AIMAN COLLEGE OF ARTS AND SCIENCE FOR WOMEN DEPATMENT OF PHYSICS

III B.Sc PHYSICS

Subject Title: NUCLEAR PHYSICS

Subject code: 16SCCPH8

Semester: 6

Unit v:

1. Classification of elementary particles- Pions and Muons- K mesons- Hyperons

Already explained this topic during class hours. Notes given from modern physics book

1. Conservation laws – exact laws- approximate conservation laws

(For exam, refer the attached pdf)

In physics, a conservation law states that a particular measurable property of an isolated physical system does not change as the system evolves over time. Exact conservation

laws include conservation of energy, conservation of linear momentum, conservation of angular momentum,

and conservation of electric charge.



* + Conservation of isospin

In particle physics and nuclear physics, isospin, I or I3, is a quantum number related to the strong nuclear

force. Isospin is associated with a conservation law which requires strong interaction decays to conserve isospin.

... Isospin is mathematically similar to spin, though it has nothing to do with angular momentum.



1. Fundamental interactions

(For exam, refer the attached pdf)



Four basic forces—[gravitational](https://www.britannica.com/science/gravity-physics), [electromagnetic](https://www.britannica.com/science/electromagnetism), [strong](https://www.britannica.com/science/strong-force), and [weak](https://www.britannica.com/science/weak-force) All the known forces of nature can be traced to these fundamental interactions. The fundamental interactions are characterized on the basis of the following four criteria:

* + the types of particles that experience the force
	+ the relative strength of the force
	+ the range over which the force is effective
	+ the nature of the particles that mediate the force.

The gravitational force acts between all objects having mass.

The [electromagnetic force](https://www.britannica.com/science/electromagnetism) is responsible for the repulsion of like and the attraction of unlike [electric charges](https://www.britannica.com/science/electric-charge).

The [strong force](https://www.britannica.com/science/strong-force) acts between [quarks](https://www.britannica.com/science/quark), the [constituents](https://www.merriam-webster.com/dictionary/constituents) of all subatomic particles, including [protons](https://www.britannica.com/science/proton-subatomic-particle) and [neutrons](https://www.britannica.com/science/neutron).

The [weak force](https://www.britannica.com/science/weak-force) [manifests](https://www.merriam-webster.com/dictionary/manifests) itself in certain forms of [radioactive](https://www.britannica.com/science/radioactivity) [decay](https://www.britannica.com/science/radioactivity) and in the [nuclear reactions](https://www.britannica.com/science/nuclear-reaction) .

1. Anti-particles

Already explained this topic during class hours. Notes given from modern physics book

1. Resonance Particles (Material for exam)

Resonance, in [particle physics](https://www.britannica.com/science/particle-physics), an extremely short-lived phenomenon associated with subatomic particles

called [hadrons](https://www.britannica.com/science/hadron) that decay via the [strong nuclear force](https://www.britannica.com/science/strong-force).

A resonance is the peak located around a certain energy found in differential cross sections of scattering experiments. These peaks are associated with subatomic particles, which include a variety of bosons, quarks and hadrons and their excitations.

It occurs when the total energy of the colliding subatomic particles is just enough to produce its rest mass, which the strong force then causes to disintegrate within10-23 second.



1. Hyper nucleus (Material for exam)

A **hypernucleus** is [a nucleus](https://en.wikipedia.org/wiki/Atomic_nucleus) which contains at least

one [hyperon](https://en.wikipedia.org/wiki/Hyperon) (a baryon carrying the [strangeness](https://en.wikipedia.org/wiki/Strangeness) quantum number) in addition to the normal [protons](https://en.wikipedia.org/wiki/Proton) and [neutrons](https://en.wikipedia.org/wiki/Neutron). They have been studied by measuring the momenta of the K and [pi](https://en.wikipedia.org/wiki/Pion) [mesons](https://en.wikipedia.org/wiki/Pion) in the direct strangeness exchange reactions.

Hypernuclei can be made by a nucleus capturing a Lambda or a [K meson](https://en.wikipedia.org/wiki/Kaon) in a compound [nuclear reaction](https://en.wikipedia.org/wiki/Nuclear_reaction) by the direct strangeness exchange reaction.

K + nucleus → [π + hypernucleus](https://en.wikipedia.org/wiki/Pion)



Hypernuclei containing the lightest hyperon, the [Lambda](https://en.wikipedia.org/wiki/Lambda_baryon), live long enough to have sharp nuclear energy levels.

Hypernucleus differs from that of normal nuclei because a hyperon, having a non-zero strangeness quantum number, can share space and momentum coordinates with the usual four nucleon states that can differ from each other

in [spin](https://en.wikipedia.org/wiki/Spin_%28physics%29) and [isospin](https://en.wikipedia.org/wiki/Isospin). They are not restricted by the [Pauli](https://en.wikipedia.org/wiki/Pauli_exclusion_principle) [exclusion principle](https://en.wikipedia.org/wiki/Pauli_exclusion_principle) from any single-particle state in the nucleus.

1. Symmetry classification of elementary particles (For exam, refer the attached pdf)
	* Conservation laws are related to three [symmetry](https://www.infoplease.com/encyclopedia/science/physics/concepts/symmetry) principles that apply to changing the total circumstances of an event rather than changing a particular quantity.

The three symmetry operations associated with these principles are:

* + charge conjugation (C), which is equivalent to exchanging particles and antiparticles;
	+ parity (P), which is a kind of mirror-image symmetry involving the exchange of left and right; and
	+ time-reversal (T), which reverses the order in which events occur.

According to the symmetry principles (or invariance principles), performing one of these symmetry operations on a possible particle reaction should result in a second reaction that is also possible.

However, it was found that parity is not conserved in the weak interactions, i.e., there are some possible particle decays whose mirror- image counterparts do not occur. Although not conserved individually, the combination of all three operations performed successively is conserved; this law is known as the CPT theorem.

1. Quark Model

(For exam, refer the attached pdf)

Quarks are the building blocks which build up matter, i.e., they are seen as the "elementary particles". There are six "flavors" of quarks. The most familiar baryons are the [proton](http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/proton.html#c1) and [neutron](http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/proton.html#c3), which are each constructed from up and down quarks. Quarks are observed to occur only in combinations of two quarks (mesons), three quarks (baryons).



|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Quark | Symbol | Spin | Charge | Baryon Number | S | C | B | T | Mass\* |
| [Up](http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/quark.html#c3) | U | 1/2 | +2/3 | 1/3 | 0 | 0 | 0 | 0 | 1.7-3.3 MeV |
| [Down](http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/quark.html#c3) | D | 1/2 | -1/3 | 1/3 | 0 | 0 | 0 | 0 | 4.1-5.8 MeV |
| [Charm](http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/quark.html#c4b) | C | 1/2 | +2/3 | 1/3 | 0 | +1 | 0 | 0 | 1270 MeV |
| [Strange](http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/quark.html#c4) | S | 1/2 | -1/3 | 1/3 | -1 | 0 | 0 | 0 | 101 MeV |
| [Top](http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/quark.html#c5) | T | 1/2 | +2/3 | 1/3 | 0 | 0 | 0 | +1 | 172 GeV |
| [Bottom](http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/quark.html#c7) | B | 1/2 | -1/3 | 1/3 | 0 | 0 | -1 | 0 | 4.19 GeV(MS)4.67 GeV(1S) |

Prepare well All the best