Quantum Physics PHYS2040

A/Prof. Clemens ULRICH

Wed.	17:00 - 18:00	RC M032
Thur.	15:00 - 16:00	RC M032

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please contact me after the lecture

Quantum Physics PHYS2040

UNSW THE UNIVERSITY OF NEW SOUTH WALES

Assignment 1:	10 %
Assignment 2:	10 %
MS Examination:	20%
Final Examination:	60 %

Mid Semester Examination: 19. April 15.00-16.00

Topic:

Properties of Light, Photoelectric Effect, De Broglie Wavelength,
Particle-Wave Dualism, Wave Package, Probability Wave,
The Schroedinger Equation

Outline

1. Introduction:

- Planck Radiation
- Bohr's Model of the Atom
- Photoelectric Effect
- Compton Effect
- Dual Nature of Light: Particle Wave Dualism
- The Particle Wave: de Broglie Wavelength
- Heisenberg Uncertainty Principle
- Probability Function

Outline

2. Quantum Theory of the free Particle:

- Schroedinger Equation of the free particle
- Time-independent Schroedinger Equation
- Eigenstate - Eigenfunction
- Particle in a box
- Linear quantum well
- The Harmonic Oscillator
- Quantum-Mechanic Tunneling

Outline

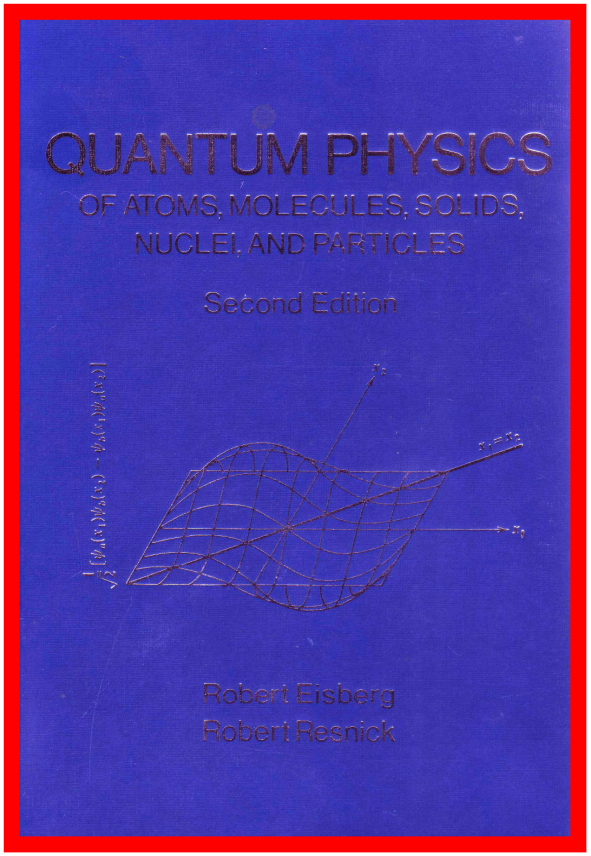
3. Atomic Wavewfunctions:

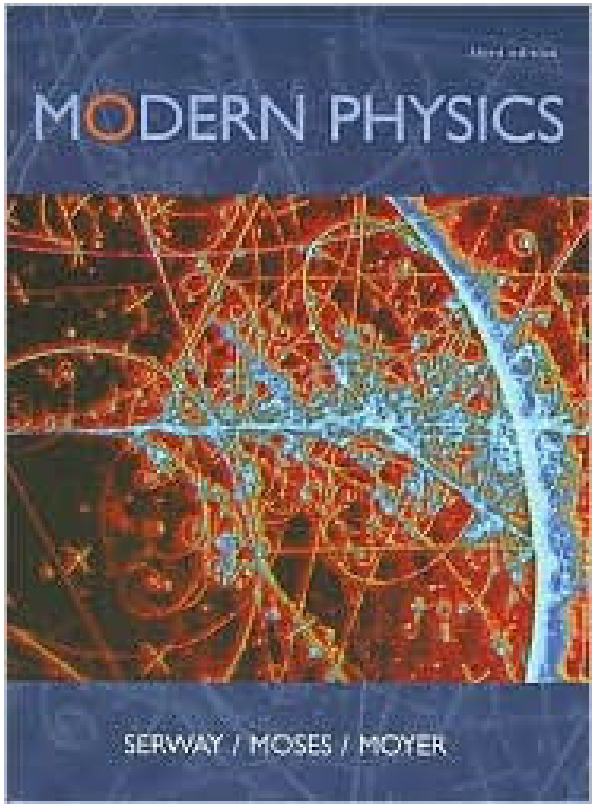
- Schroedinger Equation of the Hydrogen Atom
- Atomic wavefunctions
- Separation of the angular and radial part
- Orbitals
- Angular momentum and spin
- Quantum numbers: **n, l, m, s**
- Hydrogen atom in a magnetic field
- Pauli principle: periodic table of elements

Textbooks:

R. Eisberg and R. Resnick (E&R),

"*Quantum Physics 2nd Ed.*" (Wiley)





Textbooks:

Serway, Moses and Moyer (SMM),

"*Modern Physics 3rd Ed.*" (Thomson)

Textbooks:

- **Rae, "*Quantum Mechanics 5th Ed*" (Taylor-Francis) - more technical**
- **Griffiths, "*Introduction to Quantum Physics 2nd Ed.*" (Prentice-Hall) deeper mathematical understanding**

Furthermore: more fundamental books

- Landau-Lifschitz

- Albert Messiah

Emilio Segrè
1905 – 1989
Picture taken in
Los Alamos

A further book:

X-rays to Quarks:
Modern Physicists and Their Discoveries

Emilio Segrè
Dover Publications (2007)

Antiproton, Table of Isotopes
Nobel Prize 1959

THE
LONDON, EDINBURGH AND DUBLIN
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[FOURTH SERIES.]

MARCH 1861.

XXV. *On Physical Lines of Force.* *By* J. C. MAXWELL, *Professor of Natural Philosophy in King's College, London**.

PART I.—*The Theory of Molecular Vortices applied to Magnetic Phenomena.*

IN all phenomena involving attractions or repulsions, or any forces depending on the relative position of bodies, we have to determine the *magnitude* and *direction* of the force which would act on a given body, if placed in a given position.

$\frac{1}{4\pi}\left(\frac{d\beta}{dx}-\frac{d\alpha}{dy}\right)$ represents the *strength of an electric current parallel to* z through unit of area; and if we write

$$\frac{1}{4\pi}\left(\frac{d\gamma}{dy}-\frac{d\beta}{dz}\right)=p,\ \frac{1}{4\pi}\left(\frac{d\alpha}{dz}-\frac{d\gamma}{dx}\right)=q,\ \frac{1}{4\pi}\left(\frac{d\beta}{dx}-\frac{d\alpha}{dy}\right)=r, \quad (9)$$

then p, q, r will be the quantity of electric current per unit of area perpendicular to the axes of x, y, and z respectively.

Let us suppose μ constant, then

$$m=\frac{1}{4\pi}\left(\frac{d}{dx}(\mu\alpha)+\frac{d}{dy}(\mu\beta)+\frac{d}{dz}(\mu\gamma)\right)$$
$$=\frac{1}{4\pi}\mu\left(\frac{d^2\phi}{dx^2}+\frac{d^2\phi}{dy^2}+\frac{d^2\phi}{dz^2}\right) \quad . \quad . \quad . \quad . \quad . \quad (18)$$

represents the amount of imaginary magnetic matter in unit of volume. That there may be no resultant force on that unit of volume arising from the action represented by the first term of equations (12, 13, 14), we must have $m=0$, or

$$\frac{d^2\phi}{dx^2}+\frac{d^2\phi}{dy^2}+\frac{d^2\phi}{dz^2}=0. \quad . \quad . \quad . \quad . \quad (19)$$

We have, in fact, now come to inquire into the physical connexion of these vortices with electric currents, while we are still in doubt as to the nature of electricity, whether it is one substance, two substances, or not a substance at all, or in what way it differs from matter, and how it is connected with it.

"coefficient of magnetic induction,"

$$\mu = \pi\rho ; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (133)$$

whence

$$\pi m = V^2 \mu ; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (134)$$

and by (108),

$$E = V\sqrt{\mu} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (135)$$

In air or vacuum $\mu = 1$, and therefore

$$\left.\begin{aligned} V &= E, \\ &= 310{,}740{,}000{,}000 \text{ millimetres per second}, \\ &= 193{,}088 \text{ miles per second.} \end{aligned}\right\} \quad . \quad (136)$$

The velocity of light in air, as determined by M. Fizeau*, is 70,843 leagues per second (25 leagues to a degree) which gives

$$\begin{aligned} V &= 314{,}858{,}000{,}000 \text{ millimetres} \\ &= 195{,}647 \text{ miles per second.} \quad . \quad . \quad . \quad . \quad (137) \end{aligned}$$

The velocity of transverse undulations in our hypothetical medium, calculated from the electro-magnetic experiments of MM. Kohlrausch and Weber, agrees so exactly with the velocity of light calculated from the optical experiments of M. Fizeau, that we can scarcely avoid the inference that *light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena.*

The World of the Quantum – Everything is Quantized

energy comes in discrete, quantised 'packets' rather than as a continuum. This was quite a bold step, in his own words:

"... an act of ***despair*** *... I was ready to sacrifice any of my previous convictions about physics ..."*

14. December 1900 (Nobel Prize 1918)

Planck resolved this problem by breaking free from the idea that energy is a continuum, instead assuming that the energy of atomic oscillators is quantised, in other words,
E **=** ***n*****(*****h*****n) where** ***n*** **= 0,1,2,3… is an integer**
and ***h*** **= 6.626 × 10^{-34} Js is Planck's constant**

Max Planck 1858-1947

Max Planck

23. April 1858 - 4. Oct, 1947

Professor in
Kiel, Berlin and Goettingen

Head of the
Deutsche Physikalische Gesellschaft

President of the
Kaiser Wilhelm Institute
which in 1948 became the
Max-Planck Institute

His son Erwin Planck was executed
by the Nazis in 1945 for the participation
in an attempt to assassinate Hitler.

Max-Planck Medal 1929
Max Planck and Albert Einstein

Unsolved Problem:

Black Body Radiation

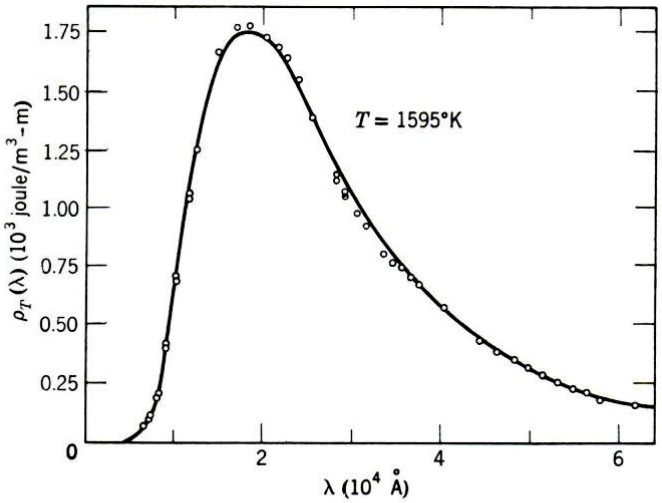


Figure 1-11 Planck's energy density prediction (solid line) compared to the experimental results (circles) for the energy density of a blackbody. The data were reported by Coblentz in 1916 and apply to a temperature of 1595°K. The author remarked in his paper that after drawing the spectral energy curves resulting from his measurements, "owing to eye fatigue it was impossible for months thereafter to give attention to the reduction of the data." The data, when finally reduced, led to a value for Planck's constant of 6.57×10^{-34} joule-sec.