Lecture 1: Introductory remarks

September 21, 2019 1:43 PM

QM I – Fall 2019
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① Introductory Remarks

② What is QM and why do we need it?

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① Introductory Remarks . Undergraduate QM

- Sunday / Tuesdays 9 – 10:30
  - Start sharp at 9
  - Finish @ ~ 10:25

  } → Punctuality

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- Grading

Midterm	2	4
Assignments	~ 11	6
Final exam		7

Maybe: Final ≥ 90 → Midterms × $\frac{10}{9}$

Midterms 1 → 12 Aban

2 → 12 Azar

In class bonus questions → ~0.1-0.2

No project

No curves

Ideal practice

- Read & prepare before you come to the class.
- Try to answer your questions in the class
- It's hard to do it all over one night, try to come with class
- You can use any resources that best fits you.

Resources

- Video lectures
- Dr. Karimipour's Notes
- Books

Zettili
Cohen Tannoudji
Shankar

Student list → Fill in the form

. ID . Email

Student representative

- Coordinate with me & your TA
- Social media channel

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Requirements

E&M, Hamiltonian, linear_algebra
Mathematical physics.

How many of you
- Has taken E&M?
- Know of Hamiltonian is?
- Know what eigenvalue decomposition is?
- Unitary/Hermitian operations
- Polarization?

General rule of thumb:
Always consider the worst.

Overview

- Introduction
  - Why & what's of QM
  - Some experiments (Instead of 11 & 12)
  - The new model
  - The linear algebra and some mathematical requirements of the new model
- Mathematical tools → Read on your own.
- Postulates
- Examples: - Simple 1D problems
  - Some Q. effects
  - 3D problems
    - → Angular momentum: 3D → 1D
    - → Simple 3D example
    - → Hydrogen atom

→ Hydrogen atom

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② A1

- Young's Double slit experiment
- Mach-Zehnder interferometer
- Beam splitter
- How to check if they can be splitted

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③ (a) What do you think "QM" is ?

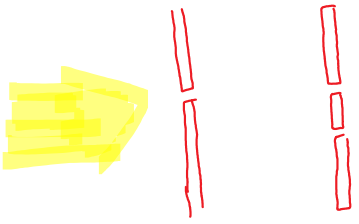
(b) Why do we "QM" ?

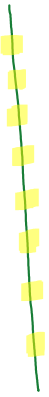
→ Some examples

- Historically
  - 1890 - Spectrum of the sun and empty lines
  - 1900 BBR: Blank: The radiation from the black body should be in quantized energies
  - 1905: Einstein: the light should be quantized in energy (Hertz experiment 1887)
  - 1911: Rutherford's experimental discovery of nuclei
  - 1913: Bohr's model for atom: the quantized energies
  - 1923: Comptons experiment: X-ray radiation has momentum and can kick the electrons
  - --------Radiation is quantized and acts a particles
  - 1923: de Broglie: Assocciated waves to Particles
  - 1927: Davisson and Germer: Diffraction of electrons and Bragg's law
  - --------Particles have wave-like behaviour
  - 1925: Shrodinger and Heisenberg put together a theory of QM
    - 1925: Matrix mechanics: discretization of radiation: particle aspects of radiations: Eigenvalue problem
    - 1926: Wave mechanics: wave-like aspects of particles: Generalization of de Broglie's idea: Differential equation
    - 1927: Born's rule: wave equation: amplitude of the probability
    - Dirac's formulation: reconciles the two mechanics

What is a wave and what characterizes the waviness?
What is a particle and what characterizes the particle character?
How can you test to see if a flow of sth is a flow of particles or waves?

Double-slit exp.





Is this a
* flow of particles
or
a wave?

→ Wave

(A1) Do the calculations for the double-slit exp and see what you get on the screen.

* How would this change for particles?

What's the key character that is distinguishing the particle flow from waves here?

Interference

Similar exp

Mach-Zehnder interferometer (MZI)

Beam-splitter

Take two prisms:

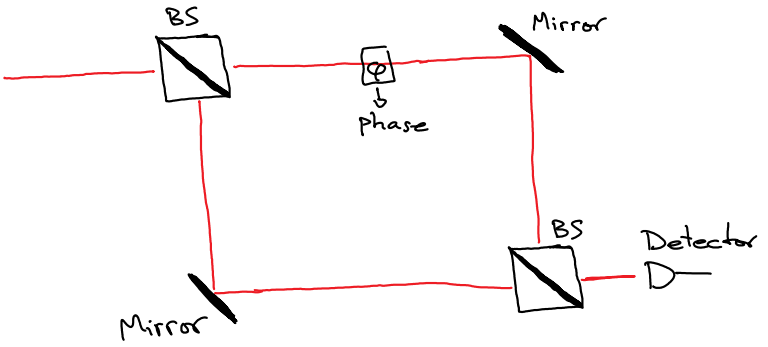
and attach them.

(A2) What happens to the light at a

(A2) What happens to the light at a beam-splitter?

(Break it down to the two single prisms, consider total reflection & optical tunneling. Also consider when the two prisms are fully attached and the distance between them is zero).

Take/Make a 50/50 BS.



(A3) Analyze the MZI & find what the signal at the detector is (It is measuring the light intensity).

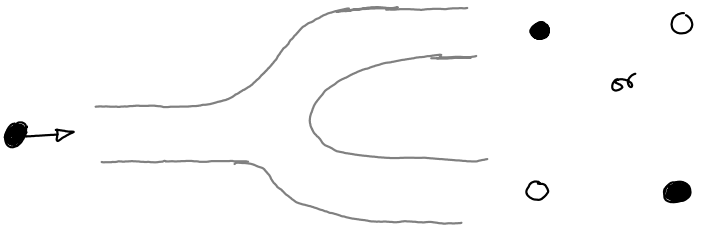
- How does the signal depends on the phase ϕ?
- How can you make/change the phase?

- What do we see for waves?
- What if we do this with particles? say Neutrons?

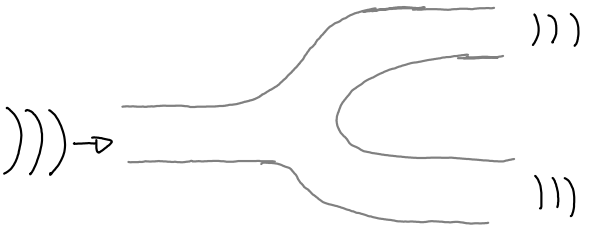
Interference gives a way to distinguish waves and particle flows. Is there any

other way?

Splitting



particles cannot be splitted



But waves do.

(A4) Design a setup can test this.
(Use what you did for MZI)