

# Outer Space Treaty

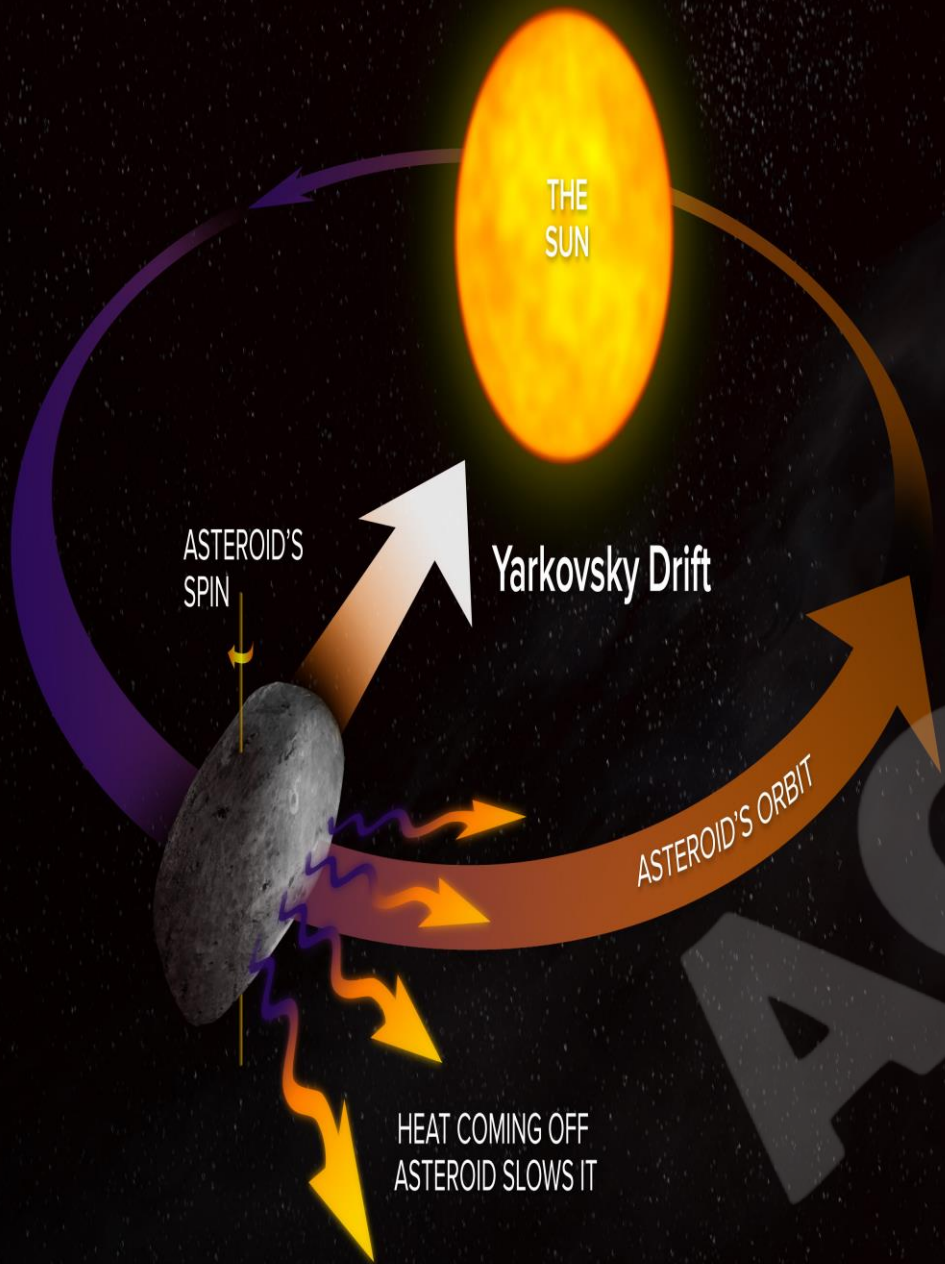
- The Outer Space Treaty was considered by the Legal Subcommittee in 1966 and agreement was reached in the General Assembly in the same year
- The Outer Space Treaty provides the basic framework on international space law, including the following principles:
  - the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind;
  - outer space shall be free for exploration and use by all States;
  - outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means;

- States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner;
- the Moon and other celestial bodies shall be used exclusively for peaceful purposes;
- astronauts shall be regarded as the envoys of mankind;
- States shall be responsible for national space activities whether carried out by governmental or non-governmental entities;
- States shall be liable for damage caused by their space objects; and
- States shall avoid harmful contamination of space and celestial bodies.

# Open Skies Treaty

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- Signed March 24, 1992, the Open Skies Treaty permits each state-party to conduct short-notice, unarmed, reconnaissance flights over the others' entire territories to collect data on military forces and activities.
- Observation aircraft used to fly the missions must be equipped with sensors that enable the observing party to identify significant military equipment, such as artillery, fighter aircraft, and armored combat vehicles.
- Though satellites can provide the same, and even more detailed, information, not all of the treaty states-parties have such capabilities. The treaty is also aimed at building confidence and familiarity among states-parties through their participation in the overflights.



## Yarkovsky effect

Rotating asteroids have a tough time sticking to their orbits. Their surfaces heat up during the day and cool down at night, giving off radiation that can act as a sort of mini-thruster. This force, called the Yarkovsky effect, can cause rotating asteroids to drift widely over time, making it hard for scientists to predict their long-term risk to Earth.

. In order to learn more about this process on asteroid Bennu, NASA is sending a spacecraft called OSIRIS-REx to make detailed observations of Bennu's shape, brightness, and surface features.

These factors are thought to influence the Yarkovsky effect, and understanding how will enable scientists to better predict the orbit of Bennu and other near-Earth asteroid

# What are gravitational waves?

Just as waves in a pond are created by disturbances in the water, gravitational waves are created by disturbances in the fabric of spacetime.

1

Black hole

Spacetime



1. A black hole by itself makes a deep dent in the fabric of spacetime, but it doesn't throw out any gravitational waves.

2. Here are two black holes orbiting each other (binary system). As they whiz around each other so quickly that, instead of just making a dent in spacetime, they plough up waves (like when you stir water with your finger) – these are gravitational waves.

But it takes energy to create gravitational waves and, with each orbit, the pair lose energy, which is carried away by the gravitational waves. As they lose energy, their orbits will begin to shrink. Eventually, it will shrink so much that the black holes will crash together.

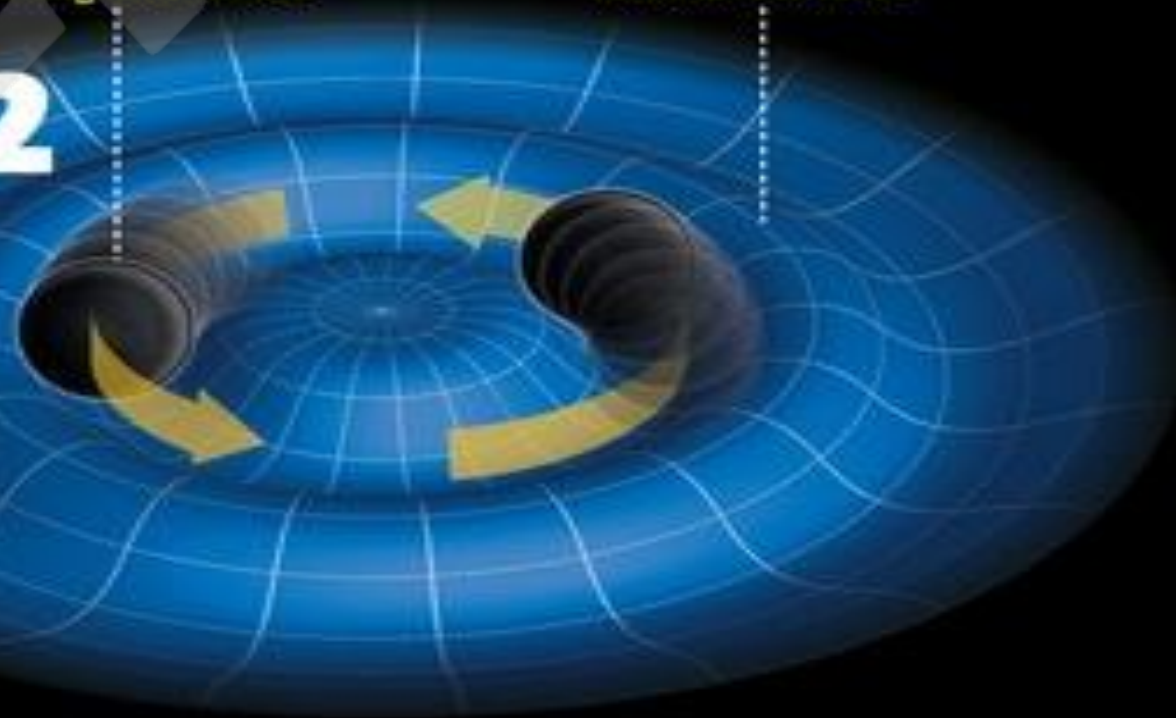
Lots of things can create gravitational waves, but most are too weak to us to measure. Luckily, because black holes distort spacetime so much, they can create waves that we can detect here on Earth.

Black holes are the collapsed remains of a star many times more massive than our Sun. When the star dies, its core collapses under the gravitational force of its own mass.

Orbiting black holes

Gravitational wave

2



# Nobel prize for detection of gravitational waves

US astrophysicists Barry Barish, Kip Thorne and Rainer Weiss awarded prize for discovery that opens a window on the universe

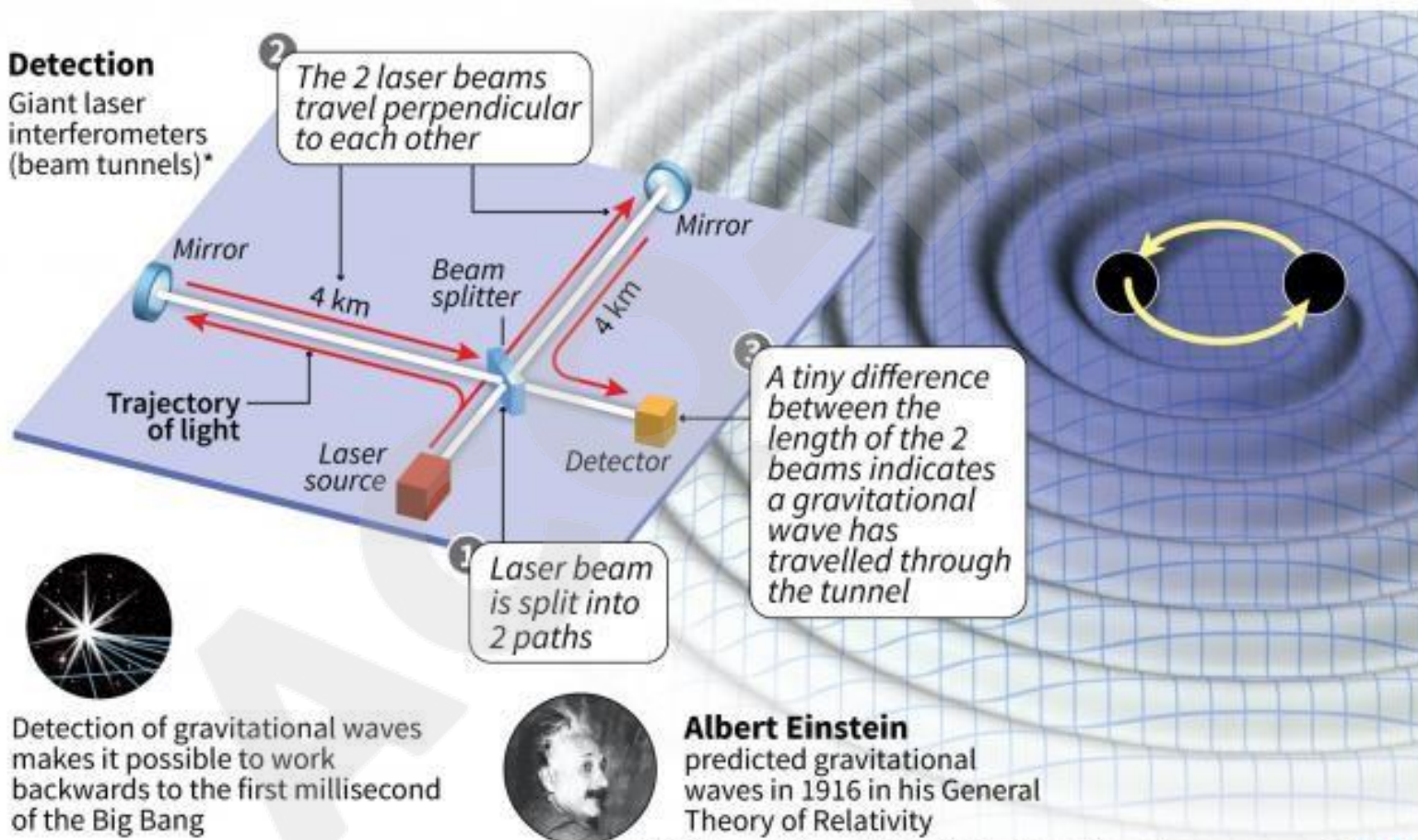
▶ Waves first detected on Sept 14, 2015

▶ Origin: fusion of 2 black holes, 1.3 billion years ago



## Detection

Giant laser interferometers (beam tunnels)\*



Detection of gravitational waves makes it possible to work backwards to the first millisecond of the Big Bang



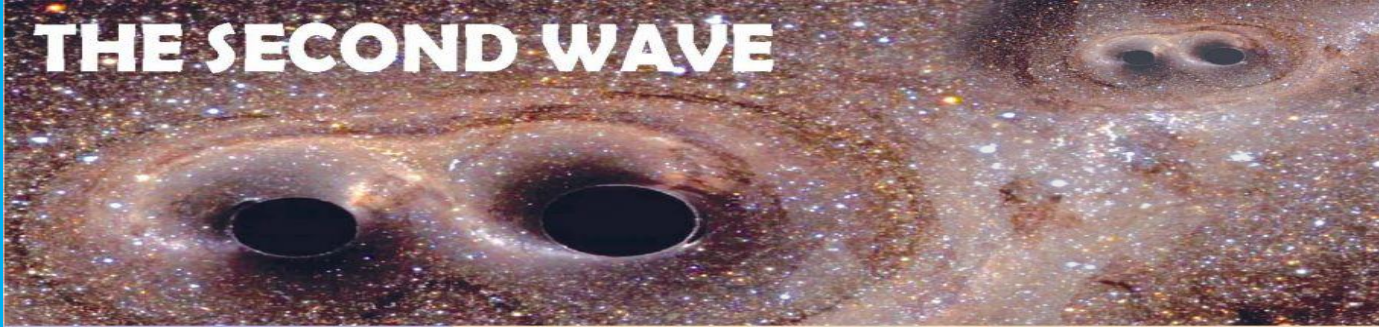
**Albert Einstein** predicted gravitational waves in 1916 in his General Theory of Relativity

Sources: LIGO, Nature, CNRS

\*LIGO: Laser Interferometer Gravitational Wave Observatory

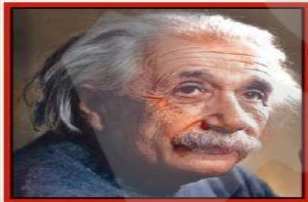
- When 2 black holes merge, it will radiate GW. GW are 'ripples' in the fabric of space-time caused by some of the most violent and energetic processes in the Universe.
- They are extremely weak so are very difficult to detect.
- Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity.
- These ripples travel at the speed of light without being scattered significantly.

# THE SECOND WAVE



## EINSTEIN'S THEORY

*Einstein predicted the existence of the waves in his theory of relativity a century ago, and scientists have been able to detect them with an instrument known as the Laser Interferometer Gravitational-Wave Observatory, or LIGO*



## GRAVITATIONAL WAVES

Black holes form in the final stage of most massive stars' evolution. The space bodies are so dense that neither light nor matter can escape them.

**Sometimes the holes** couple, orbiting in a 'dance' around each other as they lose energy in the form of gravitational waves, ultimately merging into a single black hole

**Those gravitational waves** allow scientists to detect when the black holes merge

## THE FIRST DETECTION

The first detection of waves— in September

2015 —was announced in February 2016, in a landmark discovery for physics and astronomy after decades of efforts

## THE NEW WAVE

Researchers announced they had found the waves a second time in December 2015, produced by the collision of two black holes some 1.4 billion years ago.

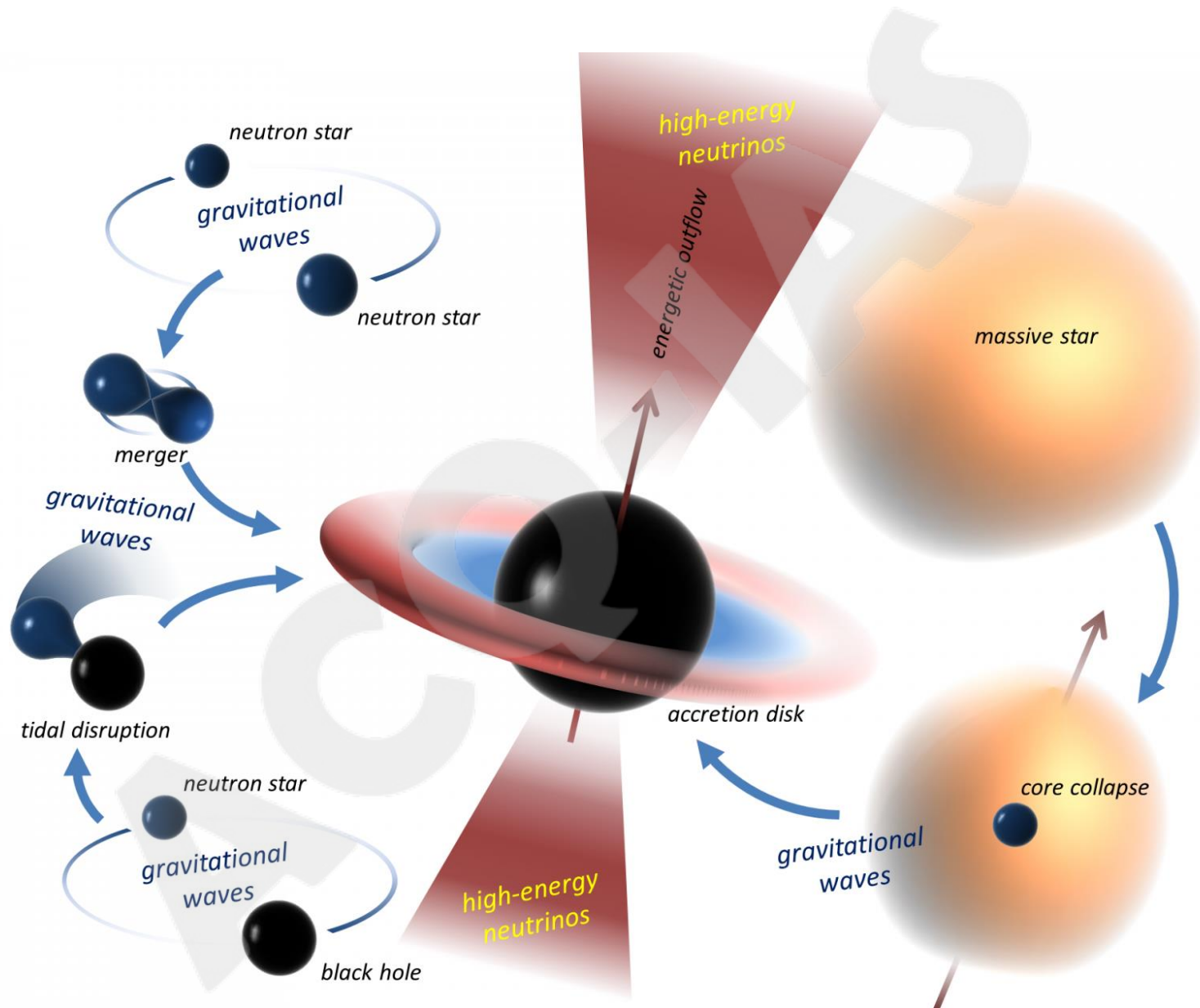
## SIZE OF BLACKHOLE

It is very significant that these black holes were much less massive than those in the first detection. It is a promising start to mapping the populations of black holes in our universe.

**WHAT IS LIGO?** The Laser Interferometer Gravitational-Wave Observatory (LIGO) consists of two identical detectors 3,000 km apart — one in Livingston, Louisiana and the other in Hanford, Washington

# Sources of Gravitational waves

- Mergers of black holes or neutron stars, rapidly rotating neutron stars, supernova explosions and the remnants of the disturbance caused by the formation of the universe, the Big Bang itself, are the strongest sources.
- There can be many other sources, but these are likely to be too weak to detect.
- Scientists have for the first time detected gravitational waves produced by the collision of a neutron star and a black hole.
- This finding confirms that there are neutron star-black hole systems and will help answer many questions about the cosmos, from star formation to the expansion rate of our universe.



- **Interferometer**

- It is an instrument that uses interference patterns formed by waves (usually light, radio, or sound waves) to measure certain characteristics of the waves themselves or of materials that reflect, refract, or transmit the waves.
- Interferometers can also be used to make precise measurements of distance.
- Interference patterns are produced when two identical series of waves are brought together.

# Laser Interferometer Gravitational Wave Observatory (LIGO)

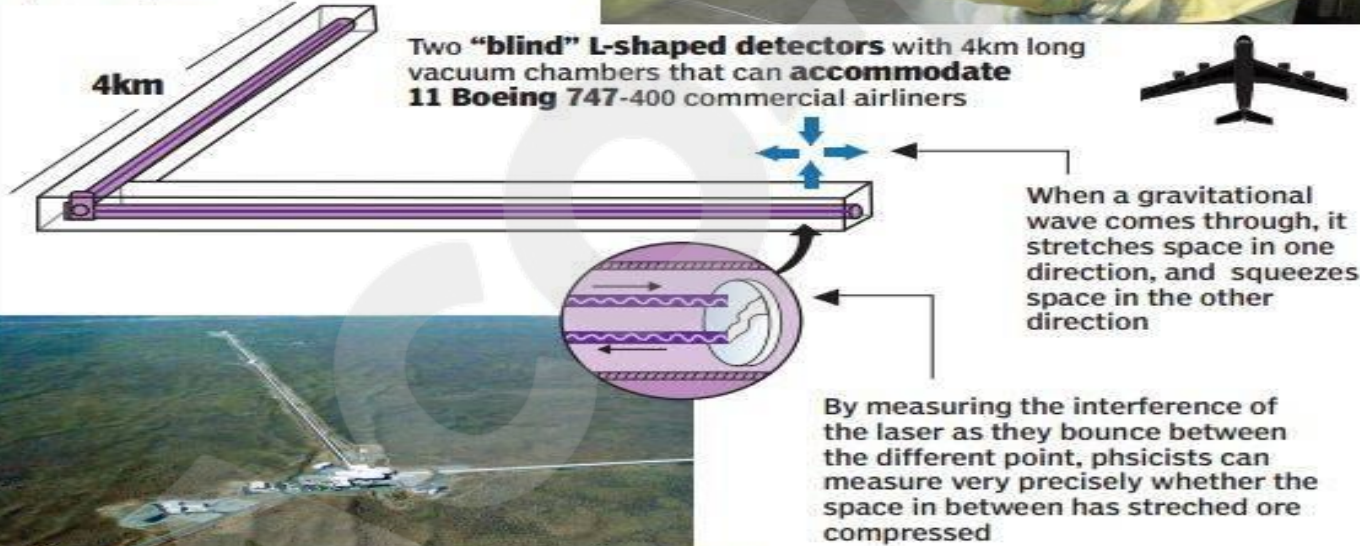
- It is the world's largest gravitational wave observatory and a wonder of precision engineering.
- It comprises of two enormous laser interferometers located thousands of kilometres apart, each having two arms which are 4 km long. The detectors are in (Livingston) Louisiana and (Hanford) Washington.
- It exploits the physical properties of light and of space itself to detect and understand the origins of Gravitational Waves (GW). Upgraded version is called Advanced LIGO.
- The Japanese detector, KAGRA, or Kamioka Gravitational-wave Detector, is expected to join the international network soon.
- LIGO detectors: Unlike optical or radio telescopes, it does not see electromagnetic radiation

## WHAT IS LIGO?

The advanced Laser Interferometer Gravitational Wave Observatory (or LIGO) is at the centre of the path-breaking find:

**The LIGO experiment is an example of extreme engineering chasing an impossible dream**

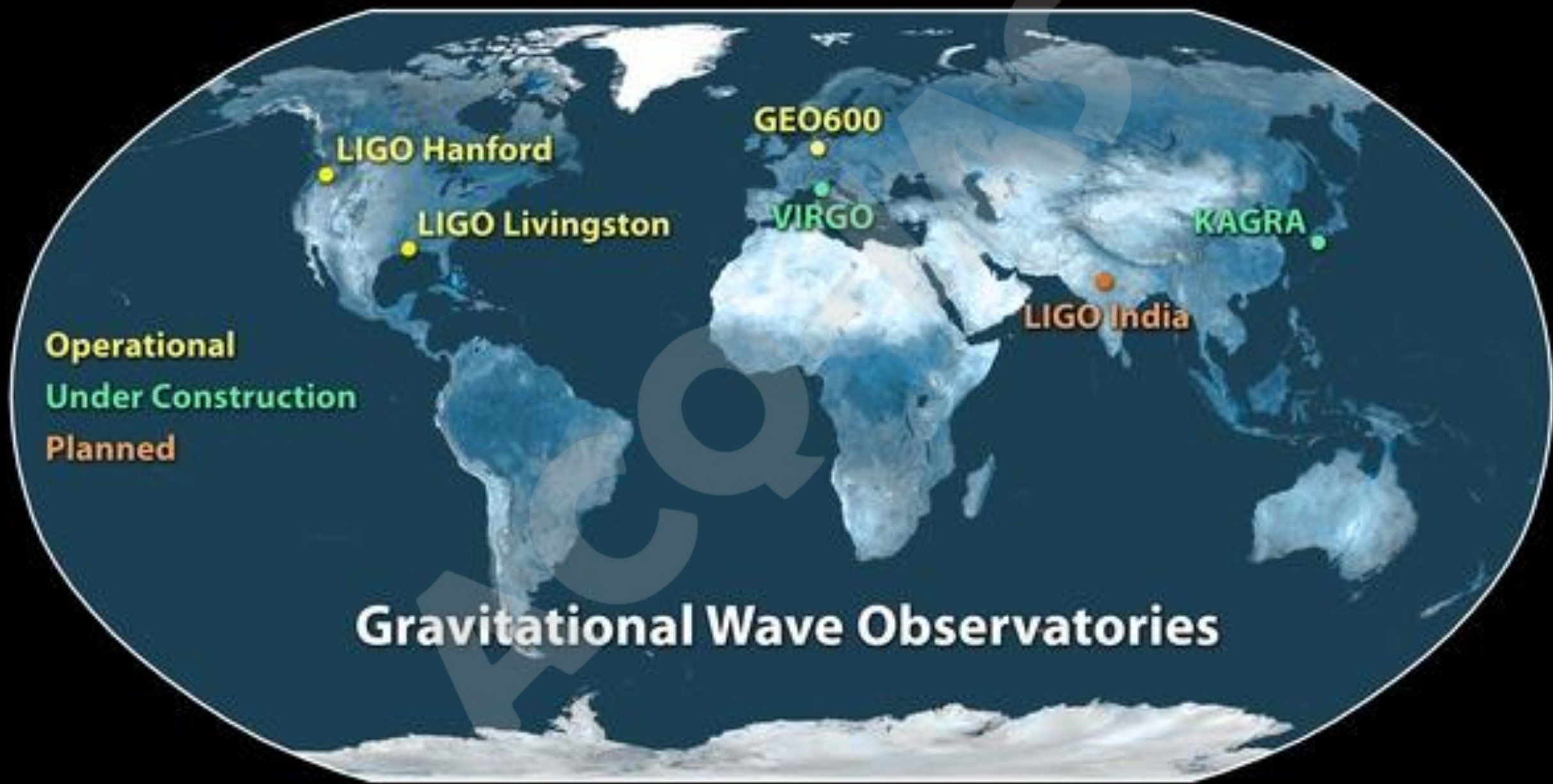
The twin LIGO installations – one in Livingston, Louisiana, and the other in Hanford, Washington – are located 3,000km apart



- Built **3,000km** apart, operating in unison
- To make the smallest measurement ever attempted by science – **a motion 10,000 times smaller than an atomic nucleus**
- Caused by the most violent and cataclysmic events in the Universe occurring millions of light years away
- Can detect gravitational waves in a volume of 1 billion cubic light years – **covering about 1 million Milky Way type galaxies**

- To detect a gravitational wave we should be able to tell when something changes in length by a few parts in 10 to the power 23
- LIGO makes the smallest measurement ever attempted – **a motion 10,000 times smaller than an atomic nucleus**
- It's like trying to hear a song being hummed in a very, very noisy party





**Operational**

**Under Construction**

**Planned**

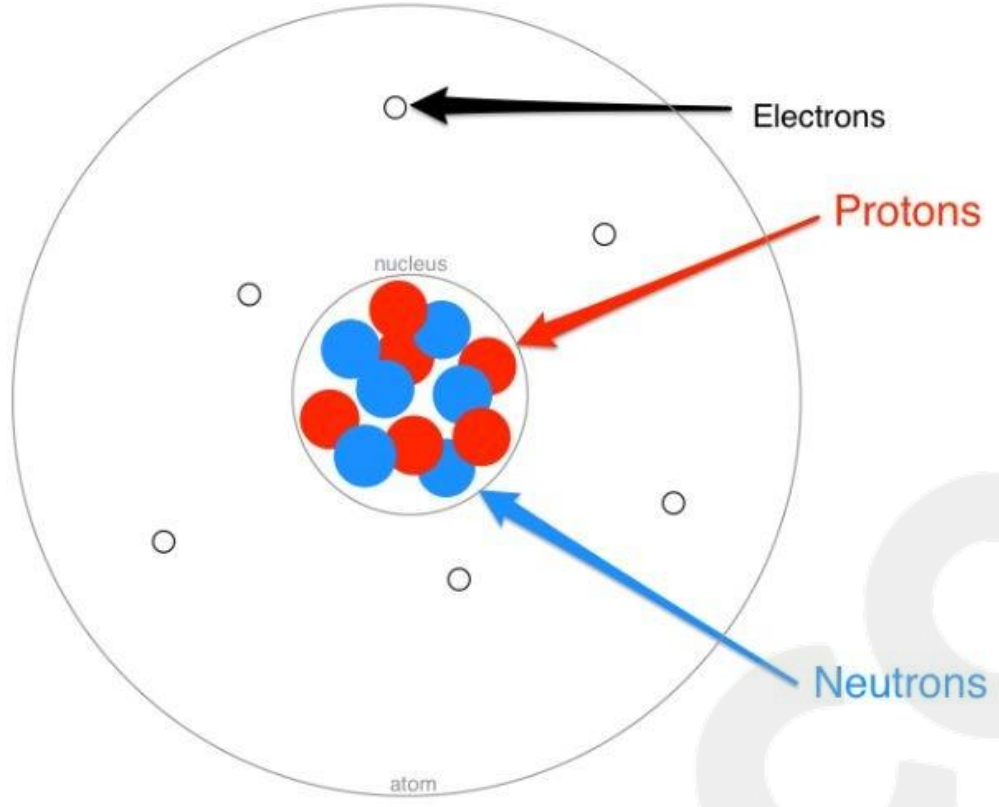
# Gravitational Wave Observatories

- **IndIGO (India Initiative of GW Observations) in Hingoli district, Maharashtra.**
- The proposed LIGO-India project aims to move one Advanced LIGO detector from Hanford to India.
- LIGO-India project is envisaged as an international collaboration between the LIGO Laboratory and 3 lead institutions in the IndIGO consortium: Institute of Plasma Research (IPR) Gandhinagar, Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune and Raja Ramanna Centre for Advanced Technology (RRCAT), Indore.

- **Significance of IndiGo Project**

- To locate the source of gravitational waves more accurately.
- Identification of new sources.
- The project will help Indian scientific community to be a major player in the emerging research frontier of GW astronomy.
- The high-end engineering requirements of the project (such as the world's largest ultra-high vacuum facility) will provide unprecedented opportunities for Indian industries in collaboration with academic research institutions.
- A cutting edge project in India can serve as a local focus to interest and inspire students and young scientists.

# Atomic Structure Schematic



ACQ-1AS

# What's a neutrino?

- It's one of the fundamental particles.
- Neutrinos have no charge at all.
- Neutrinos are also incredibly small and light
- They have some mass, but not much.
- They are the lightest of all the subatomic particles that have mass

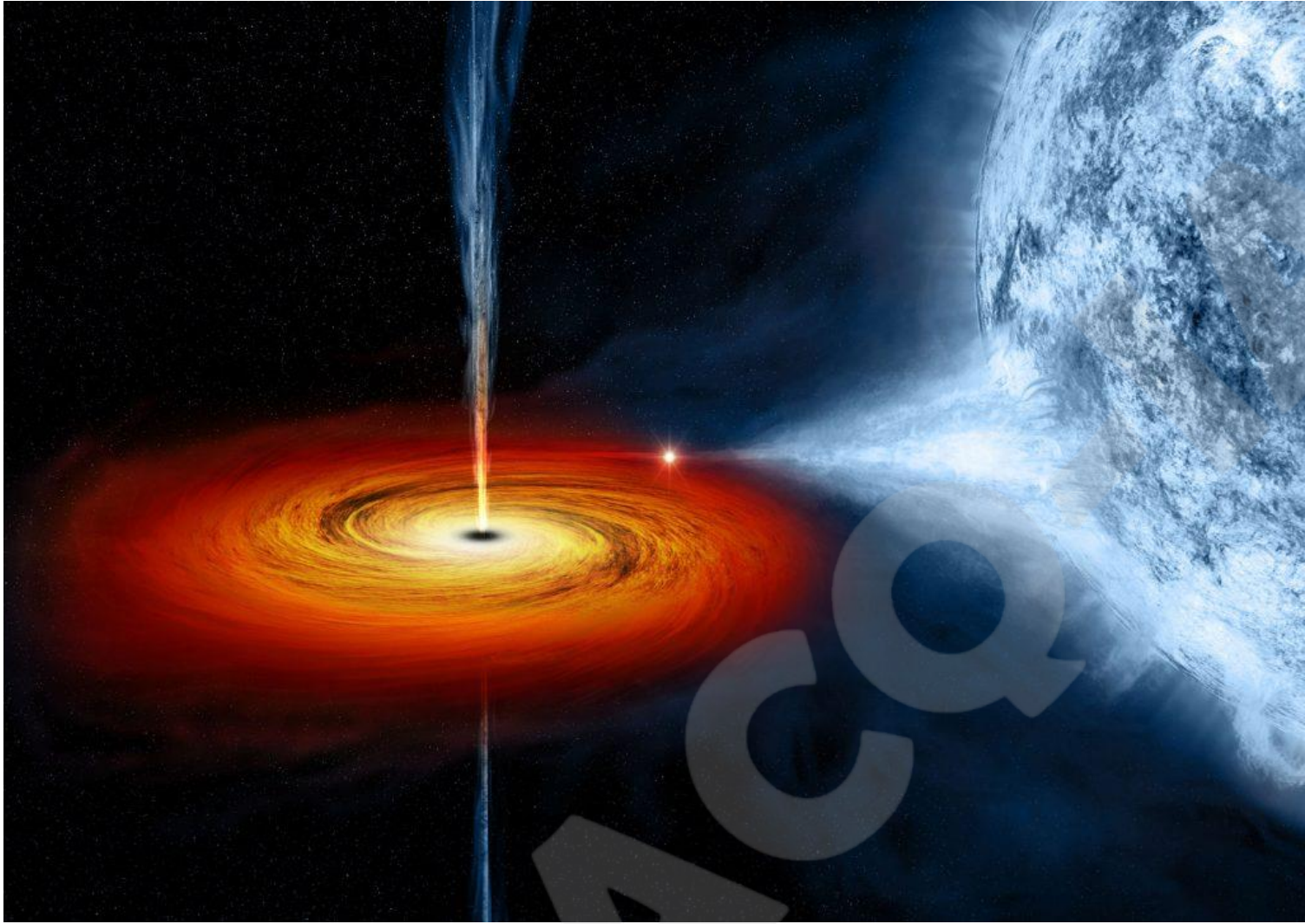
# Neutrinos

- Neutrinos was 1st proposed by Swiss scientist Wolfgang Pauli in 1930.
- It is the 2nd most widely occurring particle in the Universe, after Photons (the particle which makes up light).
- Neutrinos are so abundant among us that every second there are  
> 100 trillion of them passing right through each of us.

Most neutrinos will pass through Earth without interacting at all

# Sources of Neutrinos

- Accelerators
- Reactors
- Earth
- The sun
- The Big Bang
- The atmosphere
- Supernovae



# Properties of Neutrinos

- They are subatomic particles different from Neutrons. No charge.
- In 2015, Nobel Prize given to Takaaki Kajita and Arthur McDonald for discovering Neutrino Oscillations demonstrating that Neutrinos have mass (tiny mass).
- Not affected by electromagnetic forces which act on electrons.
- Neutrinos occur in 3 different types. They are separated in terms of different masses.
- They are least harmful of all as they almost never react with solid bodies.

# Significance

- They hold answers to fundamental questions on the origin of the Universe.
- Another application is in the area of neutrino tomograph of the earth (investigation of the structure of the Earth from Core).
- It can also be used for communication.
- It can be used to detect nuclear leakages and disasters.
- It can be used to detect oil reserves.
- It can detect nuke explosion, disaster Ex Japan as their speed > seismic waves.

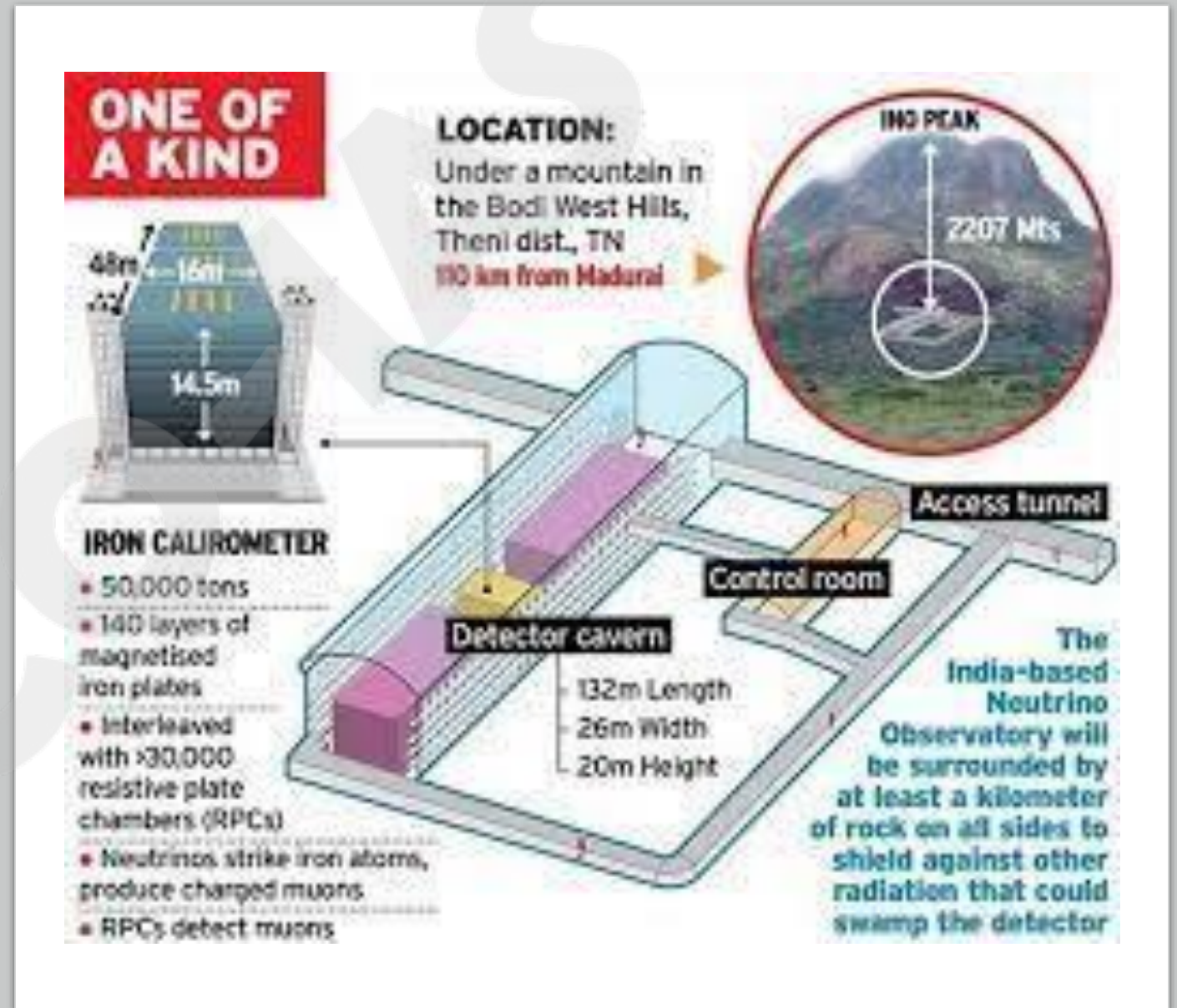
# Indian Neutrino Observatory

- It is a mega-science project jointly funded by the Department of Atomic Energy (DAE) & Department of Science and Technology (DST)
- It is a particle physics research project under construction to primarily study atmospheric neutrinos.



# Why is the laboratory underground?

- They are difficult to detect in the laboratory because of their extremely weak interaction with matter. Plus, cosmic rays (interact more than neutrinos) and natural radioactivity can make it impossible to detect on the Earth surface.
- Hence the observatories are located deep inside the Earth surface.



# Tamil Nadu says 'no' in Supreme Court to neutrino observatory project



The Hindu Bureau

NEW DELHI FEBRUARY 17, 2022 19:33 IST

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Indian Neutrino Observatory site at Pottipuram. File | Photo Credit: The Hindu

# A MATTER OF IMPORTANCE



## WHAT IS A NEUTRINO?

- > A sub-atomic particle, like an electron, which has a very small mass
- > One of the abundant particles in the universe, neutrinos have little interaction with matter and are thus difficult to detect



- > Trillions of neutrinos pass through the earth every second, not affected by its magnetic field

**NO HOPE:** Villagers who eke out a livelihood from livestock rearing fear they may lose their pastures once the project kick-starts

### WHAT IS INDIA-BASED NEUTRINO OBSERVATORY (INO) PROJECT ABOUT?

> A project that aims to build a world-class underground laboratory with a rock cover of approx. 1200m for non-accelerator based high energy and nuclear physics research in India

#### Will consist of:

An underground lab at Pottipuram in Bodi West Hills, a 50,000 ton Iron Calorimeter (ICAL) detector for studying neutrinos and a National Centre for High Energy Physics at Madurai

### OBJECTIVES

> First phase will study natural neutrinos; second phase will study factory-made neutrinos from USA, Europe, Japan and Antarctica

> The ICAL detector will help determine neutrino masses and mixing parameters



### LAB FACTS

> As laboratory cavern needs to be more than **1000m** underground (to reduce natural cosmic radiation and filter neutrinos), Bodi Hills was chosen for the project as it is made of Chamockite rocks, the hardest rock known

> The lab at Pottipuram will be set up by **blasting 10L tons** of rocks using explosives

Project will need **3,50,000 litres** water per day

## RIISING APPREHENSIONS

### Locals and activists fear that:

> The project will deteriorate the condition of ecologically fragile Western Ghats

> Blasts during setting up the project will affect dams like Mullaperiyar, Vaigai, Idukki and Megamalai situated in the watershed area of river Vaigai

> Dust generated during tunnelling will settle on the agriculture land, making it barren

### Officials answer:

> Idukki and Mullaperiyar dams are too far away to be affected

> Tunnelling is a routine activity common in TN and not akin to blasting in quarries; the controlled blasting (two or three times per day) will last only a few seconds

> Waste generated from tunnelling would be dealt with within the site; no radioactive material will be used at INO lab



# World Projects

- Underground Observatories
- Neutrino Oscillation was established by Sudbury Neutrino Observatory, Canada and Super Kamiokande experiment in Japan. They studies solar neutrinos, atmospheric neutrinos and man made neutrinos.
- It is also at Gran Sasso, Italy.
- Underwater Observatory: Amundsen, Antarctica and Antares - Mediterranean Sea, France.
- Icecube = World's largest Neutrino Telescope - made from giant cube of ice at South Pole, Antarctica. It aims at detecting subatomic particles travelling near the speed of light. It also detects Dark matter. It is buried deep in ice.

Q) Which of the following is the source of Neutrinos?

A) Nuclear Reactor

B) Sun

C) Black hole

D) All

Q) Indian Neutrino Observatory will be located underground under a Hill because:

- a) To Access more Neutrinos coming from earth
- b) Outside Neutrinos cannot Pass through Hill
- c) To Limited disturbance from Other Radiation
- d) To Provide safety for people

Q) Which of the following are the probable applications of Neutrons:

- a) Earthquake Detection
- b) Probing the early universe
- c) Detecting nuclear weapons
- d) Global communication



# Indian Missile Systems

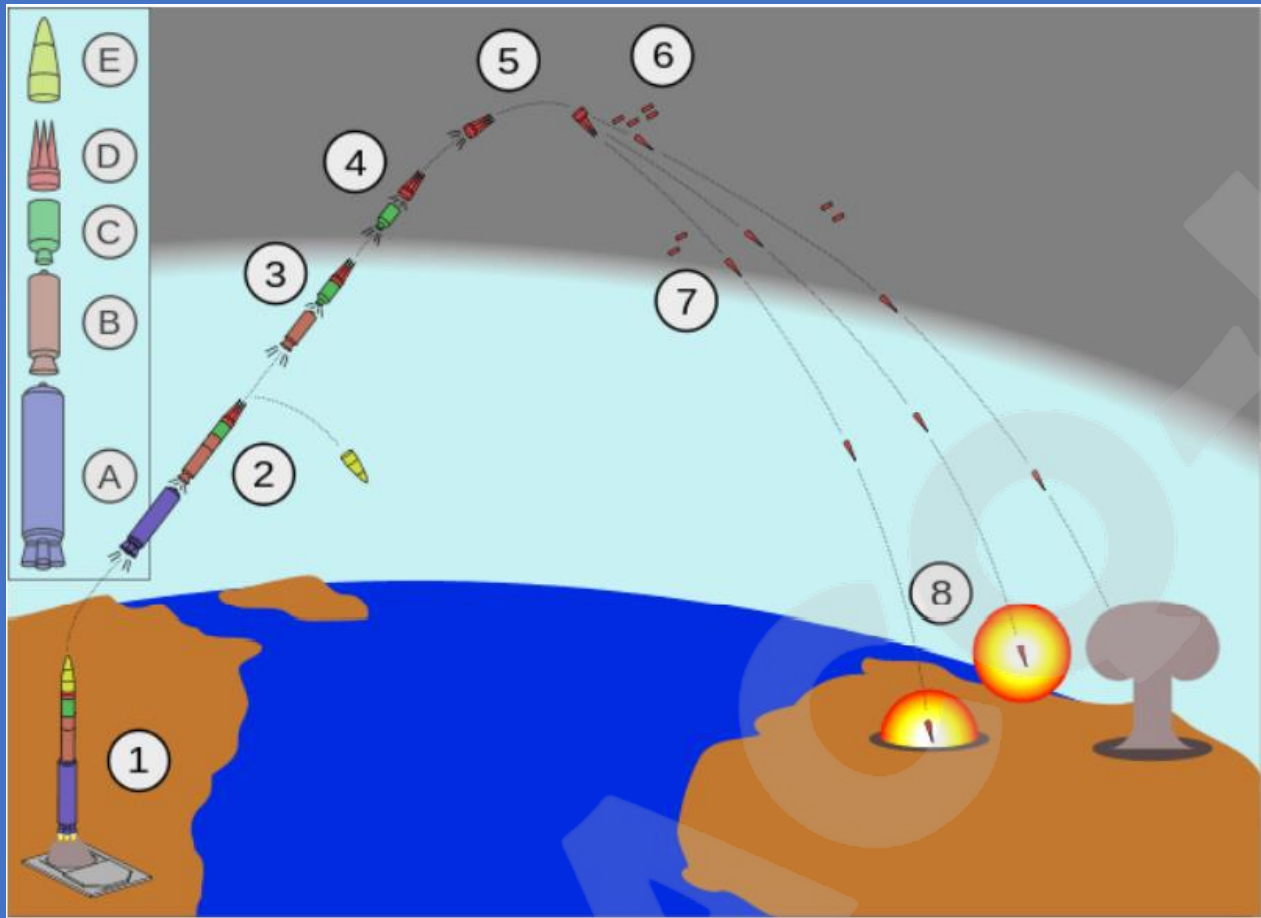
Why?



# Ballistic Missiles

Follows a ballistic trajectory to deliver one or more warheads on a predetermined target.

- A ballistic trajectory is the path of an object that is launched but has no active propulsion during its actual flight (these weapons are only guided during relatively brief periods of flight).
- Consequently, the trajectory is fully determined by a given initial velocity, effects of gravity, air resistance, and motion of the earth (Coriolis Force)



Shorter range ballistic missiles stay within the Earth's atmosphere.

Longer-ranged intercontinental ballistic missiles (ICBMs), are launched on a sub-orbital flight trajectory and spend most of their flight out of the atmosphere.

# Types of ballistic missiles based on range

Short-range (tactical) ballistic missile (SRBM): Range between 300 km and 1,000 km.

- Medium-range (theatre) ballistic missile (MRBM): 1,000 km to 3,500 km.
- Intermediate-range (Long-Range) ballistic missile (IRBM or LRBM): 3,500 km and 5,500 km.
- Intercontinental ballistic missile (ICBM): 5,500 km +

# Cruise missile

A cruise missile is a guided missile (target has to be pre-set) used against terrestrial targets.

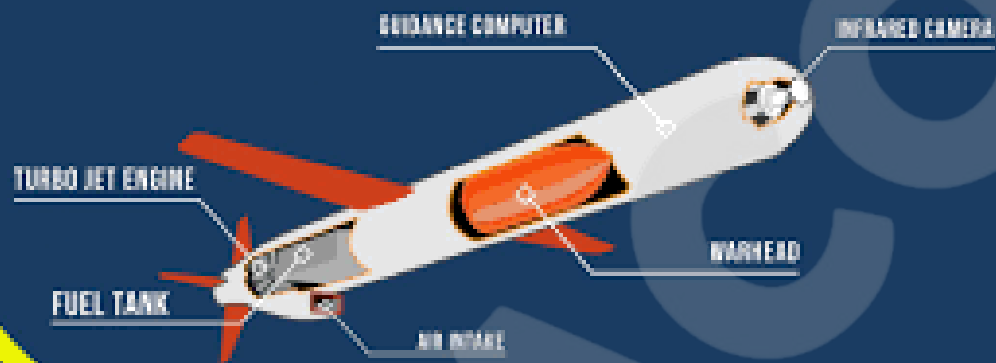
- It remains in the atmosphere throughout its flight.
- It flies the major portion of its flight path at approximately constant speed.

- Cruise missiles are designed to deliver a large warhead over long distances with high precision.
- Modern cruise missiles are capable of travelling at supersonic or high subsonic speeds, are self-navigating, and are able to fly on a non-ballistic, extremely low-altitude trajectory.



# TOMAHAWK CRUISE MISSILE

PROPERTY OF  
**MILITARY TV**



# Types of cruise missiles based on speed

Hypersonic (Mach 5): these missiles would travel at least five times the speed of sound (Mach 5). E.g.

BrahMos-II.

- Supersonic (Mach 2-3): these missiles travel faster than the speed of sound. E.g. BrahMos.
- Subsonic (Mach 0.8): these missiles travel slower than the speed of sound. E.g. Nirbhay

# Integrated Guided Missile Development Programme IGMDP

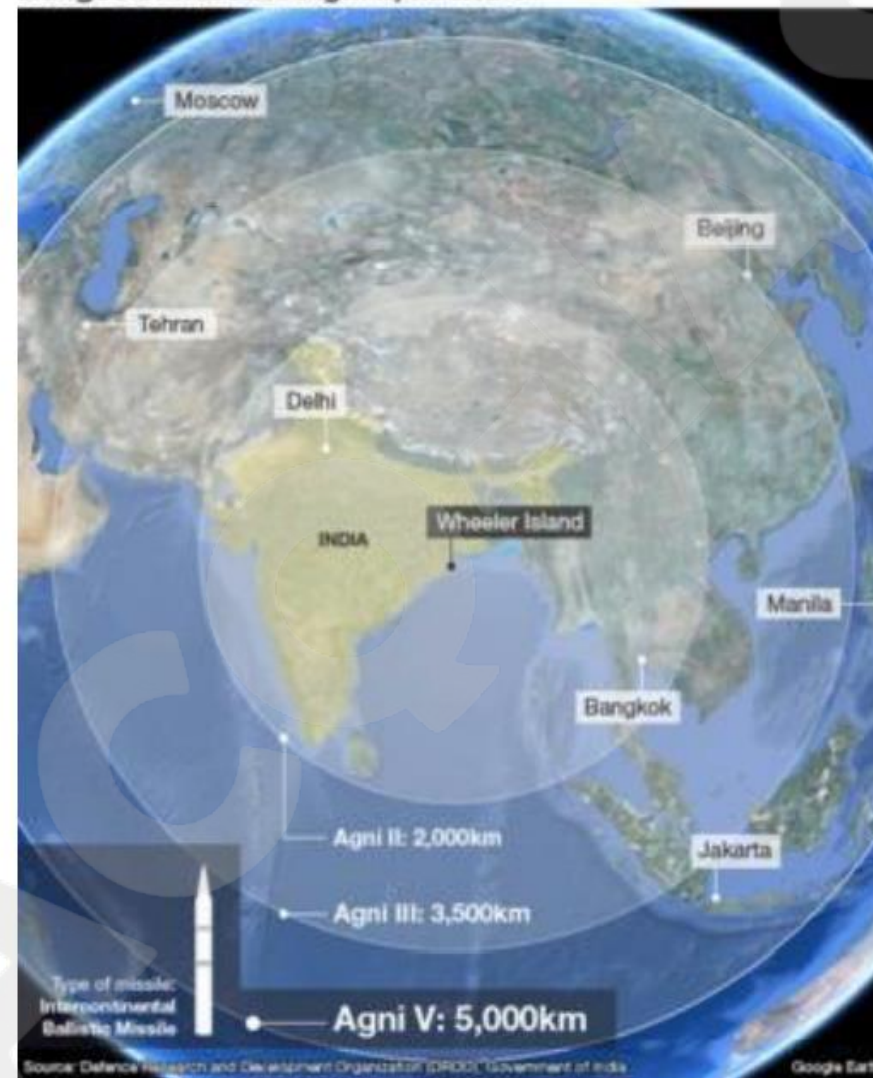
1. Prithvi: Short-range surface-to-surface ballistic missile
2. Agni: Intermediate-range surface-to-surface ballistic missile
3. Trishul: Short-range low-level surface-to-air missile
4. Akash: Medium-range surface-to-air missile
5. Nag: Third generation anti-tank missile

All the Prithvi variants are surface-to-surface SRBMs.

<b>Name</b>	<b>Version</b>	<b>Range</b>	<b>Payload in kg</b>
Prithvi I	Army version	150 km	1000
Prithvi II	Air force version	350 km	500
Prithvi III	Naval version	600 km	1000

Name	Type	Range	Payload in kg
Agni-I	MRBM	700 – 900 km	1,000
Agni-II	MRBM	2,000 – 3,000 km	750 – 1,000
Agni-III	IRBM	3,500 – 5,000 km	2,000 – 2,500
Agni-IV	IRBM	3,000 – 4,000 km	800 – 1,000
Agni-V	ICBM	5,000 – 8,000 km (Testing)	1,500 (3 – 10 MIRV)
Agni-VI	ICBM	8,000 – 10,000 km (Under development)	1,000 (10 MIRV)

### Ranges of missiles Agni II, III and V



## Barak 8

The long-range Indo-Israeli surface to Air Barak 8 Missile can travel up to a distance of 100 km to hit the target with Mach 2 speed

Barak 8 was jointly developed by India's Defence Research & Development Organisation (DRDO) and Israel Aerospace Industries (IAI)



CO-11AS

# Shaurya

The Shaurya missile is a canister launched hypersonic surface-to-surface tactical missile developed by the DRDO for use by the Indian Armed Forces.

The missile can reach a distance of 750 to 1,900 km to destroy its target.



# Astra

Astra is an Indian family of all weather beyond-visual-range active radar homing/IIR homing air-to-air missile, developed by the Defence Research and Development Organisation.

Astra Mk-1 has been integrated with Indian Air Force's Sukhoi Su-30MKI and will be integrated with Dassault Mirage 2000, HAL Tejas and Mikoyan MiG-29 in the future



# Nirbhay

- The Nirbhay subsonic cruise missile can reach a maximum range of 1,000 to 1500 km to destroy its target with a Mach 0.8 speed.
- The missile can be launched from multiple platforms and is capable of carrying conventional and nuclear warheads.



# Submarine-launched ballistic missile

A submarine-launched ballistic missile (SLBM) is a ballistic missile capable of being launched from submarines

Each missile carries a nuclear warhead and allows a single launched missile to strike several targets.

Modern submarine-launched ballistic missiles are closely related to intercontinental ballistic missiles which can be deployed to reach a range of over 5,500 km.

# Sagarika (K-15)

Sagarika (K-15) is an Indian submarine-launched ballistic missile that can reach a range of 750 km that was designed for retaliatory nuclear strikes.

## K-4 Ballistic Missile

The K-4 Ballistic Missile is a nuclear-capable Intermediate-Range submarine-launched ballistic missile developed by the DRDO to arm the Arihant-class submarines. The missile has a maximum range of 3,500 km.

## **K-5 Missile**

The K-5 is a submarine-launched ballistic missile under development by the DRDO.

The missile has a planned range of 5,000 km and will be equipped with Arihant-class submarines and is considered to be the fastest missile in its class.

## K Missile family

### K-4 intermediate range Submarine Launched Ballistic Missile (SLBM)

K-4 is a submarine-launched version of AGNI-V

The K-4 missile is best in the world in its class and the top secret indigenous "K" missiles are faster, lighter and stealthier having both **cruise** and **ballistic** variants.



### K-5 SLBM

Indian Strategic missile technology seeing fastening development of K-5 SLBM over Agni-VI. Not so secretive K-5 SLBM will have 2-tonne payload which can carry four **Multiple Independently Targetable Reentry Vehicle (MIRV)** warheads of 500kgs each.

#### KILLER K-4



OPERATIONAL RANGE  
**3,500 km**

LENGTH  
**12 metres**

WIDTH  
**1.3 metre**

WEIGHT  
**17 tonne**

WARHEAD  
**2,000 kg**

ENGINE - Solid-fueled

GUIDANCE SYSTEM  
- Ring laser gyro inertial navigation system

#### Air-Launched Missile

RANGE 200 km  
WEIGHT OF MISSILE 2 tonne  
WARHEAD 500 kg  
LENGTH 4 m  
STATUS Hypersonic missile project called the Air Launched Article. Designed to fit under the belly of a Su-30MKI. First prototype by 2012.



Submarine Launched

Air Launched

LTV BoS Underwater System

# DESI & VIDESHI MISSILE SHIELDS

## 1. Akash

Indigenous area defence missile system  
**RANGE: 25 KM**

- IAF inducting 15 squadrons of Akash-1 & two systems for Rs 10,900 crore
- Army has inducted 2 regiments for Rs 14,180cr (Two more Akash-2 regiments from Dec 2018 onwards)



## 2. S-400 Triumph

Rs 39,000-crore deal with Russia to be inked this year

**RANGE: 400 KM**

- 1st missile unit in 24 months after contract. All 5 in 54 months
- China inducting S-400 batteries under \$3 billion inked in 2014

## 4. Barak-8

Joint DRDO-Israeli Aerospace Industries project

**RANGE: 70-KM**



## 3. Spyder

Israeli low-level quick-reaction missile system

**RANGE: 15 KM**

- IAF inducting 4 Spyder systems
- DRDO developing 30-km range QR-SAM system



## 5. Ballistic Missile Defence

- Indigenous project to develop 2-tier BMD shield
- Phase-1 (interceptor missiles with 4.5 Mach speed) for 2,000-km range enemy missiles
- Phase-2 (interceptor missiles with 6-7 Mach speed) for 5,000-km range missiles
- Will take 2 years for Phase-1 to be deployed

- IAF to get initial nine medium-range SAM squadrons for Rs 10,076 crore
- Navy to get it for its frontline warships for Rs 2,606 crore (initial cost)
- 14 warships fitted with older Barak-1 systems (range 9 km)