

WAVES AND UNCERTAINTY

Prof. Stephen Sekula
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Supplementary Material for
PHY 3305 (Modern Physics)
Harris, Ch. 4.4-4.5, 5.1-5.2

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- Plane waves as "lego mindstorms"
- single-slit diffraction and certainty
 - varying slit width, momentum, and position
- uncertainty in energy and time
 - LEP and the Z boson

REVIEW

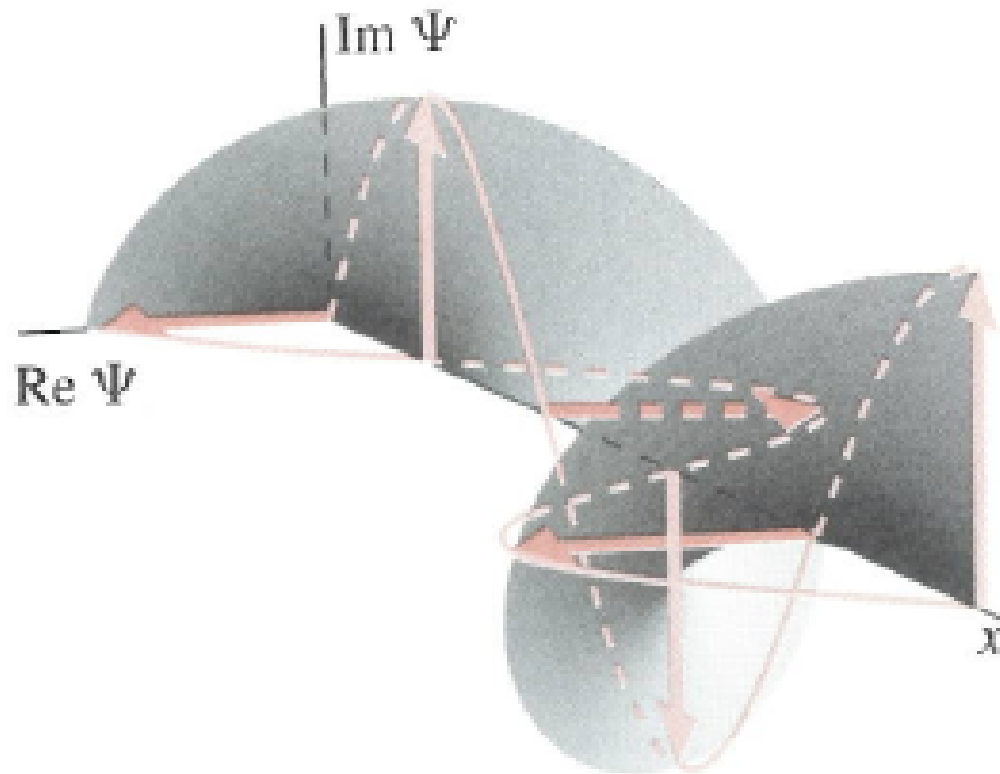
- We moved to a wave description of nature
 - particle and wave behavior (in a measurement sense) is recovered for different "relevant dimensions"
- The wave nature is described by the Schroedinger Wave Equation (SWE)
 - Like energy conservation or $F=ma$, it is derived from observations of nature and cannot be constructed from "first principles"
- We discussed complex numbers and functions
- We discussed the meaning of the "wave function", $\psi(x,t)$
 - it describes PROBABILITY DENSITY (per unit length in 2-D, per unit volume in 3-D)

ATOMS



PLANE WAVE

Figure 4.11 A plane matter wave: The real and imaginary parts of $Ae^{i(kx - \omega t)}$, plotted at $t = 0$.

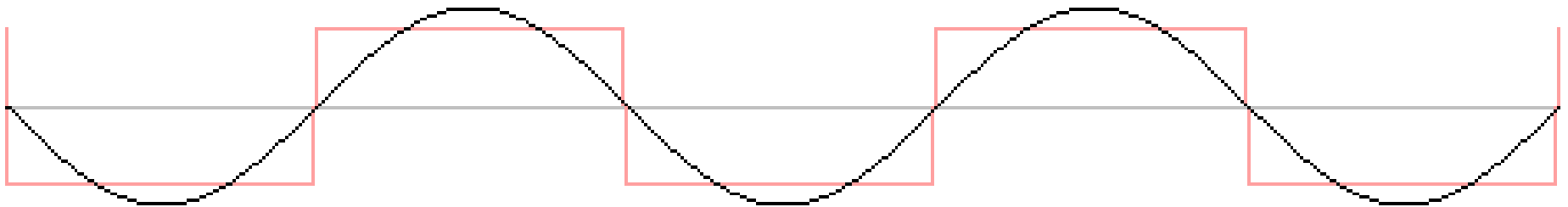


QUANTUM WAVE DEMONSTRATION

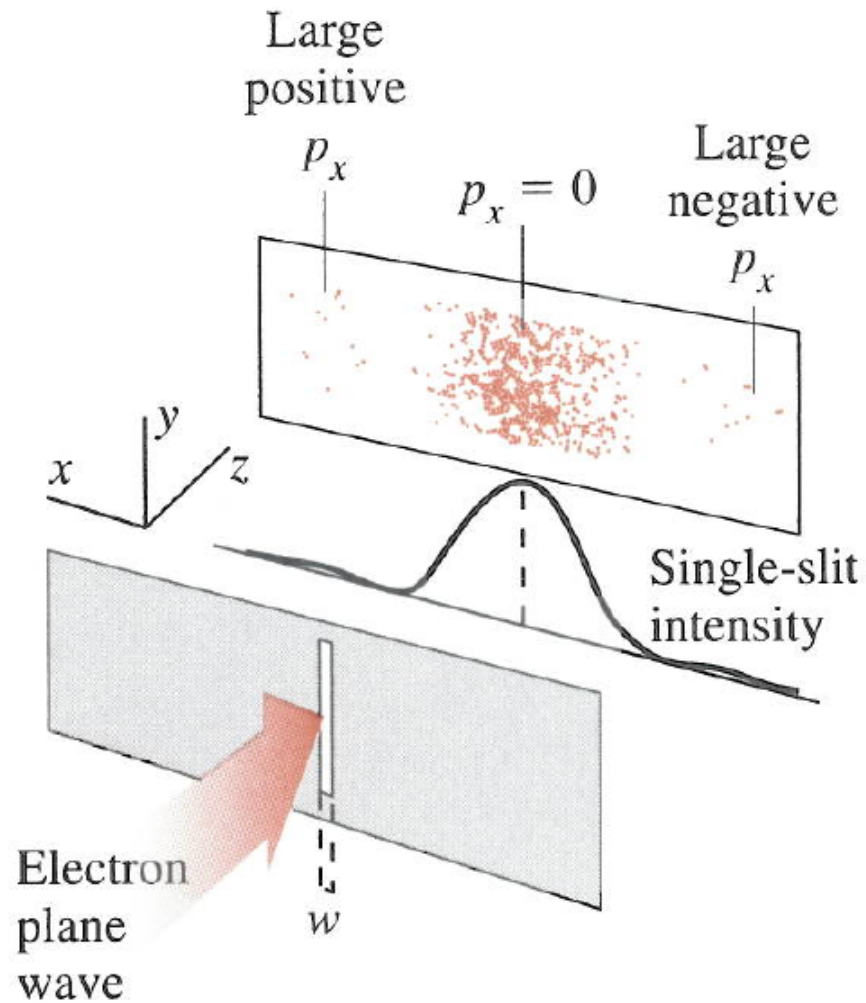
http://phet.colorado.edu/simulations/sims.php?sim=Quantum_Tunneling_and_Wave_Packets

MAKING WAVES

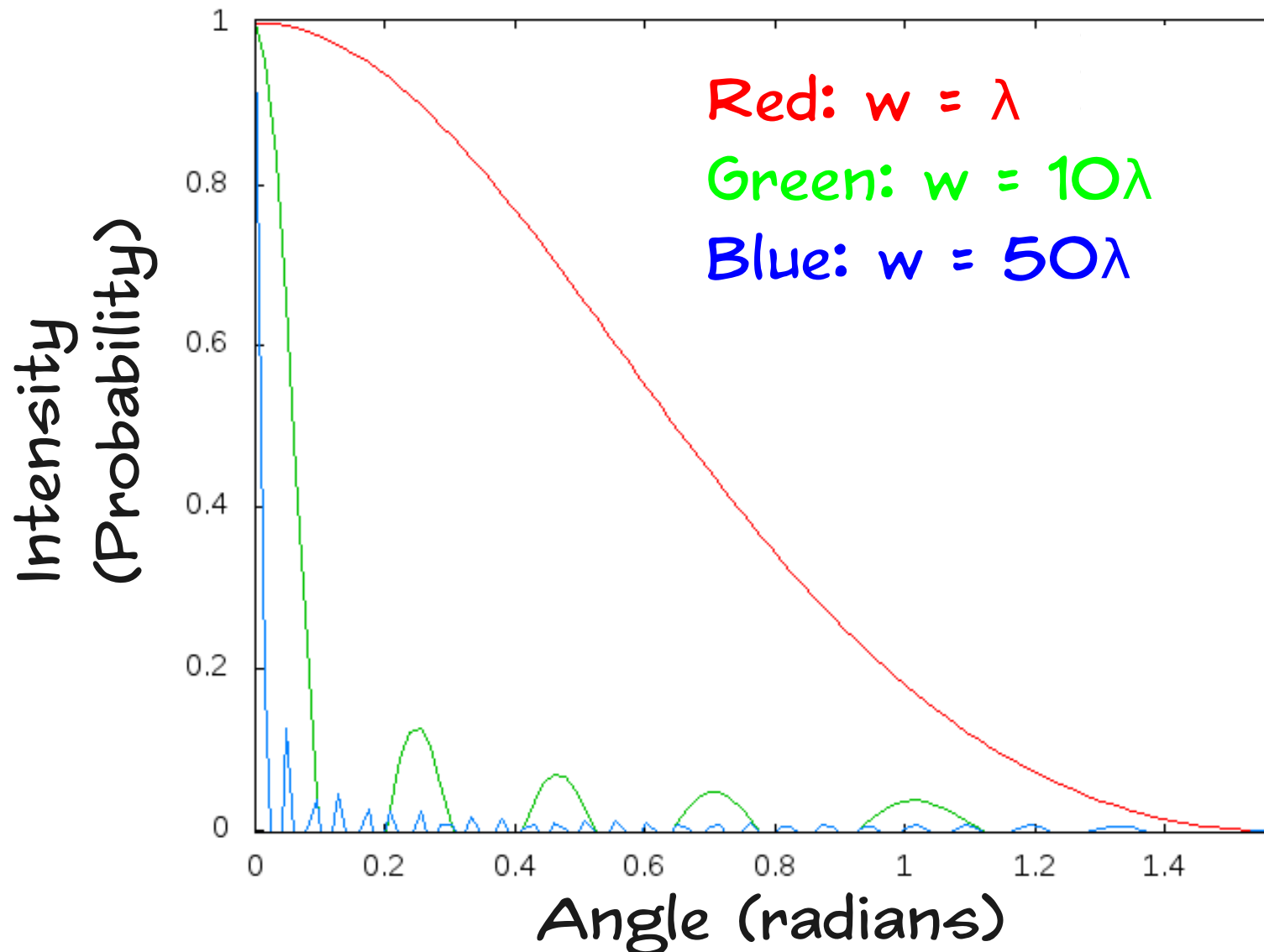
harmonics: 1



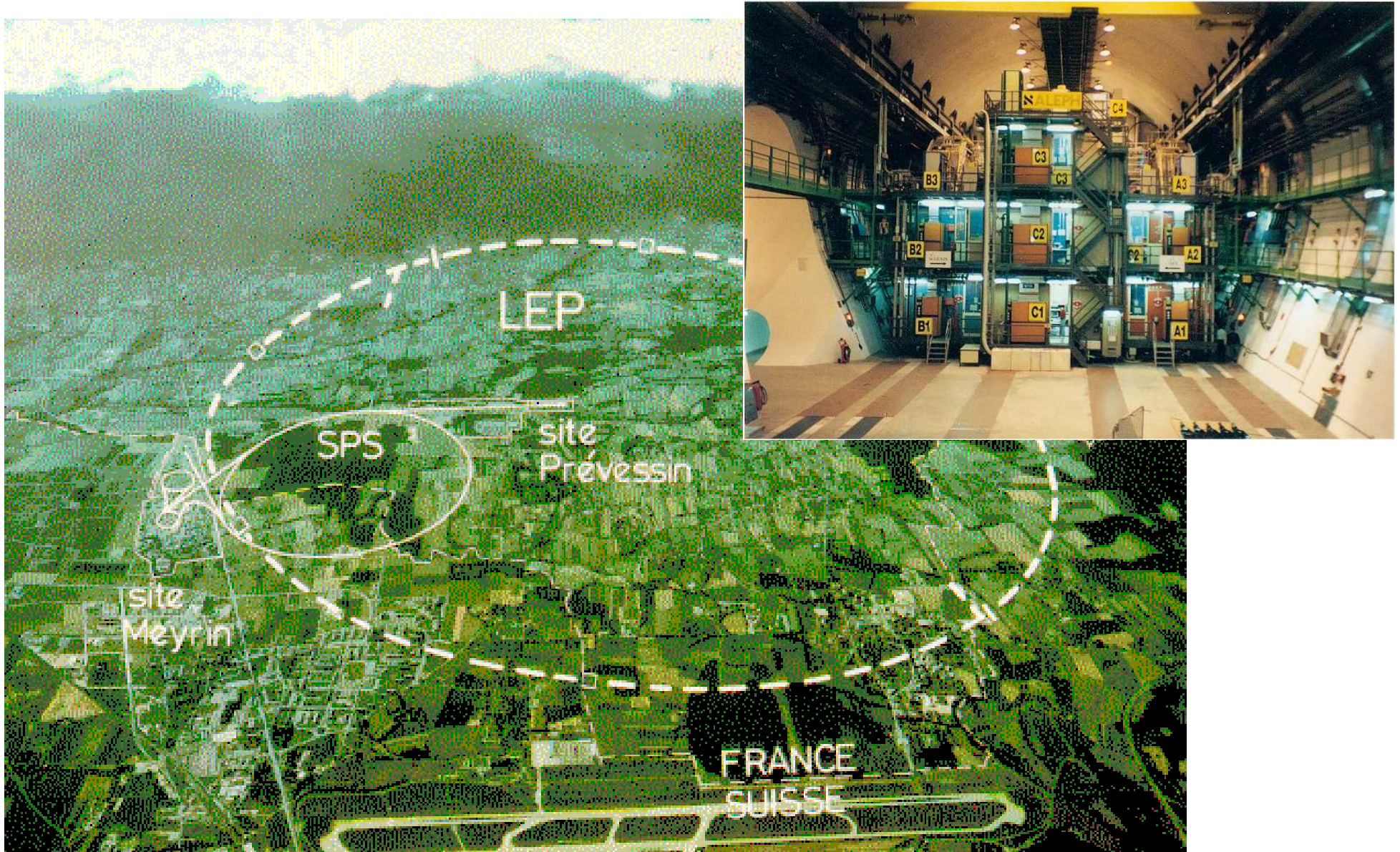
DIFFRACTION AND CERTAINTY



VARYING THE SLIT WIDTH (W)

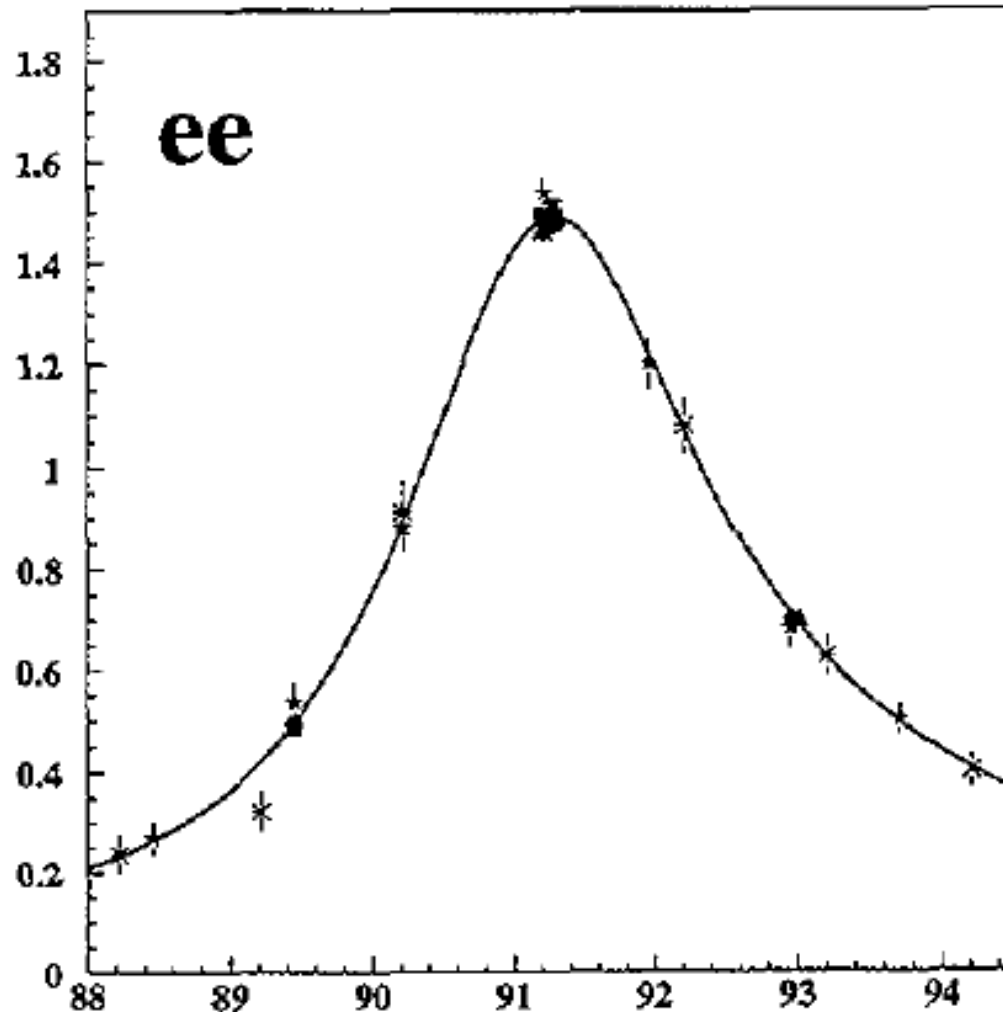


LEP AND ALEPH AT CERN



MASS OF SUBATOMIC PARTICLES

ALEPH



Measurement of the width of the Z boson by the ALEPH experiment

(Published in Eur.Phys.J.C14:1-50,2000)

Uncertainties on the collider energy were ~ 1000 times smaller than the width of the Z seen here!

NEXT TIME

- "Particle in a Box"
 - illustrates a first approach to solving for the spatial wave function, $\psi(x)$
- Reading: Harris 5.3-5.5