

GRADE XII

Chapter 25

RECENT TREND IN PHYSICS

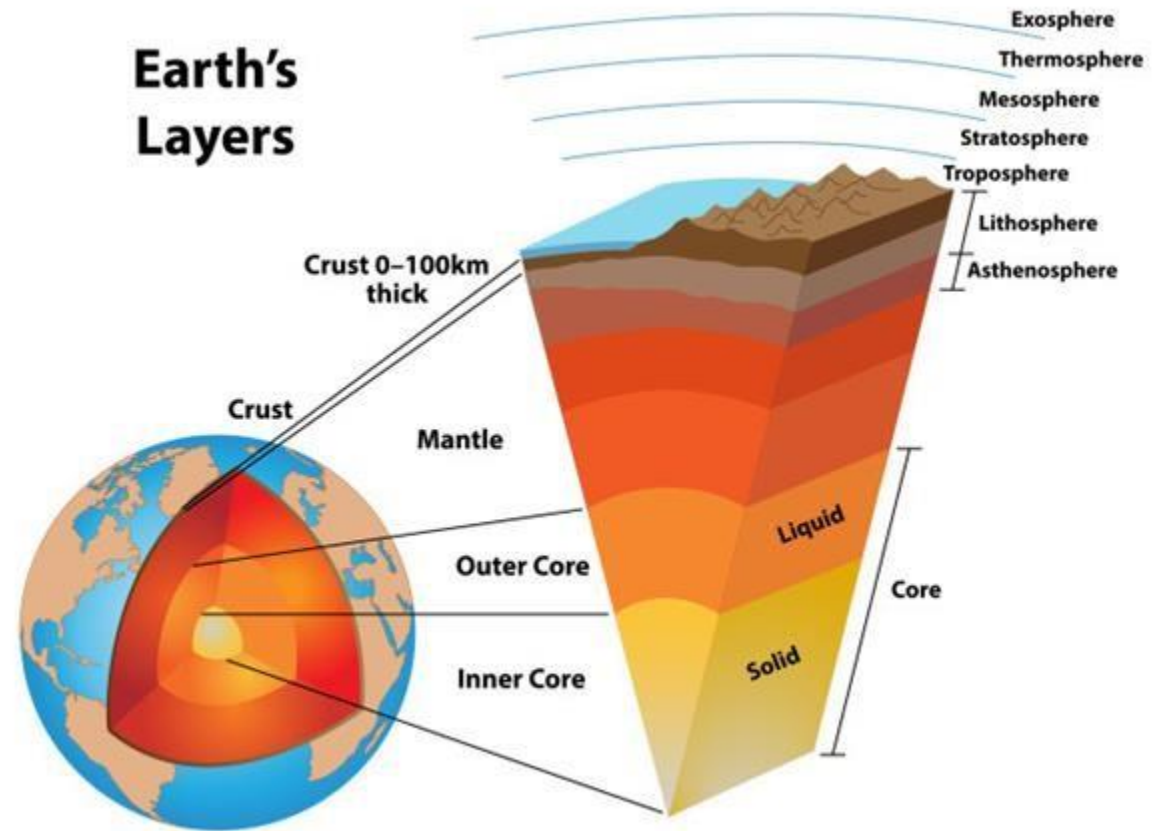
Bishwas Chapagain

Earth:

The earth is mainly divided into four parts: **crust, mantle, the outer core and the inner core.**

The outermost layer of the earth is called crust. It contains less than one percent of the total volume of earth. The lithosphere is **the rocky outer part of the Earth.** It is made up of the brittle crust and the top part of the upper mantle. **The lithosphere is the coolest and most rigid part of the Earth.**

The layer of the earth below the crust is called **mantle.** It is the thickest part of the earth's layer having **thickness up to 2900 km** and takes up 83% of earth's volume.



The central region of the earth is called core. It has two layers: **outer core and inner core.** The outer core is 2270 km thick has a temperature of up to 4000°C and is made up of liquid iron and nickel. **The thickness of inner core is about 1200 km and temperature up to 7000°C.**

Earthquake, nanotechnology, gravitational waves and Higgs boson:

Seismology:

Seismology is the scientific study of earthquakes and the propagation of elastic waves through the Earth.

Seismographs:

Seismographs are instruments used to record the motion of the ground during an earthquake.

Hypocenter(Focus)

The hypocenter is the actual point at which an earthquake occurs and the point from which body waves of an earthquake ultimately originate.

Epicenter

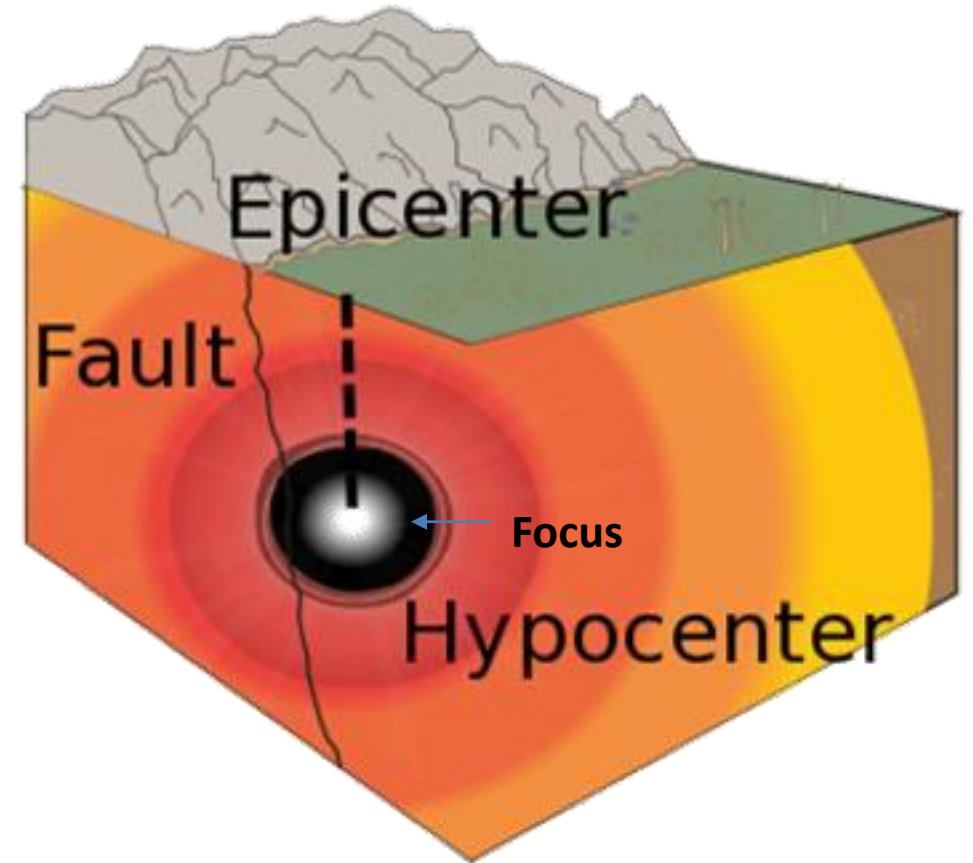
The epicenter is the location on Earth's surface directly above where an earthquake occurs and spreads.

Fault:

A fault is a planar fracture or discontinuity in a volume of rock across which there has been significant displacement as a result of rock-mass movements.

Earthquake:

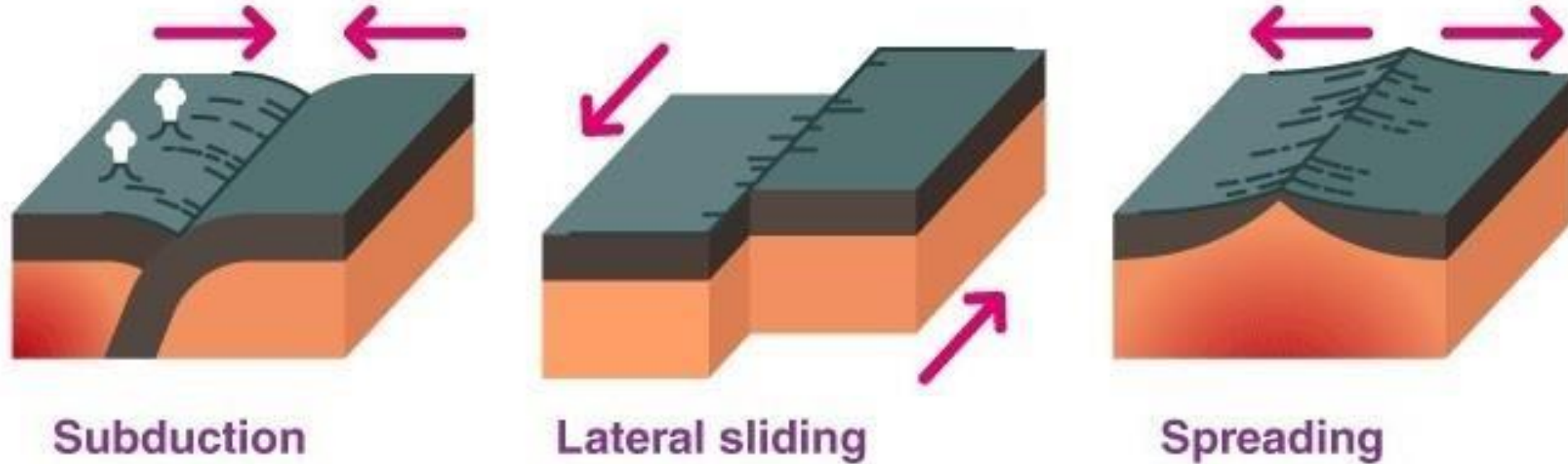
- *Earthquakes can originate from sudden motion along a fault, from a volcanic eruption, bomb blasts, landslides, or anything else that suddenly releases energy on or in the Earth.*
- **The lithosphere is made up of several pieces called tectonic plates.**
- **The plates under the oceans are called oceanic plates and the rest are continental plates.** Heat is generated at the centre of the earth from radioactive



materials which continuously flow from core to the mantle. Due to the flow of heat, the tectonic plates suddenly slip with respect to each other.

- **The surface where they slip is called fault.** Not every fault is associated with active earthquakes. Most faults are in fact no longer active but were active at some time in the geologic past. Of the active faults, only some are particularly prone to earthquakes. Some faults are slippery, and the two blocks on either side just slide by each other passively without producing major earthquakes. In other cases, however, the blocks stick together and deform until they reach a certain point at which they suddenly snap, releasing elastic potential energy in the form of seismic waves.
- **The seismic waves propagate through the earth and cause the ground surface to shake which we call earthquake.**
- **During an earthquake, several types of seismic waves can either radiate underground from the focus called **body waves** or above ground from the epicentre called **surface waves**. The body waves travel through the whole body of the Earth and move faster than surface waves, whereas surface waves cause most of the destruction associated with earthquakes because they briefly change the shape of the surface of the earth when they pass.**

Plate Tectonics



Types of seismic waves

- There are **three basic types** of seismic waves – P-waves, S-waves and surface waves. **P-waves and S-waves are sometimes collectively called body waves.**

1. P-waves

- P-waves, also known as primary waves or pressure waves, travel at the greatest velocity through the Earth. When they travel through air, **they take the form of sound waves** – they travel at the speed of sound (330 ms^{-1}) through air but may travel at 5000 ms^{-1} in granite. **Because of their speed, they are the first waves to be recorded by a seismograph during an earthquake.**

- They differ from S-waves in that they propagate through a material by alternately compressing and expanding the medium, where particle motion is parallel to the direction of wave propagation – this is rather like a slinky that is partially stretched and laid flat and its coils are compressed at one end and then released.

2. S-waves

- S-waves, also known as secondary waves, shear waves or shaking waves, **are transverse waves** that travel slower than P-waves. In this case, particle motion is perpendicular to the direction of wave propagation. Again, imagine a slinky partially stretched, except this time, lift a section and then release it, a transverse wave will travel along the length of the slinky. S-waves cannot travel through air or water but are **more destructive than P-waves because of their larger amplitudes**

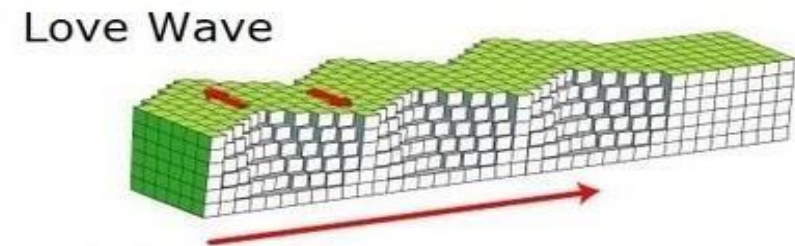
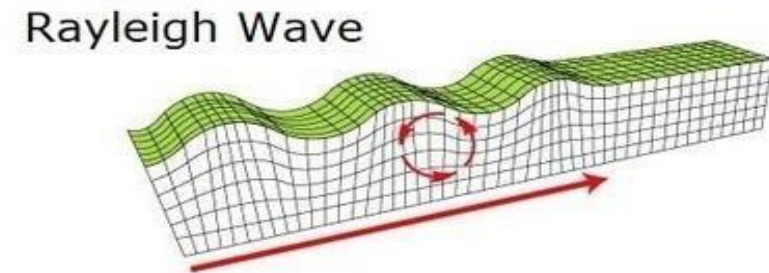
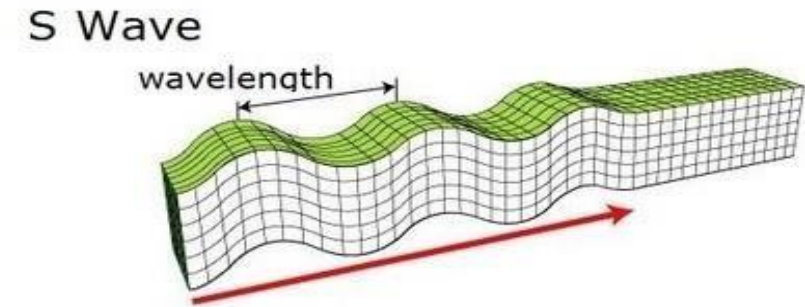
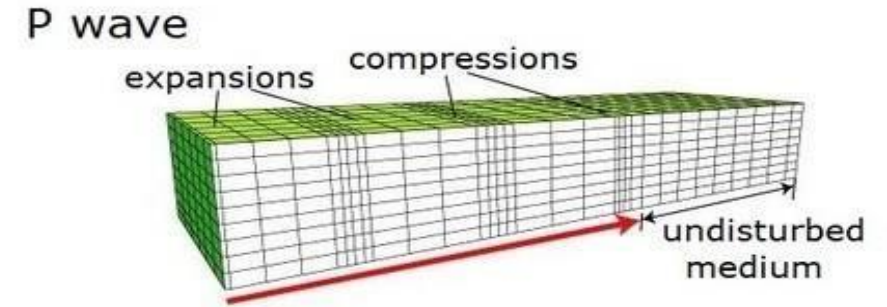
3. Surface waves

- Surface waves are similar in nature to water waves and travel just under the Earth's surface. They are typically generated when the source of the earthquake is close to the Earth's surface. Although surface waves travel more slowly than S-waves, they can be much larger in amplitude and can be the most destructive type of seismic wave.

There are two basic kinds of surface waves:

- **Rayleigh waves**, also called ground roll, travel as ripples similar to those on the surface of water. People have claimed to have observed Rayleigh waves during an earthquake in open spaces, such as parking lots where the cars move up and down with the waves.
- **Love waves** cause horizontal shearing of the ground. They usually travel slightly faster than Rayleigh waves.

<https://www.britannica.com/video/20704/Rayleigh-wave>

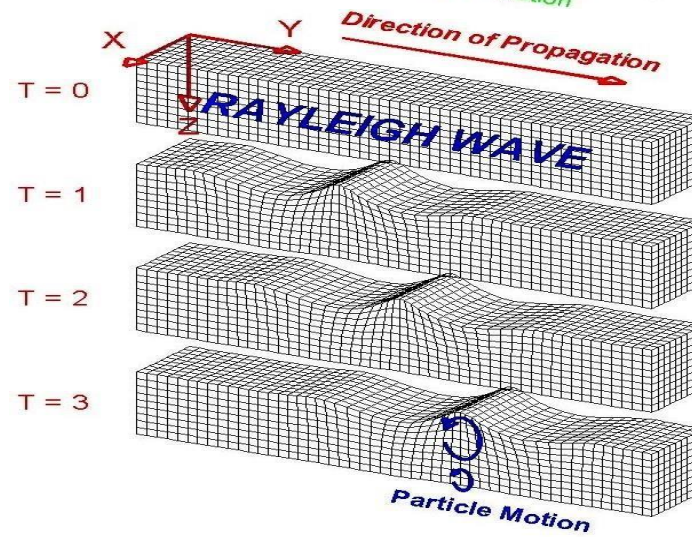
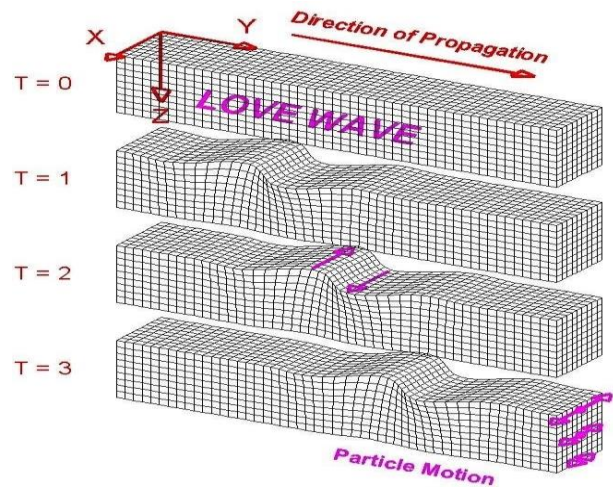
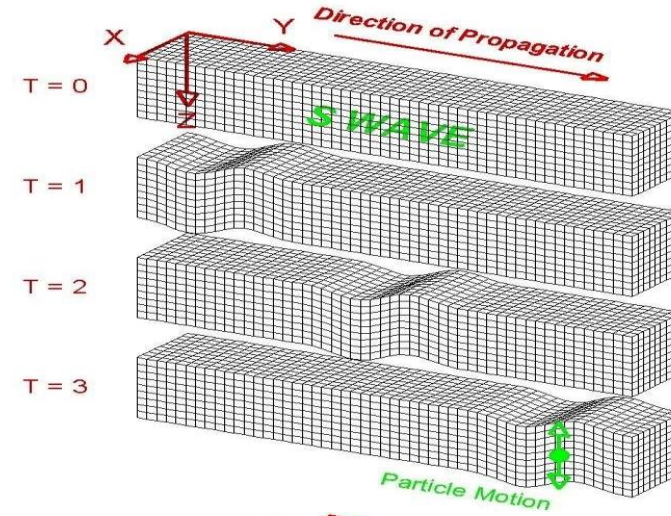
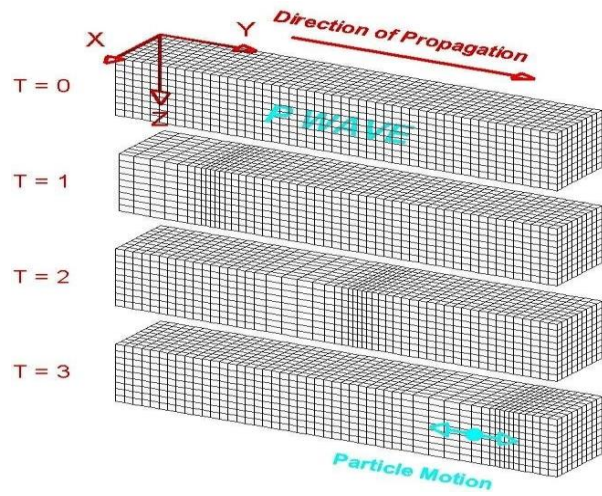


Characteristics of love waves:

- They only form on the surface of the earth after a large earthquake.
- They travel with a lower velocity than body waves but faster than Rayleigh waves.
- They form when S-waves interact with the earth's surface.
- They are transverse in nature.
- Their amplitude decreases with depth.
- They are dispersive in nature.

Characteristics of Rayleigh waves:

- Rayleigh waves are seismic surface waves which propagate near the earth surface.
- They include both longitudinal and transverse waves.
- Rayleigh waves move in an elliptical fashion, creating the rolling sensation of the ground.
- They cause both vertical and horizontal ground motion so they can be the most destructive waves.
- Their amplitude decreases with depth.
- They are dispersive in nature.



What can seismic waves tell us?

- Studies of the different types of seismic waves can tell us much about the nature of the Earth's structure.
- For example, seismologists can use **the direction** and **the difference** in the arrival times between P-waves and S-waves to determine the distance to the source of an earthquake.
- If the seismographs are too far away from the event to record S-waves, several recordings of P-waves can be crunched in a computer program to give an approximate location of the source.

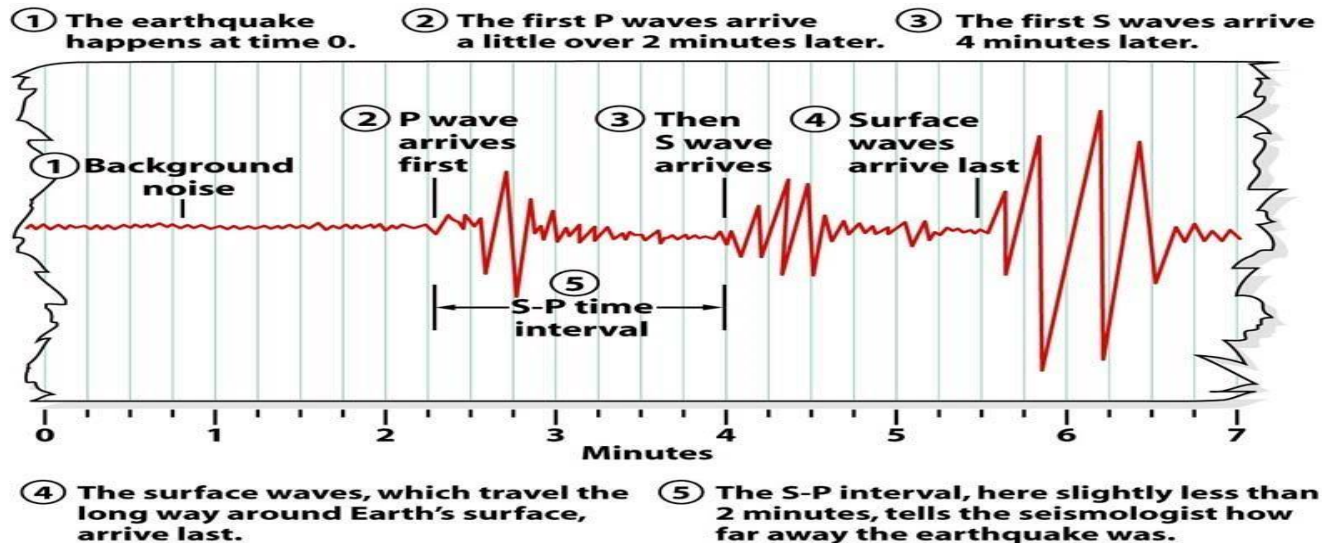


Fig.

Schematic illustration of average travel time of seismic waves recorded in seismograph

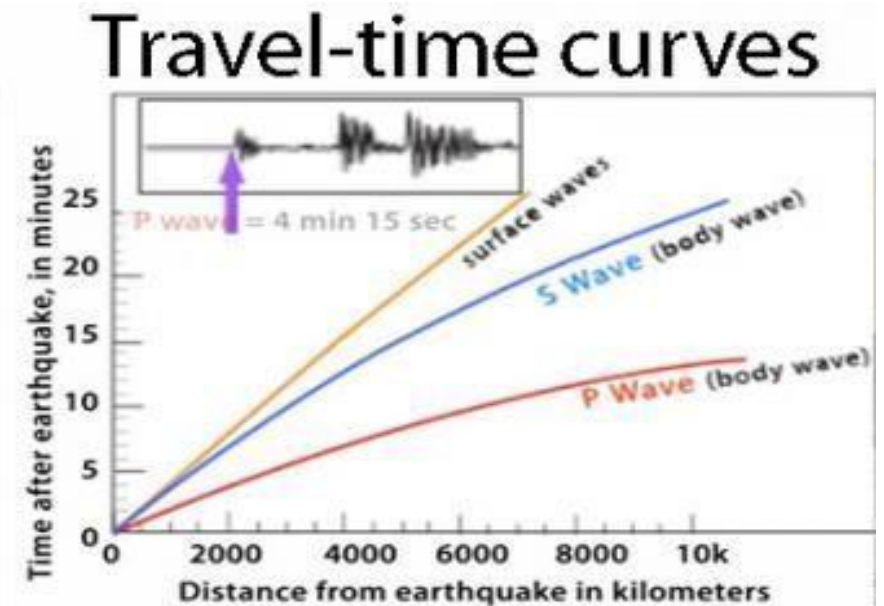


Fig.

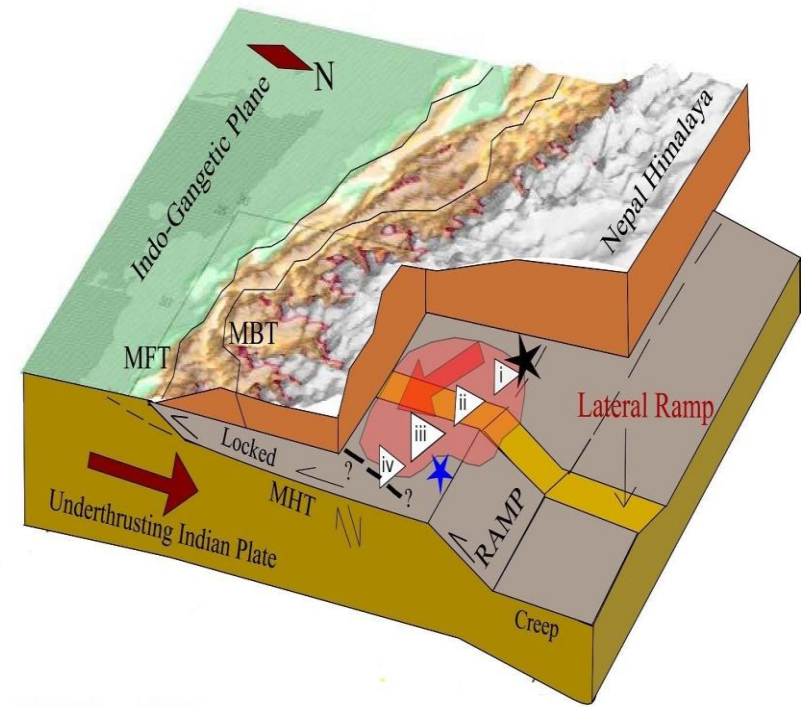
travelling time of seismic waves recorded in seismograph

Wave pattern of Gorkha earthquake 2015:

- Earthquake is one of the most dangerous natural phenomena that can cause large scale loss of life and property. **A massive earthquake occurred in Nepal on April 25, 2015 (Baisakh 12, 2072) at 11:56 AM (local time) which is known as Gorkha Earthquake.** About 10000 people were killed, many thousands more were injured and huge infrastructures in Kathmandu and nearby towns were either damaged or destroyed. Most casualties reported so far were in the Kathmandu valley where buildings have collapsed in densely populated areas, including historic buildings such as the Dharahara tower.
- **The magnitude of Gorkha earthquake was registered 7.8 on Richter scale and its epicenter was located in Gorkha District about 80 km northwest of Kathmandu and its hypocenter was about 15 km underground.** Two large **aftershocks, with magnitudes 6.6 and 6.7 shook the region within 24 hours** of the main quake and several dozen smaller aftershocks occurred in the region during the succeeding days.

The 2015 Gorkha earthquake **occurred by thrust faulting on a ~150 km long and ~70 km wide**, locked downdip segment of the **Main Himalayan Thrust (MHT)**, causing the Himalaya to slip SSW (south and southwest) over the Indian Plate, and was followed by major-to-moderate aftershocks.

The main-shock initiated ~80 km west of Katmandu, close to the locking line on the MHT and propagated eastwards along ~117° azimuth for a duration of ~70 s, with varying rupture velocity on a heterogeneous fault surface. The rupture initiated with a *Schematic block diagram depicting the fault slow buildup in the STF and then propagated rupture area and location off our sub events of the Gorkha at a velocity of ~3.5 kms⁻¹ earthquake in context of the ramp-flat-ramp geometry and lateral ramp on the MHT*



(Source:

Figure:

Geophysical Journal International, Volume 208, Issue2, February 2017, Pages9921008, <https://doi.org/10.1093/gji/ggw438>

Gravitational waves:

- Gravitational waves are '**ripples**' in **space-time** caused by some of the most violent and energetic processes in the Universe. Gravitational waves travel at the speed of light (186,000 miles per second). These waves squeeze and stretch anything in their path as they pass by. *Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity.*
- The strongest gravitational waves are produced by cataclysmic events such as colliding black holes, supernovae (massive stars exploding at the end of their lifetimes), and colliding neutron stars.
- Einstein predicted that something special happens when two bodies—such as planets or stars—orbit each other. He believed that this kind of movement could cause ripples in space. These ripples would spread out like the ripples in a pond when a stone is tossed in. Scientists call these ripples of space **gravitational waves**.
- In short, Gravitational waves are disturbances or ripples in the curvature of spacetime, generated by accelerated masses, that propagate as waves outward from their source at the speed of light.

Gravitational waves emitted by these events have to travel over a great distance to reach the earth so the energy is spread over a very large sphere whose radius is equal to the distance between emitter and earth. Therefore, however strong the gravitational waves at the source may be, we receive only a very weak signal at the earth, which makes the detection very weak and difficult.

Sources of Gravitational wave:

- Two objects orbiting each other, as a planet would orbit the Sun, *will radiate*.
- A spinning non-axisymmetric planetoid – say with a large bump or dimple on the equator – *will radiate*.
- A supernova *will radiate* except in the unlikely event that the explosion is perfectly symmetric.
- An isolated non-spinning solid object moving at a constant velocity *will not radiate*. This can be regarded as a consequence of the principle of conservation of linear momentum.
- A spinning disk *will not radiate*. This can be regarded as a consequence of the principle of conservation of angular momentum. However, it *will show gravitomagnetic effects*.

- A spherically pulsating spherical star (non-zero monopole moment or mass, but zero quadrupole moment) *will not radiate*

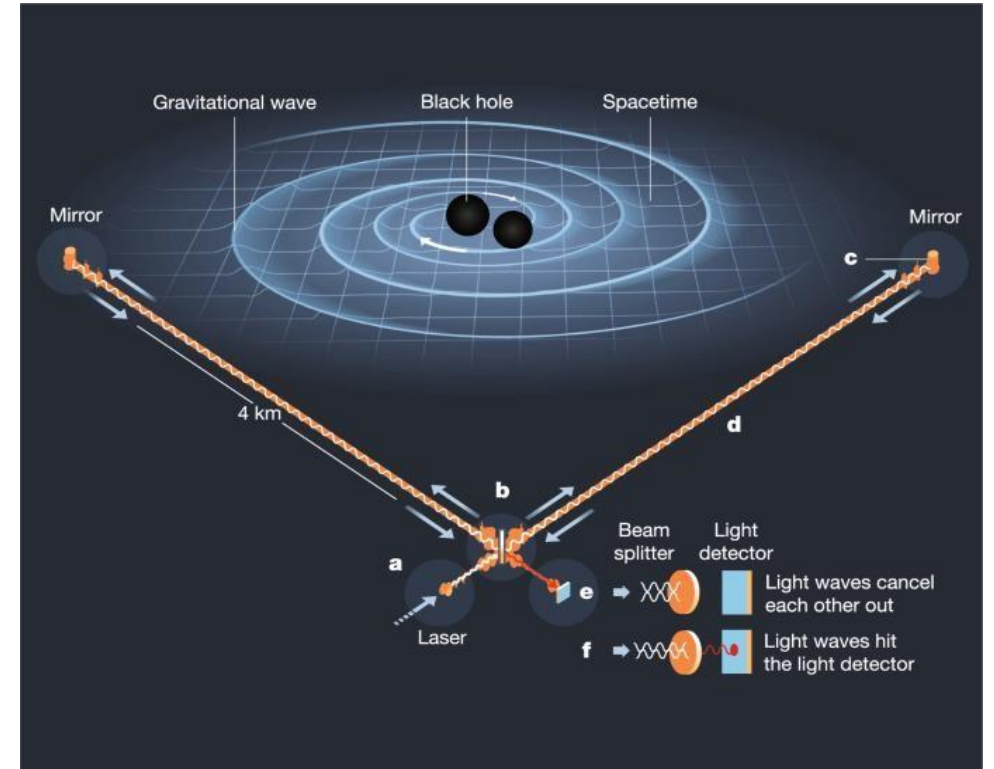
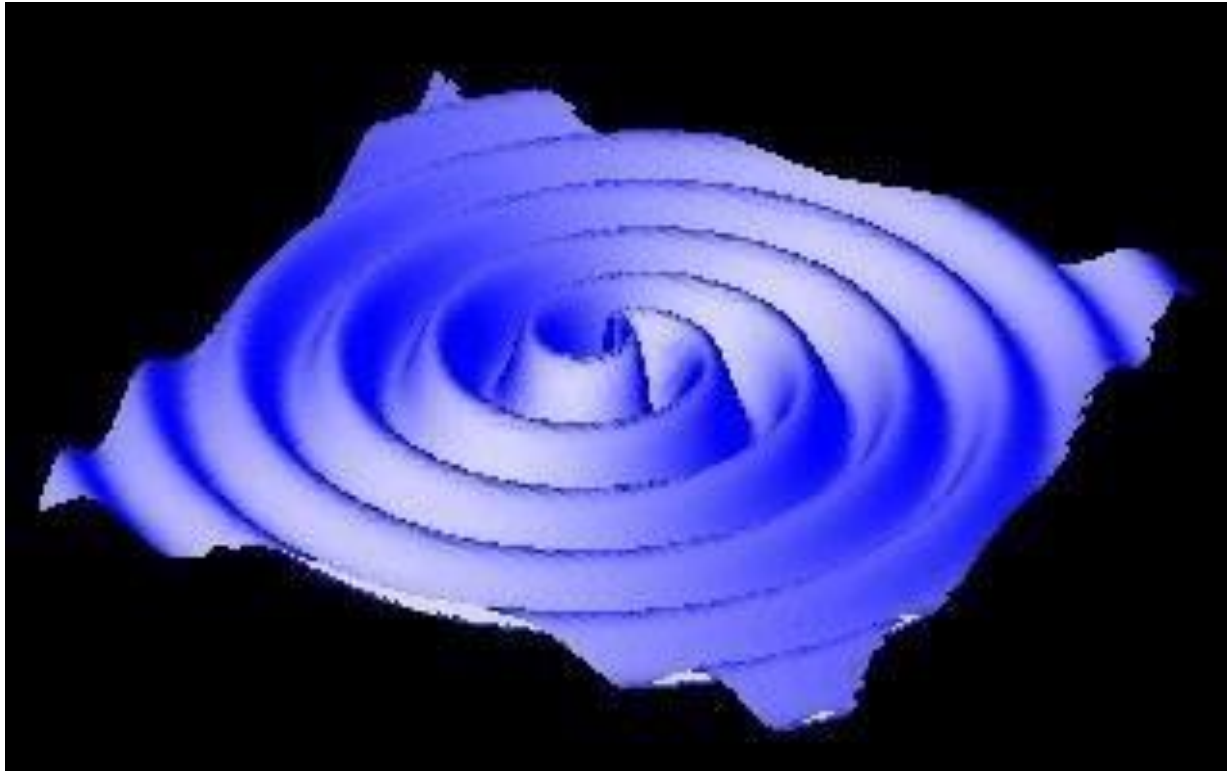


Fig. Two-dimensional representation of gravitational waves generated by two neutron stars orbiting each other.

Why they are important?

- Gravitational waves are providing a completely new avenue for looking at and understanding the universe around us. Detecting and analyzing the information carried by gravitational waves is **allowing us to observe the Universe in a way never before possible**, providing astronomers and other scientists with their first glimpses of literally un-seeable wonders.

Properties of gravitational waves:

- A powerful property is that universe is essentially transparent to them. This makes gravitational waves a unique messenger with which to observe the universe. There is nothing that can block the observation of a gravitational wave. **They are transverse waves.**
- **They show polarization like electromagnetic waves**
- They do not show reflection or refraction

Higgs boson:

- The **Higgs boson** is the fundamental particle associated with the Higgs field, a field that gives mass to other fundamental particles such as electrons and quarks. **A particle's mass determines how much it resists changing its speed or position when it encounters a force.**
- Not all fundamental particles have mass. The photon, which is the particle of light and carries the electromagnetic force, has no mass at all.
- The Higgs boson was proposed in 1964 by Peter Higgs, François Englert, and four theorists other to explain why certain particles have mass. Scientists confirmed its existence in 2012 through the ATLAS and CMS experiments at the Large Hadron Collider (LHC) at CERN in Switzerland. This discovery led to the 2013 Nobel Prize in Physics being awarded to Higgs and Englert.
- Scientists are now studying the characteristic properties of the Higgs boson to determine if it precisely matches the predictions of the Standard Model of particle physics. If the Higgs boson deviates from the model, it may provide clues to new particles that only interact with other Standard Model particles through the Higgs boson and thereby lead to new scientific discoveries.

Standard Model of Elementary Particles

three generations of matter (fermions)			interactions / force carriers (bosons)	
	I	II	III	
mass	$\approx 2.2 \text{ MeV}/c^2$	$\approx 1.28 \text{ GeV}/c^2$	$\approx 173.1 \text{ GeV}/c^2$	$\approx 124.97 \text{ GeV}/c^2$
charge	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0
spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	0
QUARKS	u up	c charm	t top	g gluon
	d down	s strange	b bottom	γ photon
	e electron	μ muon	τ tau	Z Z boson
LEPTONS	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson

GAUGE BOSONS
VECTOR BOSONS

SCALAR BOSONS

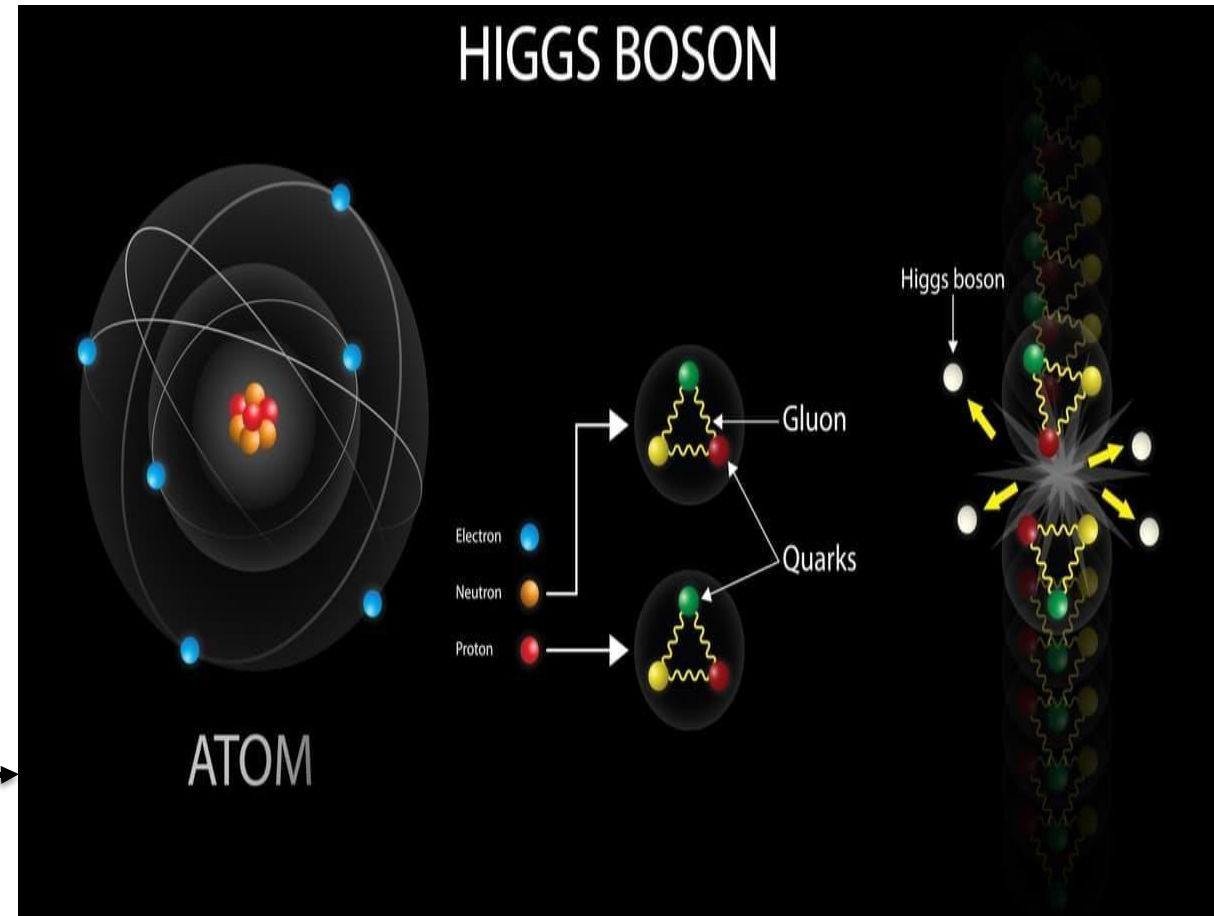


Figure. Standard model of Elementary particles

Higgs Boson Facts

- The Higgs boson gets its mass just like other particles—from its own interactions with the Higgs field.
- There may be more than one Higgs boson. One theoretical model of new physics predicts five Higgs bosons.

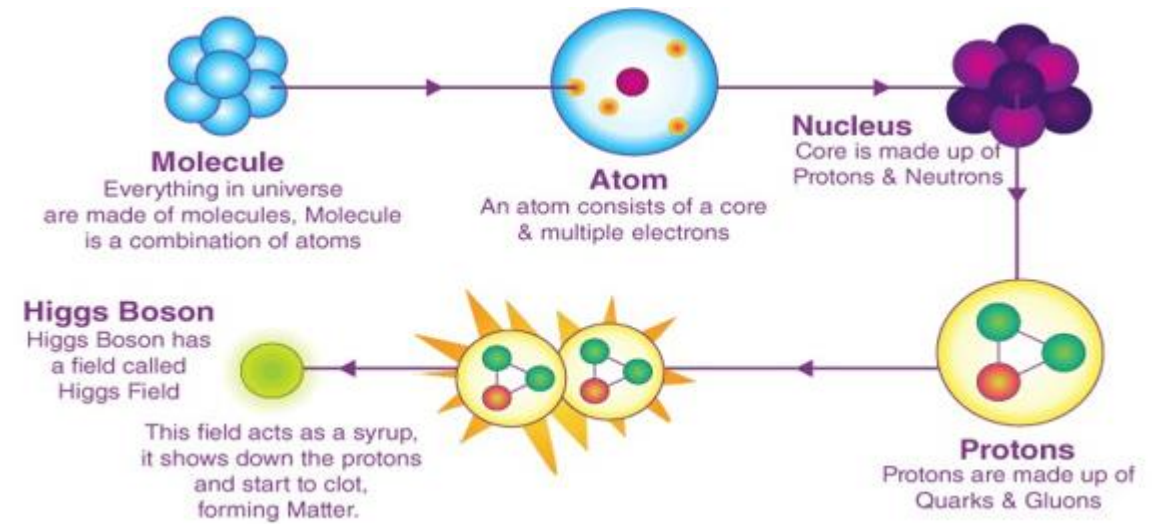
- **Fundamental particles in our universe acquire mass through their interactions with the Higgs field.**
- **The Higgs boson can be a unique portal to finding signs of dark matter due to its own distinctive characteristics and properties.**
- **Higgs boson decays into other particles. It typically decays into quarks, but it's also been found to decay into a completely different class of particle called muons. This is a strong indication that muons, like quarks, really do get their mass via the Higgs mechanism.**
- **Higgs boson are the quanta of Higgs field just like photons are the quanta of electromagnetic field.**
- **They are called “god particles” because their existence is fundamental to the creation of the universe.**
- **As soon as they are formed, they turn into other particles. So, they are highly unstable.**
- **They are chargeless having zero spin.**

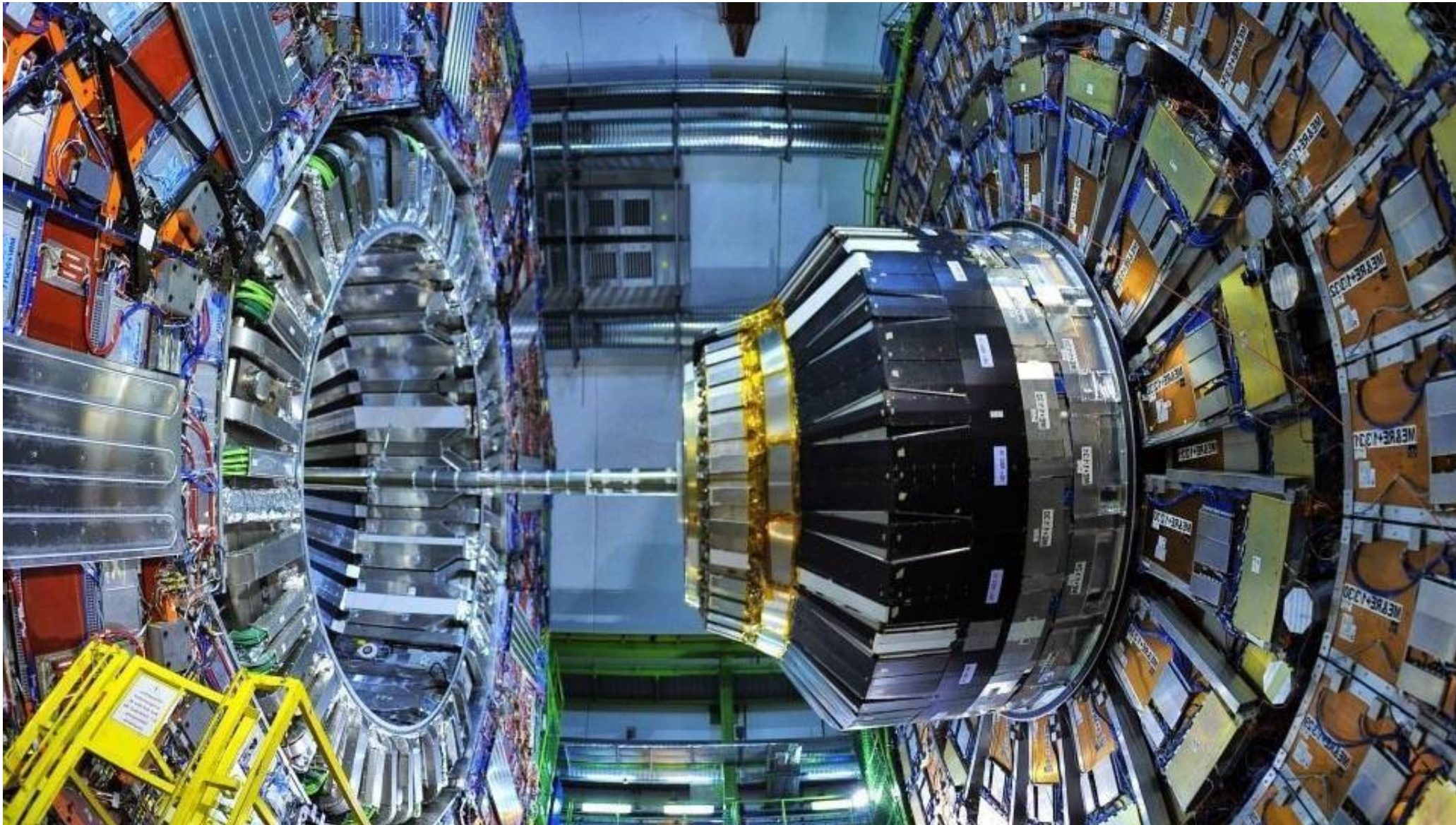
*The nickname “God particle” originated from a book by Nobel laureate **Leon Lederman**.*

Physicist Leon Lederman unwittingly gave the Higgs boson what may be its most-disliked descriptor with the title of his book, *The God Particle*

Lederman likes to joke that he actually wanted to call the Higgs boson the "**goddamn particle**" because it's so darned difficult to find.

The nickname makes for attention-grabbing headlines, but it also makes most particle physicists cringe.





Large Hadron Collider (LHC) in CERN (Switzerland) Where the Observations and Demonstrations on Higgs Boson were carried out.

Nanotechnology:

- Nanotechnology involves research and technology development at the atomic, molecular or macromolecular levels in the range of approximately **1-100 nanometers** to provide fundamental understanding of phenomena and materials at the nanoscale. The nanometer scale is about a billionth of a meter. In comparison, a human hair is about 10,000 nanometers in diameter.
- Basically, nanotechnology is used to create structures, devices and systems that have novel properties and functions because of their minute size.
- Actually, the **matter shows unusual physical and chemical properties due to increase in surface area compared to volume as particles get smaller in size & this is called quantum size effect**. This means **the bulk properties of materials at nanoscale can be very different from those at larger scale**. Taking the advantage of these characteristic of material, scientist designs and produces devices by manipulating the shape and size at nano scale with wide-range of implications which could include medicine, electronics, military applications, computing, space science and many more.

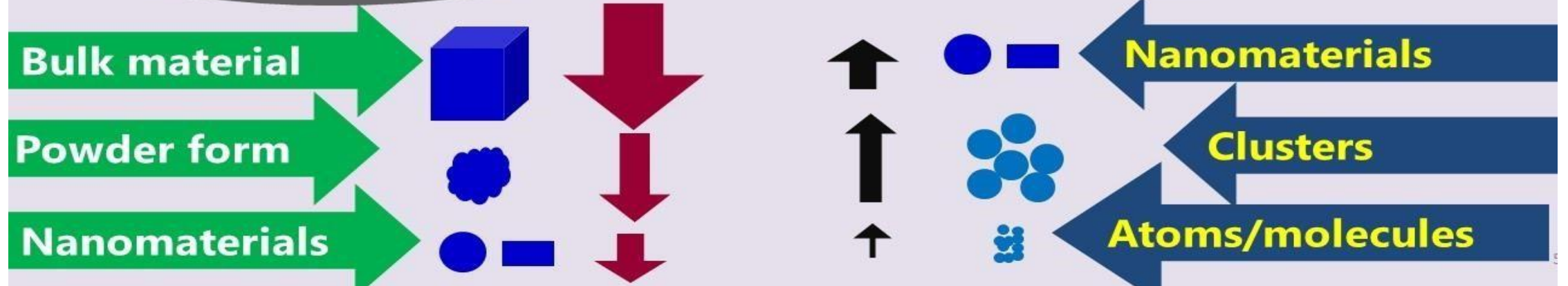
Nanomaterial's synthesis

Top- down Approach

Top- down Approach is referred as **Physical Methods**.

Bottom- up Approach

Bottom- up Approach is referred as **Physical & Chemical Methods**.



Properties of nanomaterials:

- Opaque materials become transparent. for example: gold, copper etc.
- Reactivity increases/ they are chemically very reactive
- These materials are exceptionally strong, hard ductile at high temperature
- Insulators become conductors

Uses/applications of nanotechnology:

Nanotechnology is used

- in food preservation
- for preserving death body
- in electronics to make p-n diodes, transistors, IC's, quantum computer
- to construct nano wires or tubes, applicable in optical communication
- Nanoparticles are used in medicine as diagnosis, drug delivery and treatment of various types of diseases.
- Nanoparticles are used to clean industrial water pollutants in ground through chemical reaction

Property	Applications
High surface-to-volume ratio	Catalysis, solar veils, and gas sensors
Low percolation threshold	Conductive materials and sensors
Increasing hardness/wear resistance with decreasing grain size	Hard coatings and protective layers
Increasing resistivity with decreasing grain size	Electronics, passive components, and sensors
Improved atomic transport kinetics	Batteries and hydrogen storage
Low melting and sintering temperatures	Materials processing and low-temperature sintering materials
Improved reliability and fatigue resistance	Electronic components and MEMS

Multiple Choice Questions

1. The energy in the form of seismic waves is radiated in all direction from the source, also known as
a. Fault **b. Hypocenter** c. Epicentre d. Rapture
2. Which is not a seismic wave?
a. Primary (P) wave b. Secondary (S) wave c. Love wave **d. Hate wave**
3. The point on the earth's surface directly above the focus is known as
a. Fault b. Hypocenter **c. Epicentre** d. Rapture
4. Nanotechnology is the study of matter of dimensions
a. 0.01 to 1.0 nm **b. 1 to 100 nm** c. 1 to 100 m d. 1 to 100 μm
5. Which is not a Nano technological approach for production of new materials?
a. Top-down approach b. Bottom-up approach. Sideways approach d. Self-assembly approach
6. The theory that classifies all the known elementary particles is called
a. Standard Model b. Sub-standard model c. High-standard model d. Particle model 7.
7. Which of the following is not the magnitude scale of an earthquake?
a. Local magnitude (ML) **b. Universal magnitude (Mu)** c. Body-wave magnitude (Mb) d. moment magnitude (Mw)
8. The Higgs boson is the carrier particle of the
a. Gravitational field b. Electric field c. Magnetic field **d. Higgs field**

Thank you!