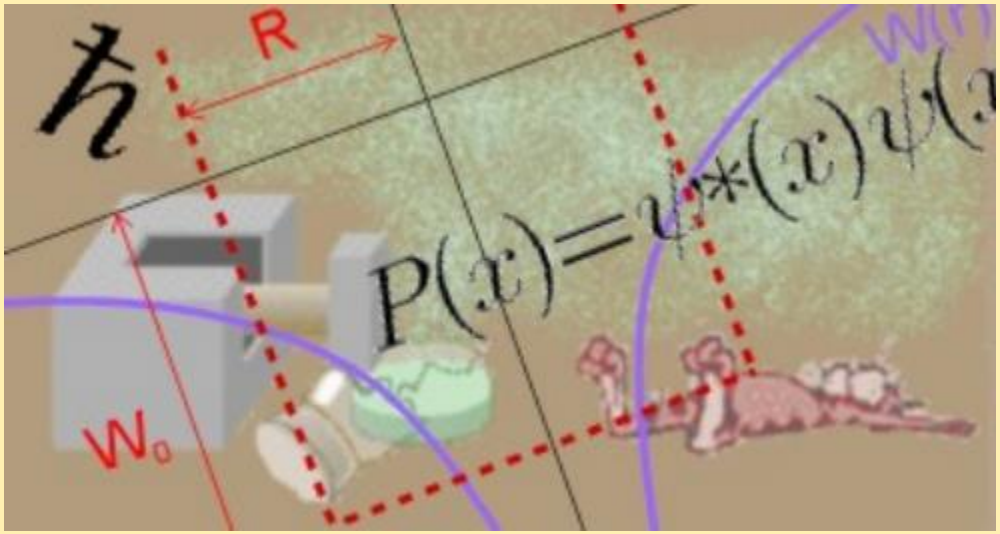
Technische Universität Braunschweig

Institut für Fachdidaktik der Naturwissenschaften

Abteilung Physik und Physikdidaktik

IFdN



milq – Quantum Physics in Secondary School

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The aims of the milq project

(milq = **M**unich **I**nternet Project to **L**earn **Q**uantum Physics)
established c. 1999

Principle aim:
Convey the **modern world view** of quantum physics to secondary school students

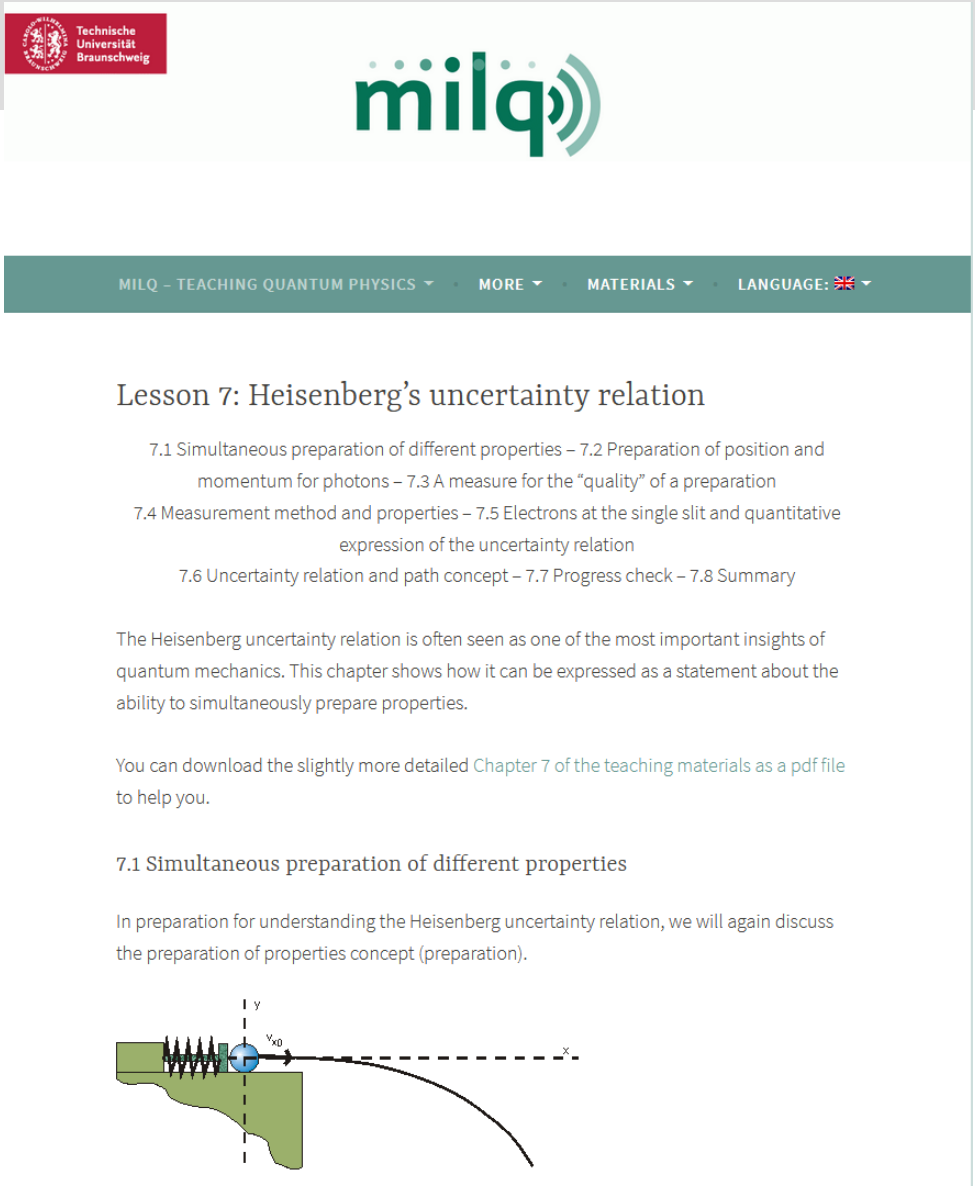
Conceptual approach to quantum physics

Qualitative reasoning based on **reasoning tools** (basic rules of quantum physics)

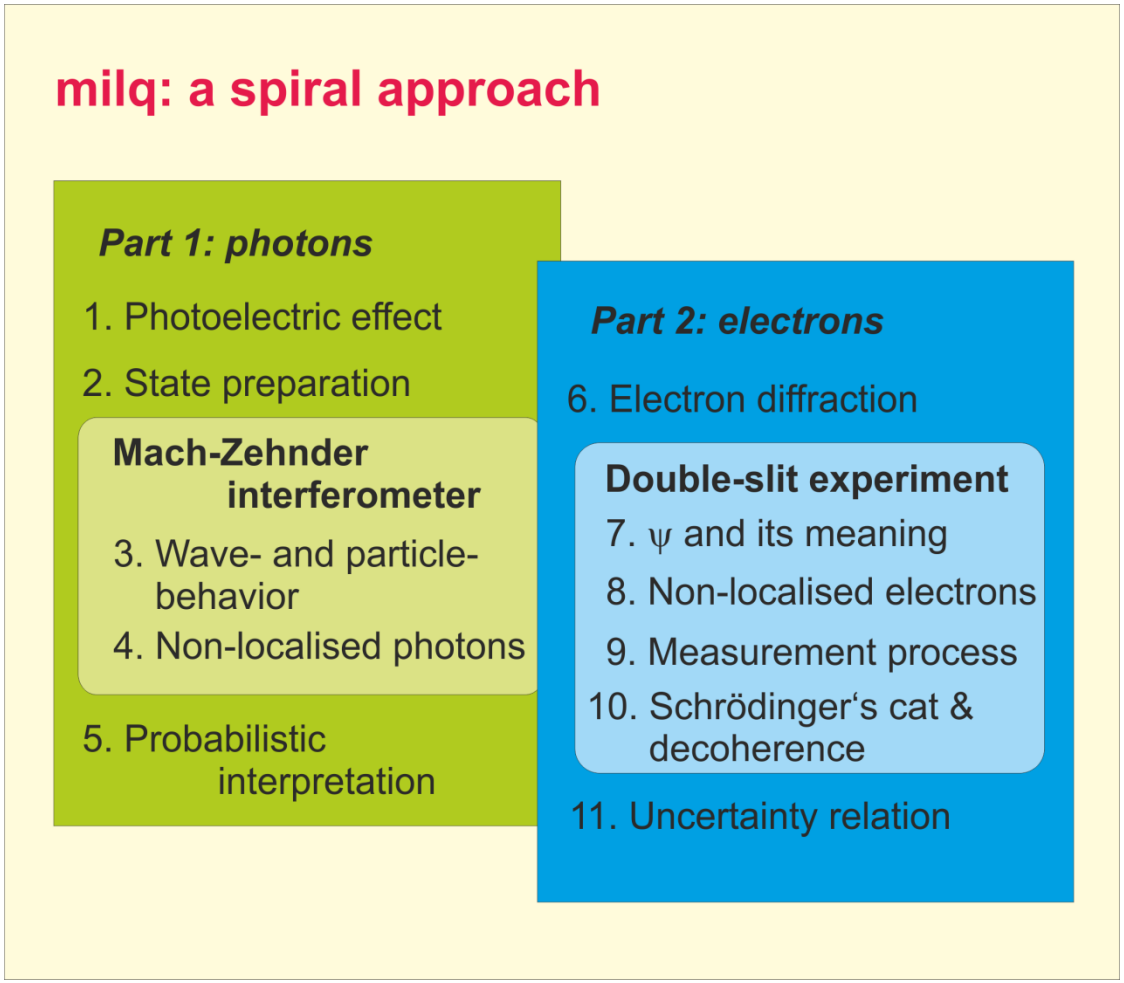
Use of interactive simulation programs (double slit, Mach-Zehnder interferometer)

Website

Available in English since last year:
http://milq.tu-bs.de/en

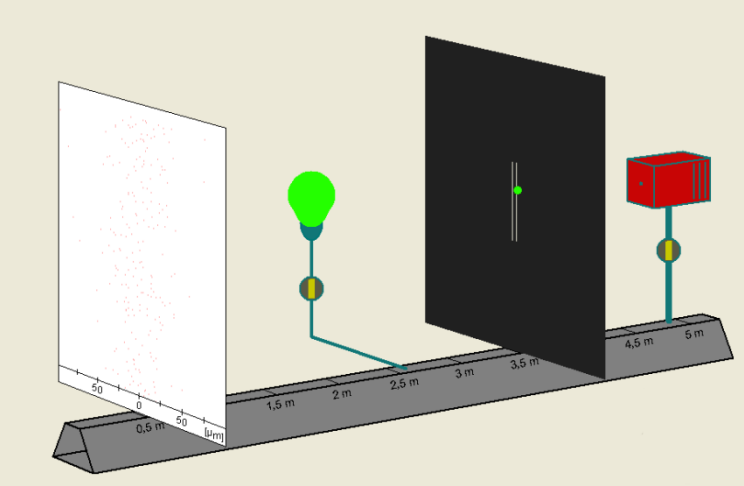


Outline of the milq course

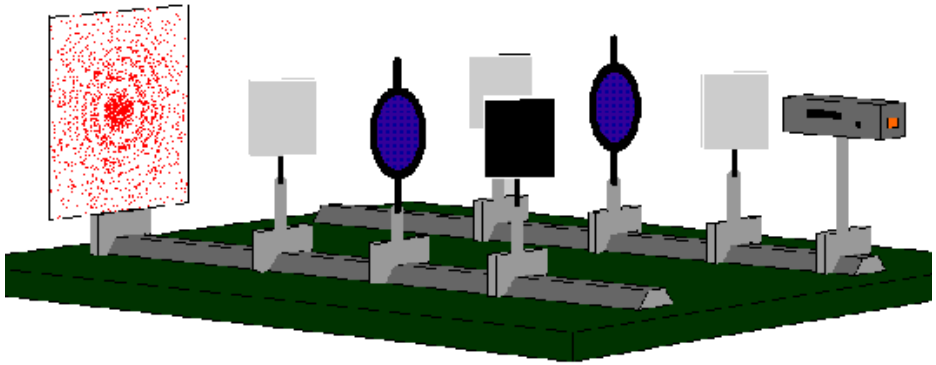


Simulation programs

Double-slit experiment



Mach-Zehnder interferometer



Reasoning tools

In quantum physics: Proper language is crucial

Reasoning tools:

A set of four qualitative rules: The basic traits of quantum physics

„Qualitative mini-axiomatic“ provides students with a verbal tool they can use in discussions and argumentations.

Enable students for qualitative discussions, predict quantum effects, help to avoid learning difficulties.

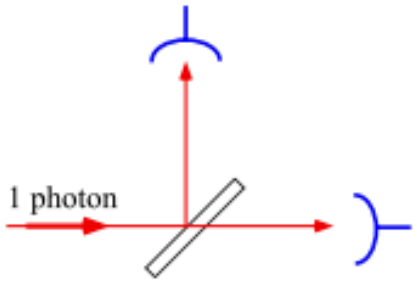
Reasoning tools

Rule 1: Statistical behavior:

A result of a single event cannot be predicted, it is random!

Only statistical predictions (for many repetitions) are possible in quantum physics.

Example: Anticoincidence of single photons at a beam splitter



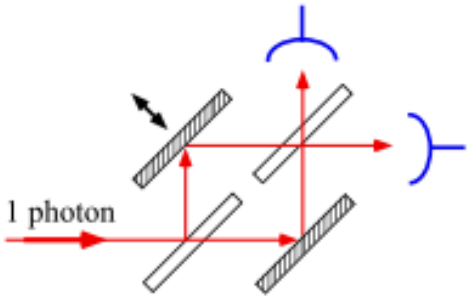
Reasoning tools

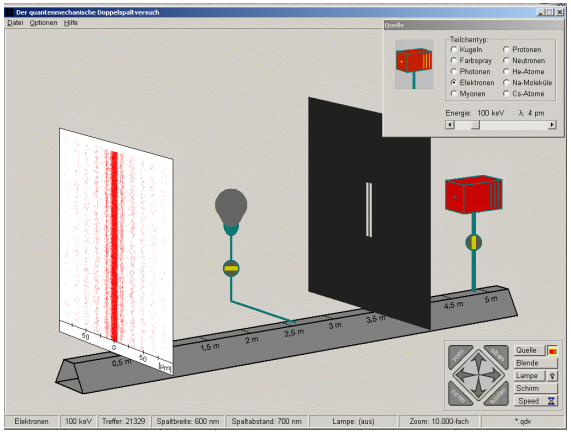
Rule 2: Single quantum objects can contribute to an interference pattern.

Interference occurs if there is **more than one classical alternative** leading to the same experiment result.

Superposition states: None of these alternative will be “realized” in a classical sense.

Example: Two paths in an interferometer; two-slit interference





Reasoning tools

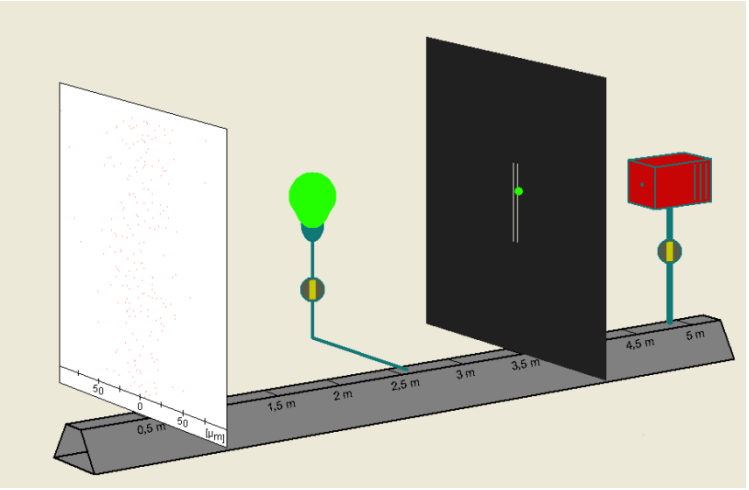
Rule 3: Unique measurement results

Even if a quantum object in a superposition state need not have a fixed value of the measured quantity, you always find a unique measurement result.

This is the measurement postulate of quantum mechanics

Example:

- Stern-Gerlach experiment,
- Feynman's light bulb



Reasoning tools

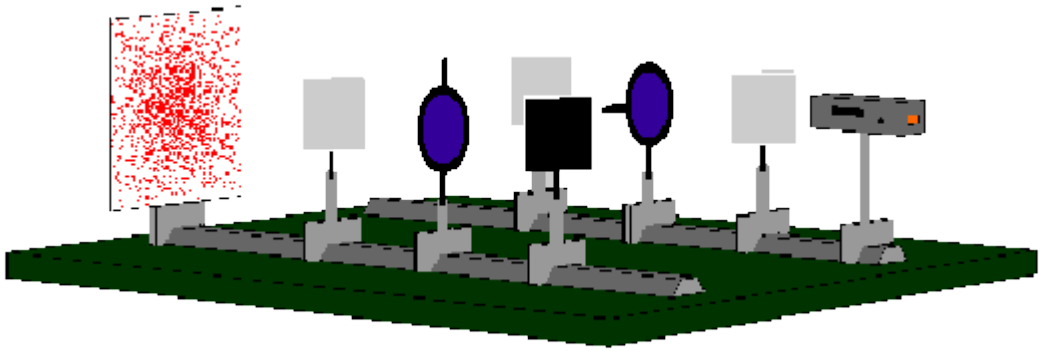
Rule 4: Complementarity

Which-way information and interference pattern are mutually exclusive.

Quantum objects can not be prepared in a defined position with a defined momentum at the same time.

Examples:

- Heisenberg's uncertainty relation
- Quantum Eraser experiments



Future developments

In view of EU‘s prospected need for Quantum Technology workforce:

- The conceptual approach of milq is well-suited for **creating „quantum awareness“**
- Qualitative reasoning tools can form a **basis for intuitive understanding**

→ promising starting point for the education and training of **„Quantum Engineers“**

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visit us on:
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