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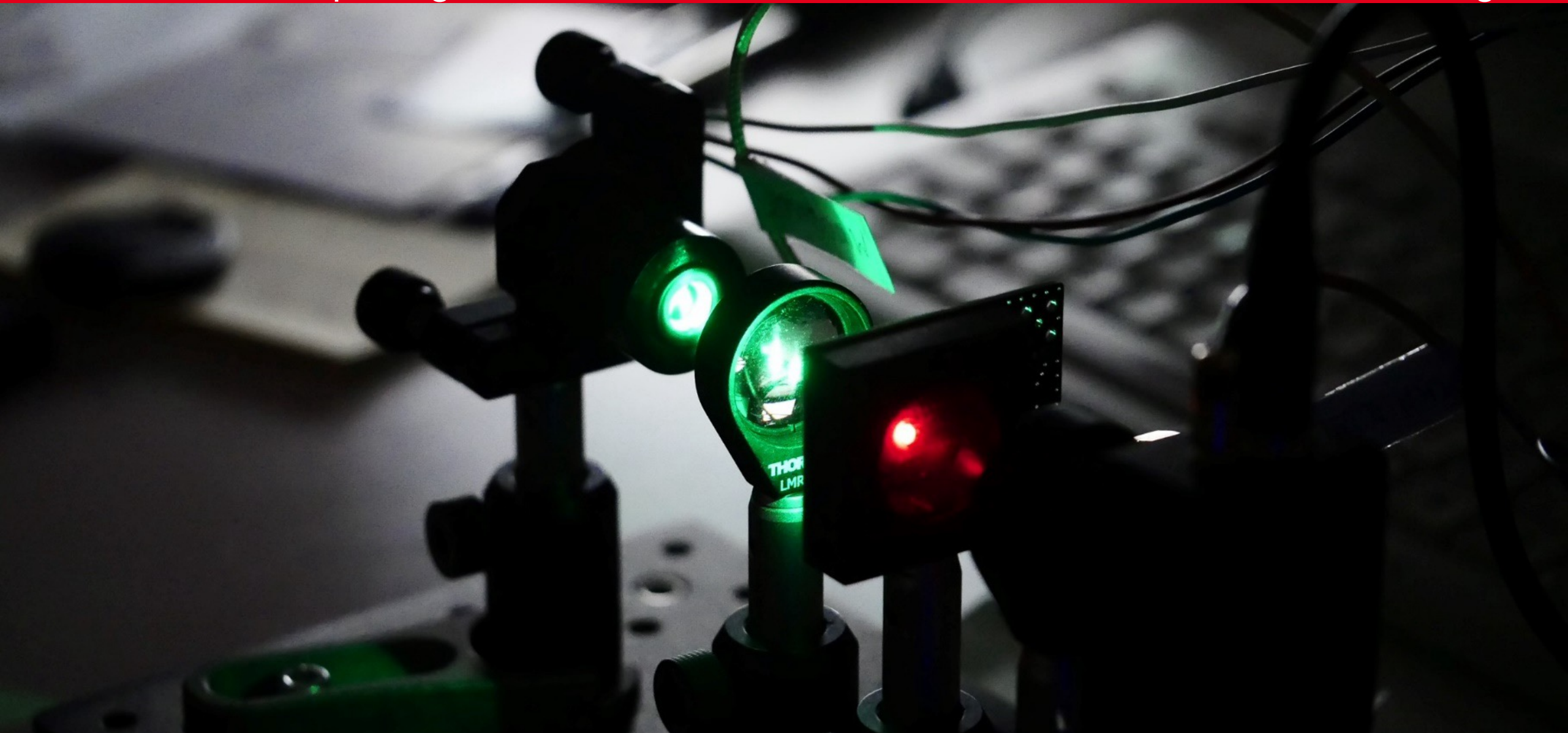
Quantum Computing Circle

Bernd Hänsch-Rosenberger



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Contact:

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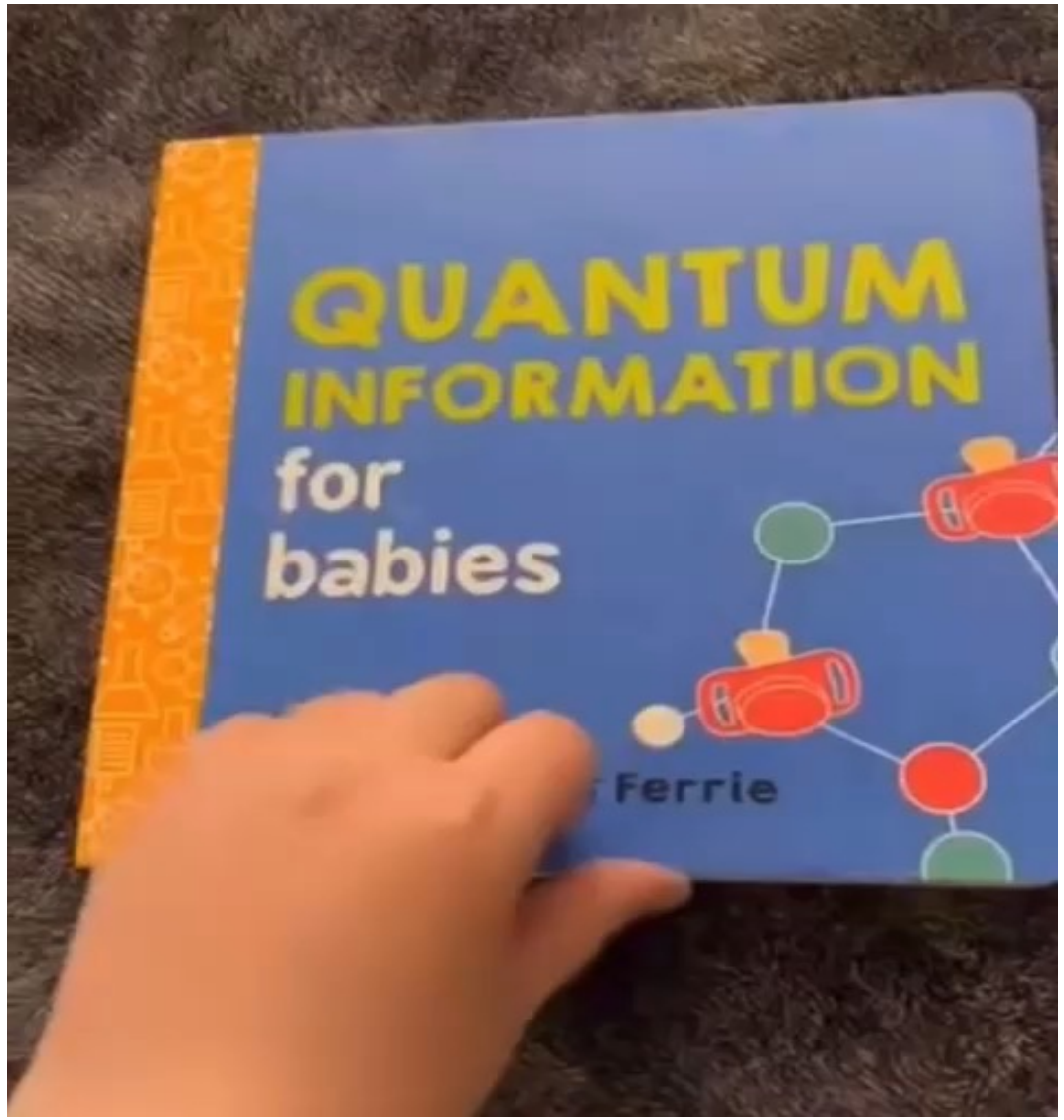
haensch@lehre.DHBW-Stuttgart.de

A short funny Video



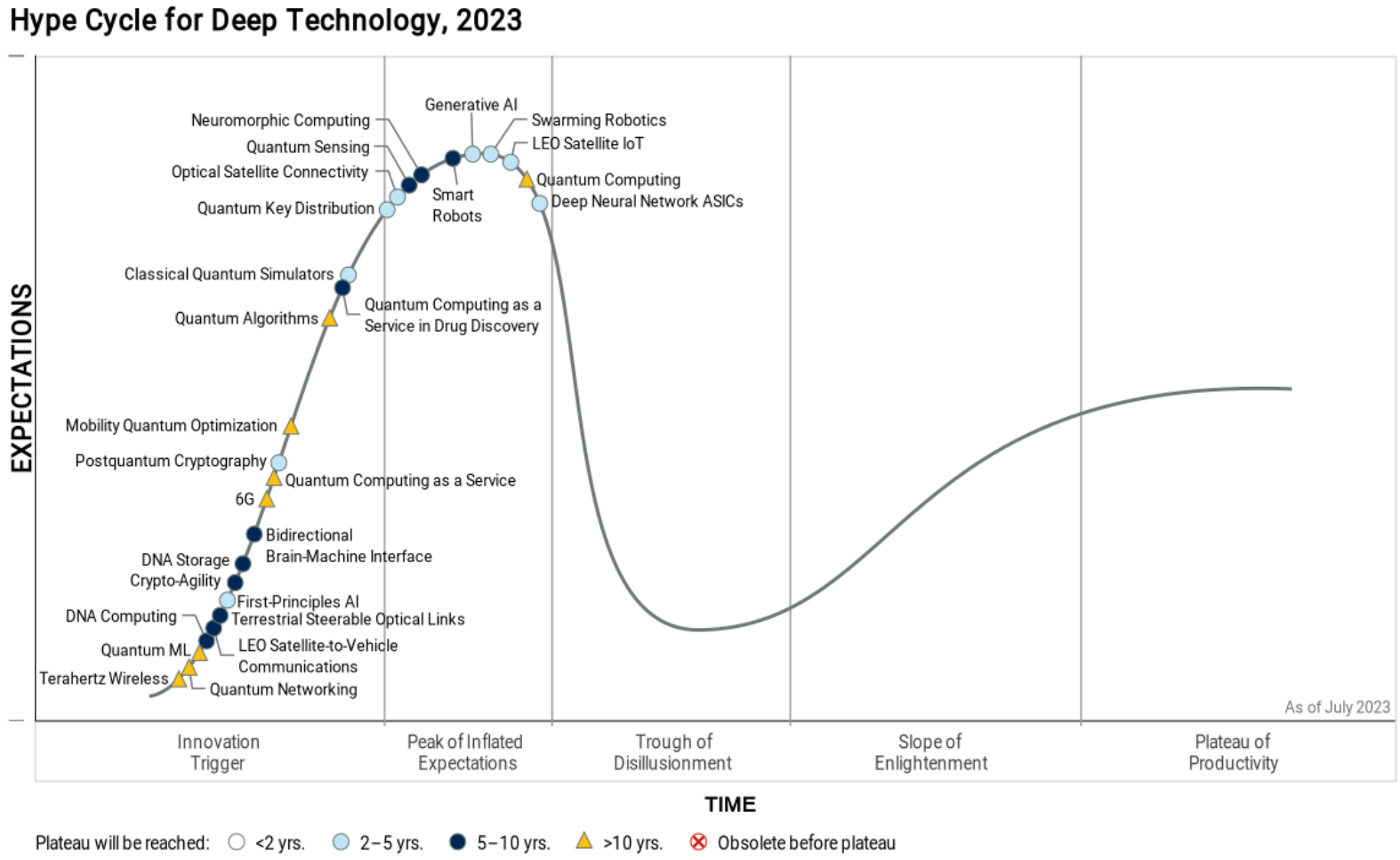
Structure

- Introduction
- The financial expectation
- A short technical view
- A short philosophical remark
- Outlook

Financial Expectation

- Some Studies:
  - Handlungskonzept Quantentechnologien der Bundesregierung [Deutschlands]
  - Gartner
  - Center for Strategic & International Studies
  - PWC

Financial Expectation Gartner



Gartner

Financial Expectation CSIS

in 2022:

$ 40 billion worldwide

Country	Estimated Total
China	$ 10 billion
EU	$ 8.7 billion
USA	$ 7.4 billion
UK	$ 5.0 billion
Canada	$ 1.7 billion
Japan	$ 1.7 billion
Australia	$ 1.0 billion
Russia	$ 790 million
India	$ 730 million

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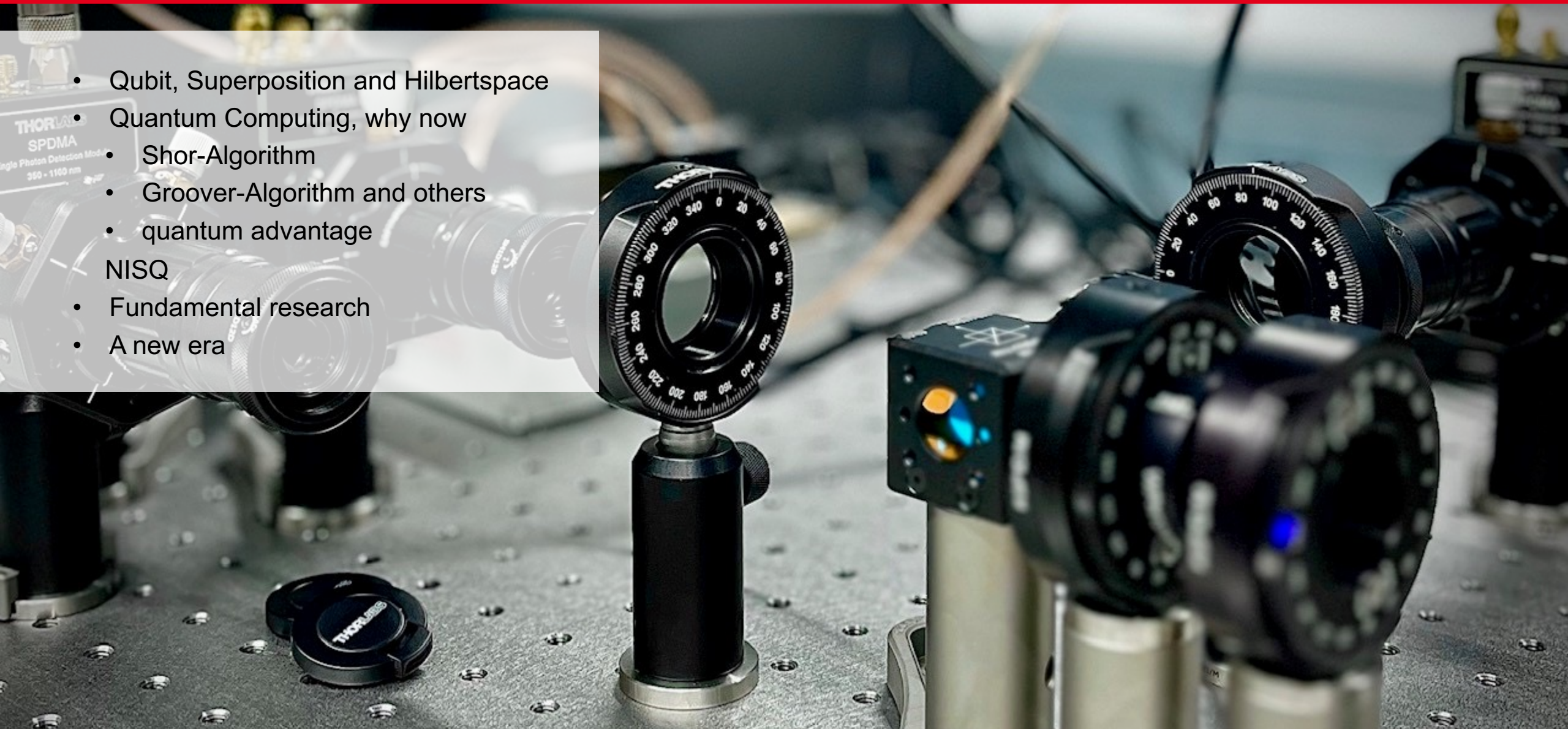
A short technical view



- Qubit, Superposition and Hilbertspace
- Quantum Computing, why now
  - Shor-Algorithm
  - Groover-Algorithm and others
  - quantum advantage

  NISQ
- Fundamental research
- A new era

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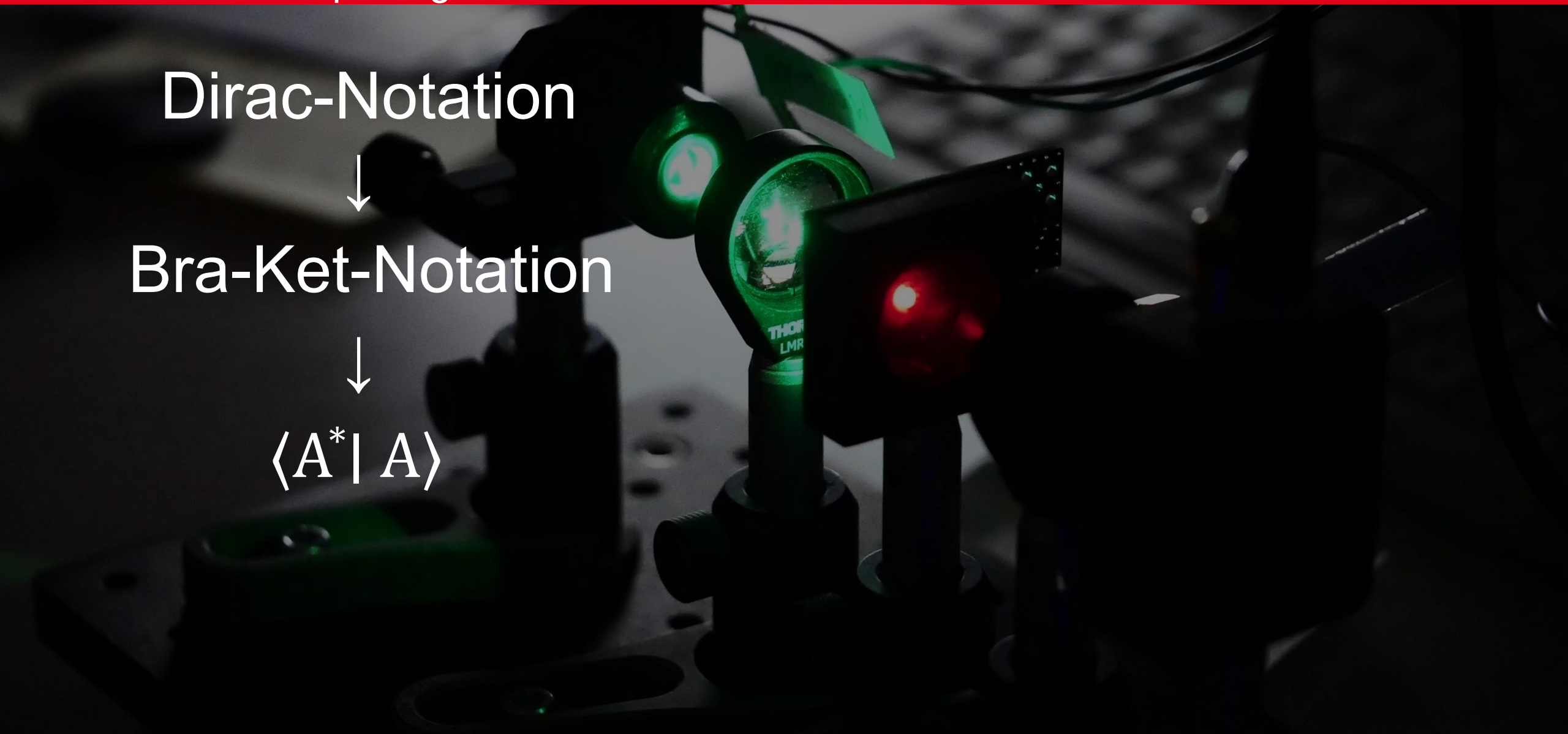

Quantum Computing Circle

Bra

⟨a Symbol

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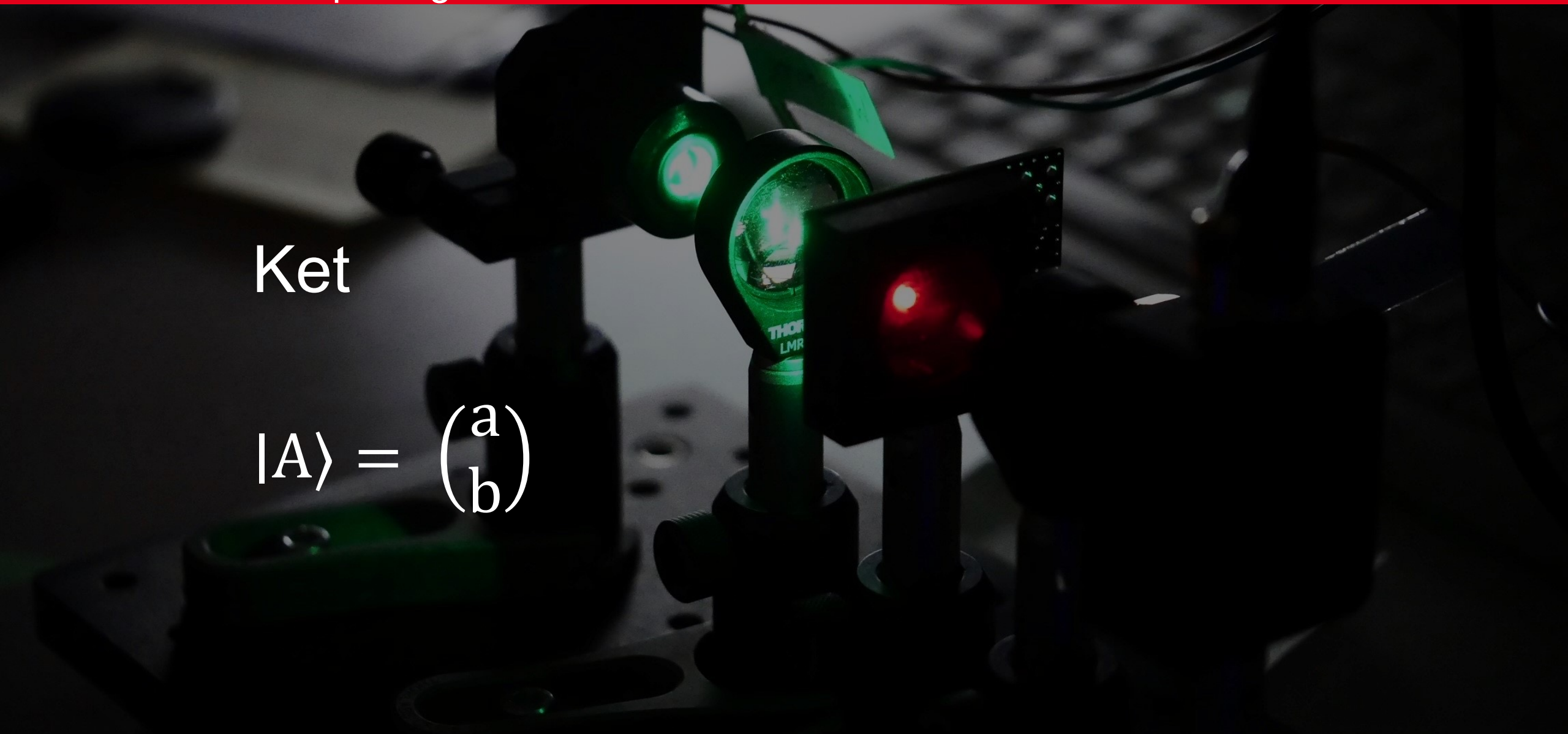


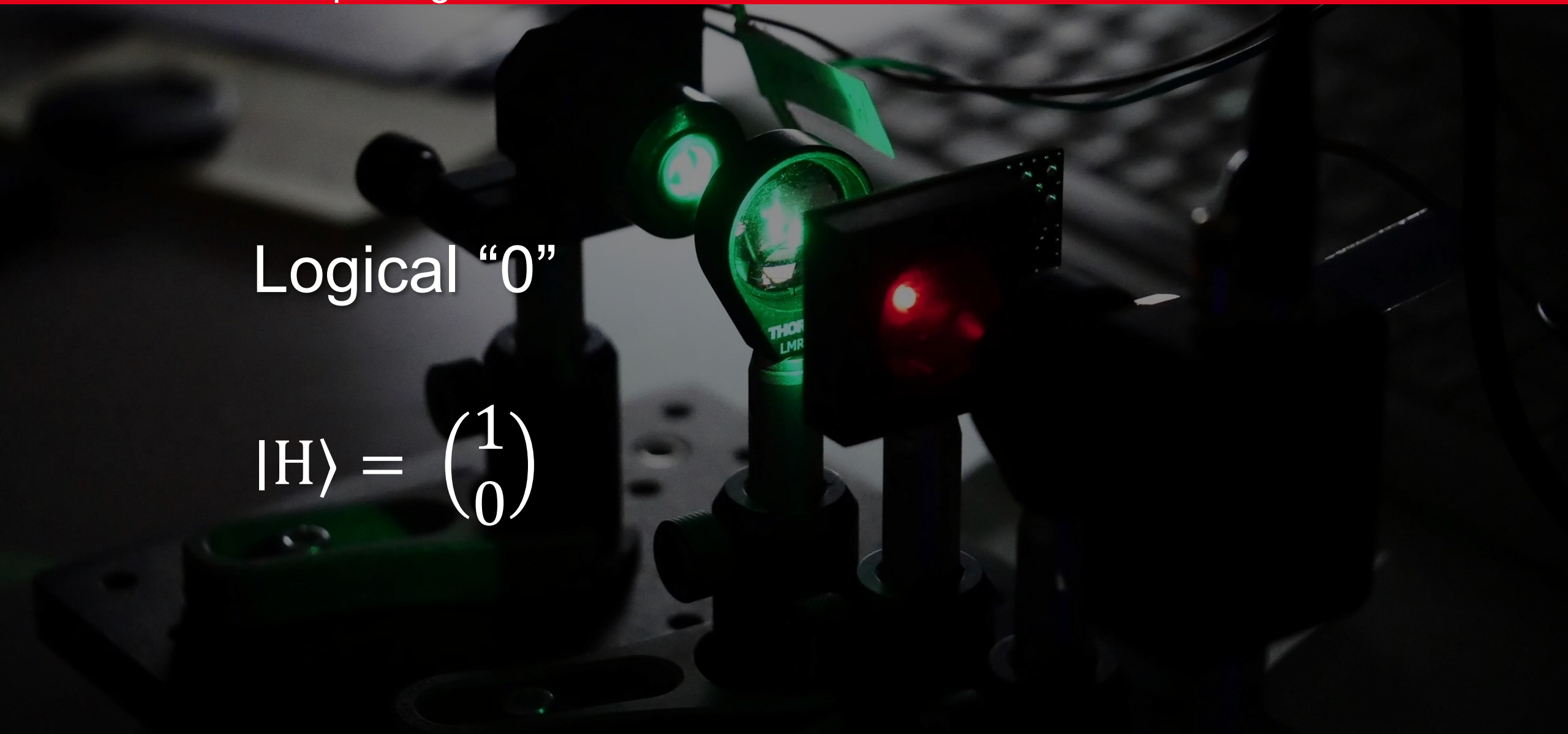
Ket

$$|A\rangle = \begin{pmatrix} a \\ b \end{pmatrix}$$

Bra-Ket-Notation

$\langle A^* | A \rangle$

Quantum Computing Circle



Logical “0”

$$|\mathrm{H}\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

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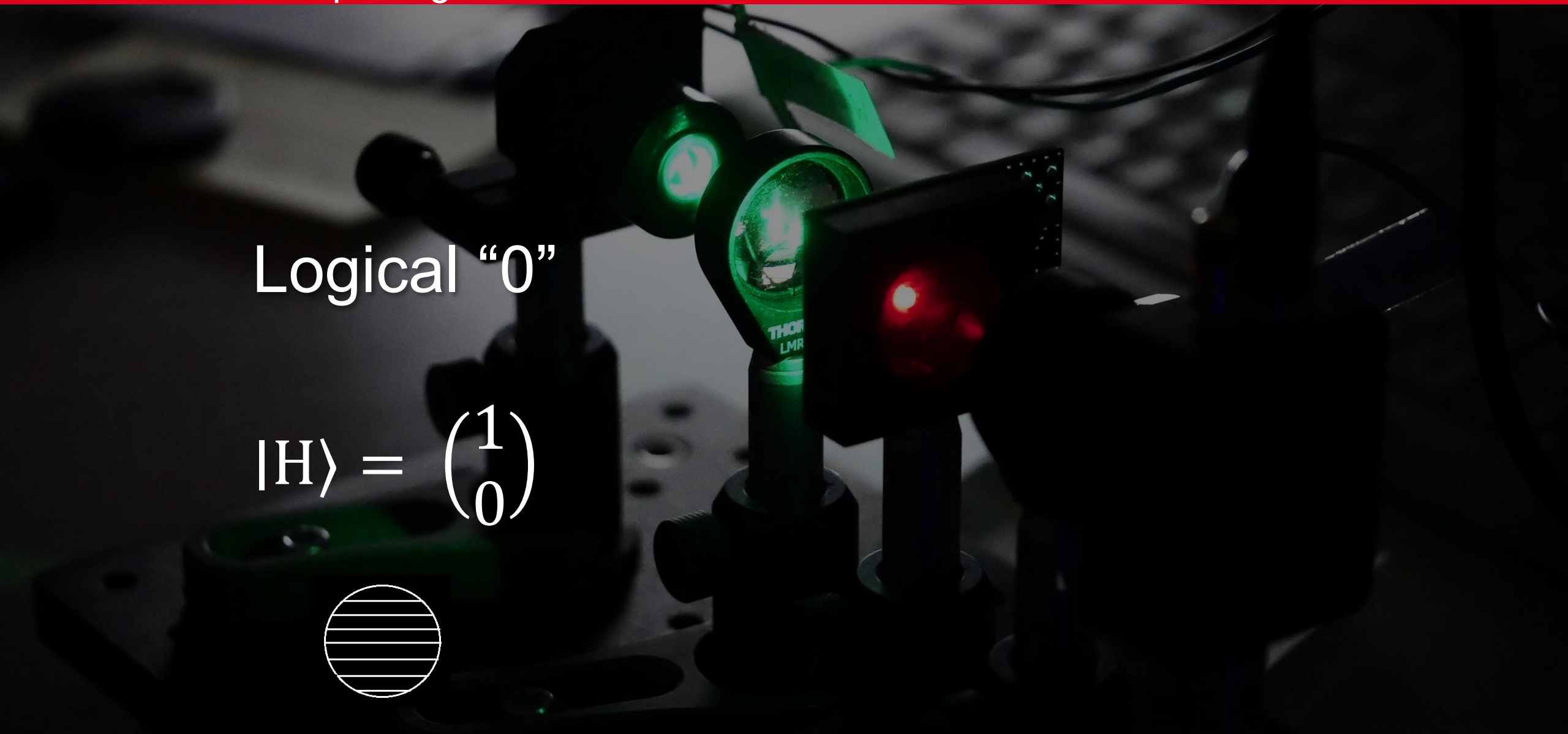

Logical “0”

$$|H\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

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Logical “0” Logical “1”

$$|H\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

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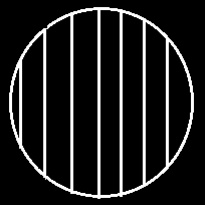
Logical “0”

$$|H\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

Logical “1”

$$|V\rangle = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$



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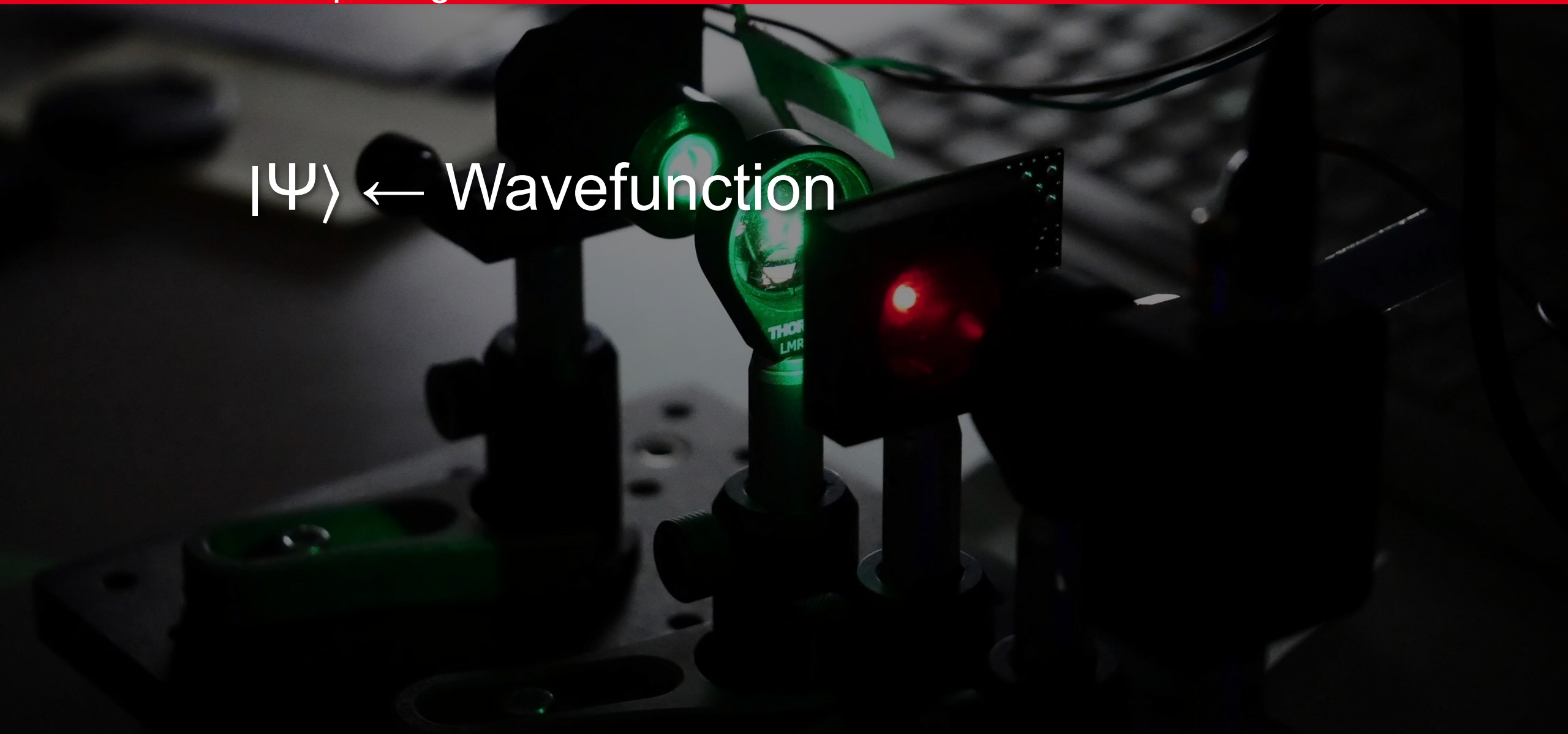

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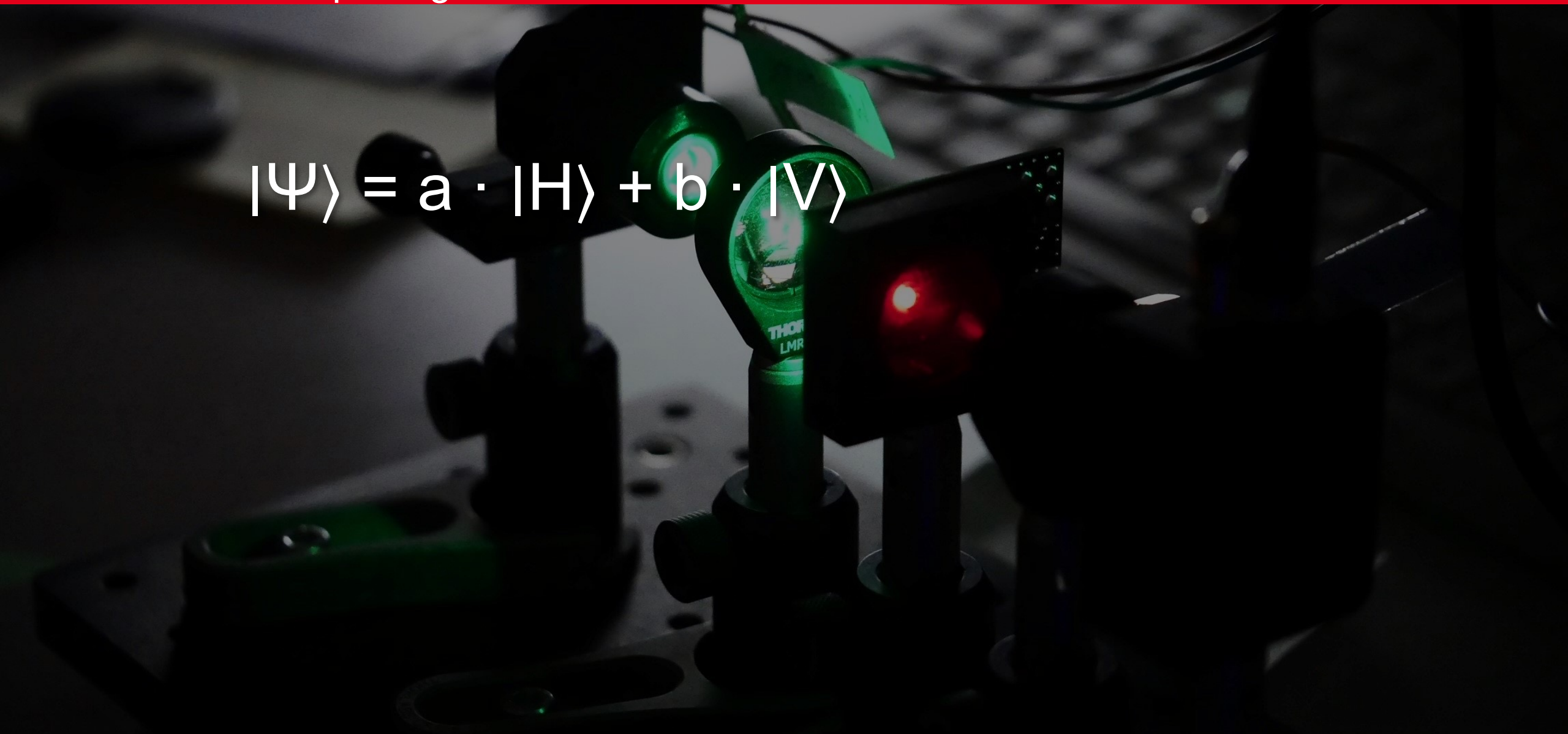
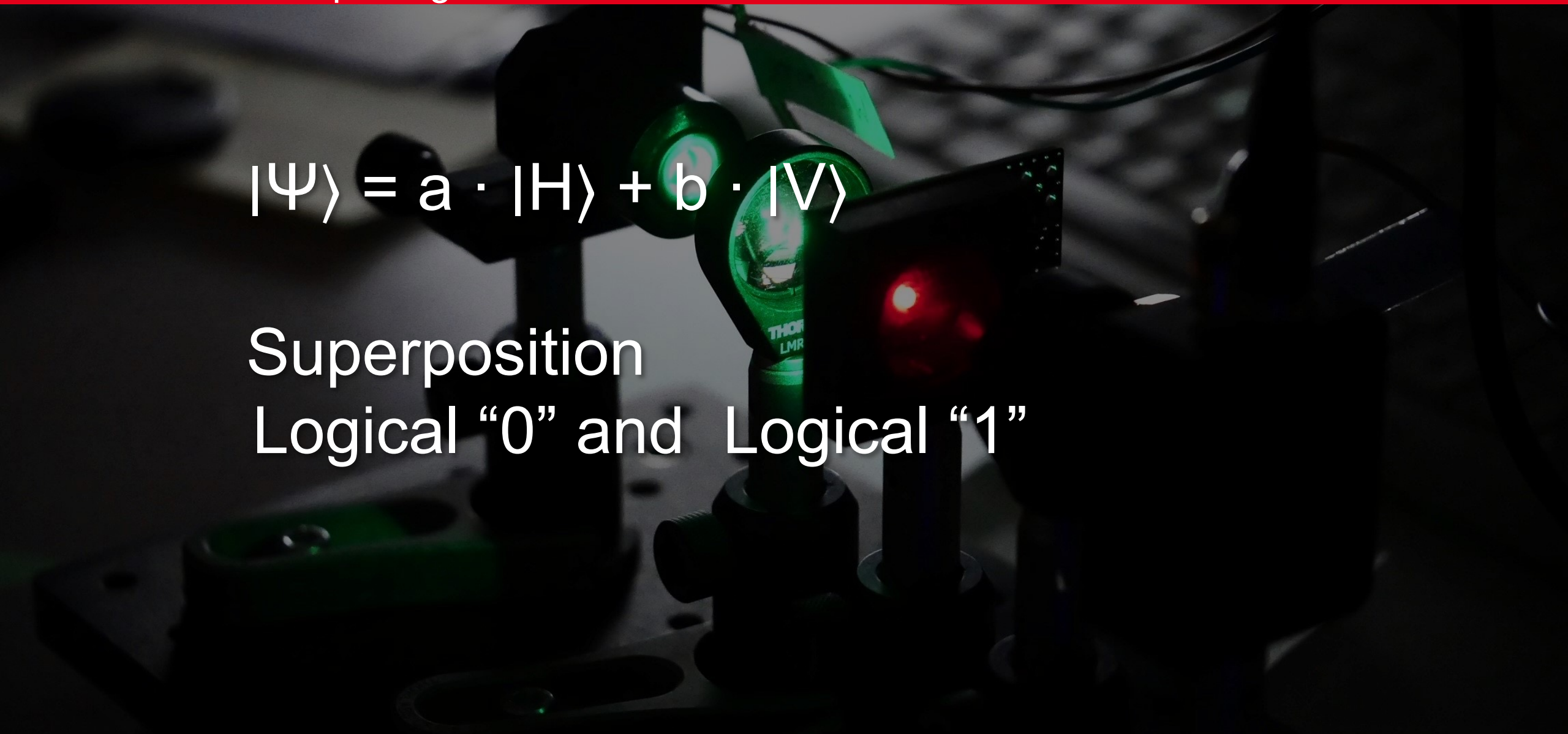


Quantum Computing Circle



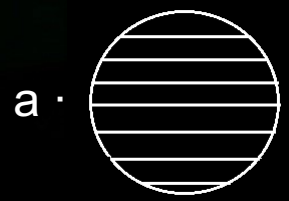
$$|\Psi\rangle = a \cdot |H\rangle + b \cdot |V\rangle$$

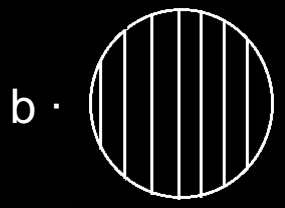
Superposition
Logical “0” and Logical “1”

Quantum Computing Circle

$$|\Psi\rangle = a \cdot |H\rangle + b \cdot |V\rangle$$

Superposition
Logical “0” and Logical “1”





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Quantum Computing Circle

$$|\Psi\rangle = a \cdot |H\rangle + b \cdot |V\rangle$$

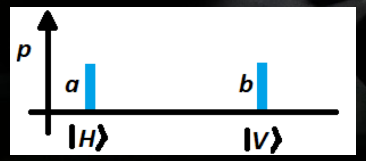
Superposition
Logical “0” and Logical “1”

Quantum Computing Circle

$$|\Psi\rangle = a \cdot |H\rangle + b \cdot |V\rangle$$

Superposition
Logical “0” and Logical “1”

a ·

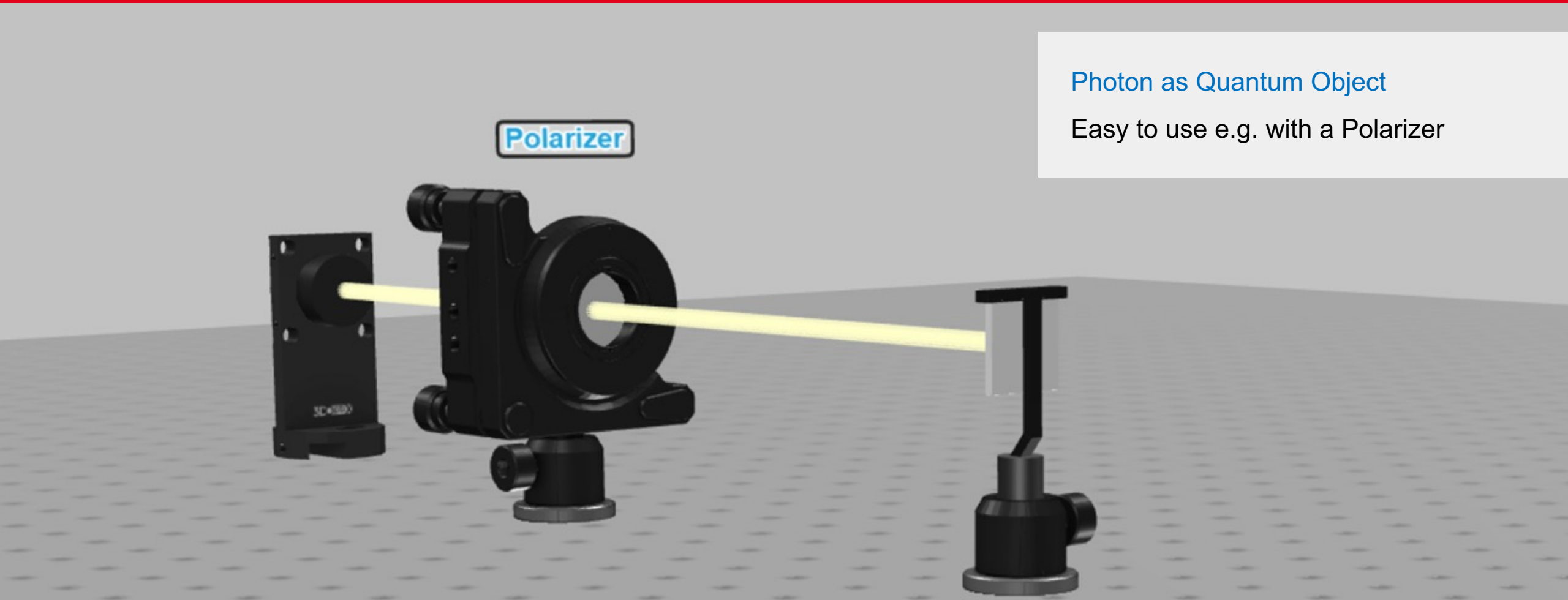


b ·

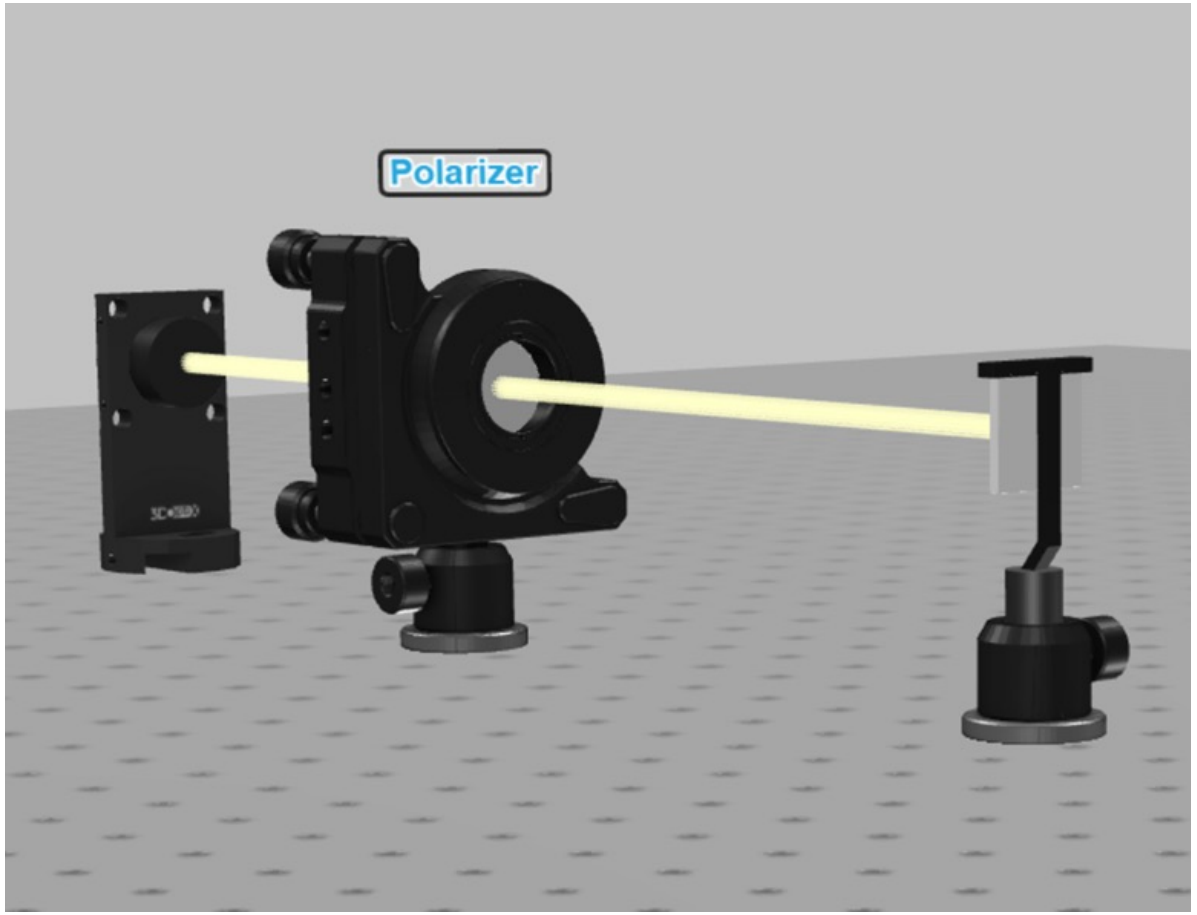
Realization of a Photonic Superposition

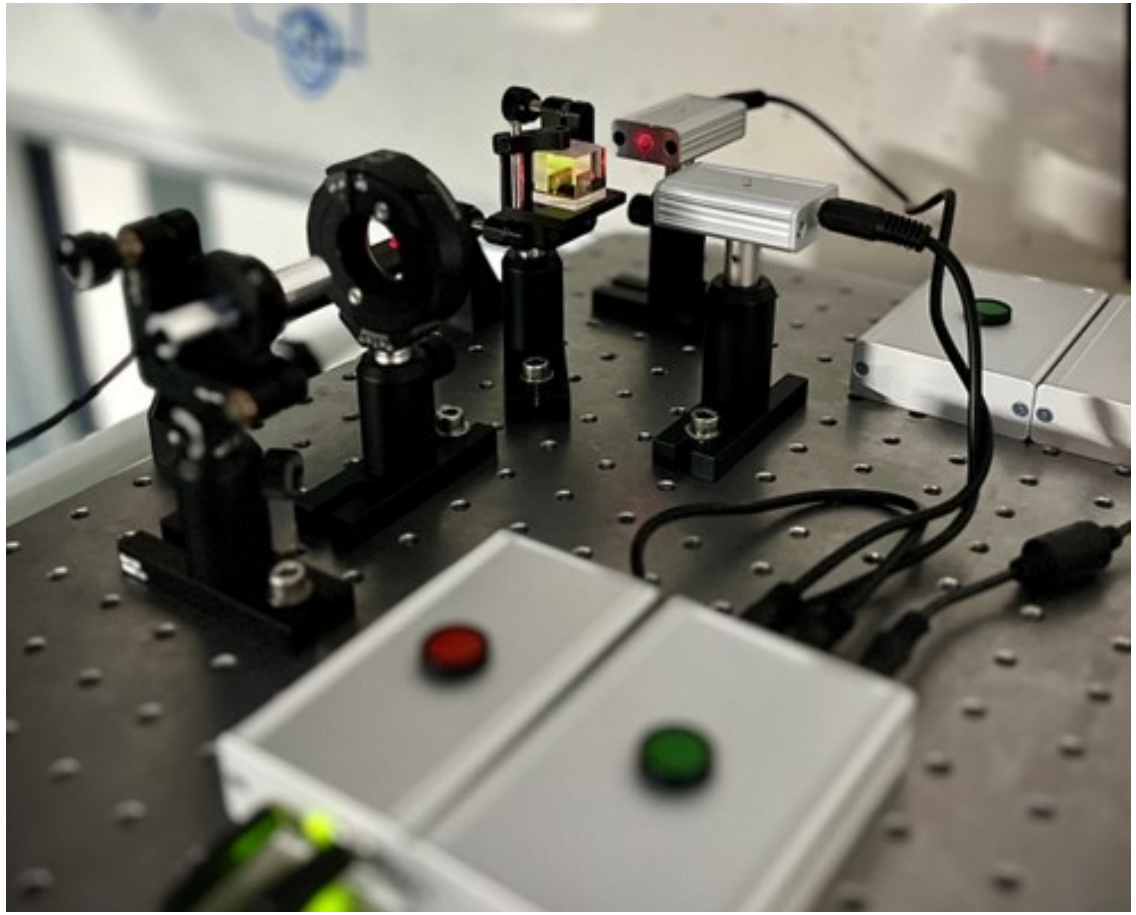
Photon as Quantum Object

Easy to use e.g. with a Polarizer

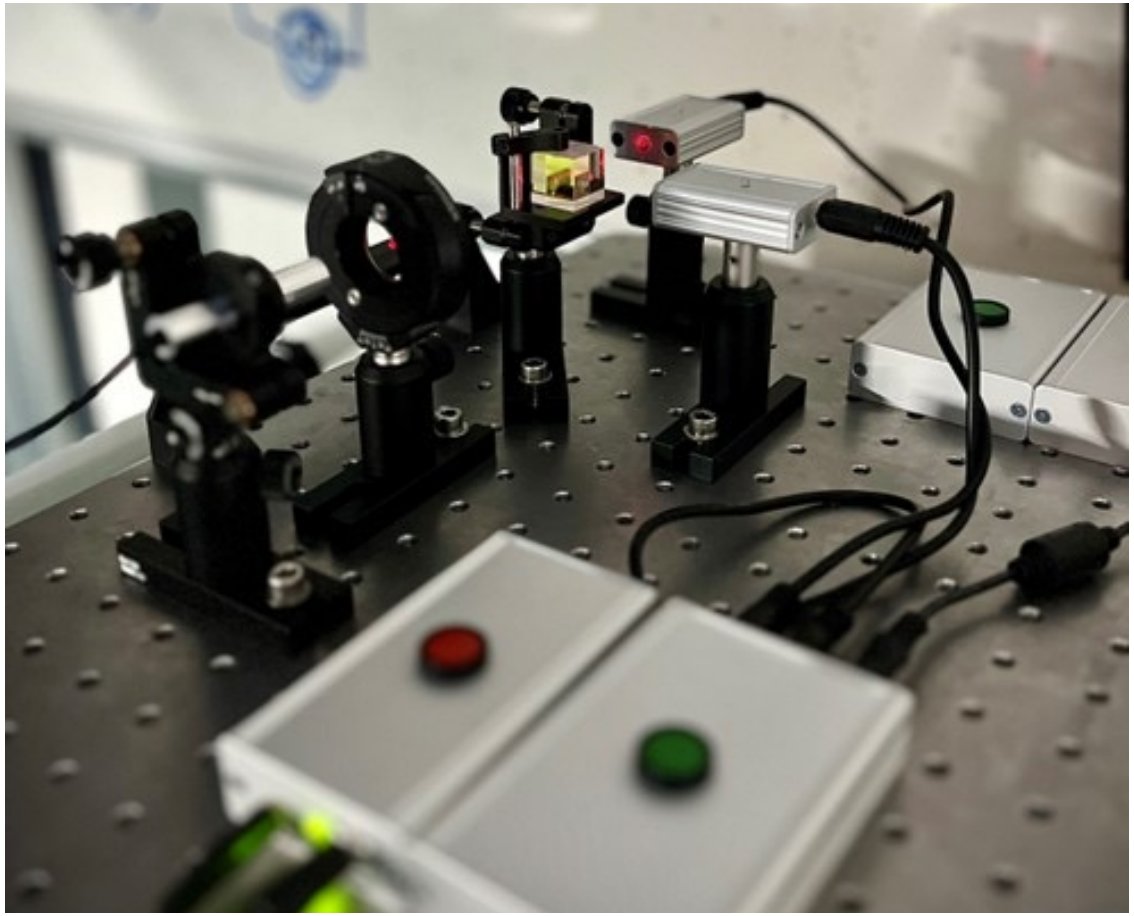


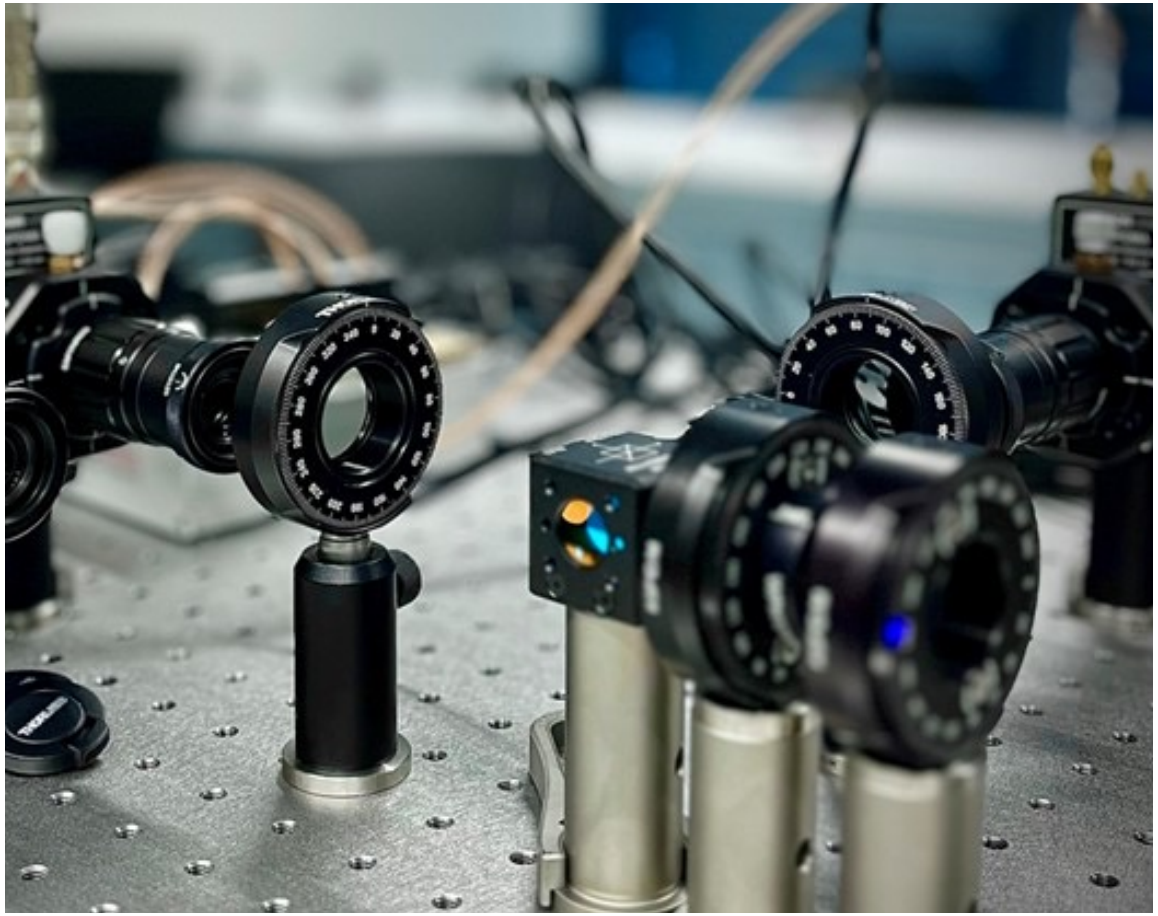
Realization of a Photonic Superposition as a Qubit





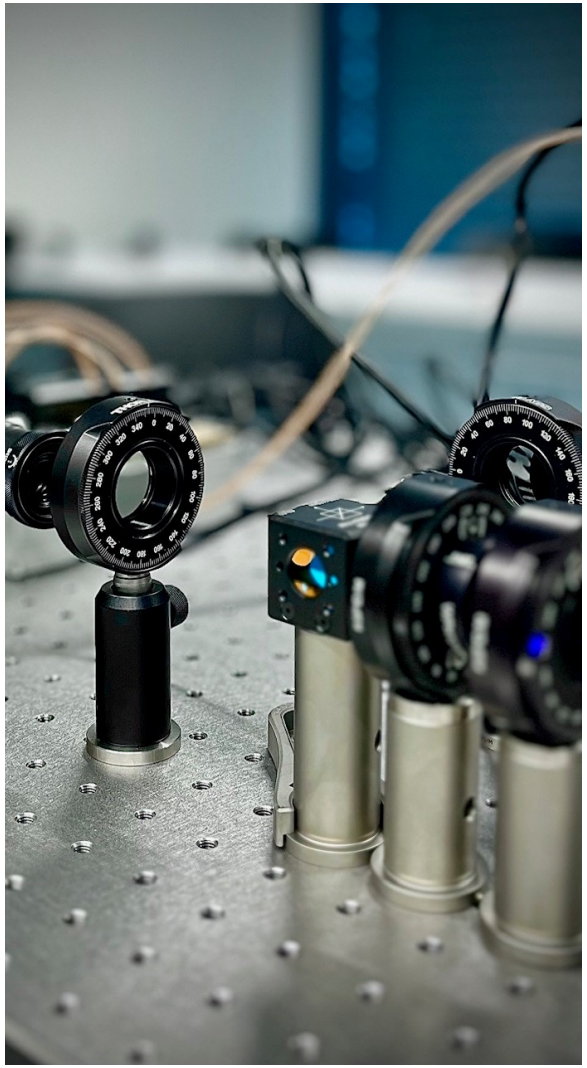
Realization of a Photonic Superposition as a Qubit





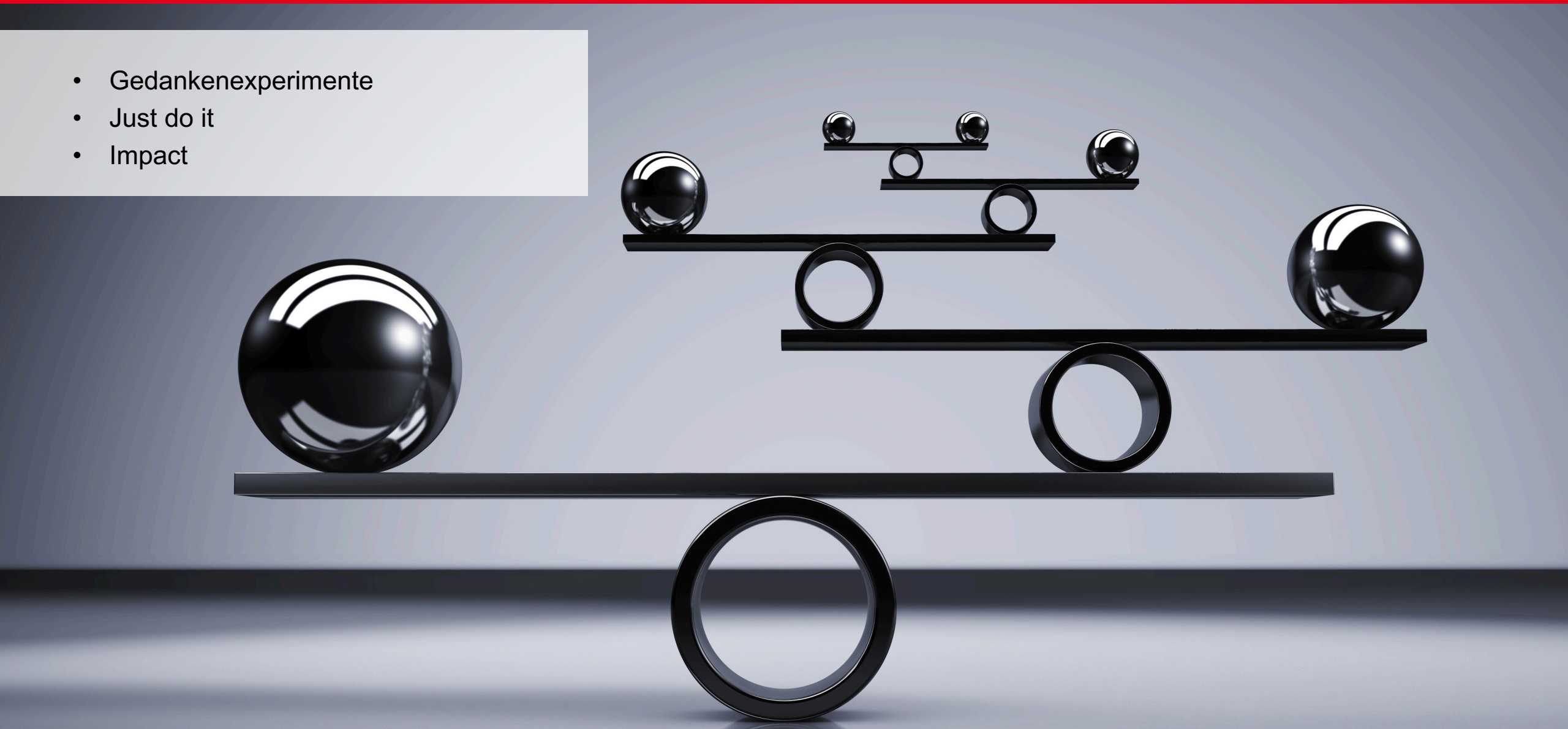
Further steps

- Peter Shor started the game
- Groover and others, see: www.quantumalgorithmzoo.org
- Demonstration of Quantum Supremacy and Quantum Advantage
- Noisy-Intermediate-Scale-Quantum – the NISQ era
- The 20 years before and the new era



A short philosophical final remark

- Gedankenexperimente
- Just do it
- Impact



A short philosophical final remark

v.l.t.r.: Dirk Bouwmeester, Harald Weinfurter, Anton Zeilinger, Jian-Wei Pan, Manfred Eibl, Klaus Mattle. The team that carried out the first teleportation in Insbruck in 1997

v.l.t.r.: David M. Greenberger, Michael A. Horne u. A. Zeilinger.
Authors of the GHZ-paper (GHZ: Greenberger, Horne, Zeilinger)

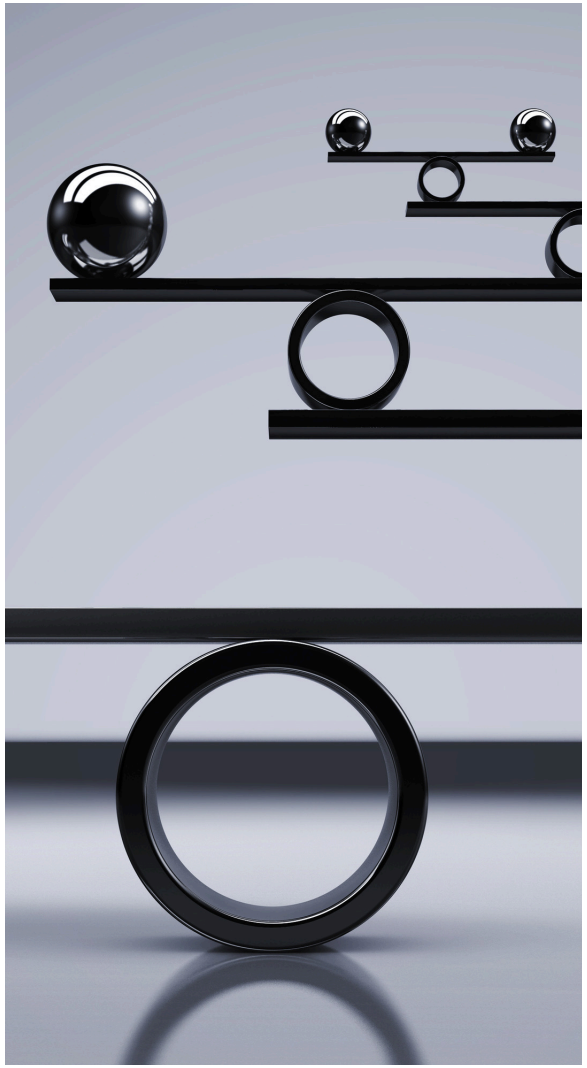
Your takeaways

- We have entered a new part of the story.
- New players have new ideas, and more new players have more new ideas
- What we do in quantum technology

  will have an impact to the theory, it will enhance our view on quantum physics.
- Although quantum physics is our best tested theory,

  you can guess that we are not at the end yet,

  and we have to say today: “things are not fully consistent”.



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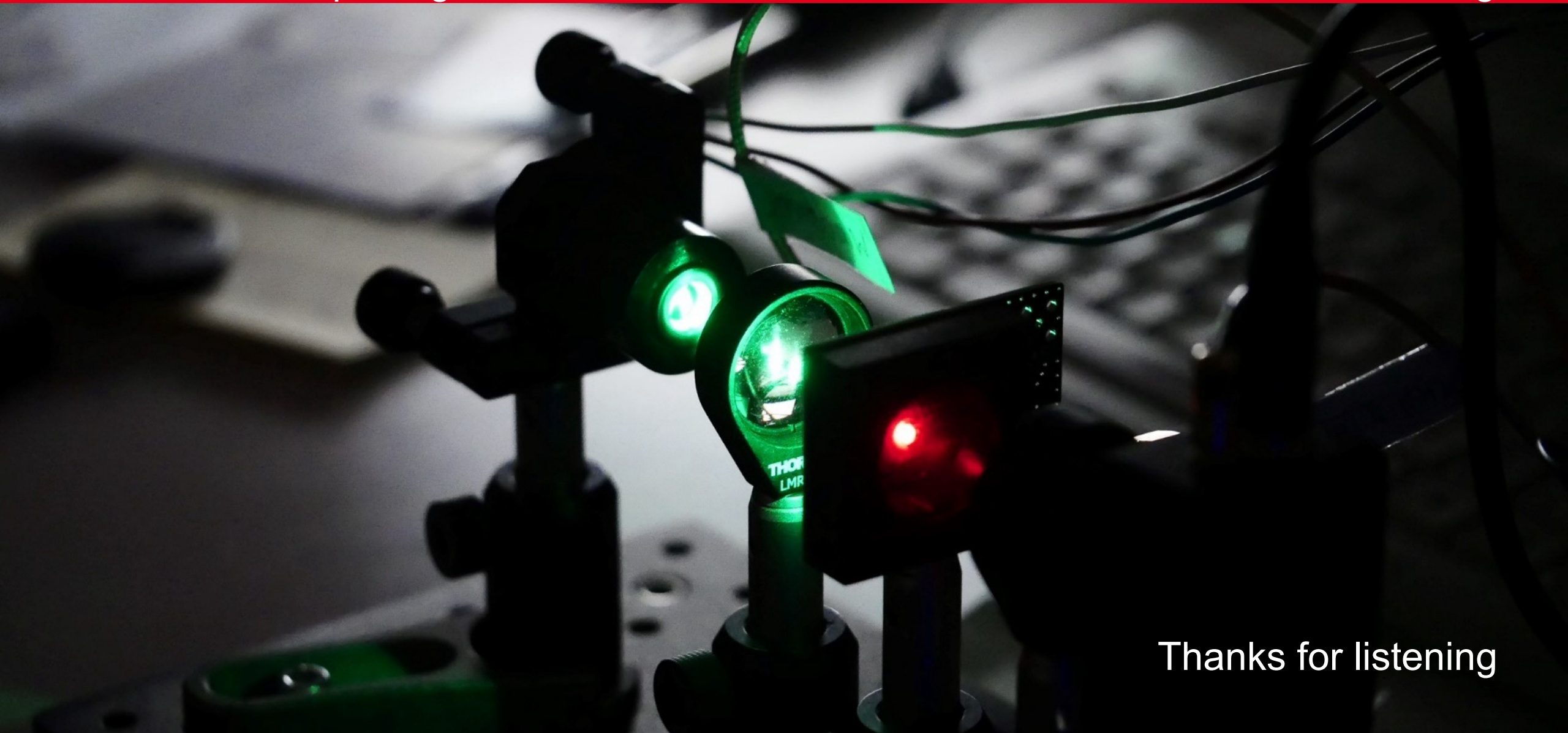

Thanks for listening