PH5211 - High Energy Physics

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Abstract

Instructor :James Libby (HSB 116A) **Lecture Timings** : E Slot (Tue – 11am, Wed – 10am, Thu - 8am)
Venue : HSB 210
Course Outline:

1. Nuclear Physics
2. Elementary Particle Properties
3. Particle Dynamics
4. Particle accelerators and detectors

Textbooks :

1. Introductory Nuclear Physics, Kenneth S. Krane, Wiley India Pvt Ltd.
2. Introduction to High Energy Physics, Donald H. Perkins, Cambridge.
3. Introduction to Elementary Particles, 2nd Edition, David Griffiths, Wiley-VCH.
4. Refer to Syllabus for more text books.

Evaluation :

1. **Problem sets** (10 marks): one question of three or four will be selected for marking - best ten of eleven will be averaged to give the grade.
2. **Quiz I** (20 marks): 8am Thursday 1st of September
3. **Quiz II** (20 marks): 8am Thursday 29th of October
4. **End - Semester** (50 marks): 1pm-4pm Friday 18th of November CRC 303

Contents

Chapter 1

Introduction

Lecture 1: First Lecture

1.1 Overview

So far you have worked at order of 10^{-10}
We are going to work at order of $10^{-15} = 1fm$

- Nuclear Physics: Strong and weak interactions.
- Particle Properties: Welcome to the zoo.
- Particle dynamics: how things happen.
- Introduce accelerators + detectors.

1.2 Nomenclature

$$^{A}_{Z}X_{N}$$

X = H, He, Li ...
Z = Atomic Number = No. of protons

Lecture 5: Continution

Measure spin: Hyper fine splitting
Perturbation α $\vec{\mu}.\vec{B}_{e^{-}inatom}$ α $\vec{I}.\vec{J}$ where, $\vec{J}$ = total angular momentum of e^{-}state

Definition 1.2.1.

$$\vec{F} = \vec{I} + \vec{J} \Rightarrow \left|\vec{I} - \vec{J}\right| \leq F \leq \left|\vec{I} + \vec{J}\right|$$

H in 1s $\Rightarrow$ $\vec{J} = \frac{1}{2}$ and $\vec{I} = \frac{1}{2}$ So, 1s splits into 2 states F=1 and F=0. with energy difference is $5.9X10^{-6}eV$.
Gamma wave is released when transition happens with $\nu = 1.42GHz$ or $\lambda = 21cm$. The half life time of the state F=1 is $\tau = 10^{7}years$.
to measure consider

$$\left|\vec{F}\right|^2 = \left|\vec{I}\right|^2 + \left|\vec{J}\right|^2 + 2\vec{I}.\vec{J}$$

$$\vec{I}.\vec{J} = \frac{1}{2}(\left|\vec{F}\right|^2 - \left|\vec{I}\right|^2 - \left|\vec{J}\right|^2)$$

$$\vec{I}.\vec{J} = \frac{1}{2}(F(F+1) - I(I+1) - J(J+1))$$

Lecture 6: duetron

This is the anologue of atomic H for nucleus $\therefore {}^2_1H \equiv D \equiv d$.
Mass from a spectrometer using the tricks we discussed(see krane)
$m_D = 2.014101771(15)u \Rightarrow B_D = 2.22eV \ll 16eV$
V small B $\Rightarrow$ no excited states
No γ spectroscopy, however, we can learn about V(r)

$$-\frac{\hbar^2}{2m}\frac{d^2u}{dr^2} + V(r)u = Eu$$

where u $= \frac{\Psi(r)}{r}$
Inside Well

$$u_i = A\sin k_1 r + B\cos k_1 r$$
$$u_o = Ce^{-k_2 r} + De^{k2r}$$

with,

$$k_1 = \sqrt{\frac{2m(E+V_0)}{\hbar^2}}, k_2 = \sqrt{\frac{-2mE}{\hbar^2}}$$

1. finite at r $\to 0 \Rightarrow B = 0$
2. $\Psi \to 0$ at $r \to \infty \Rightarrow D = 0$
3. $\frac{du_i}{dr}_R = \frac{du_o}{dr}_R \Rightarrow Ak_1\cos k_1 R = -Ck_2 e^{-k_2 R}$
4. $u_i(R) = u_o(R) \Rightarrow A\sin k_1 R = Ce^{-k_2 R}$

from 3 and 4 $\Rightarrow k_1 \cot k_1 R = -k_2$ depends on V_o , R $\Rightarrow V_o = 35MeV$

$$p + p \to D + e^+ + v_e + 0.42MeV$$
$$p + D \to^3 He + \gamma + 5.5MeV$$
$${}^3He +^3 He \to^4 He + p + p + \gamma + 12.98MeV$$

Total

$$4p \to {}^4\text{He} + 2e^+ + 2v_e + 24.8MeV$$

The $24.8MeV$ is sunshine.

Appendix