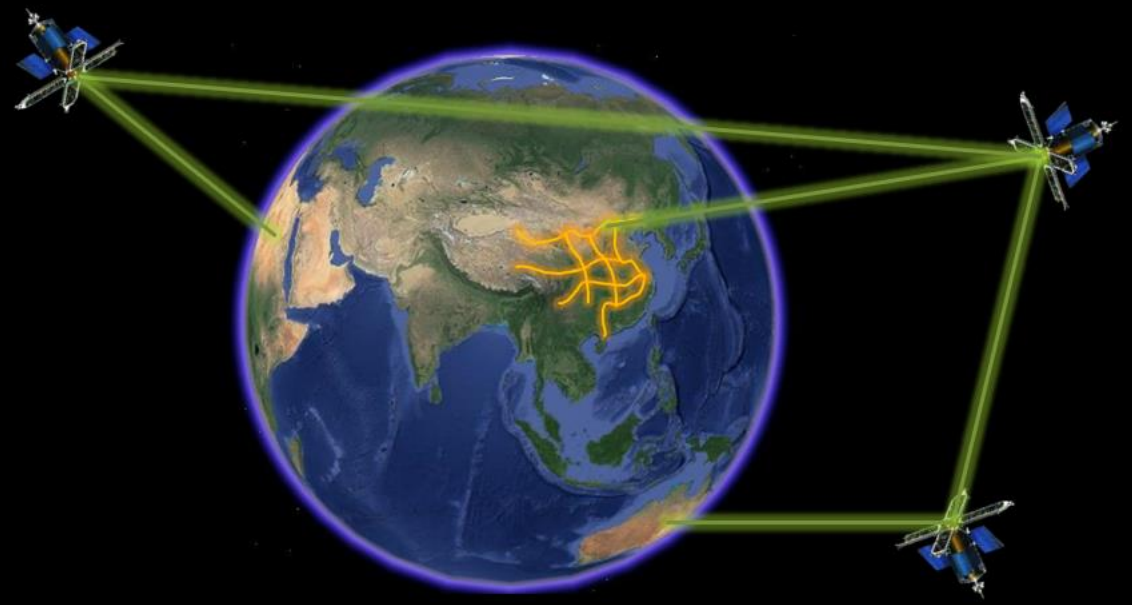


Quantum Information Technology Development in China

Yuao Chen

Chinese Academy of Science (CAS) Center for Excellence in Quantum Information and Quantum Physics

University of Science and Technology of China (USTC)

Supports of the State at All Levels

The NPC has adopted the outline of China's 13th five-year plan

	2005	2007	2009	2019
The State Council	• The medium and long-term plans for major national science and technology infrastructure (2012-2030)	• National medium and long-term science and technology development plan outline (2006-2020)	• Outline of the national strategy for innovation-driven development • National plan for scientific and technological innovation • National development plan for strategic emerging industries • National information plan	
MOST and Joint Departments			• National technical innovation project planning • National special program for basic research • Civil-military integration of science and technology development planning	• The national 12th five-year plan for science and technology development • The 12th five-year plan of the national major scientific research plan for quantum regulation research
National Development and Reform Commission			• Notice on organizing and implementing the 2018 new-generation information infrastructure construction project	

National Wide-Area Quantum Secure Communication Network

Introduction to the CAS Center

Operations jointly supported by the CAS and the Ministry of Education

Hosted by **USTC**, Directed by **Jian-Wei Pan**

includes top CAS institutes and universities on quantum physics

Shanghai Institute of Technical Physics

Institute of Semiconductors

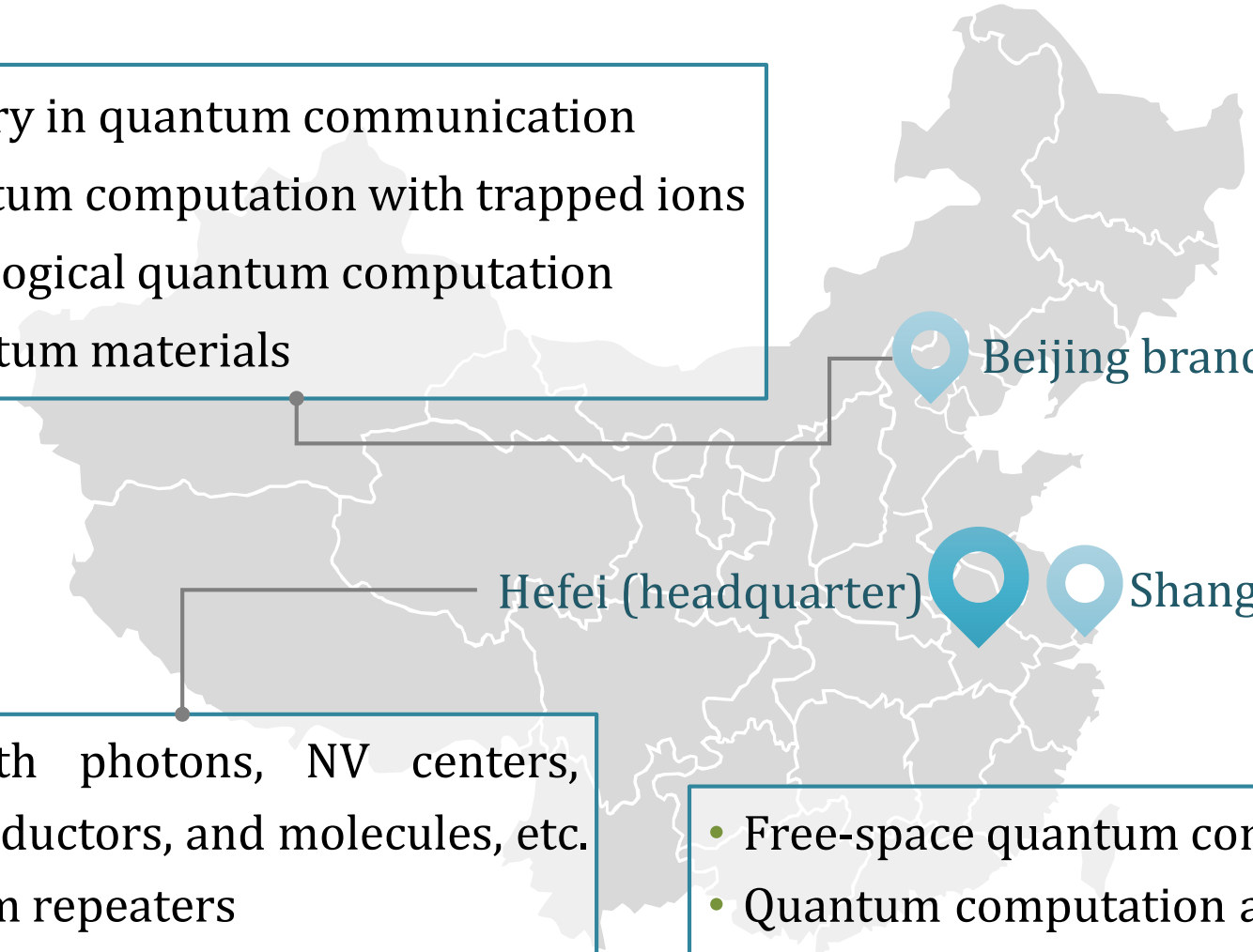
Institute of Optics and Electronics

Nanjing University

and excellence groups among China's universities:

Tsinghua University, Peking University, Fudan University, etc.

Organization of the CAS Center



- Theory in quantum communication
- quantum computation with trapped ions
- Topological quantum computation
- Quantum materials

Beijing branch

Hefei (headquarter)

Shanghai branch

- QIP with photons, NV centers, semiconductors, and molecules, etc.
- Quantum repeaters
- Quantum communication
- Quantum sensors

- Free-space quantum communication
- Quantum computation and simulation with superconductors and ultra-cold atoms
- Single-photon detection

Industry Chain Partners

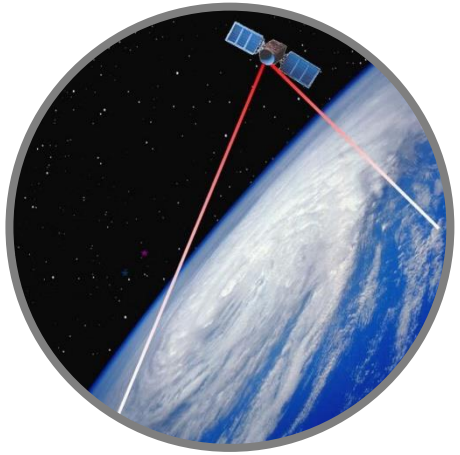
Quantum Key Distribution, Quantum Computation, etc.

Research the CAS Center

Research Fields: Quantum Physics & Quantum Information

Outperform classical information systems in terms of

Unconditional security

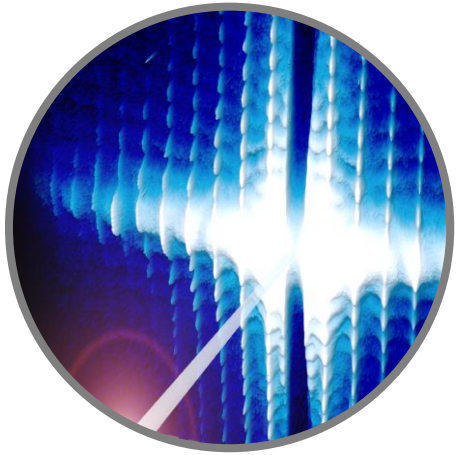


Quantum communication

Computational capacities

Quantum computation and simulation

Super-resolution



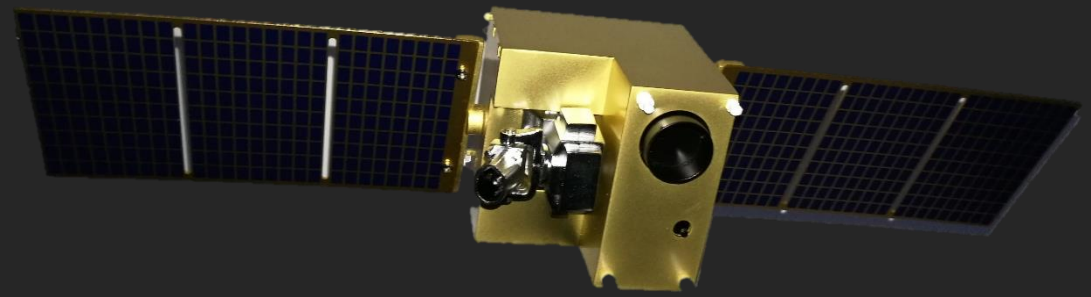
Quantum Metrology

National Quantum Communication Backbone Project

- Inter-city quantum communication backbone with 32 trusted relays (~2000km)
- For financial applications, public affairs, etc.
- Test-bed for quantum foundations (e.g. frequency dissemination)
- Completed at Sep. 2017

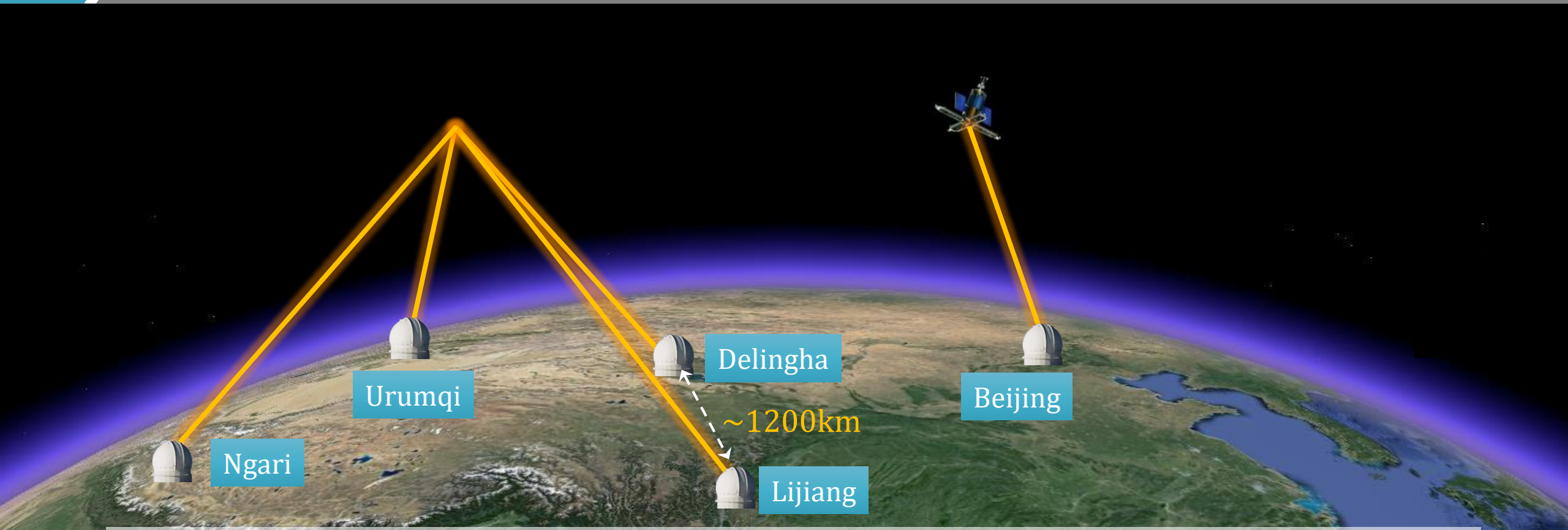
CAS Strategic Priority Research Program: Quantum Satellite

"Micius" was launched on 16th Aug, 2016 in Jiuquan Satellite Launch Center



- Weight: ~640kg
- Power: 560W
- Sun-synchronous orbit, altitude 500km

Three Missions of Micius



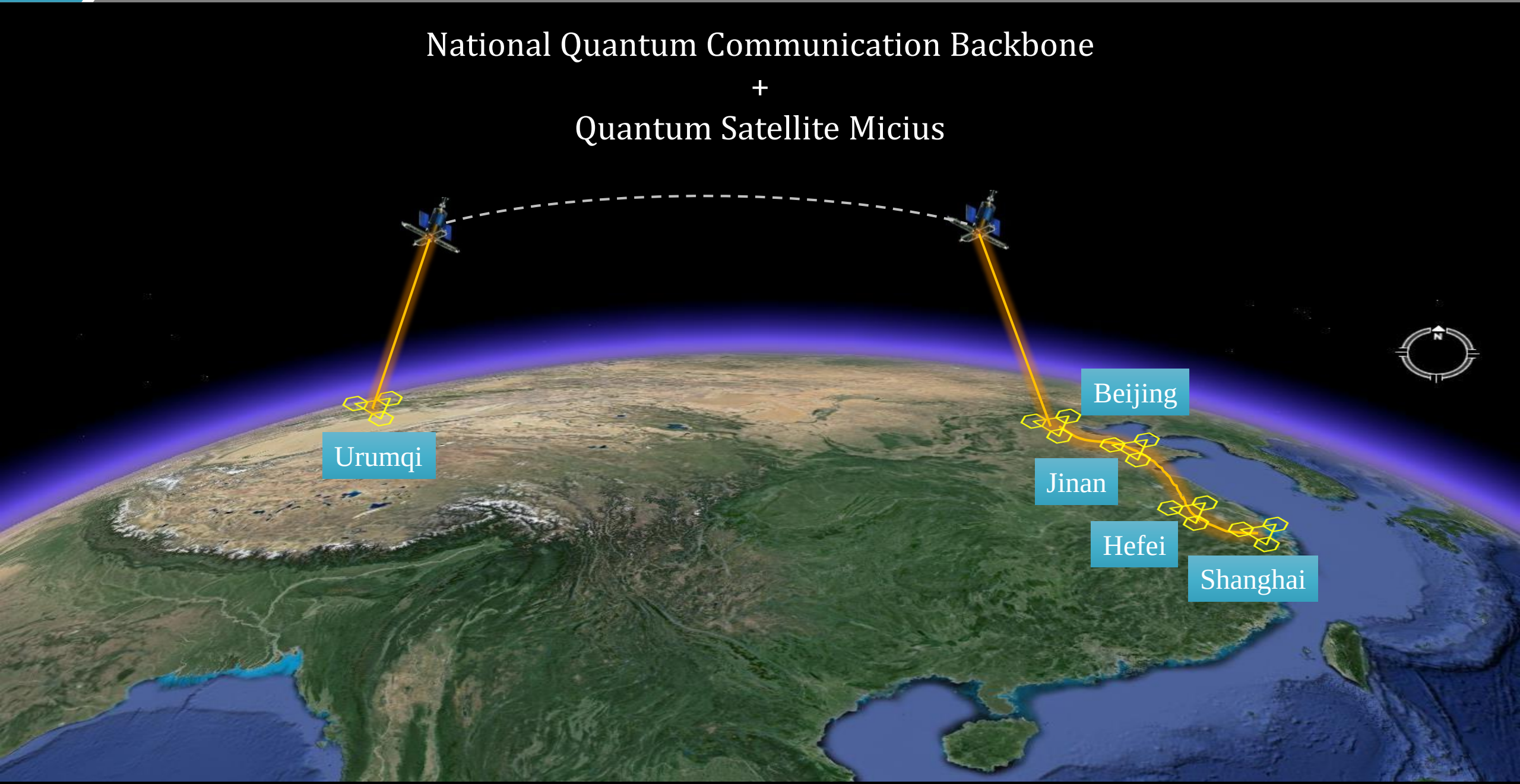
- QKD between satellite and ground, key rate ~1kbps (recently ~400kbps) ➡ 20 orders of magnitudes higher than using fiber channel at 1200 km
- Quantum entanglement distribution from satellite, test of quantum nonlocality under strict Einstein's locality condition
- Quantum teleportation between ground and satellite

Large Scale Quantum Communication Infrastructure

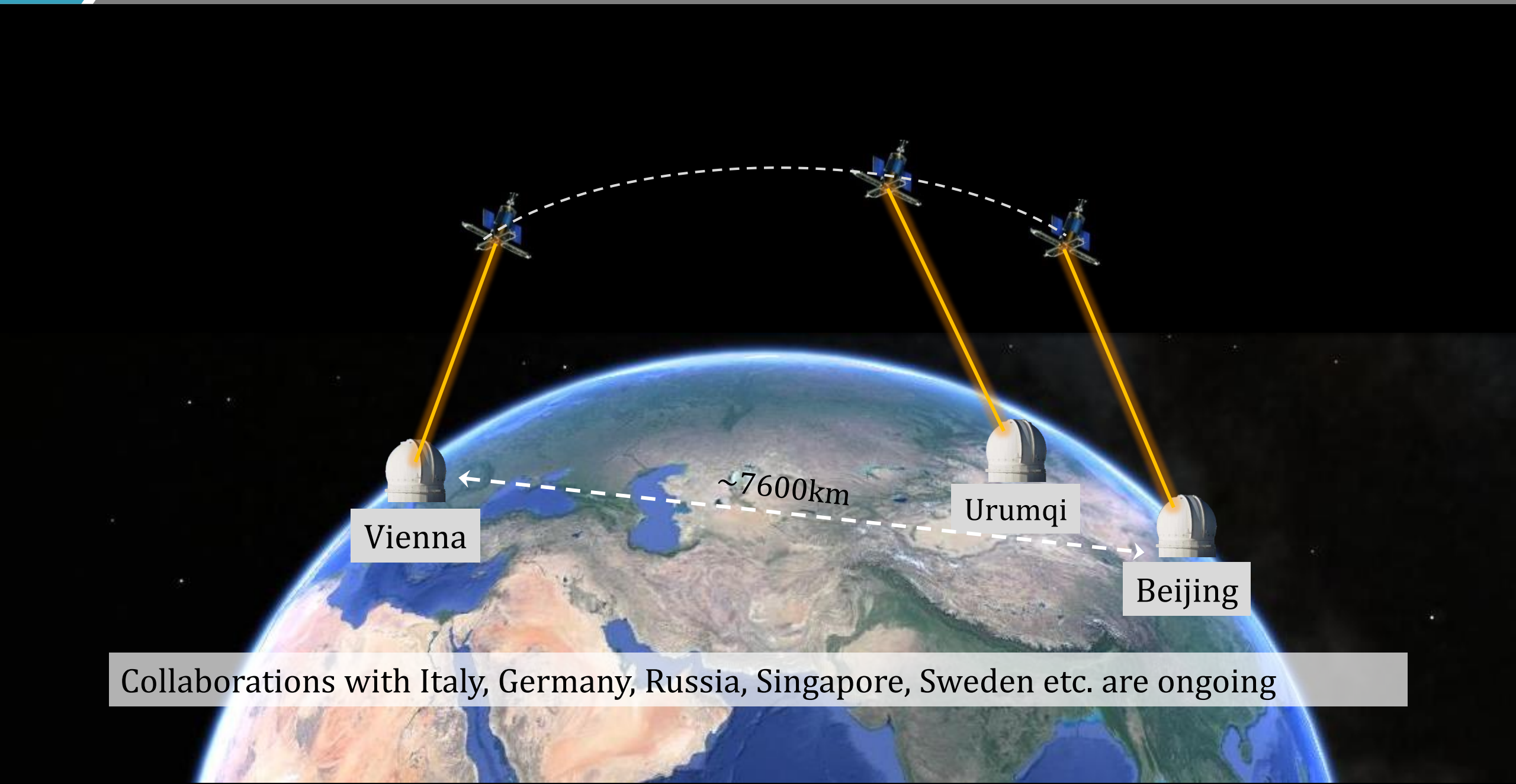
National Quantum Communication Backbone

+

Quantum Satellite Micius



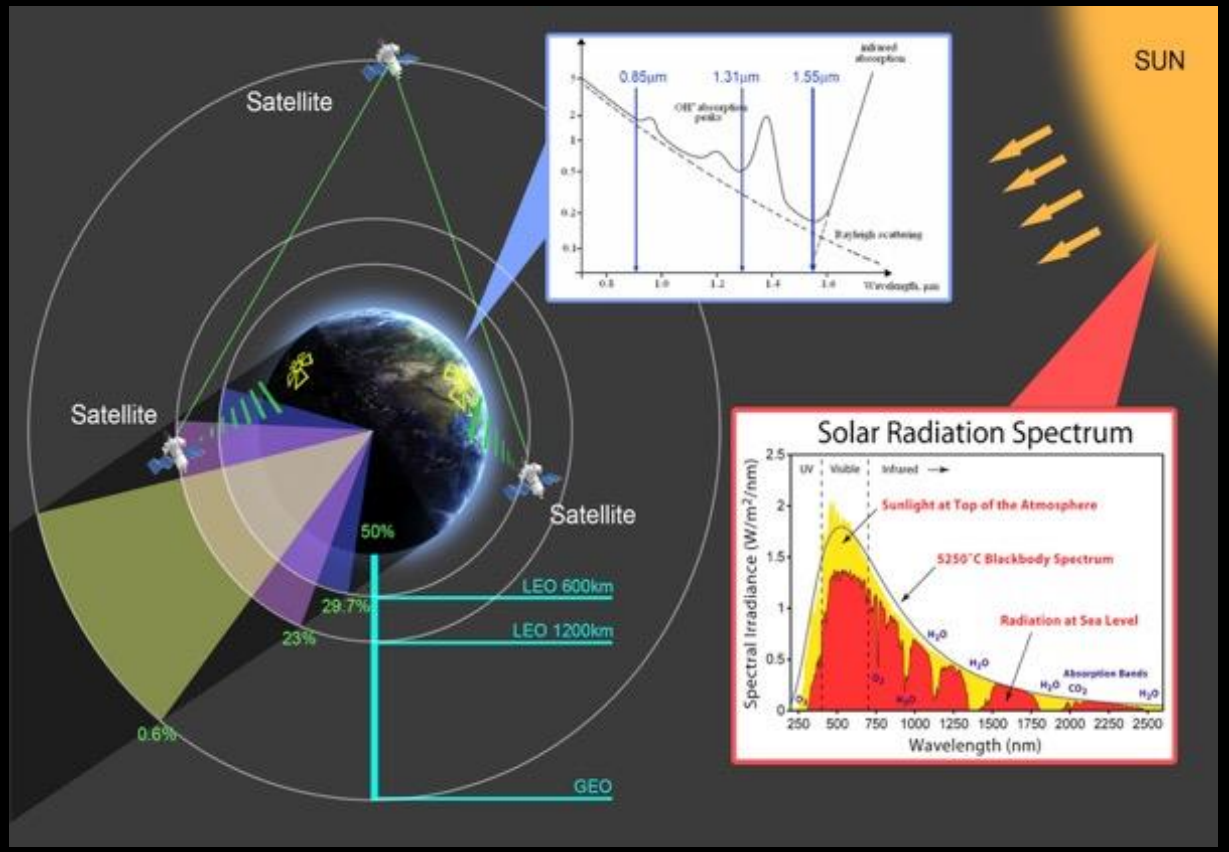
Intercontinental Quantum Key Distribution



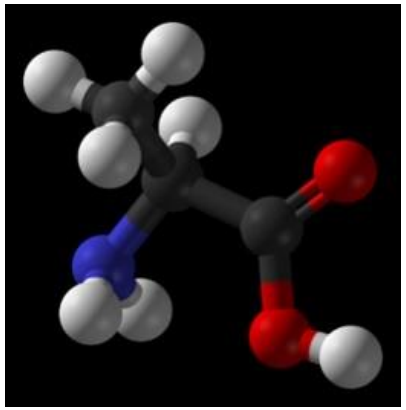
Collaborations with Italy, Germany, Russia, Singapore, Sweden etc. are ongoing

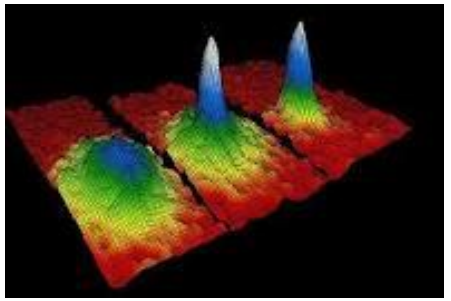
In Progress

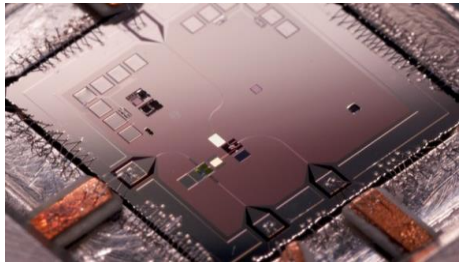
- ☒ LEO orbit can not cover the whole earth directly
- ☒ Only working in earth's shadow
- ☑ Solution: Quantum Constellation! A pre-requirement: work in solar radiation background
- ☑ Long-distance daylight QKD in 2017



Candidates for Quantum Computation







Cold atoms

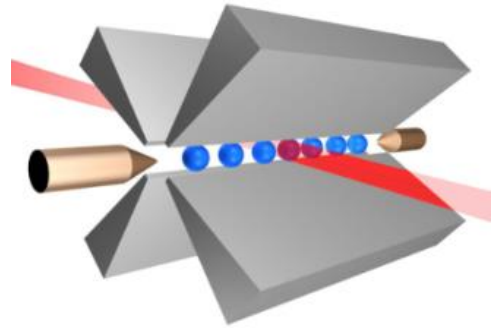
Super conductor

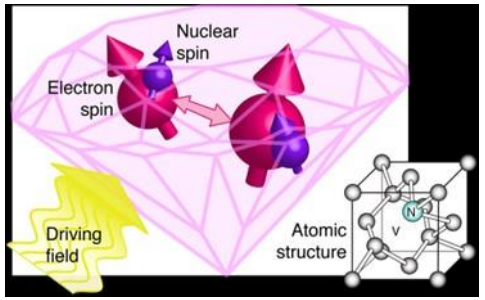
Trapped ions

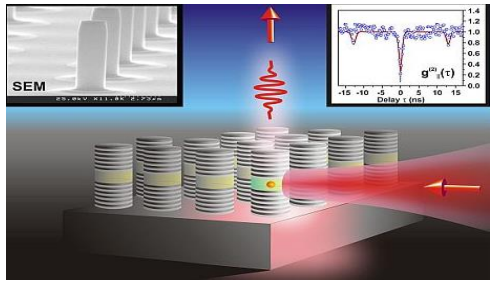
Photons

N/V center

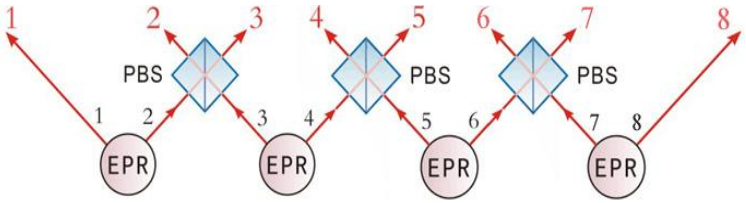
NMR



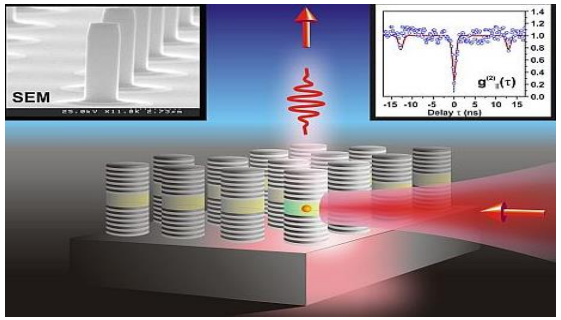




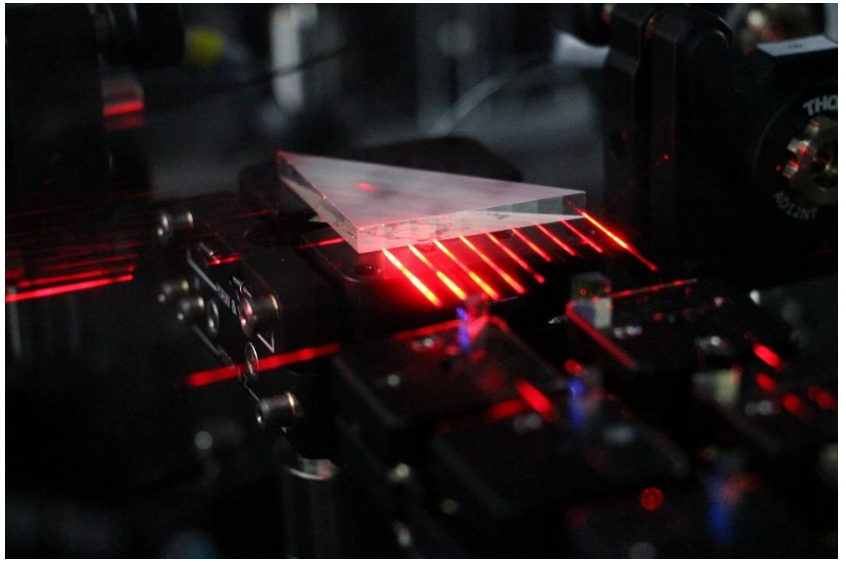
Optical Quantum Computing



Multi-photon entanglement



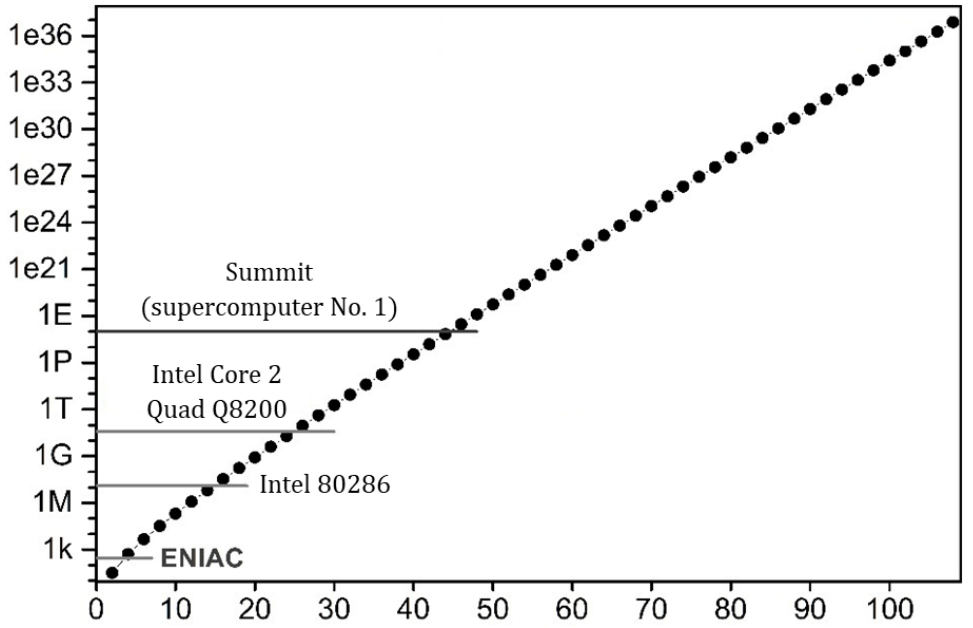
Quantum-dot single photon sources



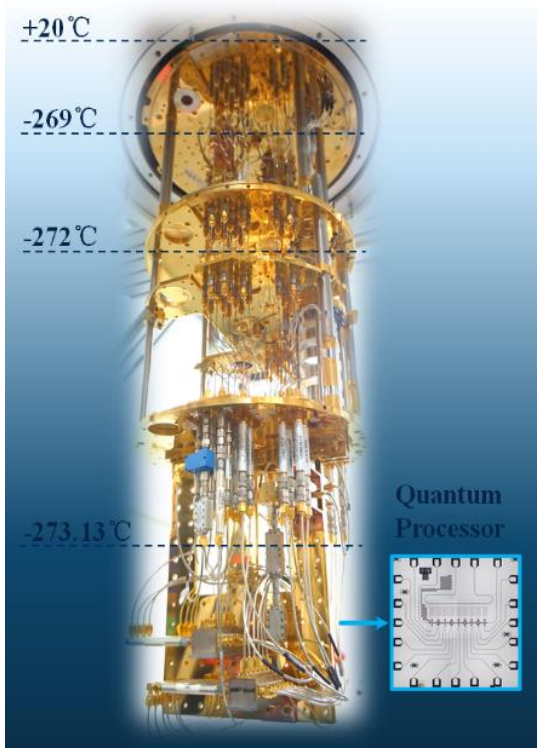
- High-efficiency multiphoton Boson Sampling machine, provably faster than ENIAC and TRADIC for the first time
- Single-photon source with overall efficiency exceeding 80% ➡

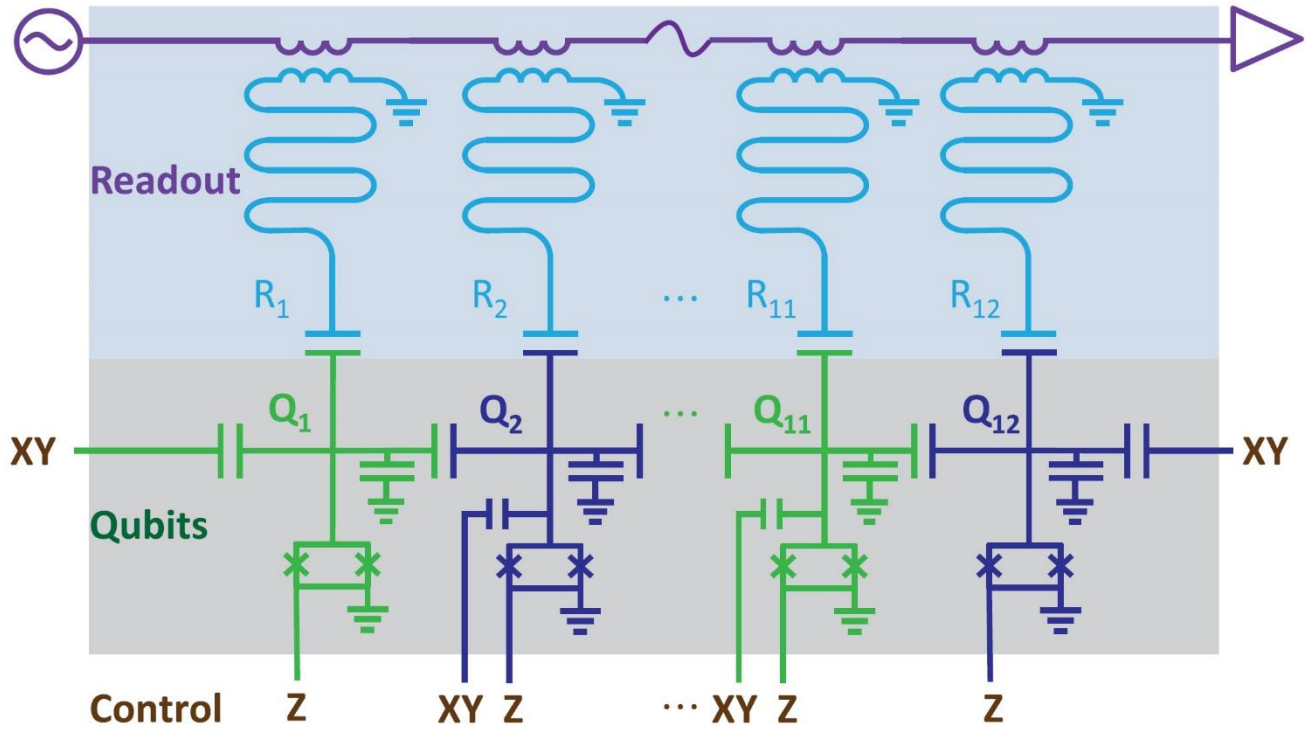
  Coherent manipulation of 20-30 photons

  Boson sampling with a complexity beating laptop



Superconductor Quantum Computing

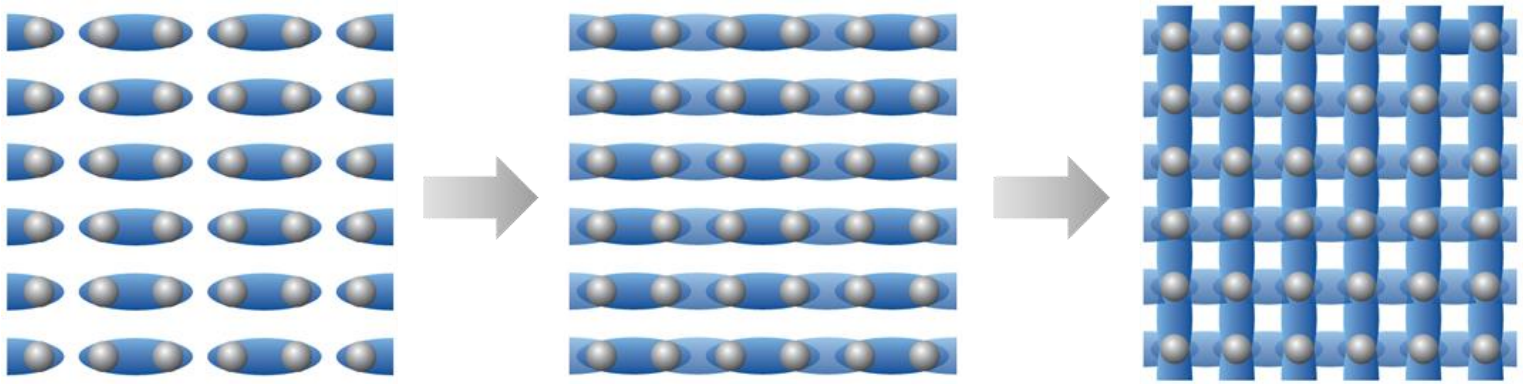




- Entanglement of 12 superconducting qubits
- Scalable engineering of high-fidelity 24 qubits

Fabrication and measurement of 30-50 qubit entanglement in progress

Quantum Computation and Simulation with Ultra-Cold Atoms

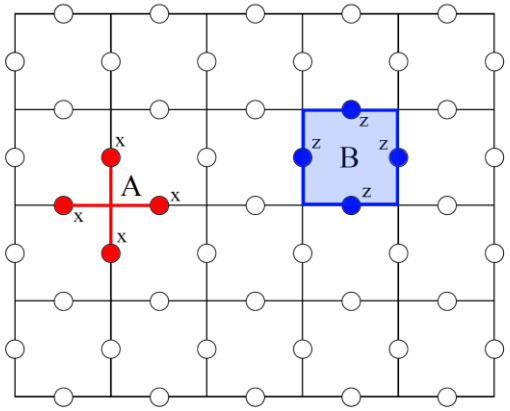


- Entanglement of atomic spins in optical lattice (~600 pairs in parallel)
- Demonstration of a Toric-code Hamiltonian and the Anyonic fractional statistics

$$H_0 = -\sum_s A_s - \sum_p B_p$$

$$A_s = \prod_{j \in \mathrm{star}(s)} \sigma_j^x$$

$$B_p = \prod_{j \in \mathrm{boundary}(p)} \sigma_j^z$$



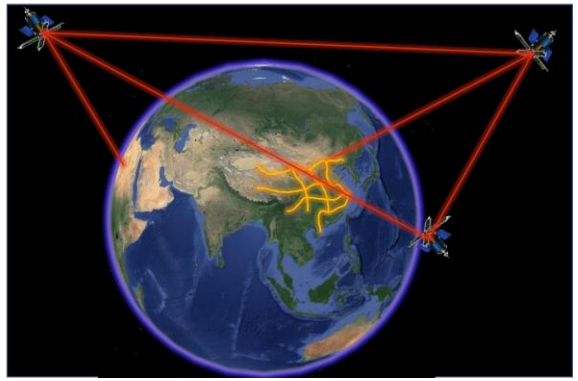
Next step:

- Coherent manipulation of an entangled state of ~100 atoms
- To mimic strongly correlated topological matter

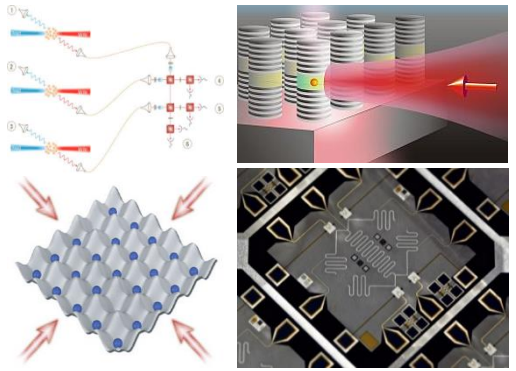
China's Future National Projects

The CAS Center is now playing a **leading** role in organizing

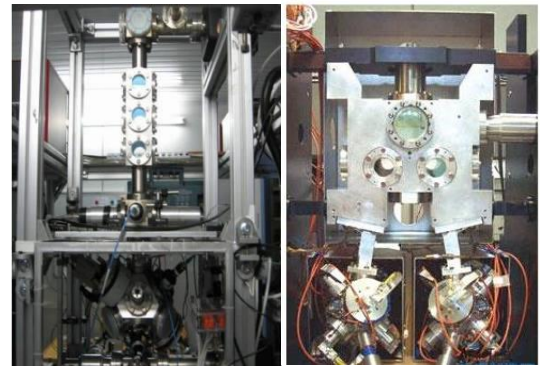
- National Science and Technology Project on Quantum Information in the next 10-15 years, similar to European Quantum Technologies Flagship and National Quantum Initiative of USA
- **National Laboratory for Quantum Information Sciences (NLQIS)**



Global Quantum Communication Networks

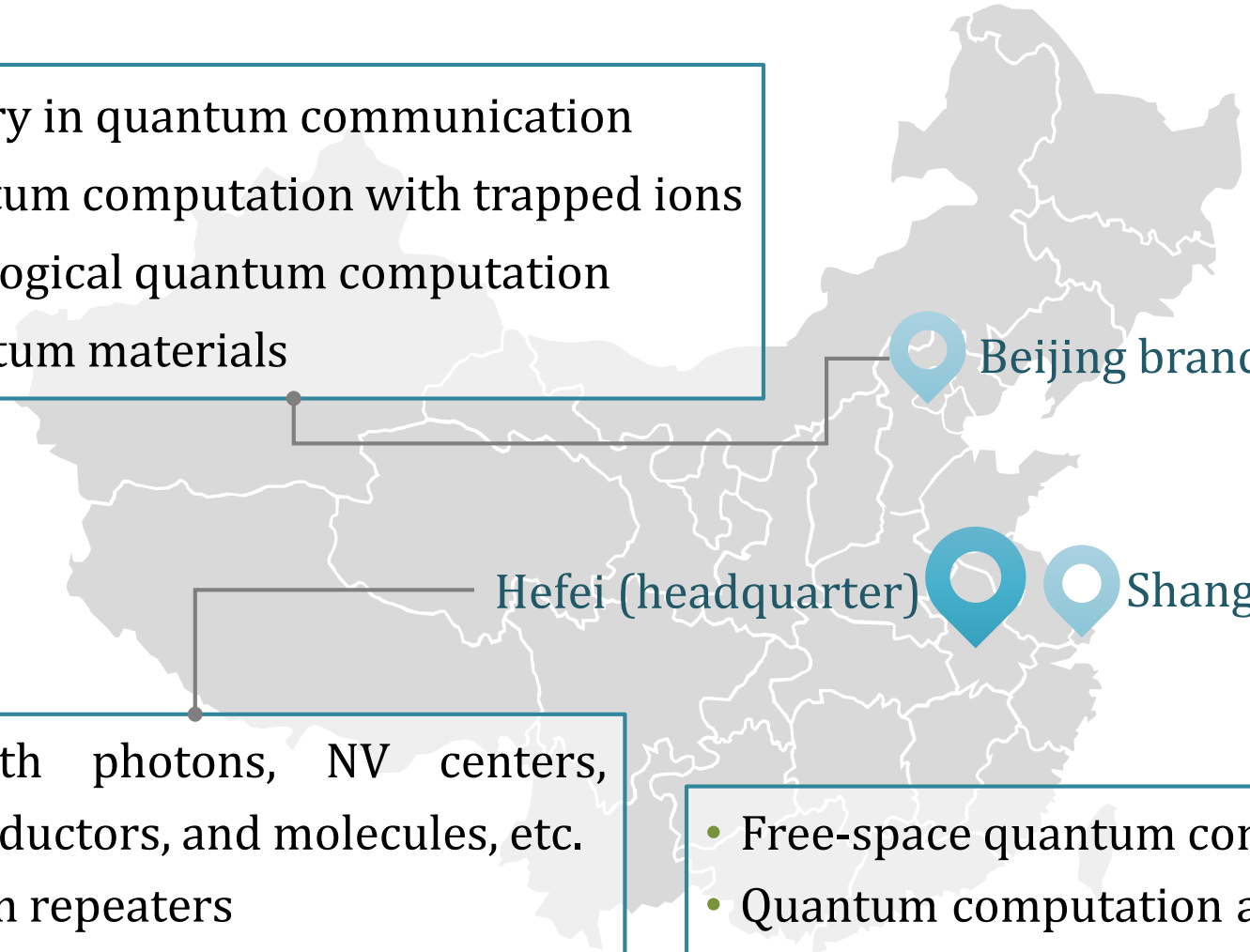


Scalable Quantum Computation and Quantum Simulation



Super-resolution Quantum Metrology

National Laboratory for Quantum Information Sciences



- Theory in quantum communication
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- QIP with photons, NV centers, semiconductors, and molecules, etc.
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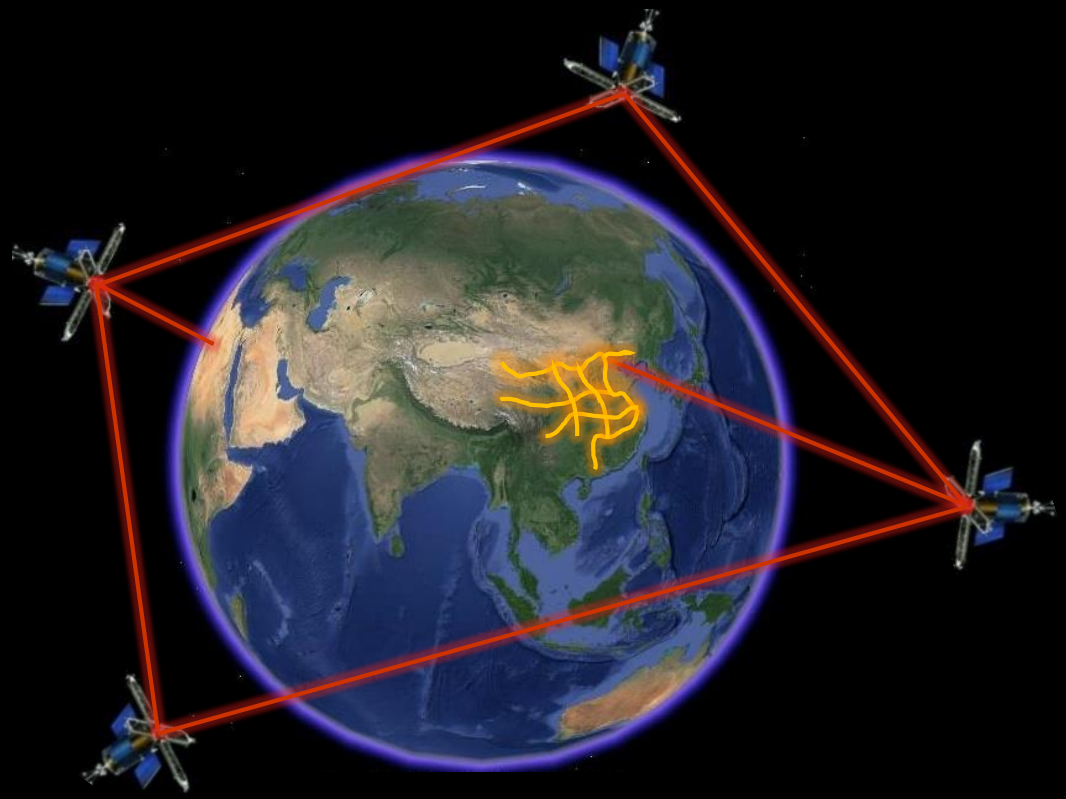
- Single-photon detection

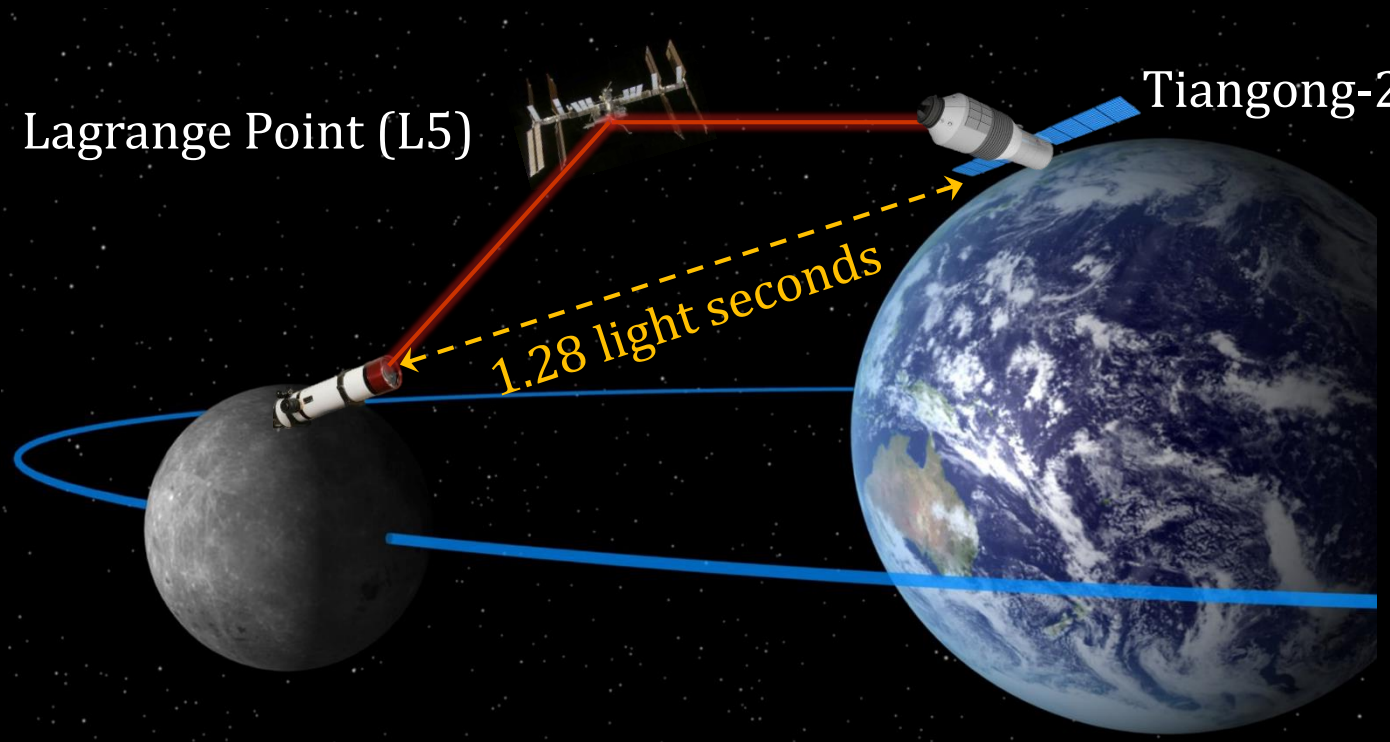
Towards Global Quantum Communication Network



- Quantum Constellation covering the whole earth directly, with MEO and GEO satellites which will be launched in next 5-10 years
- Global quantum communication infrastructure ➡ "Quantum Internet"

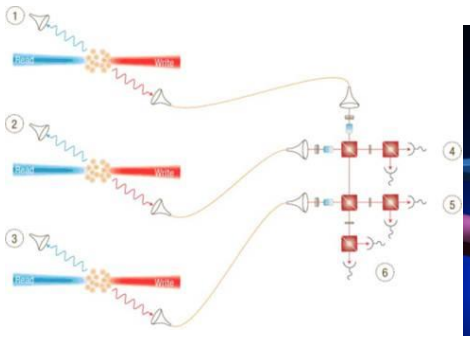
Large-scale Bell test

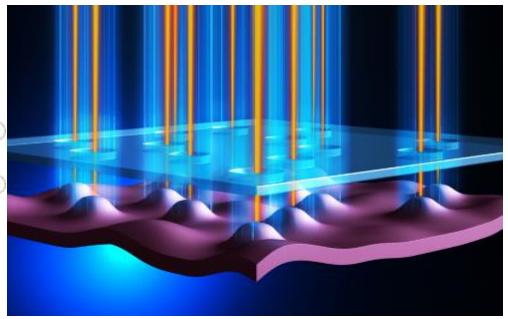
To close freedom of choice loophole and collapse locality loophole



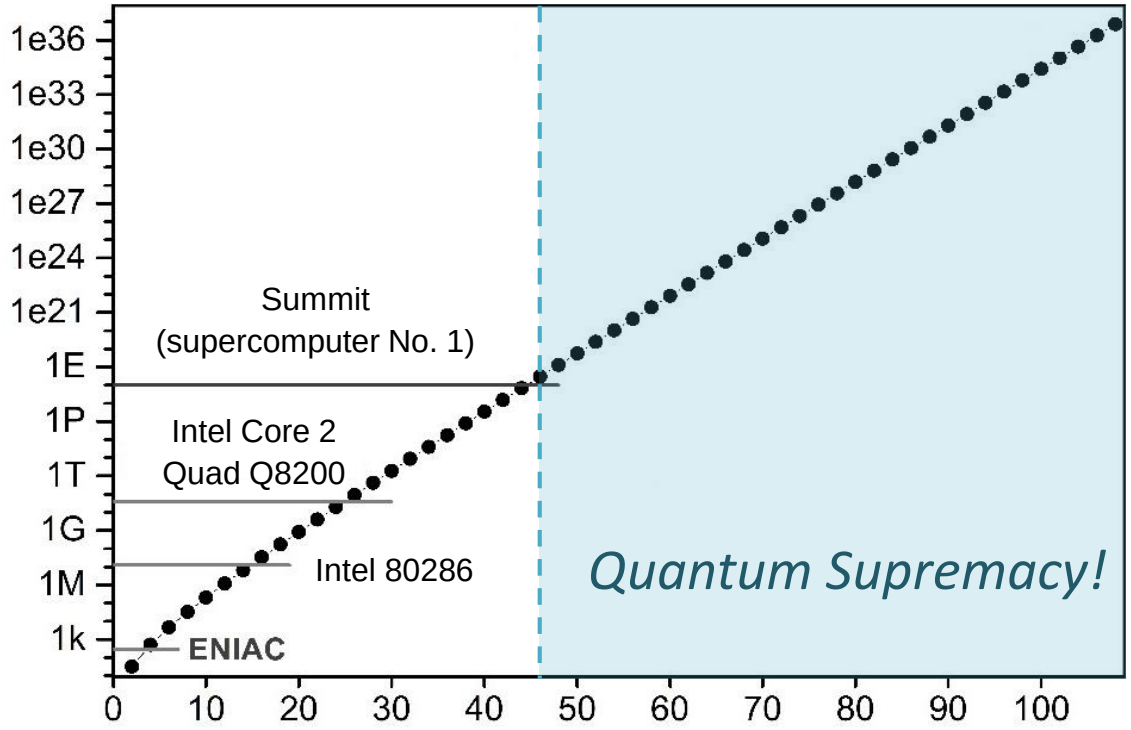
Entanglement distribution between Moon and Earth with China's future Moon landing project

Towards Scalable Quantum Computation and Simulation





- More entangled particles with the help of quantum memory
- Efficient quantum dot single photon emitters



- In next 3-5 years: quantum computer with 50-60 qubits ➡ beating classical super computer in specific tasks (e. g. Boson sampling and portfolio optimization)
- In next 5-10 years: quantum computer with hundreds of qubits ➡ mimicking condensed matter physics (e. g., high temperature superconductor, quantum Hall effect, etc.)

High-resolution and Highly Sensitive Measurements

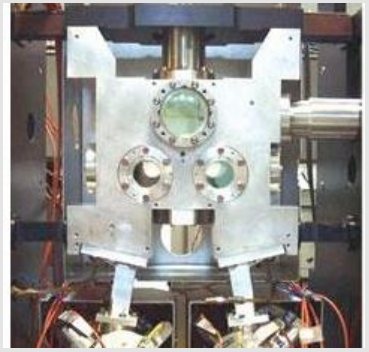
Optical clock

+

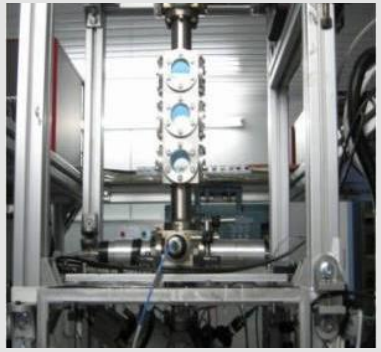
large scale optical time-frequency transfer network

High precision navigation and timing

High precision inertial navigation

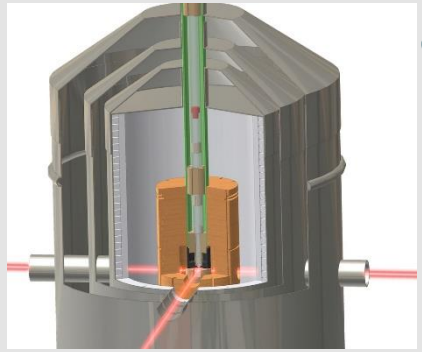


Atomic gyroscope



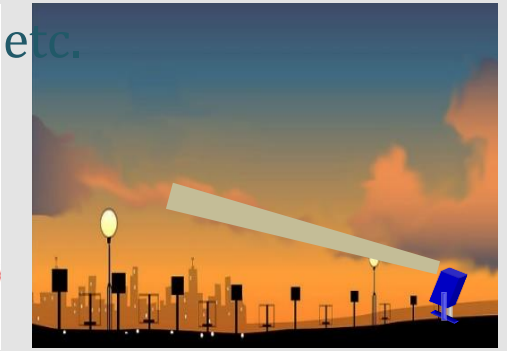
Atomic gravimeter

Applications for medical test and environmental monitoring



Atomic magnetometer

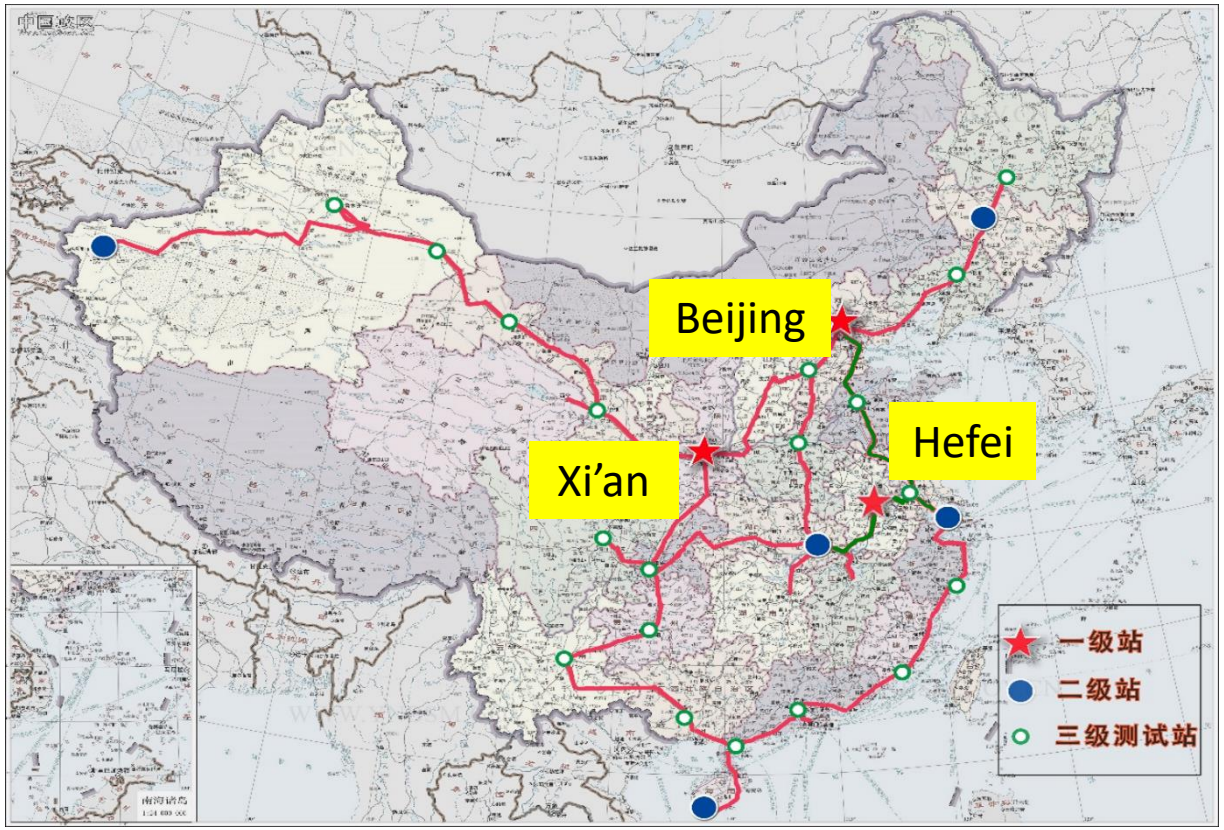
etc.



Single photon LIDAR

Precise Timing Information Sharing

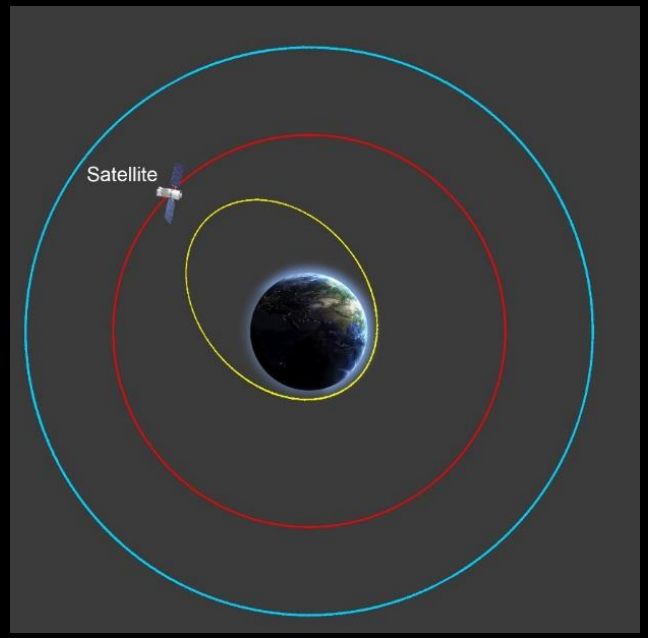
The Project “High-precision ground-based time service system”



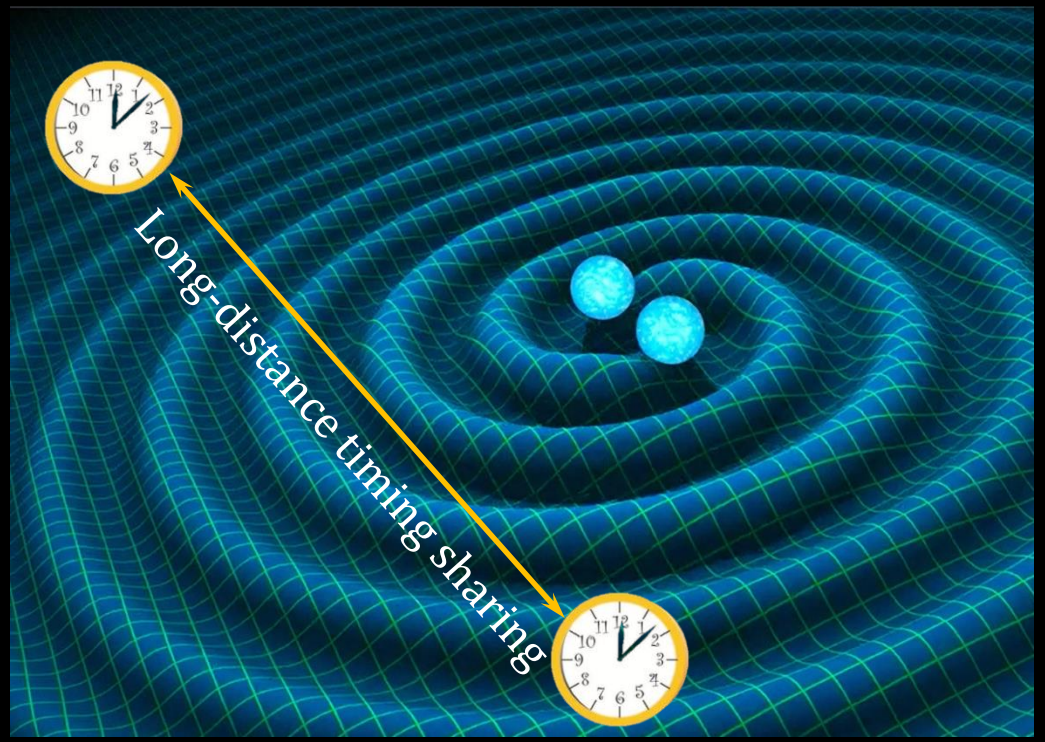
- To build the world's largest optical fiber time-frequency transfer network, with the most advanced indicators of the performance
- 3 primary stations, 5 secondary stations and 19 tertiary test stations

Ultra-precise optical clocks in outer space

Negligible magnetic and gravitational noise ➡ Fractional instability ~10^{-21}



- Precisely detecting gravitational red shift at different altitude of orbits



- Detecting gravitational wave signal with lower frequency to 0.1Hz ➡ revealing more kinds of astronomical events! (LIGO: ~100Hz)

Thank you for your attention.

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