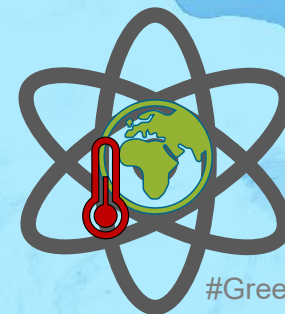


QUANTUM TECHNOLOGIES FOR CLIMATE CHANGE

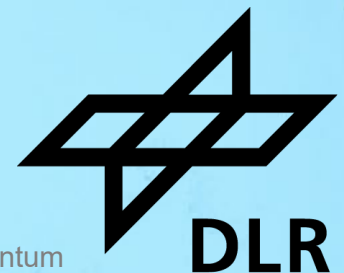
#GreenQuantum

Dr. Lisa Wörner

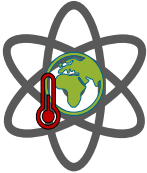
Deutsches Zentrum für Luft- und Raumfahrt (DLR e.V.), Institut für Quantentechnologien
Wilhelm – Runge Strasse 10, 89081 Ulm
+49 (0) 731 400 198802, +49 (0) 173 7508310, lisa.woerner@dlr.de



#GreenQuantum



Quantum Technologies for Climate Change

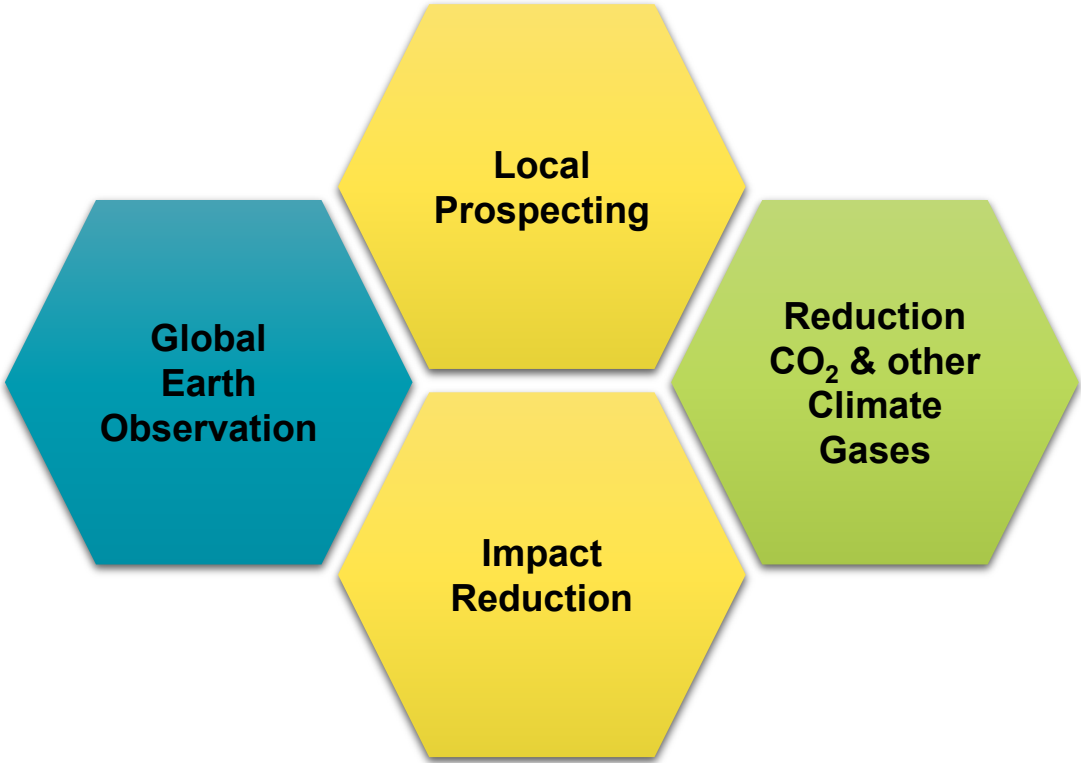


#GreenQuantum

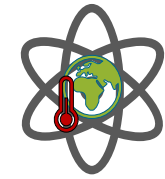


DLR

Relevant Areas



Quantum Technologies for Climate Change

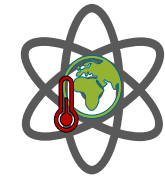


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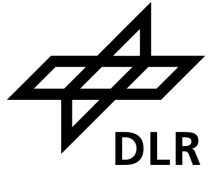
Relevant Areas

**Global
Earth
Observation**

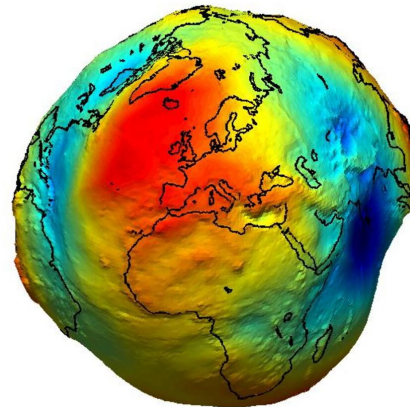
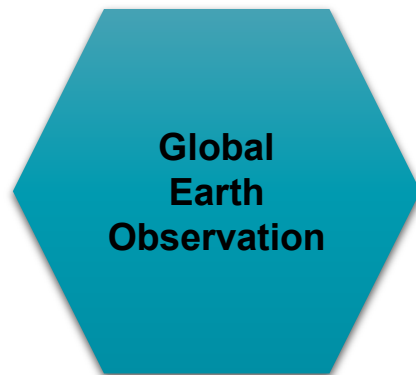
Quantum Technologies for Climate Change



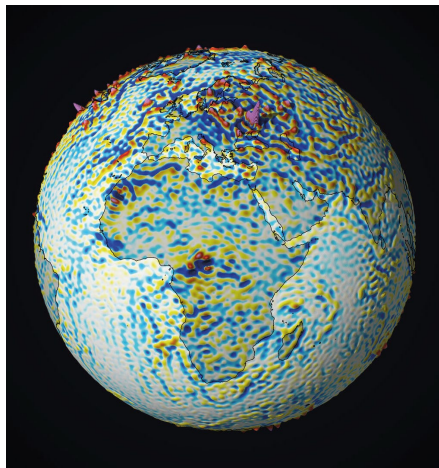
#GreenQuantum



Earth Observation



Pictures: © ESA.int



Monitoring

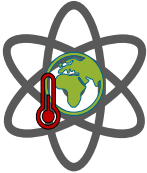
Sea Level Rise

Sea Currents

Distribution of Ice / Land Masses

Impact of Measures

Quantum Technologies for Climate Change



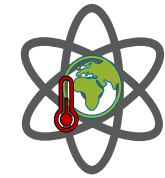
#GreenQuantum



Impact Reduction



Quantum Technologies for Climate Change



#GreenQuantum

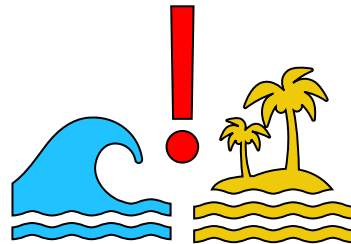


DLR

Impact Reduction

Local
Prospecting

Impact
Reduction



Impact Reduction

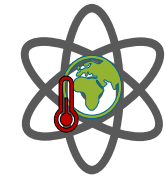
Local Ressource Prospecting

Secure Cities & Infrastructure

Early Warning Systems

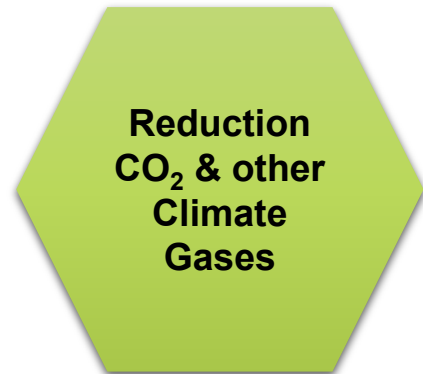
Reduce / Prevent War & Migration

Quantum Technologies for Climate Change

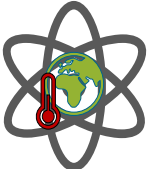


#GreenQuantum

Active Reduction



Quantum Technologies for Climate Change



#GreenQuantum



Active Reduction



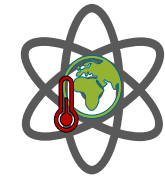
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Active Reduction

Improved Navigation

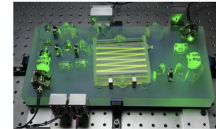
**Reduction
CO₂ & other
Climate
Gases**

Quantum Technologies for Climate Change



#GreenQuantum

Active Reduction



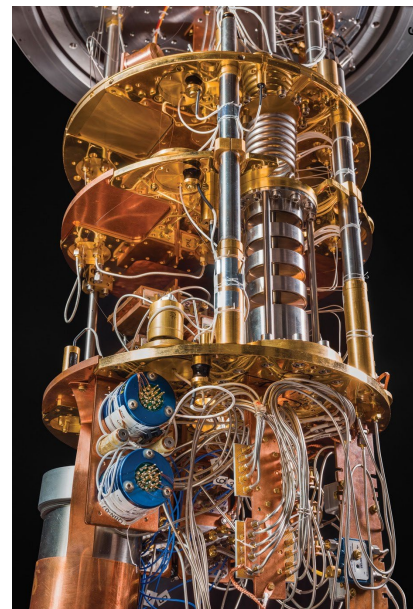
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Active Reduction

Improved Navigation

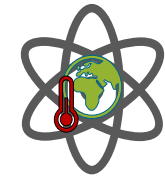


Reduction
CO₂ & other
Climate
Gases



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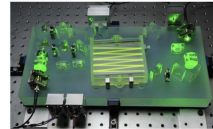
Quantum Technologies for Climate Change



#GreenQuantum



Active Reduction

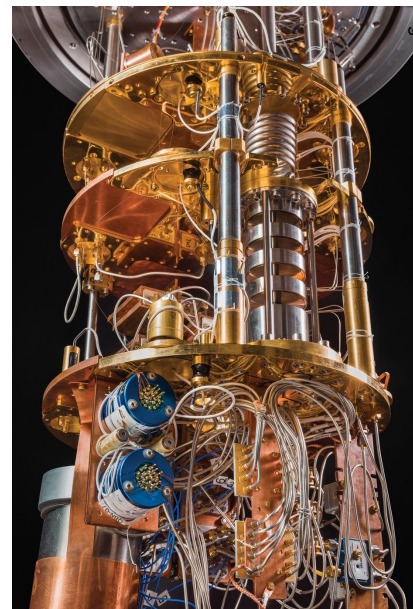


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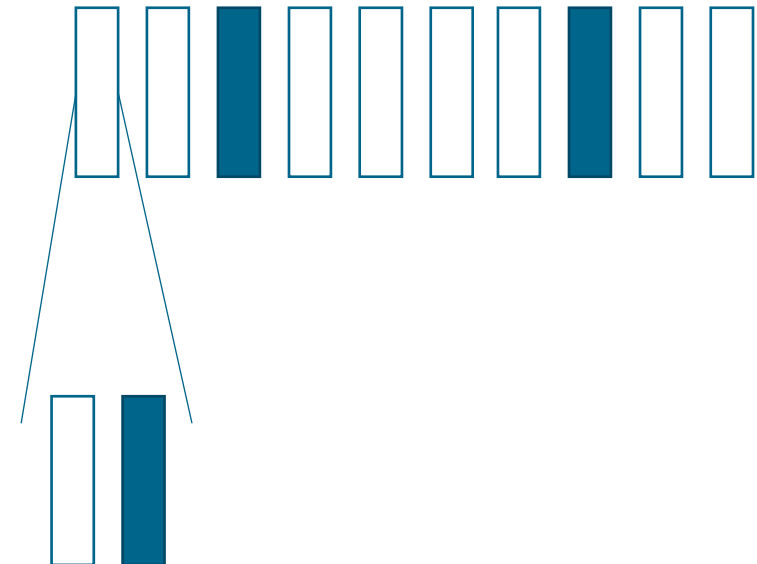
Active Reduction

Improved Navigation

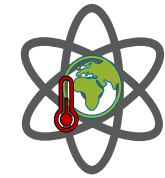
Reduction
CO₂ & other
Climate
Gases



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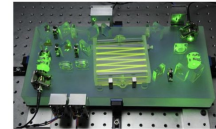
Quantum Technologies for Climate Change



#GreenQuantum



Active Reduction

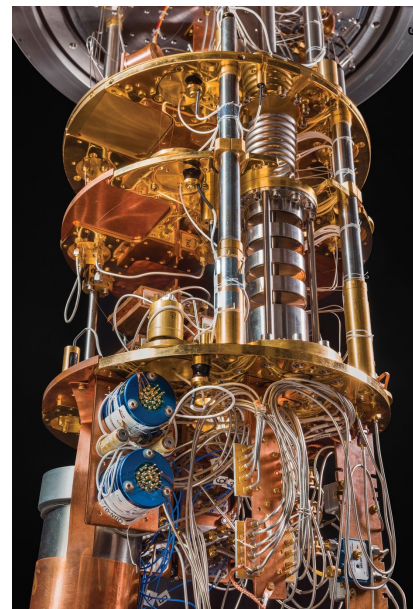


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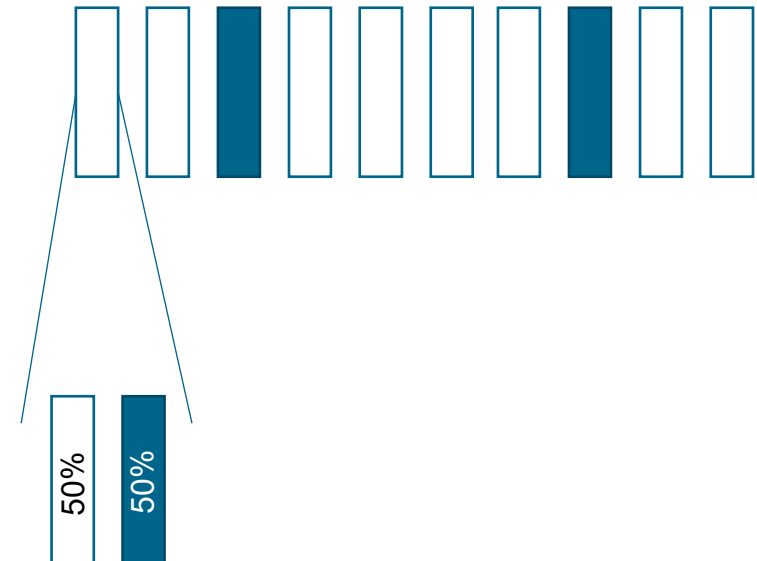
Active Reduction

Improved Navigation

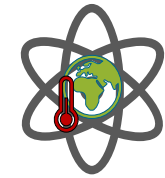
Reduction
CO₂ & other
Climate
Gases



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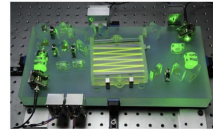
Quantum Technologies for Climate Change



#GreenQuantum



Active Reduction

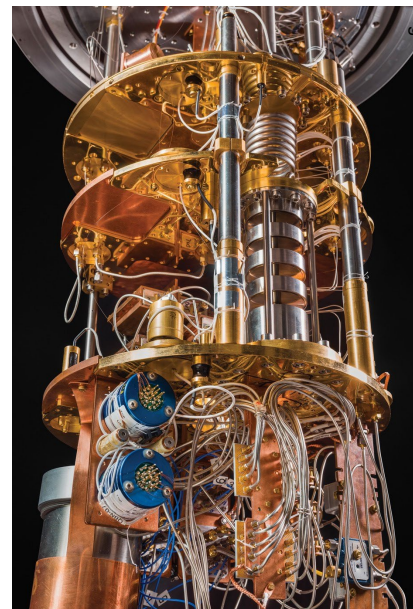


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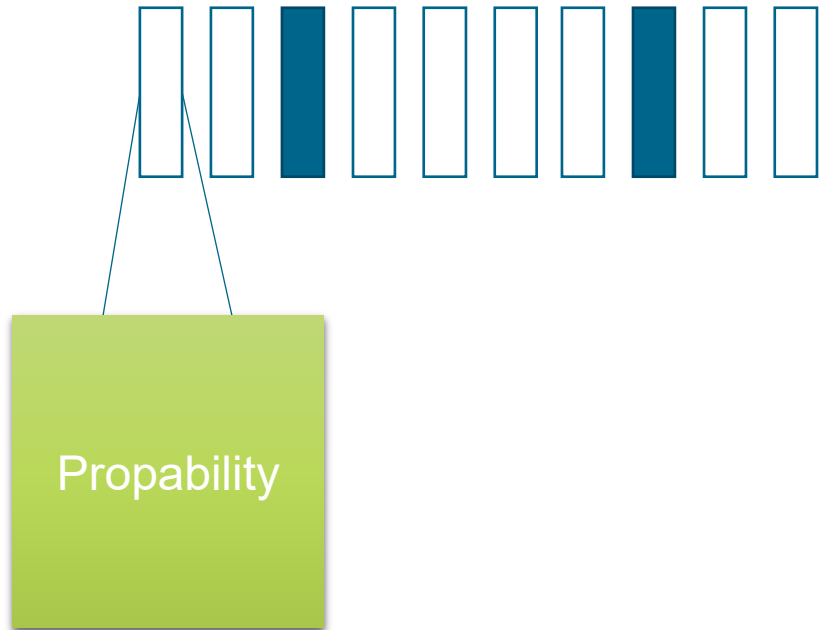
Active Reduction

Improved Navigation

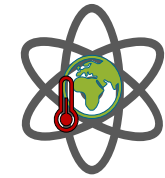
Reduction
CO₂ & other
Climate
Gases



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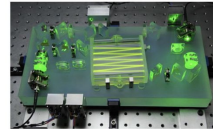
Quantum Technologies for Climate Change



#GreenQuantum



Active Reduction

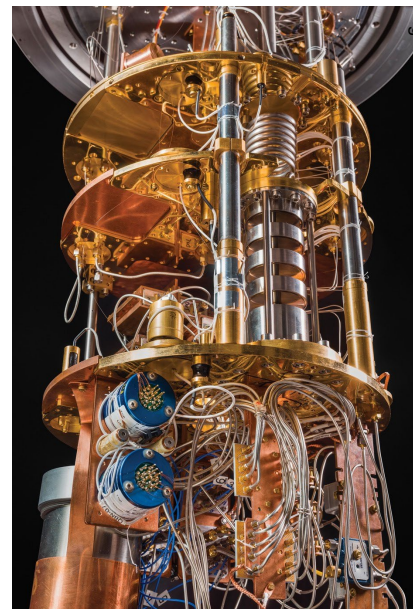


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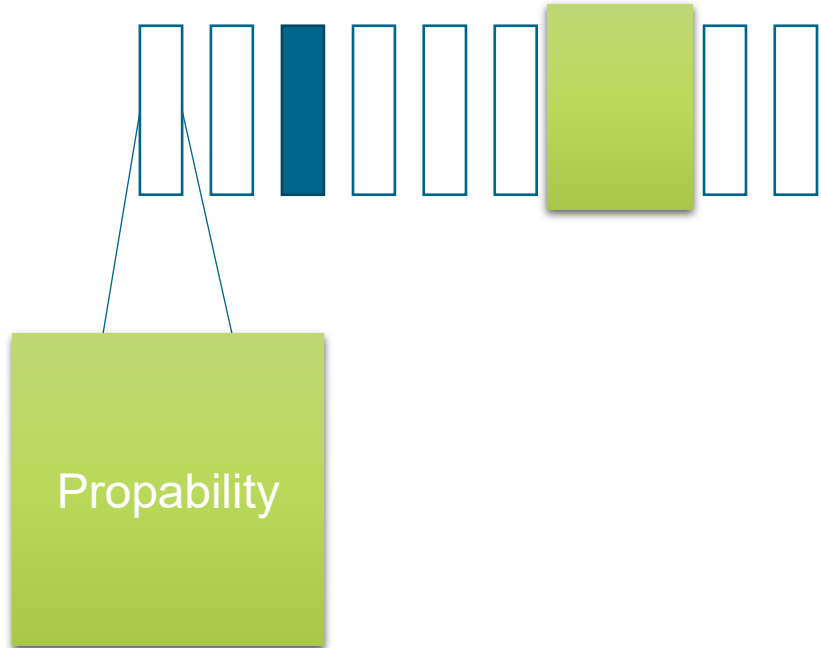
Active Reduction

Improved Navigation

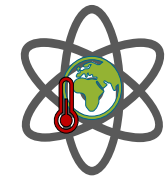
Reduction
CO₂ & other
Climate
Gases



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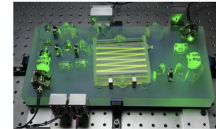


Quantum Technologies for Climate Change



#GreenQuantum

Active Reduction

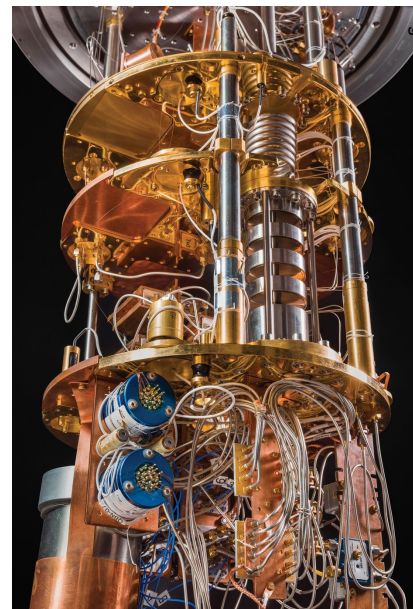


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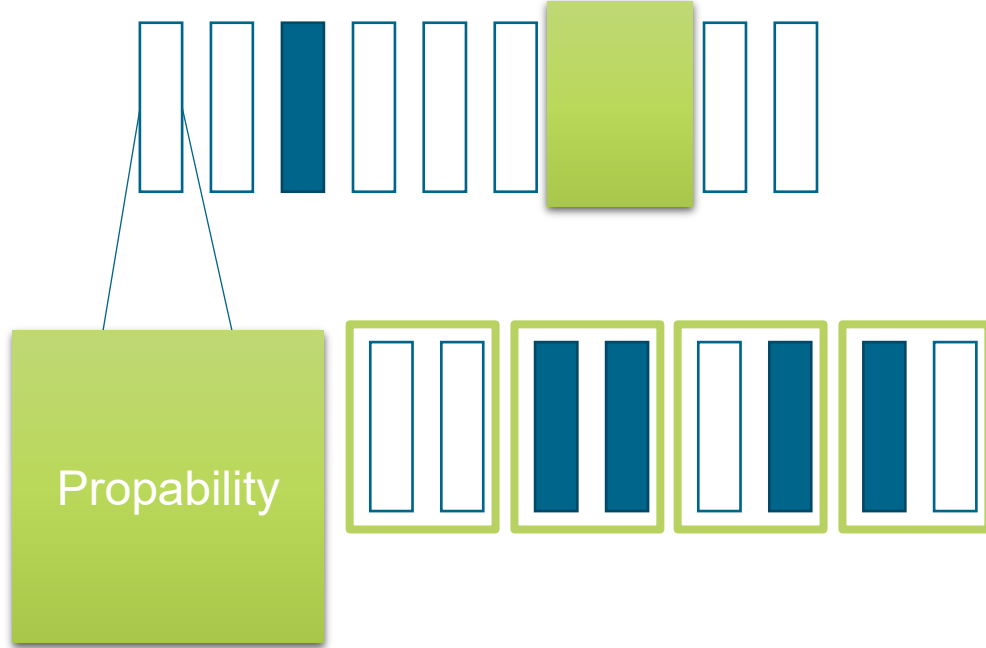
Active Reduction

Improved Navigation

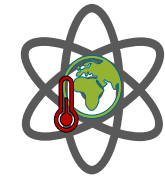
Reduction
CO₂ & other
Climate
Gases



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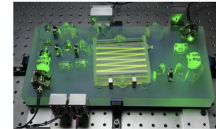


Quantum Technologies for Climate Change



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Active Reduction

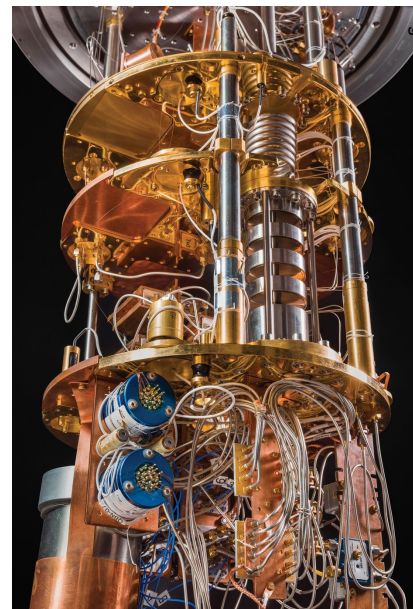


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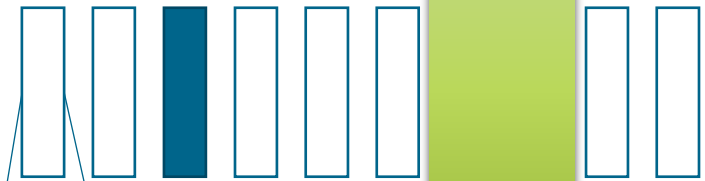
Active Reduction

Improved Navigation

Reduction
CO₂ & other
Climate
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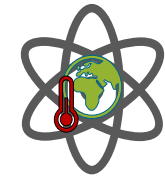
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Propability



No, lets add ,Quantum'.



Active Reduction

Nobel Prize in Physics

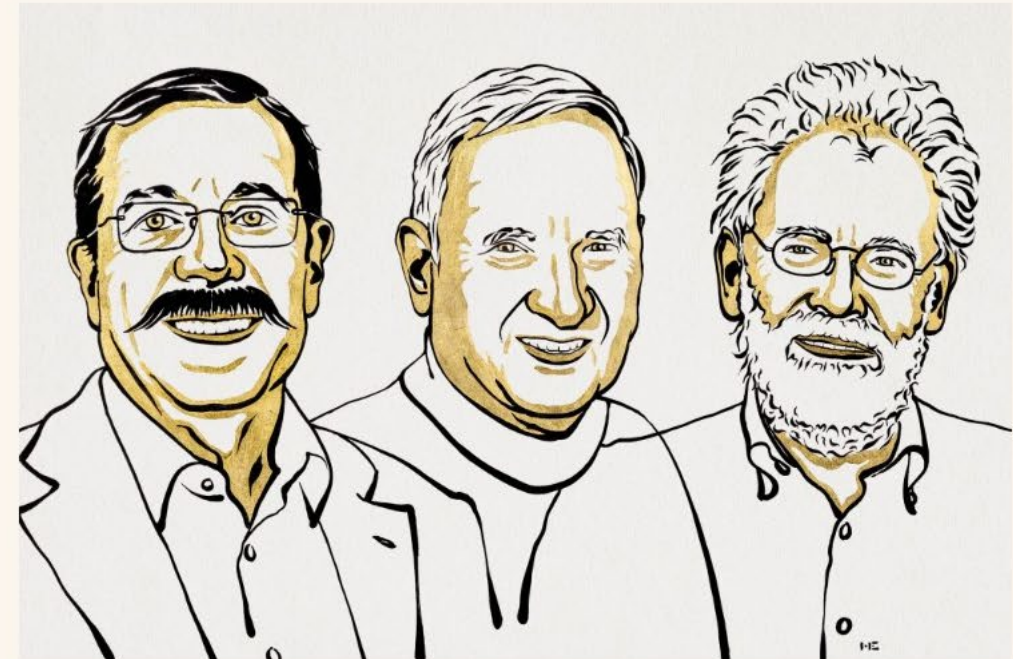
The 2022 physics laureates

The Nobel Prize in Physics 2022 was awarded to [Alain Aspect](#), [John F. Clauser](#) and [Anton Zeilinger](#) “for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science”.

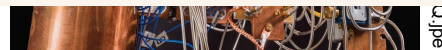
Their results have cleared the way for new technology based upon quantum information.

Entanglement in a nutshell:

Knowledge of the **overall state** but **not** the individual **constituent states**.



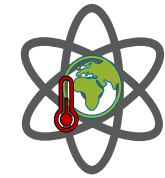
Ill. Niklas Elmehed © Nobel Prize Outreach



ed/c

No, lets add ,Quantum'.

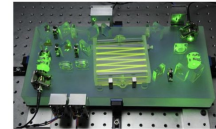
Quantum Technologies for Climate Change



#GreenQuantum



Active Reduction



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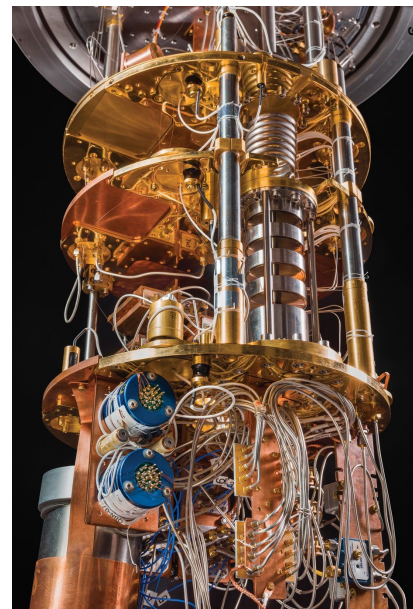
Active Reduction

Improved Navigation

Entanglement
(,Spooky Interaction at a Distance')

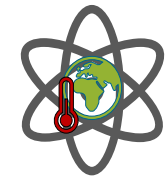
Propability

Reduction
CO₂ & other
Climate
Gases

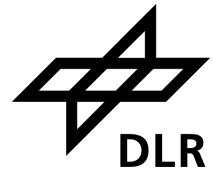


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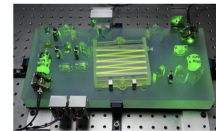
Quantum Technologies for Climate Change



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Active Reduction



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Active Reduction

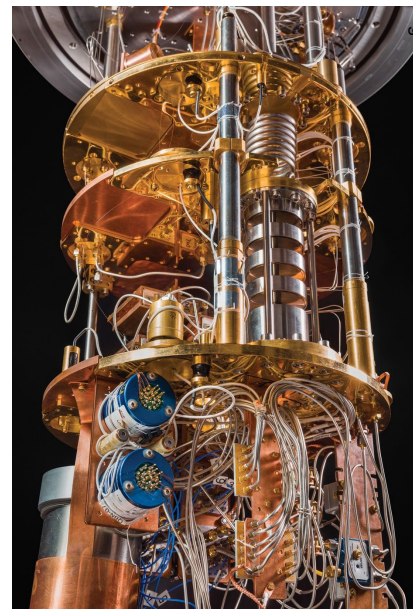
Improved Navigation

Entanglement
(,Spooky Interaction at a Distance')

Propability

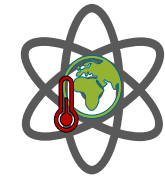
n classical bits
 2^n quantum bits

Reduction
CO₂ & other
Climate
Gases



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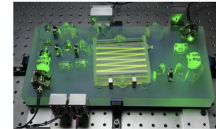
Quantum Technologies for Climate Change



#GreenQuantum



Active Reduction

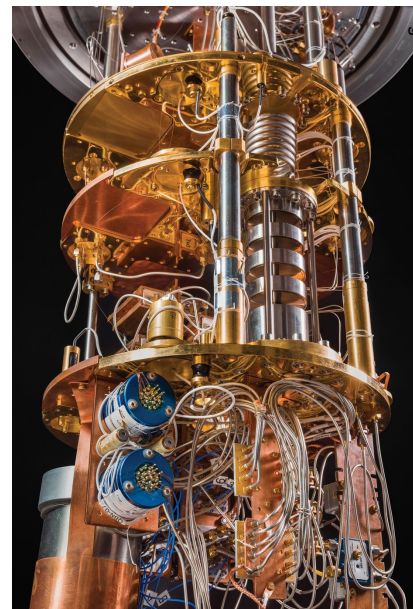


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Active Reduction

Improved Navigation

Reduction
CO₂ & other
Climate
Gases



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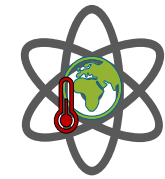
Entanglement
(,Spooky Interaction at a Distance')

Propability

n classical bits
 2^n quantum bits

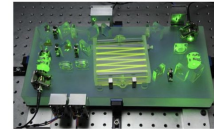
Error Correction
Result Verification

Quantum Technologies for Climate Change



#GreenQuantum

Active Reduction

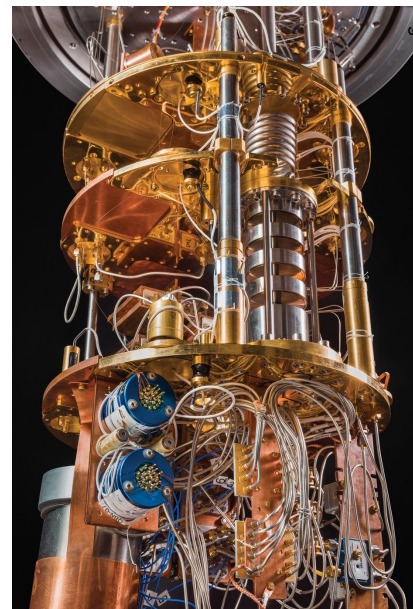


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Active Reduction

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Reduction
CO₂ & other
Climate
Gases



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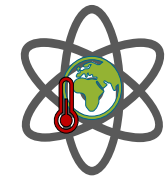
Entanglement (,Spooky Interaction at a Distance')

Propability

433 qbits => 2^{433} possible States

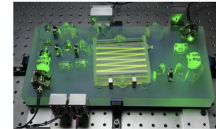
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Quantum Technologies for Climate Change



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Active Reduction

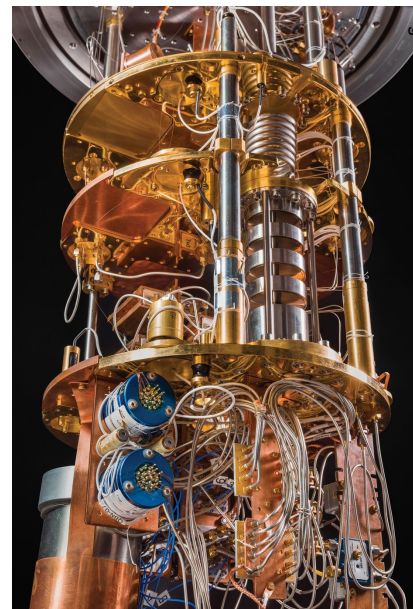


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Active Reduction

Improved Navigation

Reduction
CO₂ & other
Climate
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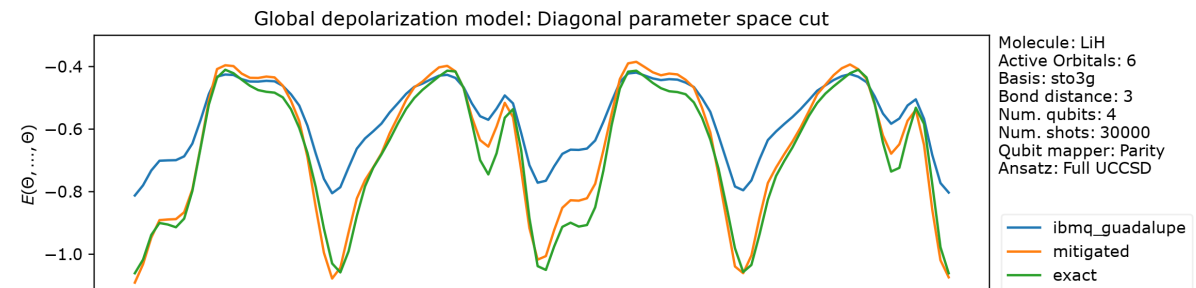


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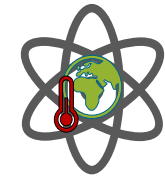


S. Wölk, DLR - QT

- Quantum Computing
 - Hardware is noisy
 - Efficient Implementation
 - Error Mitigation to Improve

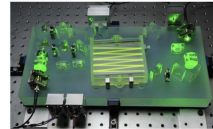


Quantum Technologies for Climate Change



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Active Reduction

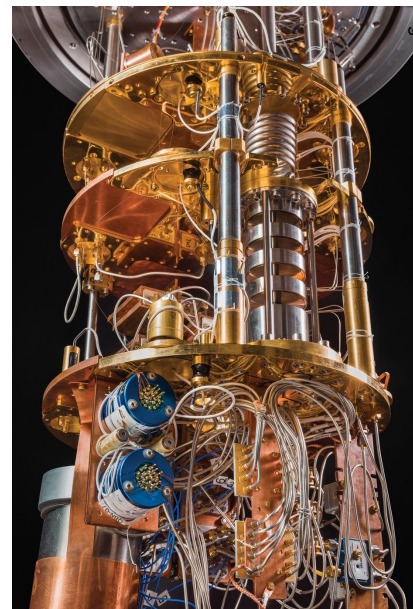


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Active Reduction

Improved Navigation

Reduction
CO₂ & other
Climate
Gases

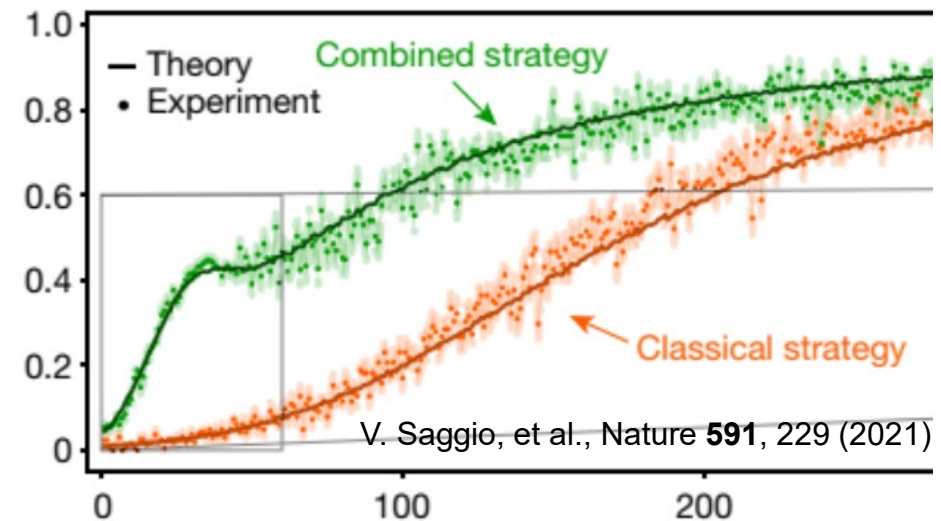


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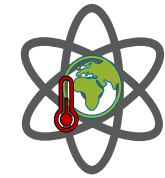


S. Wölk, DLR - QT

- Quantum Computing
- Quantum Reinforcement Learning



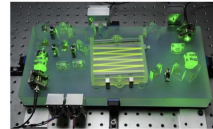
Quantum Technologies for Climate Change



#GreenQuantum

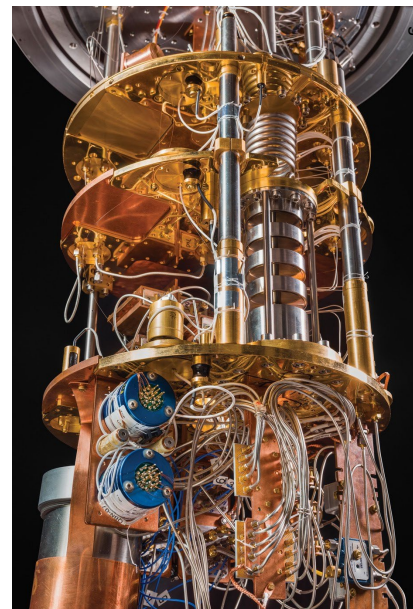


Active Reduction



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**Reduction
CO₂ & other
Climate
Gases**



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Active Reduction

Improved Navigation

Process / Resource Optimization

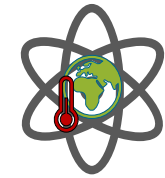
Route Optimization

Battery Improvement

Weather / Climate Models

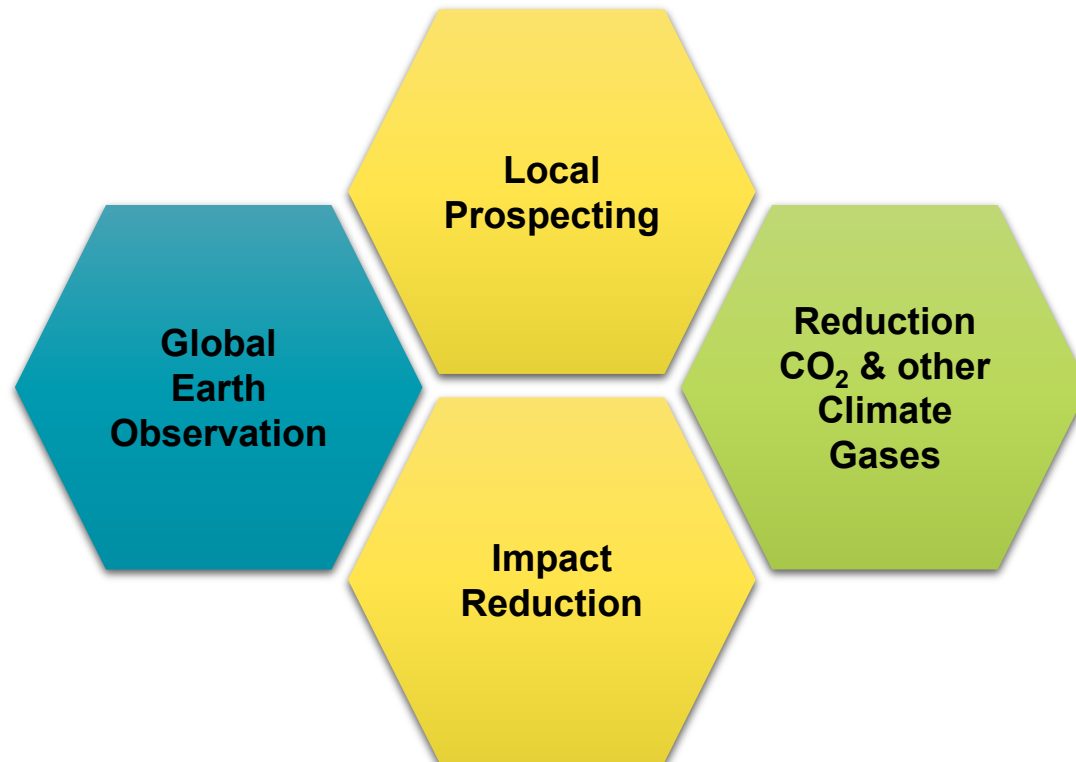
Traffic Development

Quantum Technologies for Climate Change

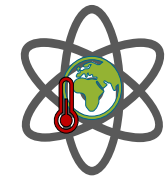


#GreenQuantum

Relevant Areas

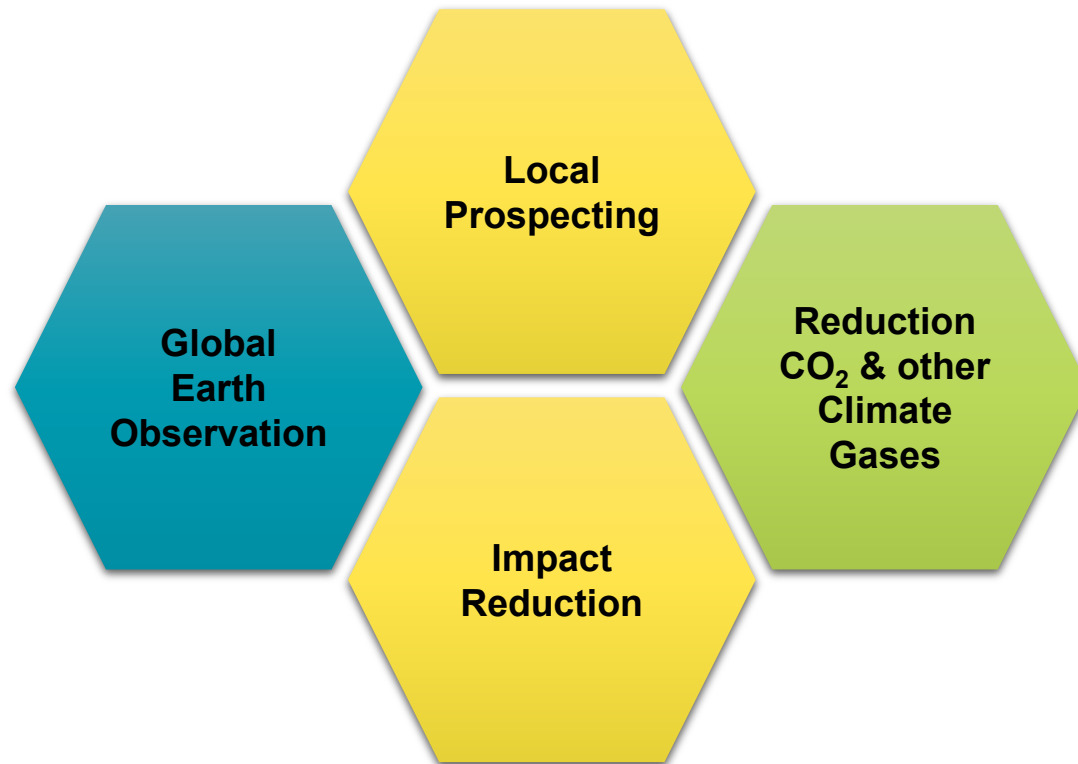


Quantum Technologies for Climate Change

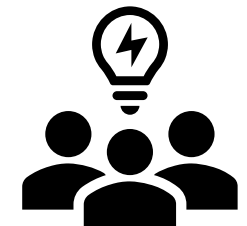


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Relevant Areas



55 DLR Institutes



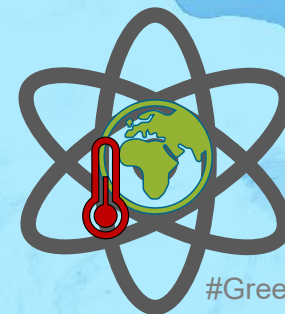
... further Industrial, Governmental, and Academic Partners

QUANTUM TECHNOLOGIES FOR CLIMATE CHANGE

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