

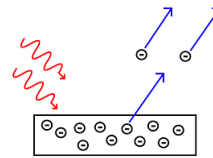
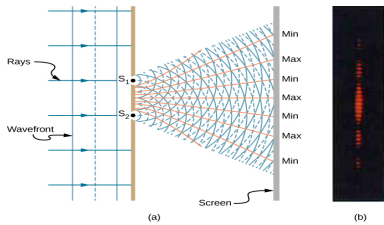
Overall goal: Three talks to provide background for discussion of quantum computing and quantum cryptography

Waves vs. Particles

- Particles are localized in space
- Waves are distributed in space; they exhibit interference

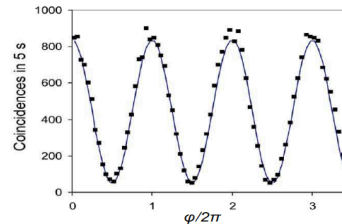
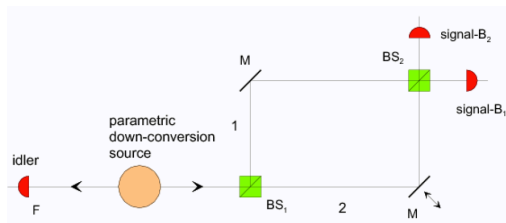
Wave-Particle Duality: How a patent clerk and a prince showed us that we need quantum mechanics

- Einstein light quanta and photoelectric effect: $E = hf$
- R. A. Millikan verifies Einstein's prediction: $E_{\max} = hf - \phi$
- Prince Louis de Broglie predicts matter waves: $\lambda = \frac{h}{p}$



Double-slit interference: (a) set up (b) fringes

Photoelectric effect



Mach-Zehnder interferometer with tagged single photon source

Counts in B₂ when M is moved

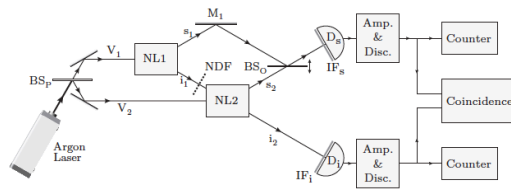


FIGURE 19.7 Schematic diagram of two-crystal analogue of double-slit interference apparatus. Taken with permission from X.Y. Zou, L.J. Wang, and L. Mandel, *Phys. Rev. Lett.* 67, 318-321 (1991) ©1991 The American Physical Society

Three references:

1. *Modern Introductory Physics*, Holbrow, Lloyd, Amato, Galvez, & Parks. Springer (2010)
2. *What Is Real? The unfinished quest for the meaning of quantum physics*, Adam Becker, Basic Books (2018)
3. *Erwin Schrödinger and the Quantum Revolution*, John Gribbin, Science (2013)

Mach-Zehnder with down converters that allow which-way identification