (Innsbruck Üniversitesi)

Dünya rekoru!!!11bir

Universal Digital Quantum Simulation with Trapped Ions

B. P. Lanyon,^{1,2*} C. Hempel,^{1,2} D. Nigg,² M. Müller,^{1,3} R. Gerritsma,^{1,2} F. Zähringer,^{1,2} P. Schindler,² J. T. Barreiro,² M. Rambach,^{1,2} G. Kirchmair,^{1,2} M. Hennrich,² P. Zoller,^{1,3} R. Blatt,^{1,2} C. F. Roos^{1,2}

A digital quantum simulator is an envisioned quantum device that can be programmed to efficiently simulate any other local system. We demonstrate and investigate the digital approach to quantum simulation in a system of trapped ions. With sequences of up to 100 gates and 6 qubits, the full time dynamics of a range of spin systems are digitally simulated. Interactions beyond those naturally present in our simulator are accurately reproduced, and quantitative bounds are provided for the overall simulation quality. Our results demonstrate the key principles of digital quantum simulation and provide evidence that the level of control required for a full-scale device is within reach.

Although many natural phenomena are accurately described by the laws of quantum mechanics, solving the associated equations to calculate properties of physical systems, i.e., simulating quantum physics, is in gen-

eral thought to be very difficult (*1*). Both the number of parameters and differential equations that describe a quantum state and its dynamics grow exponentially with the number of particles involved. One proposed solution is to build a

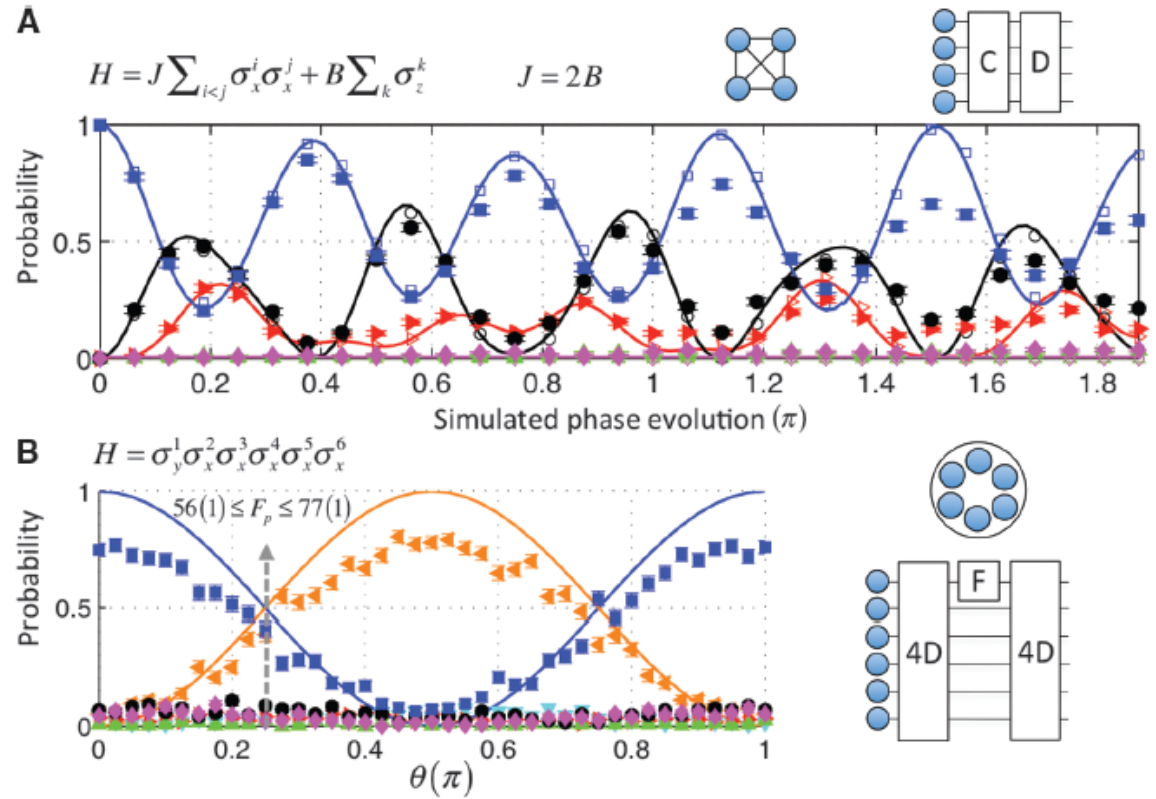
highly controllable quantum system that can efficiently perform the simulations (*2*). Recently, quantum simulations have been performed in several different systems (*3–13*), largely following the analog approach (*2*) whereby an analogous model is built, with a direct mapping between the state and dynamics of the simulated system and those of the simulator. An analog simulator is dedicated to a particular problem, or class of problems.

A digital quantum simulator (*2, 14–16*) is a precisely controllable many-body quantum system on which a universal set of quantum operations (gates) can be performed, i.e., a quantum computer (*17*). The simulated state is encoded in a register

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*To whom correspondence should be addressed. E-mail: ben.lanyon@uibk.ac.at

Fig. 4. Digital simulations of four and six spin systems. Dynamics of the initial state where all spins point up. **(A)** Four spin long-range Ising system. Each digital step is $D.C = O_4(\pi/16,0).O_2(\pi/32)$. Error bars are smaller than point size. **(B)** Six spin six-body interaction. $F = O_1(\theta,1)$, $4D = O_4(\pi/4,0)$. The inequality at $\phi = 0.25 \pi$ bounds the quantum process fidelity F_p at $\theta = 0.25 \pi$ [see (23) for details]. Lines; exact dynamics. Unfilled shapes: ideal digitized; filled shapes: data ($\blacksquare P_0$ $\blacklozenge P_1$ $\bullet P_2$ $\blacktriangle P_3$ $\blacktriangleright P_4$ $\blacktriangledown P_5$ $\blacktriangleleft P_6$, where P_i is the total probability of finding i spins pointing down).



Çok önemli bir deney. 6 kubit ile 100'den fazla mantık kapısı operasyonu yapıp çeşitli kuantum sistemleri simüle etmişler

Katıhal kuantum hafızalar

(Kendi labımız 😊)



Rare-earth elementleri içeren Y_2SiO_5 kristali

Eylül 2010



Eylül 2010



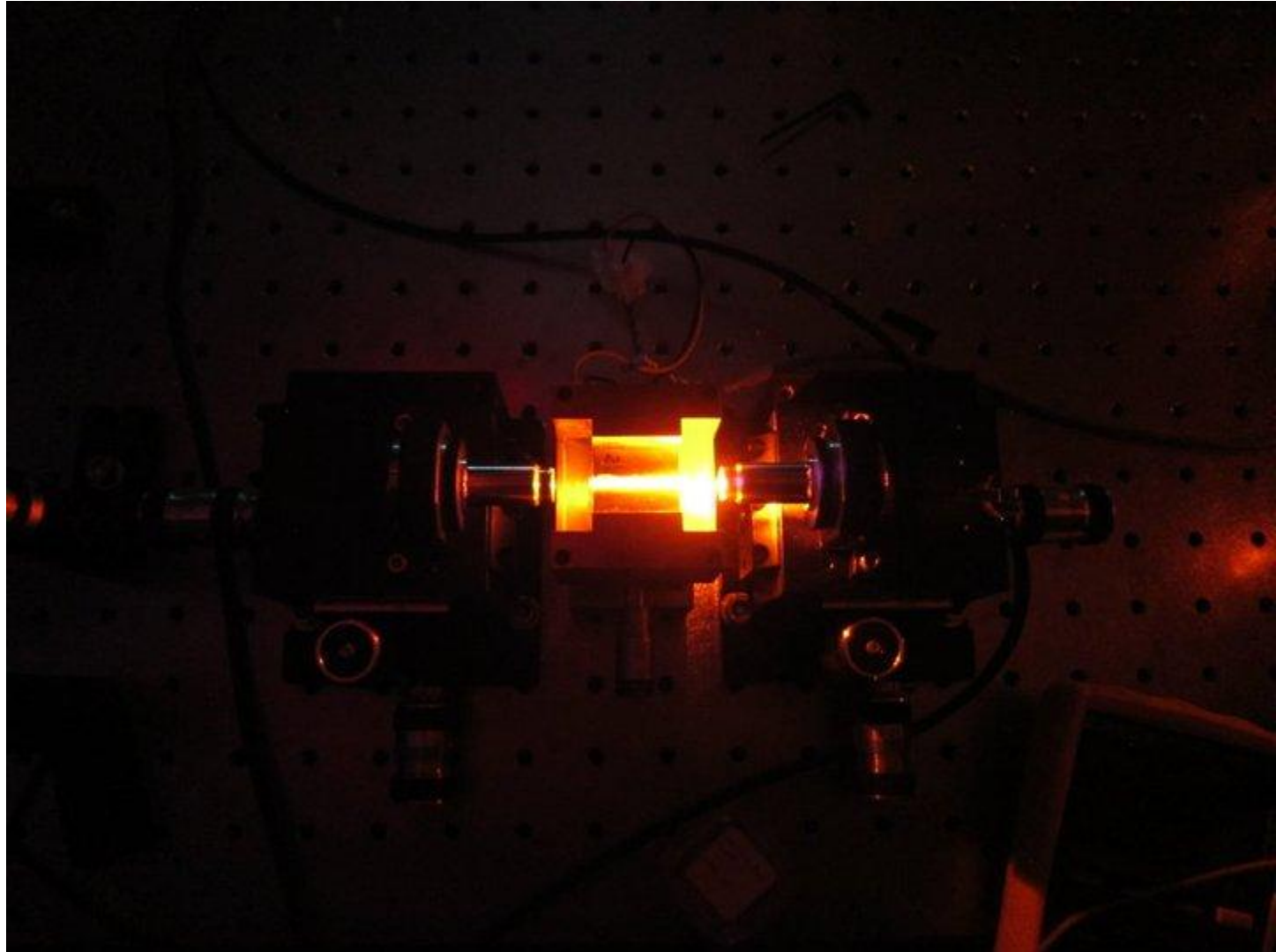
Ekim 2010



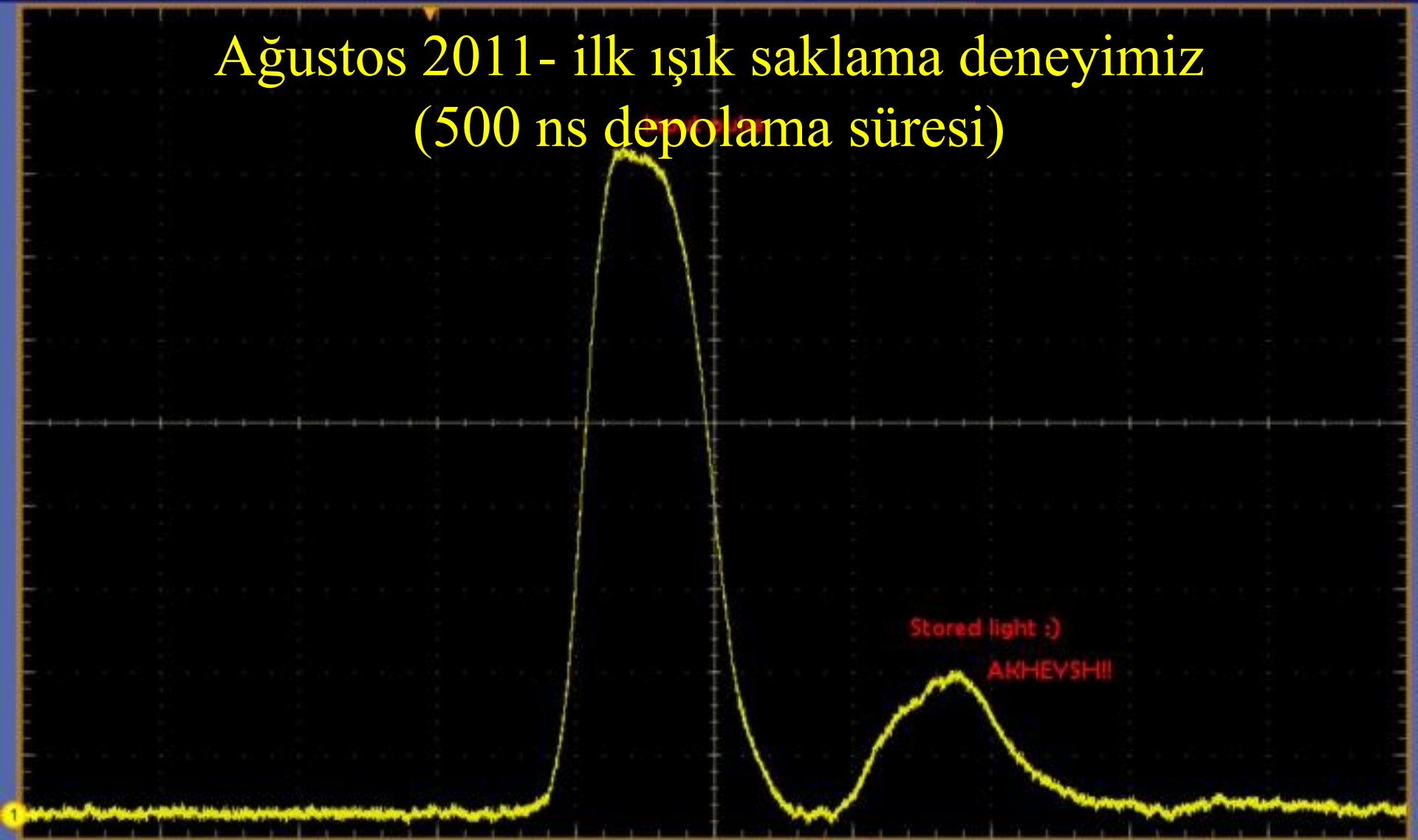
Kasım 2010



Aralık 2010



Ağustos 2011- ilk ışık saklama deneyimiz (500 ns depolama süresi)



40.0mV/div 50Ω BW:1.0G

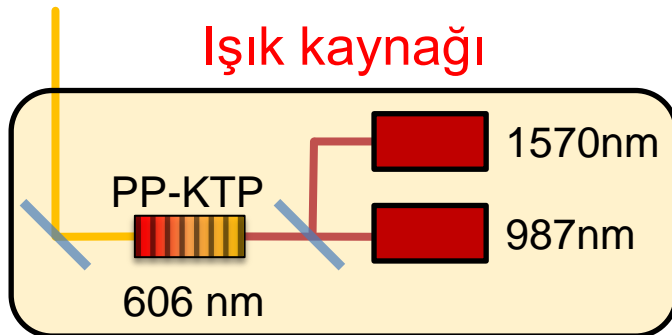
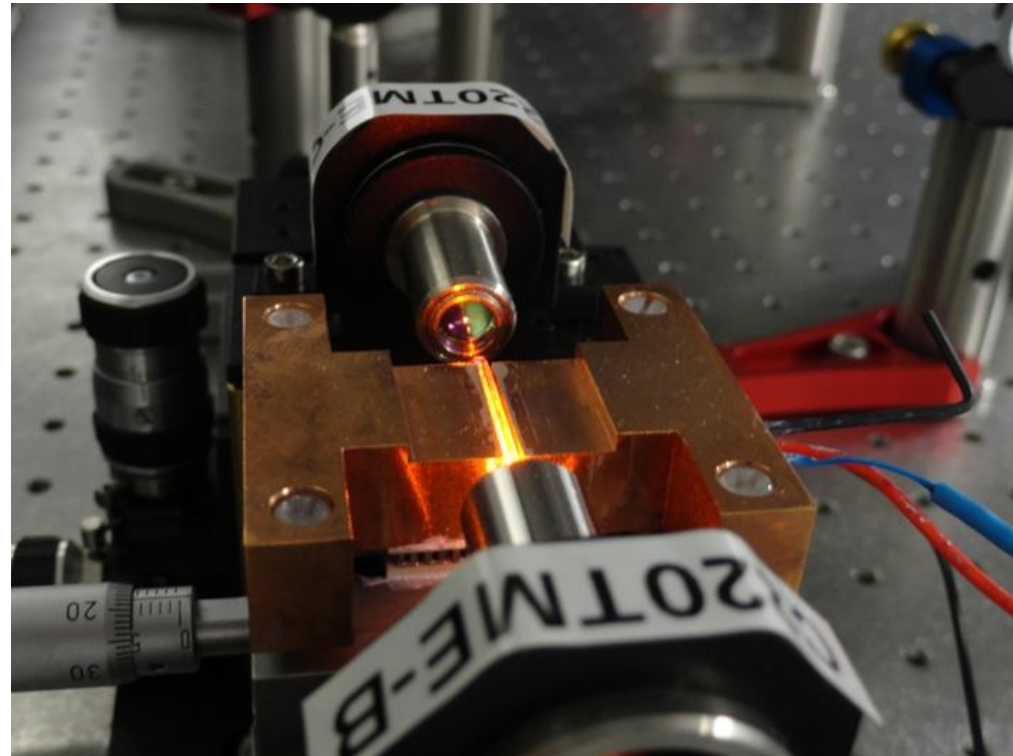
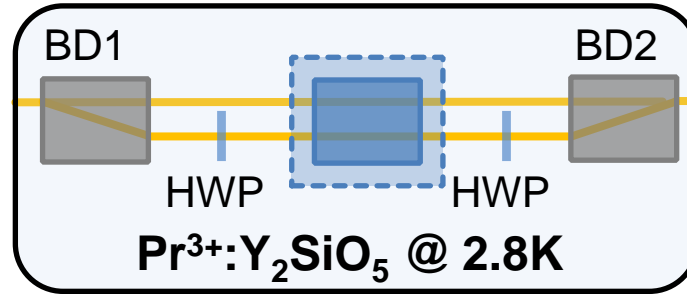
798mV Ready Normal

200ns/div 5.0GS/s IT 2.5ps/pt

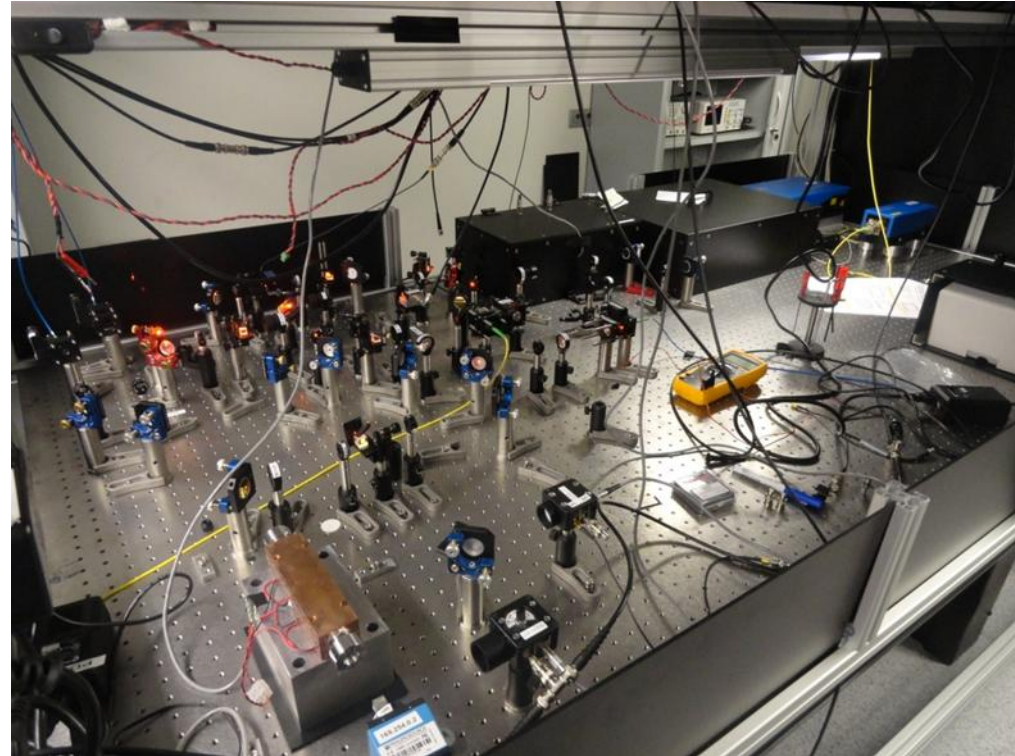
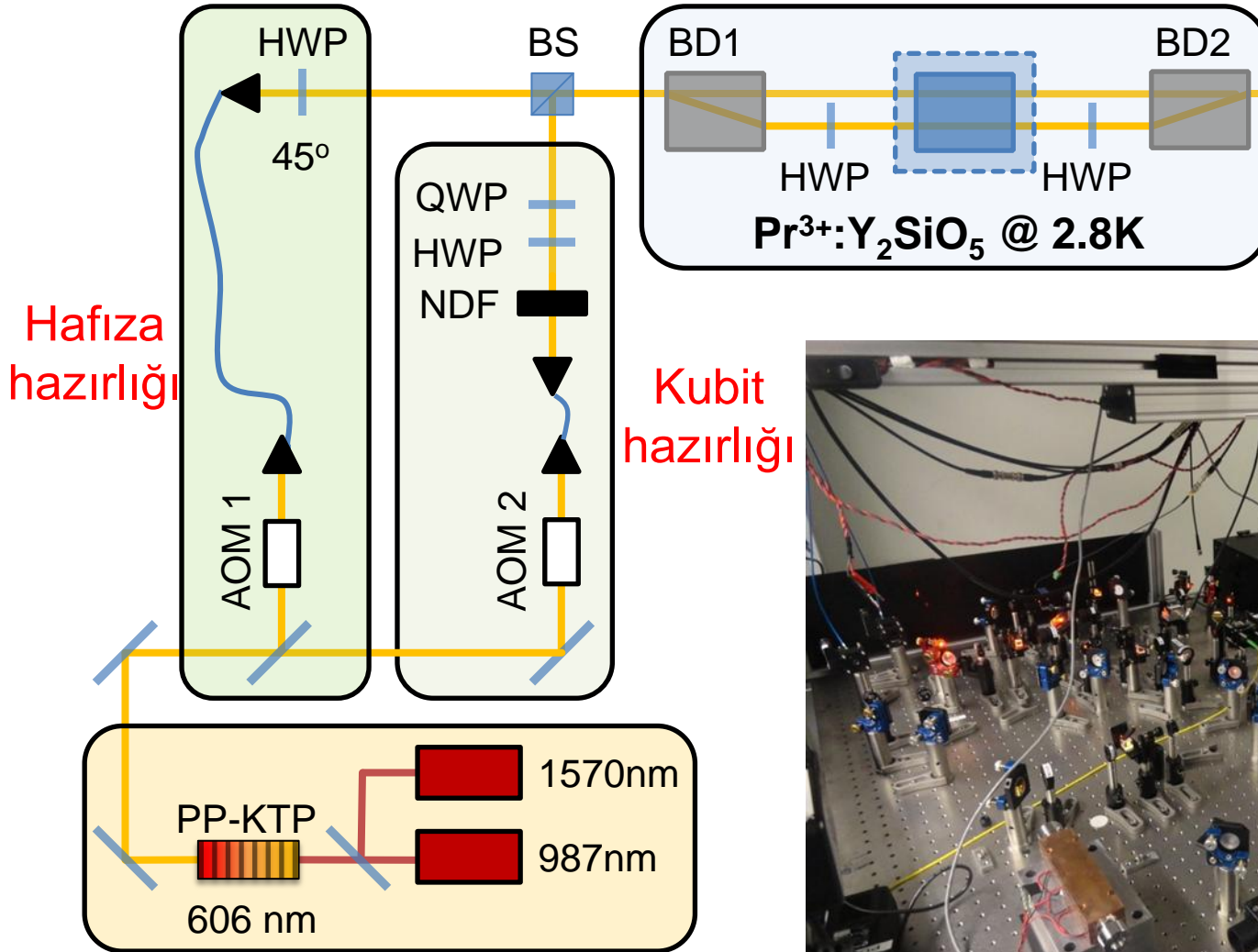
	Value	Mean	Min	Max	St Dev	Count	Info
Ampl	1.64mV	1.6400001m	1.64m	1.64m	0.0	1.0	
Mean	8.2857	8.6545146	8.285	9.024	522.9m	2.0	

Run Sample
1 acqs RL:800k
Auto August 12, 2011 15:36:10

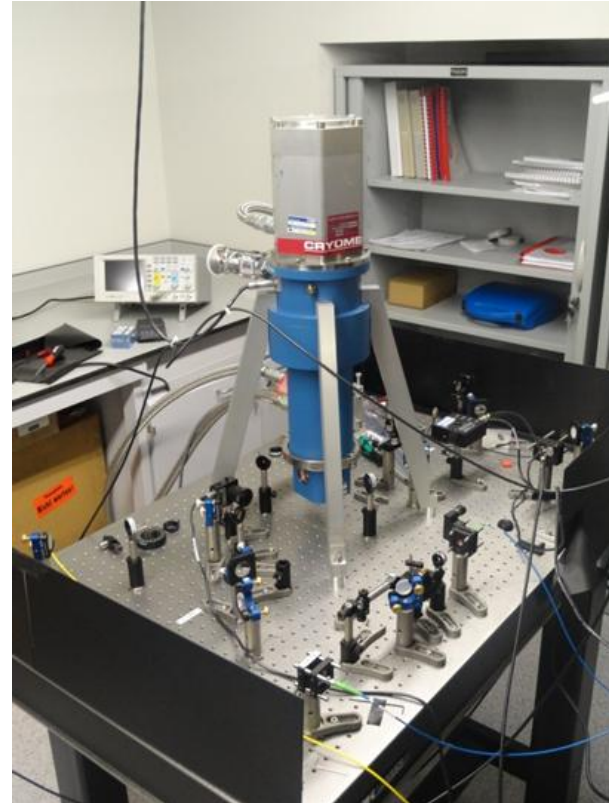
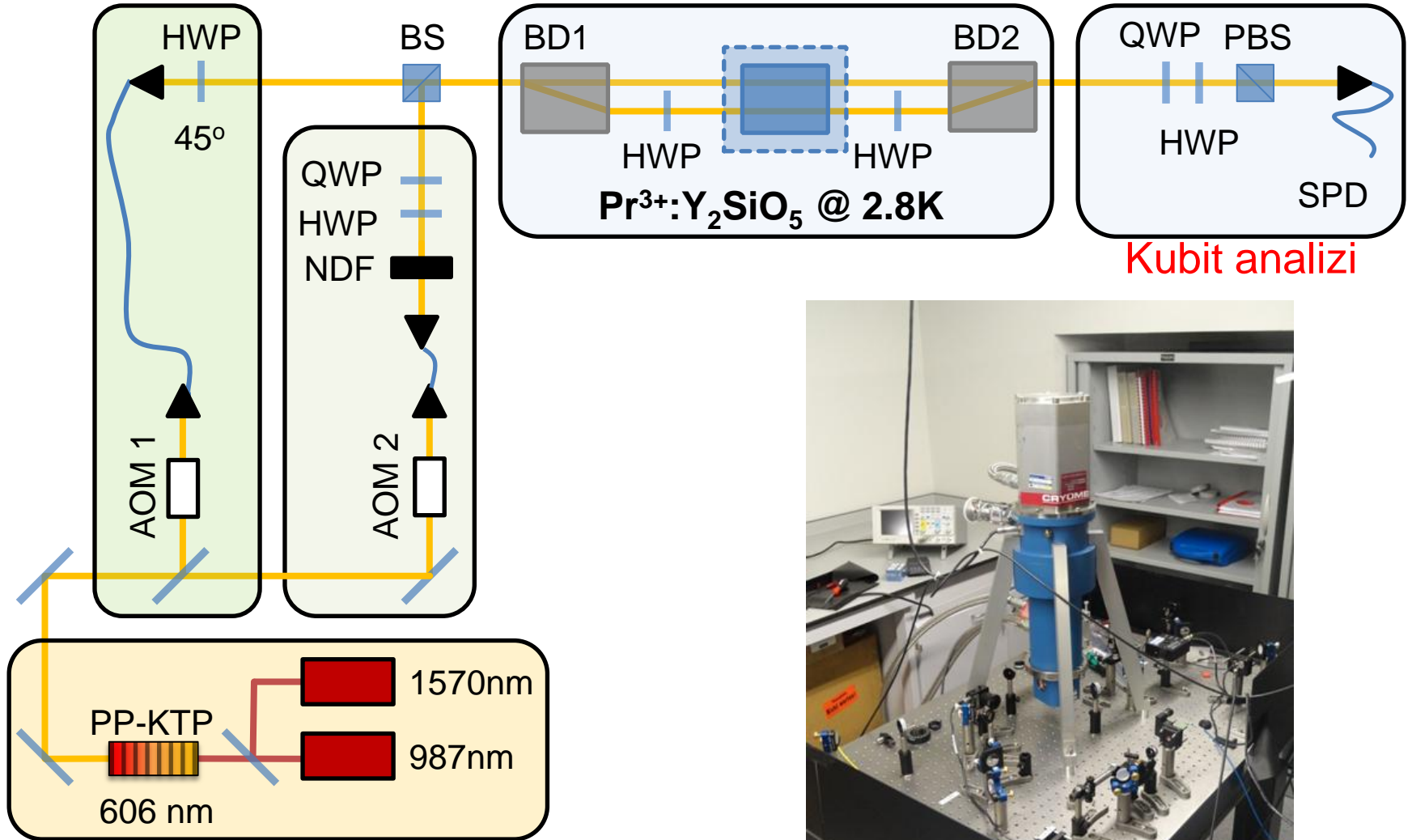
Deneysel düzenek



Deneysel düzenek



Deneysel düzenek



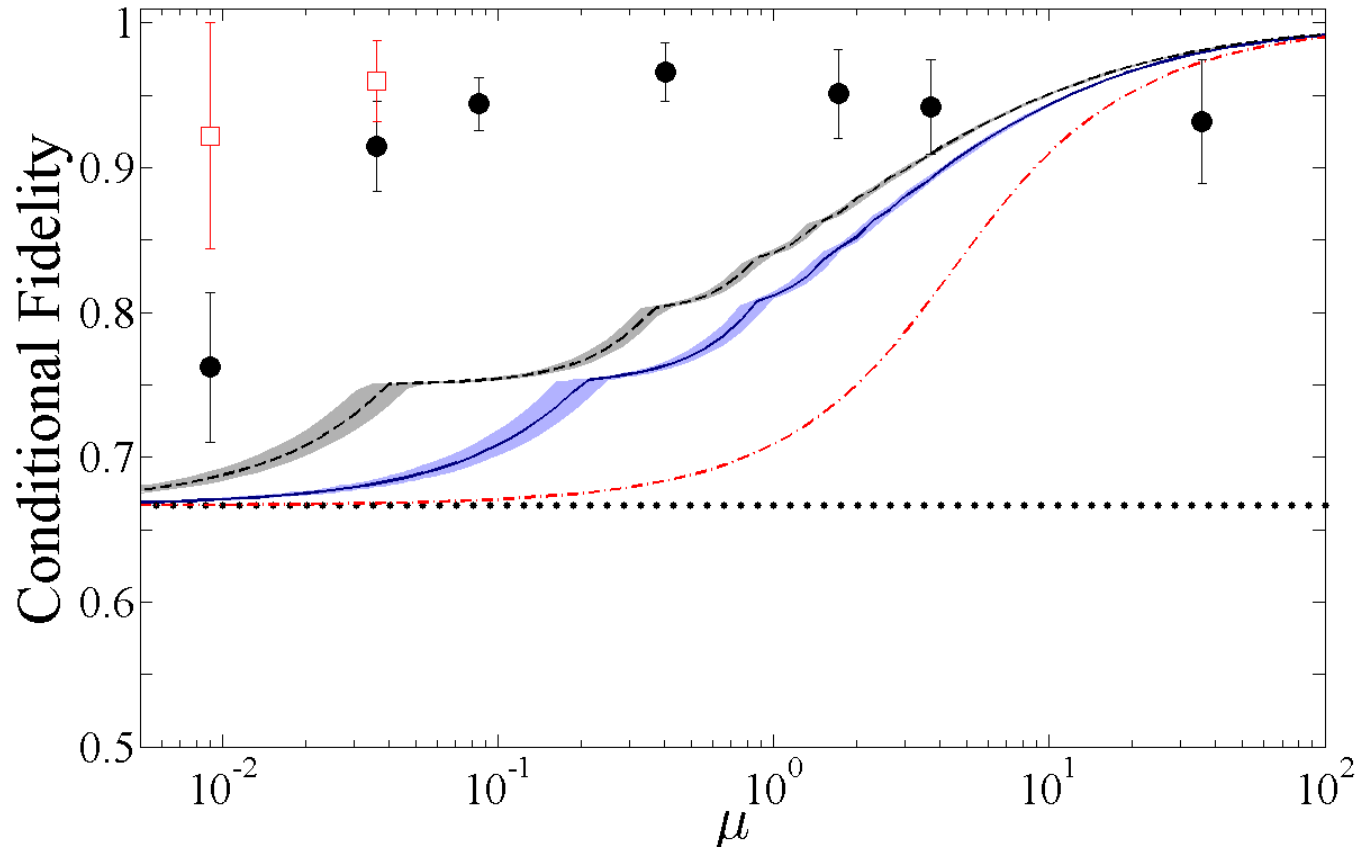
Aralık 2011

Katı-hal bir sistemde ilk defa polarizasyon kubitini saklanması

Input State	Fidelity	Input State	Fidelity
$ H\rangle$	0.982 ± 0.003	$ V\rangle$	0.983 ± 0.002
$ D\rangle$	0.968 ± 0.005	$ A\rangle$	0.938 ± 0.009
$ R\rangle$	0.954 ± 0.007	$ L\rangle$	0.926 ± 0.01

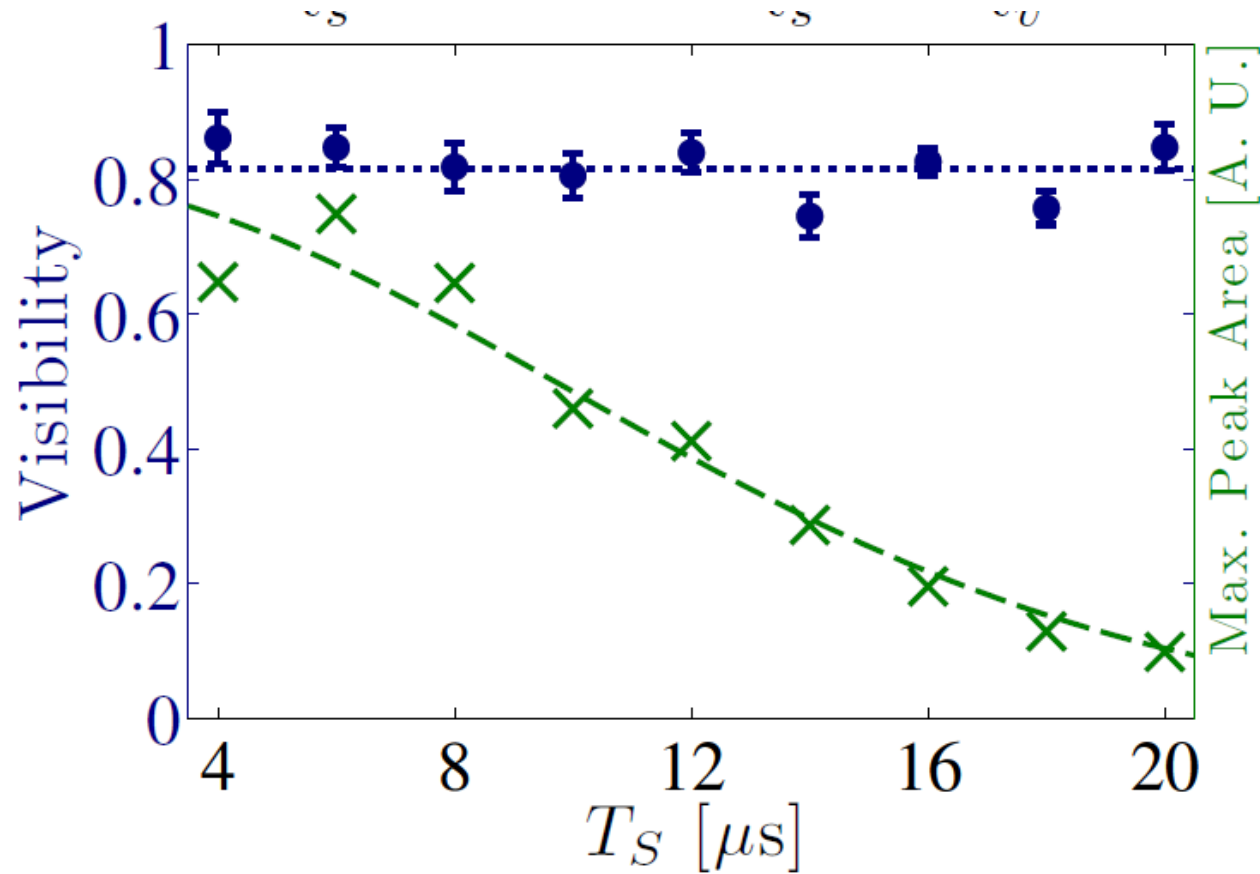
Aralık 2011

3-4 foton/puls seviyesine kadar *kuantum*



Aralık 2012

Depolama süresi 500 ns'den 20-25 μ s'ye çıkmış durumda



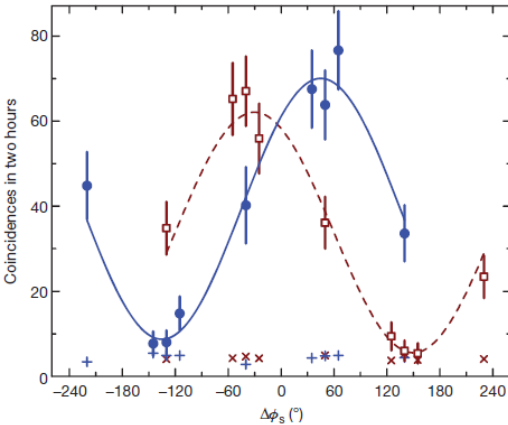
Katı hal kuantum hafızalar

LETTER

doi:10.1038/nature09662

Quantum storage of photonic entanglement in a crystal

Christoph Clausen^{1*}, Imam Usmani^{1*}, Félix Bussi eres¹, Nicolas Sangouard¹, Mikael Afzelius¹, Hugues de Riedmatten^{1,2,3} & Nicolas Gisin¹



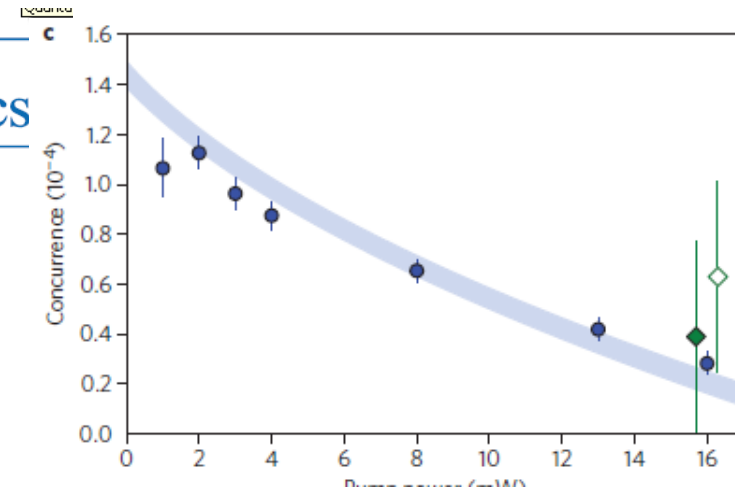
LETTERS

PUBLISHED ONLINE: 4 MARCH 2012 | DOI: 10.1038/NPHOTON.2012.34

nature
photonics

Heralded quantum entanglement between two crystals

Imam Usmani, Christoph Clausen, Félix Bussi eres, Nicolas Sangouard, Mikael Afzelius* and Nicolas Gisin



Katı hal kuantum hafızalar

Amaç:

Depolama süresini artırmak (milisaniye hatta *prensip*te saniye mertebesine çıkarmak mümkün)

Uzun süreli ışık-katı ve sonrasında katı-katı dolanıklılığı göstermek

Genel son sözler

Özellikle kuantum anahtar dağıtımının çoktan beri kullanımında olduğunu düşünürsek temel düzeyde kuantum hesaplamalar yakın zamanda gerçek olabilir.

Genel son sözler

Özellikle kuantum anahtar dağıtımının çoktan beri kullanımında olduğunu düşünürsek temel düzeyde kuantum hesaplamalar yakın zamanda gerçek olabilir.

ABD Ulusal Güvenlik Ajansı (National Security Agency)'nın bu konuda çok ciddi çalışmaları olduğu söyleniyor/biliniyor.

Genel son sözler

Özellikle kuantum anahtar dağıtımının çoktan beri kullanımında olduğunu düşünürsek temel düzeyde kuantum hesaplamalar yakın zamanda gerçek olabilir.

ABD Ulusal Güvelik Ajansı (National Security Agency)'nın bu konuda çok ciddi çalışmaları olduğu söyleniyor/biliniyor.

Belki de zaten böyle bir makine yapıldı, ama haberimiz yok!?

TÜBİTAK kırılmayan şifre peşinde

HABER

Yazı boyutu - +



NATO için çok sayıda kriptoloji cihazı geliştiren ve Türkiye'de de ilk kez kriptolu cep telefonu üretmeyi başaran **TÜBİTAK** araştırmacıları, son çalışmalarında kırılmayan şifreleme sistemi olarak bilinen kuantum kriptoloji sistemlerine el attı.

TÜBİTAK'ın yeni hedefi, kuantum kriptoloji sistemlerinde uzmanlık alanını geliştirerek, tümüyle yeni hesaplama yöntemlerini destekleyen ve yeni algoritmalar yazmaya olanak tanıyan kuantum bilgisayarlar konusunda araştırmalar yapmak.

Paylaş

