Lecture 2

Experimental Nuclear Physics
PHYS 741

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Colloquium Announcement

Friday, September 12th

Petr Vogel, Caltech

Double Beta Decay-The Key to Neutrino Properties

4:00 pm; 2241 Chamberlin Hall (coffee at 3:30 pm)
Seminar This Week

NPAC (Nuclear/Particle/Astro/Cosmo) Forum

Time & Place: Thursday, 4:00pm, 4274 Chamberlin

Speaker: Calvin Johnson, San Diego State University

Title: Cold gases and cartoon nuclei
Review

- properties of nuclei:
  - nucleons
  - magnetic moments
  - nuclear radii
  - binding energies
  - [mass of nuclei]
  - [nuclear quantum states (excited states)]
  - [nuclear forces/interactions]
- nucleons have pairwise interaction
- nucleon densities do not increase with A
- binding energies are additive (=nuclear force saturates)
- $B/A \sim 8$ MeV
- pairwise interaction + Pauli-Heisenberg + $1/r$ potential cannot explain saturation of nuclear force
- geometric packing of nucleons in sphere + Pauli-Heisenberg predict qualitatively correct result
Binding Energies
Mass Separator/Spectrometer
Mass Spectroscopy
Penning Trap

- Magnetic field
- Penning-Trap
- Electrical field
- Ion

\[ v_c = \frac{q}{m} \frac{B}{2\pi} \]

- axial (z)
- magnetron (-)
- cyclotron (+)

\[ m \sim \frac{T_{RF} \cdot q \cdot B \cdot \sqrt{N}}{\delta m \cdot m} \]
A Penning Trap - Explained

Cyclotron motion

harmonic potential

$$f = \frac{f_0}{2r_0^2} (x^2 + y^2 - 2z^2)$$

traps ions along z
By applying a B-Field along the Z-axis the ions will have a cyclotron motion in the X-Y plane commonly known as the magnetron motion. The ions will also undergo a second smaller (reduced) cyclotron motion due to the effects of the applied electrostatic field.

\[ \omega_C = \frac{q}{m} B \]

\[ \omega_C = \omega_+ + \omega_- \]
Research with a Penning Trap

Antihydrogen Trap Collaboration (ATRAP)

- **magnetic field**
- **superconducting solenoid and dewar**
- **22Na positron source (150 mCi)**
- **(at CERN but not installed because AD hall was closed)**
- **e^+ trap**
- **p^- trap**
- **BGO positron gamma detector**
- **not yet installed**

- positrons enter
- positron trap
- rotating electrode
- interaction regions
- antiproton trap
- antiprotons enter

Karsten Heeger, Univ. Wisconsin
Experimental Nuclear Physics - PHYS741
Excited States of Nuclei

\[ ^{16}\text{O} \text{ has highly bound nucleus} \]

one particle spectrum of \( ^{17}\text{O} \)
Excited States of Nuclei

- collective vibrational states
- rotational states
Excited States of $^{152}$Dy

*why nuclear physics looks so messy....*
Excited States of $^{152}$Dy

quick cascade of super-deformed band
Yukawa Potential & Nucleon-Nucleon Potentials

\[ V(r) = -g^2 \frac{e^{-mr}}{r} \]

Paris potential
Mirror Nuclei
Mirror Nuclei

![Mirror Nuclei diagram](image-url)