

**ESOF2020**  
EUROSCIENCE OPEN FORUM  
**TRIESTE**



# Quantum Physics for schools

**Oxana Mishina**

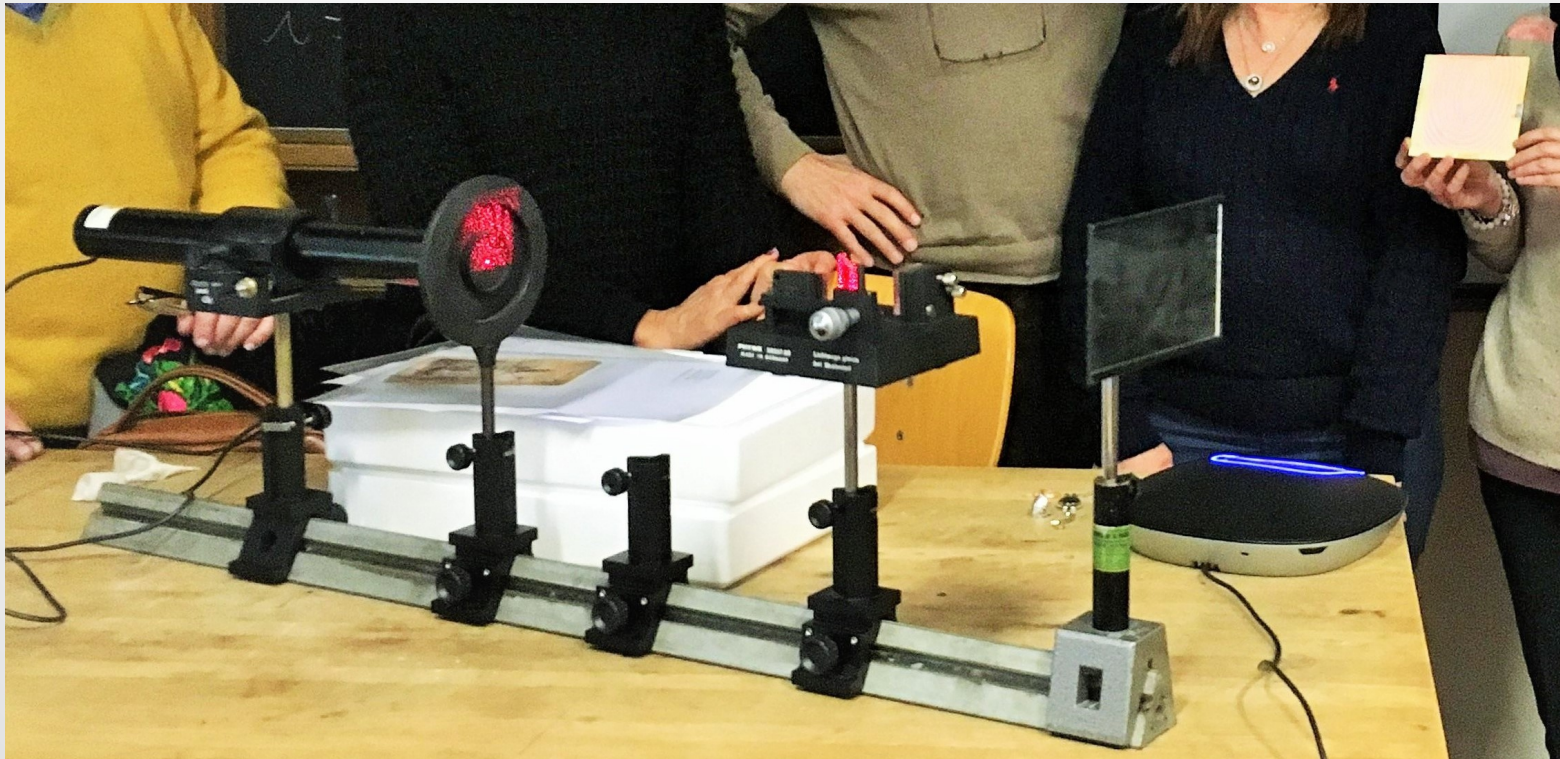
**Trieste University, Italy**

**Braunschweig University, Germany**

# Trieste



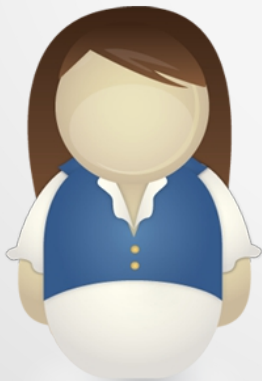
# Trieste University - PLS - workshop



# Trieste team - "didactic"



**Giorgio Pastore**



**Maria Peressi**

**Trieste University**



**ICTP**



# Braunschweig- Teacher's teacher



## Physics Education Research

<https://www.tu-braunschweig.de/ifdn/physik/mitarbeiterinnen>

# Copenhagen - Niels Bohr

If quantum mechanics hasn't profoundly shocked you,  
you haven't understood it yet.

**Niels Bohr**



Everything we call real is made of things that  
cannot be regarded as real.

**Niels Bohr**

# Quantum reasoning tools

Küblbeck & Müller 2002

School teacher

University Prof.



Rule 1: **Statistical behavior**

Rule 2: **Ability to interfere**

Rule 3: **Measurement outcome**

Rule 4: **Complementarity**

# Quantum reasoning tools

Küblbeck & Müller 2002

School teacher

University Prof.



A result of a **single event** can not be predicted, it **is random**!

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

Rule 1: **Statistical behavior**

Rule 2: **Ability to interfere**

Rule 3: **Measurement outcome**

Rule 4: **Complementarity**

# Quantum reasoning tools



Küblbeck & Müller 2002

School teacher

University Prof.

Single quantum object can contribute to an interference pattern, if there are **more than one classically possible ways** leading to the same experiment result.

Non of this ways will than “realize” in a classical sense

Rule 1: **Statistical behavior**

Rule 2: **Ability to interfier**

Rule 3: **Measurment outcome**

Rule 4: **Complementarity**



# Quantum reasoning tools

Küblbeck & Müller 2002

School teacher

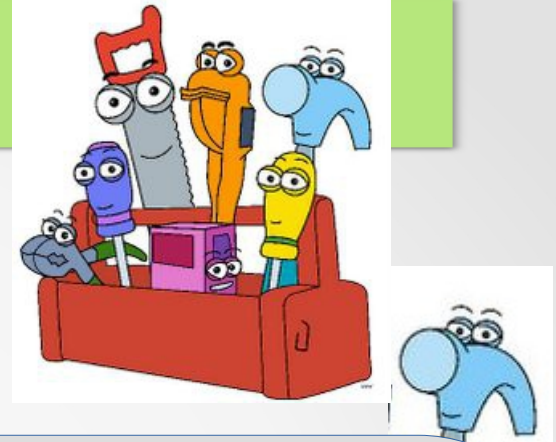
University Prof.

Rule 1: **Statistical behavior**

Rule 2: **Ability to interfere**

Rule 3: **Measurement outcome**

Rule 4: **Complementarity**



## **Measurement rule:**

Although a quantum object in a state does not have a fixed value of the measured quantity, you always find a unique measurement result.

Repeating the same measurement will give the same result.

# Quantum reasoning tools

Küblbeck & Müller 2002

School teacher

University Prof.



Rule 1: **Statistical behavior**

Rule 2: **Ability to interfere**

Rule 3: **Measurement outcome**

Rule 4: **Complementarity**

**Which way information** and **Interference pattern** are mutually exclusive.

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

# Murmanks – Home!

**Milq** – quantum physics for schools  
web page: [milq.tu-bs.de/en](http://milq.tu-bs.de/en)

**QuaNTH** – quantum information for schools  
web page: <https://qig.itp.uni-hannover.de/quanth/index.php/Hauptseite>

