



Interaction-Free Measurement: The Foundation of Quantum Computing

KALEEN SHRESTHA

“

I think I can safely say that
nobody understands quantum
mechanics.

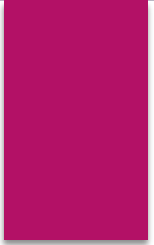
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DR. RICHARD P. FEYNMAN

Quantum mechanics is weird, and so bear with me, sometimes this can confuse me as well!

Some Motivation

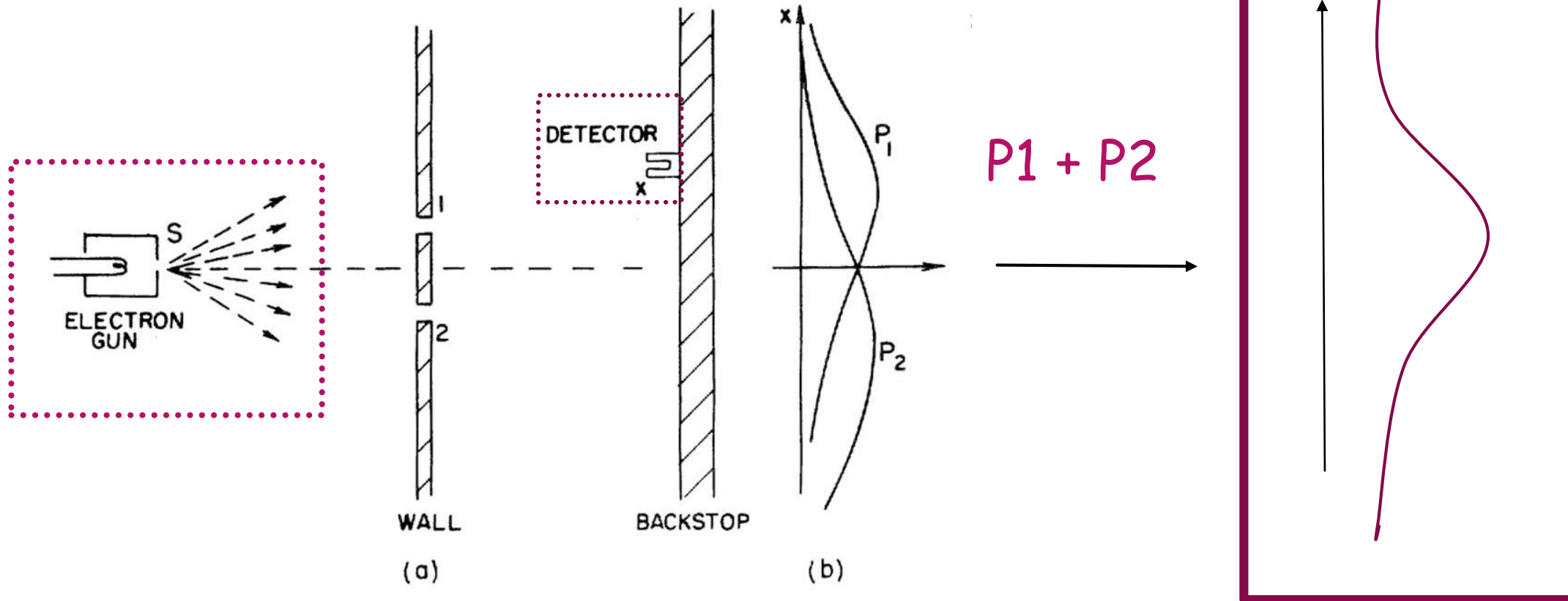
- ▶ Quantum computers
 - ▶ Exponential \rightarrow Polynomial Time
 - ▶ Intractable \rightarrow Tractable
 - ▶ Huge help in science, many possibilities for new discoveries



Quantum Mechanics: The Particle-Wave Duality Nature Phenomenon

PROOF VIA THE DOUBLE-SLIT
EXPERIMENT

Classical Calculation of Probability

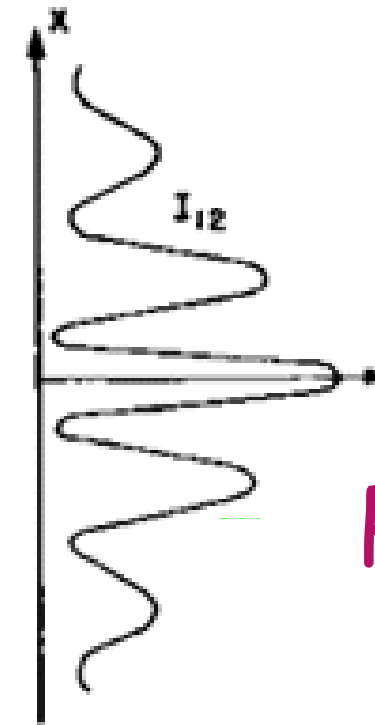
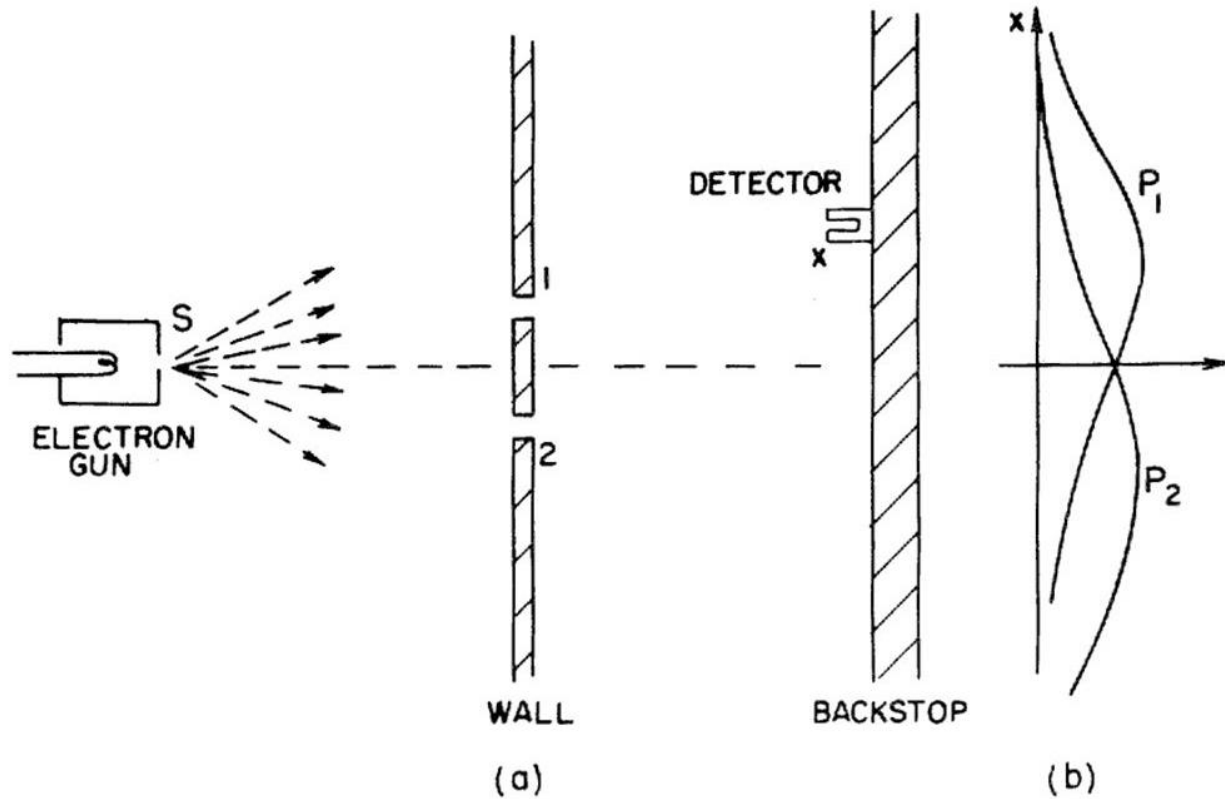




However,

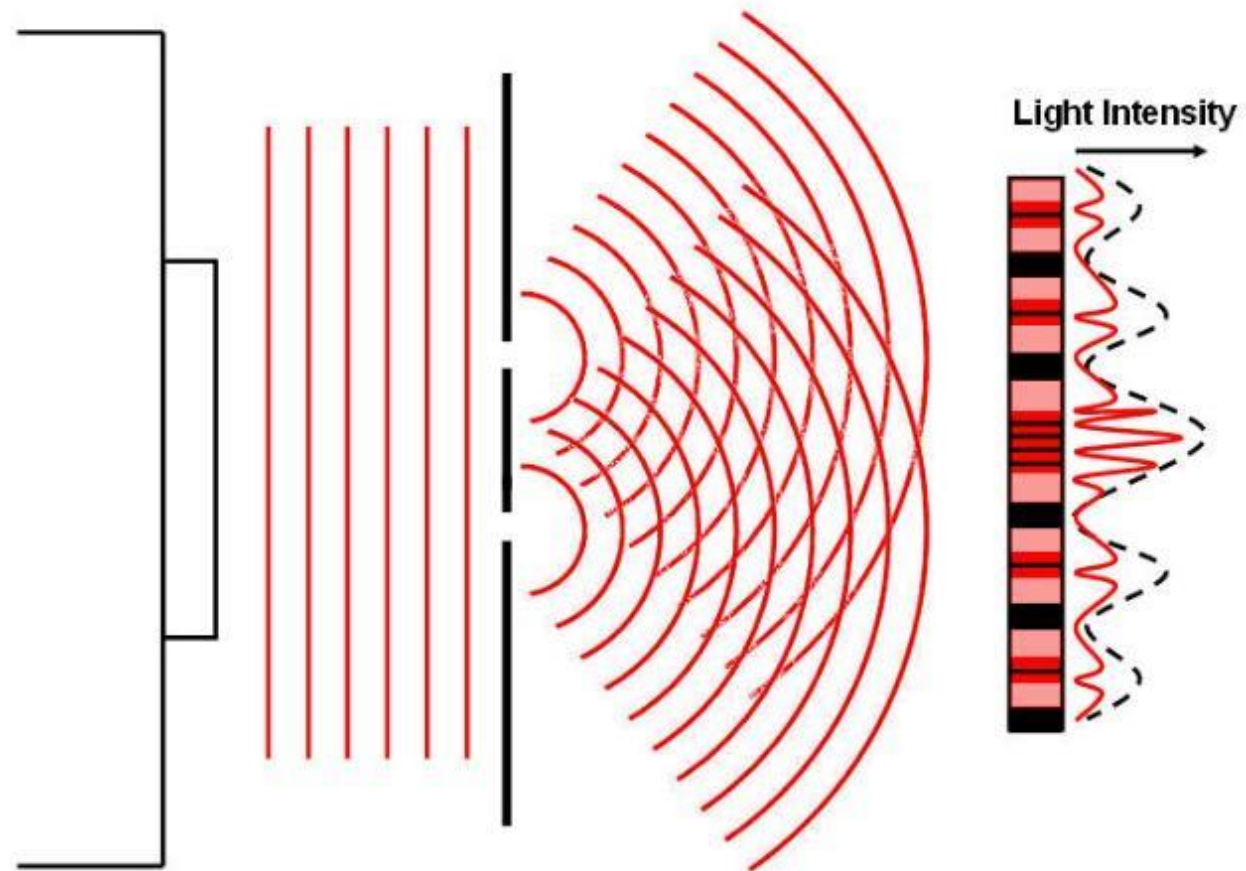
THE GRAPH LOOKS A BIT DIFFERENT...

Interference pattern



$$P \neq P_1 + P_2$$

Wave Behavior

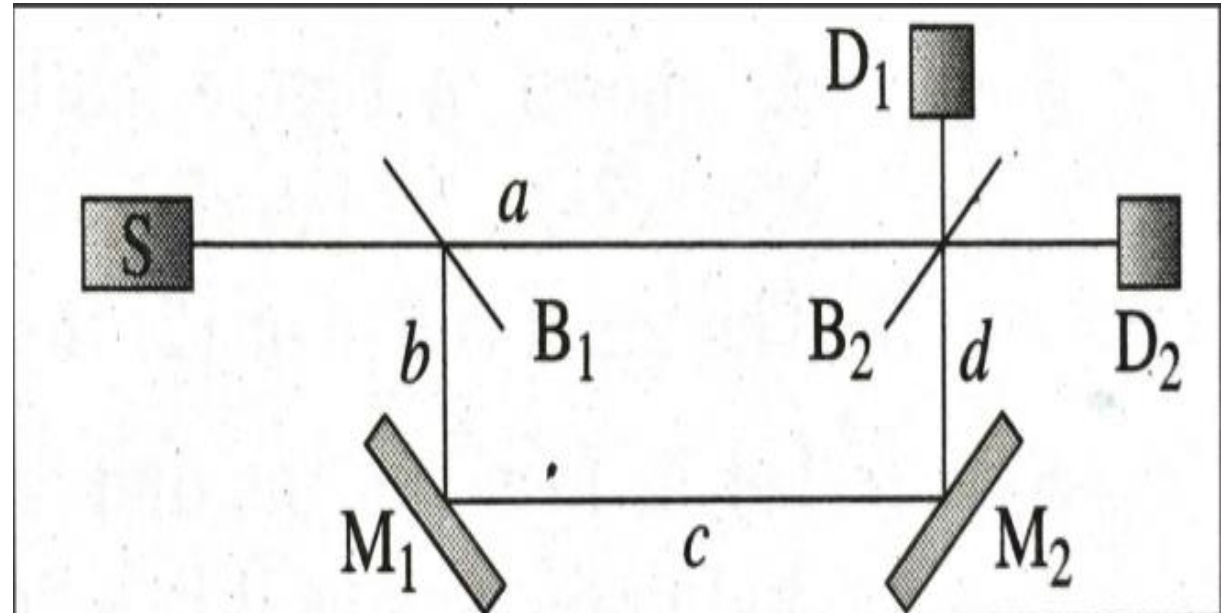


Interaction – Free Measurements

ELITZUR-VAIDMAN THOUGHT
EXPERIMENT

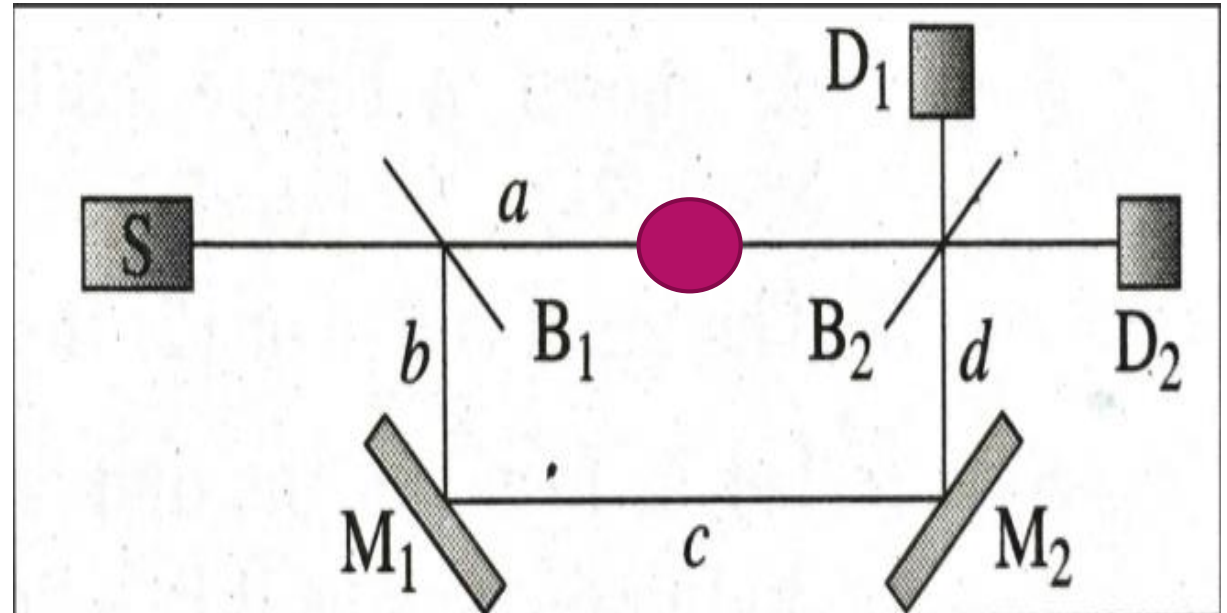
Mach-Zehnder interferometer

- ▶ S = source of light (photons)
- ▶ D_1, D_2 = detectors
- ▶ B_1, B_2 = beam splitters
- ▶ M_1, M_2 = mirrors
- ▶ Tuned so only D_2 receives light



Mach-Zehnder interferometer

- ▶ Photosensitive grains
 - ▶ Some are live, some are “duds”
 - ▶ Live = 100% absorptive
 - ▶ Dud = 100% transparent
- ▶ If live grains are struck by a photon, they are damaged
- ▶ Problem: how to tell which are live without damaging them?



Relation to computing

- Qubit – Quantum Logical Bit
 - 1 and 0 at the same time (superposition)
- Direct measurement will change the state of the qubit
- Scheme needed to utilize qubits

References

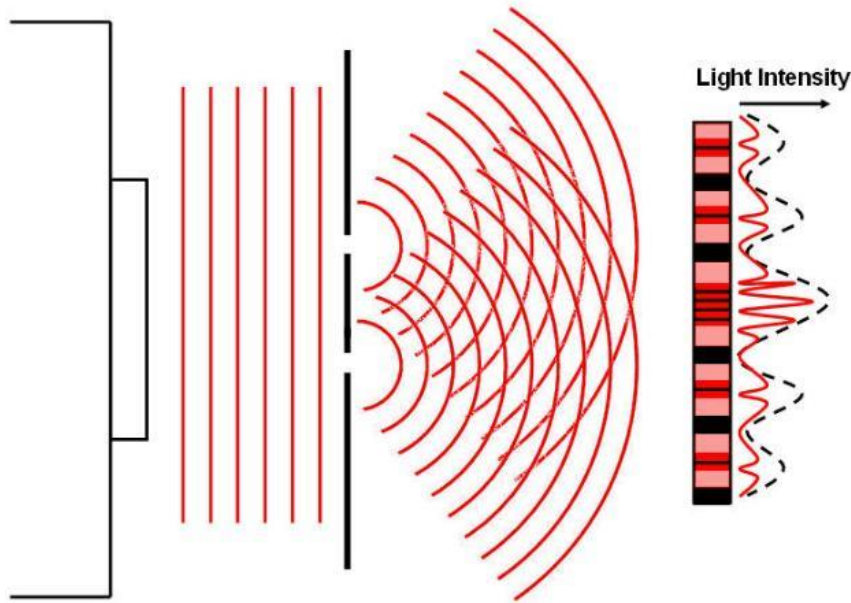
- ▶ *Automatic Quantum Computer Programming: A Genetic Programming Approach* by Lee Spector
- ▶ *The Foundations of Quantum Mechanics: From Photons to Quantum Computers* by Reinhold Blümel
- ▶ *Quantum Computer Science: An Introduction* by N. David Mermin
- ▶ *Quantum Mechanics and Path Integrals* by Richard P. Feynman and Albert R. Hibbs

Questions?



Some terms and specifics

Probability Amplitude



- Wave Amplitudes are represented by complex numbers
- $P(x) = |\phi|^2$
- $\phi = \phi_1 + \phi_2$
- $P_1(x) = |\phi_1|^2$
- $P_2(x) = |\phi_2|^2$