

PHY138Y **Nuclear and** **Radiation**

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First Question

Which of the following medical or dental procedures have you or a family member undergone?

- A. X-rays - for diagnosis or therapy
- B. Use of Radioisotopes
- for diagnosis or therapy
- C. MRI (Magnetic Resonance Imaging)
- D. More than one of the above
- E. None of the above

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Nuclear and Radiation - OUTLINE

I Atomic and Nuclear Physics (review?)

- Models & Structure of the Atom
- The Photon
- Units

II X-Rays

- Production and Properties
- Interaction of Photons with Matter
- Diagnostic Use

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Nuclear and Radiation - OUTLINE

III Radioactivity

- Types of decay
- Energetics

IV Biological effects of radiation

- Exposure, dose
- Environmental Exposure
- Interaction of radiation with biological cells
- Radiation in therapy

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Nuclear and Radiation - OUTLINE

V Radioisotopes in Medicine

- Diagnosis
- Therapy
- Generation

VI MRI

- NMR and MRI

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Nuclear and Radiation - Summary

I Atomic and Nuclear Physics (review?)

II X-Rays

III Radioactivity

IV Biological effects of radiation

V Radioisotopes in Medicine

VI MRI

**DOWNLOAD NOTES
FROM N&R MAIN PAGE**

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This Week – Readings
Supplementary Notes I : SNI
Introductory Nuclear
and
Atomic Physics
download from N&R Web page



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Study Aids

- **Pre-class quizzes** –
posted **Wednesdays at noon**,
due the following Monday at 10 am
- **Problem Sets** –
posted **Wednesdays at noon**,
due the **Sunday?** of the following week
at midnight
- **One Written Problem Set** –
posted 15nd March (due 30th)

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Questions?

Tuesdays, 1;30 to 2:30 pm
in MP401
Hunting licence at other times

E-mails to key@physics.utoronto.ca
if you want a reply!

BUT use the mail box on main 138 page for
technical questions (Dr Savaria)

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Boltzmann



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Boltzmann

**committed
suicide
1906**



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Boltzmann's
Constant
 $S = k \log W$
Entropy
Number of
States available
to the system

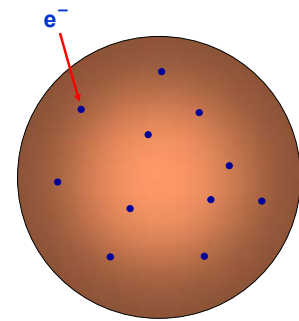
J.J. Thomson

Discovered electron in 1897



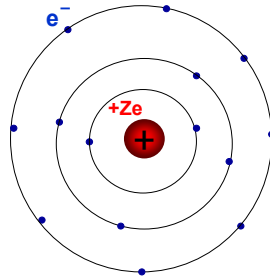
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Plum Pudding Model of the Atom



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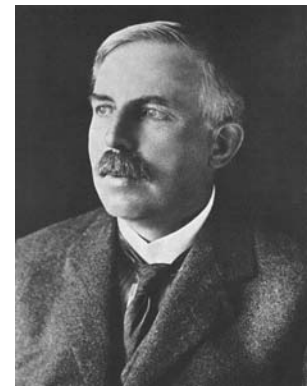
Planetary Model of the Atom



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Ernest Rutherford

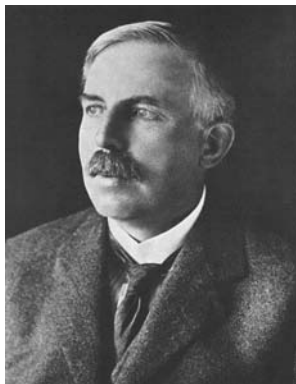
Student of Thomson
1898-1906
McGill



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Ernest Rutherford

Nobel Prize 1908
for his investigations into the disintegration of the elements, and the chemistry of radioactive substances



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Henri Becquerel

1896
Discovered Radioactivity
(Nobel Prize 1903)

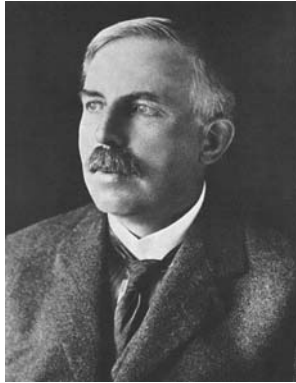


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Ernest Rutherford

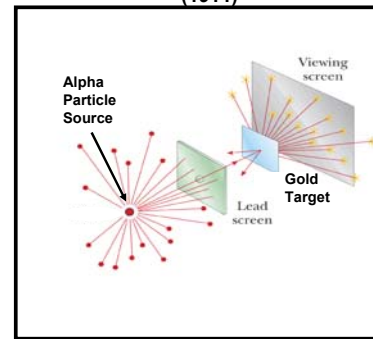
1898 – 1906
McGill

Identified alpha particles as Helium Nuclei



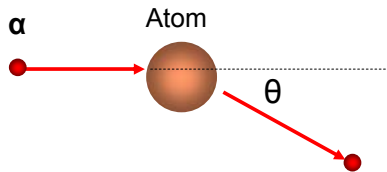
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Rutherford's Scattering Experiment (1911)



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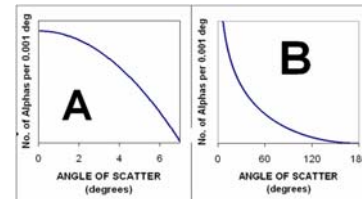
Alpha Scattering from Atoms



θ is the Angle of Scattering

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Alpha Scattering Experiment

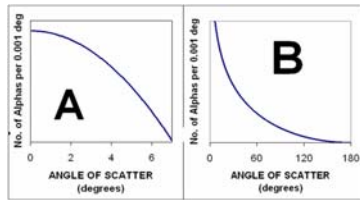


Which graph is the prediction of the Thomson Plum Pudding Model?

- A. A
- B. B
- C. Don't Know
- D. Don't Care

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Alpha Scattering Experiment



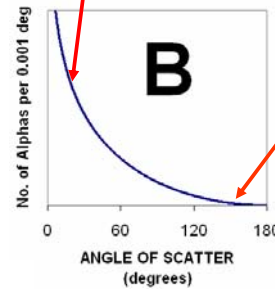
Which graph is the prediction of the Thomson Plum Pudding Model?

- A. A**
- B. B
- C. Don't Know
- D. Don't Care
- E. I refuse to answer on the grounds it may incriminate me

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Experimental Observation

Implies Atoms have a small, dense, heavy central nucleus



Significant numbers of large angle scatters $\propto \text{cosec}^4(\theta/2)$

Planetary Model Triumphant!

$\approx 10^{-10} \text{ m}$

$\approx 10^{-15} \text{ m}$

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Problem with Planetary Model!

Predicted
by the work of
this
man...

... whose
four equations
predicted...

James Clerk Maxwell

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.....Electromagnetic Waves

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ALL Accelerating charges emit e-m Radiation !

Leading to
the Collapse
of the Universe!

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Another problem with the Planetary Model!

Maxwell's Equations would predict a
CONTINUOUS SPECTRUM
emitted from the planetary model

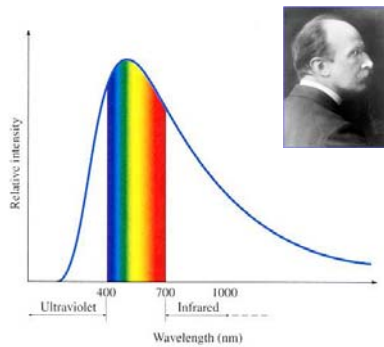
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Another Problem with the Planetary Model!

BUT the actual observation ...
shows **LINE SPECTRA!**

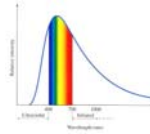
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Black Body Spectrum



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Max Planck



Electromagnetic Radiation
Is emitted only in discrete
(quantized) form: $E_\nu = hf$

Nature "jumps"

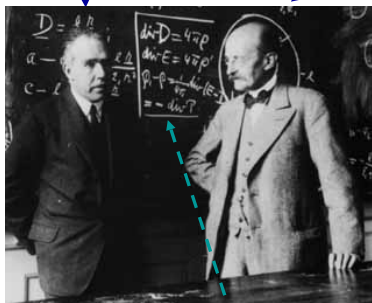
The size of the jumps
is $h = 6.6 \times 10^{-34} \text{ J}\cdot\text{s}$



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Niels Bohr

Max Planck



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Maxwell's Equations

Niels Bohr

Model of the atom



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Neils Bohr



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The Bohr Atom

- Electrons exist in a finite number of non-radiating orbits, each with a fixed energy
- Radiation is emitted when an electron "jumps" from a higher to a lower energy state
- The energy of the radiation is given by

$$E_n - E_m$$

Where $E_n = -13.6/n^2 \text{ eV}$

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Flash!

See Dr Harrison's flash animation of
the Bohr model –

linked to the N&R Web page

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