New Method to Determine Hubble Constant

For Prelims: New Method to Determine Hubble Constant, Gravitational Lensing, Expansion of Universe, **Big Bang**, Cosmic Microwave Background.

For Mains: Method to Determine Hubble Constant.

Source: TH

Why in News?

Recently, some researchers from India and the US have **proposed a novel method to determine the Hubble constant** and the Rate of Expansion of the Universe.

Note: About 13.8 billion years ago, a really small, really dense, and really hot spot lying beyond spacetime began to expand. Its expansion and cooling – in an event that scientists have called the Big Bang **– produced the universe as we know it**. The universe continued to expand, at first really rapidly before slowing down to a great degree. Then, about **five or six billion years ago, dark energy** – an unknown and largely uncharacterised form of energy – accelerated its expansion again.

What is Hubble Constant?

- **About:**
  - In 1929, Edwin Hubble formulated Hubble's law, providing the **first mathematical description of the universe's expansion.**
  - The precise rate of this expansion, termed the Hubble constant, remains a contentious issue in cosmology.
- **Measurement:**
  - Two details are required to calculate the value of the Hubble constant:
    - The distance between the observer and astronomical objects,
    - The velocity at which these objects are moving away from the **observer as a result of the expansion of the universe.**
  - So far, scientists have used **three methods to get these details:**
    - They compare the observed brightness of a stellar explosion, called a supernova, with its **expected brightness to figure how far away it** could be. Then they measure how much the wavelength of the light from the star has been **stretched by the expansion of the universe** – i.e. the redshift – to figure how much it's moving away.
    - They use changes **to the Cosmic Microwave Background (CMB)** – radiation leftover from the Big Bang event – to estimate the Hubble constant.
      - The CMB is a faint, nearly uniform glow of microwave radiation that fills the observable universe. It is often referred to as the **"afterglow" of the Big**

Bang.

- They use gravitational **waves, ripples in spacetime produced** when massive astronomical objects – like neutron stars or black holes – collide with each other. Detectors that observe **gravitational waves record the data in the form of curves.**

  - Using the shape of these curves, astronomers can calculate the amount of energy that the collision released. Comparing this with the amount of energy the waves had when they reached earth **allows researchers to estimate the distance between these objects and earth.**

- **Discrepancy in Measurement:**
  - Measurements from the first method have reported a Hubble constant about two units higher than the one derived by the second method; the third method **hasn't yet matured enough to provide a precise measurement.**
  - The discrepancy **could be due to a mistake in the methods used** – or it could indicate that the Hubble constant is itself evolving with time.
  - This possibility arises because the three methods estimate the Hubble constant today based on information from different stages of the universe.
  - The CMB way is based on a much younger universe while the other two are based on an older universe (i.e. closer to the one today).

What is the New Approach for Estimation of Hubble Constant?

- Researchers proposed analyzing a **collection of lensed gravitational waves** and their time delays to derive information **about the universe's rate of expansion.**
  - Gravitational lensing is a phenomenon in which the gravitational field of a massive object, such as a galaxy or a cluster of galaxies, bends and distorts the light from objects located behind it.
- This method offers an independent **estimation of the Hubble constant** and could help determine other cosmological parameters such as matter density.
  - Experts in the field find the study **fascinating and see it as a significant cosmological application** of gravitational waves.

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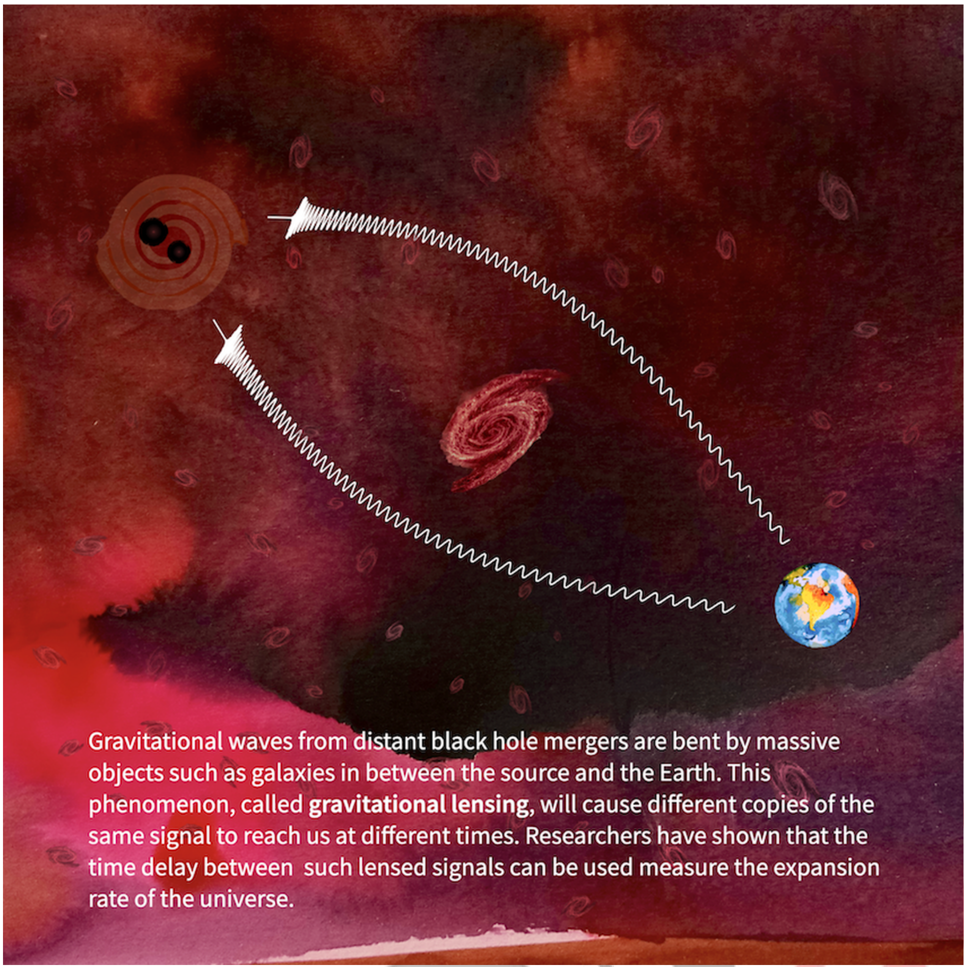

Q. Which of the following is/are cited by the scientists as evidence/evidences for the continued expansion of universe? (2012)

1. Detection of microwaves in space
2. Observation of redshift phenomenon in space
3. Movement of asteroids in space
4. Occurrence of supernova explosions in space

Select the correct answer using the codes given below:

(a) 1 and 2
(b) 2 only
(c) 1, 3 and 4
(d) None of the above can be cited as evidence

Ans: (a)

Exp:

- Arno Penzias and Robert Wilson in 1963 found mysterious microwaves coming equally from all directions. The radiation called the Cosmic Microwave Background Radiation was the radiation predicted years earlier by Gamow, Herman, and Alpher. This convinced most astronomers that the Big Bang theory was correct and provided an evidential base for continued expansion of the universe. **Hence, 1 is correct.**
- Edwin Hubble in 1929 measured the redshifts of a number of distant galaxies. On ploting redshift against relative distance, the redshift of distant galaxies increased as a linear function of their distance. Astronomers measure the movement of objects relative to us using Doppler shift. Light from distant objects in the universe is redshifted (shift in the frequency of light towards red

colour), which tells us that the objects are all receding away from us. **Hence, 2 is correct.**

- Movement of an asteroid in space may provide information regarding the type of material in early universe, but as such no evidence regarding expanding universe is provided. **Hence, 3 is not correct.**
- The supernova explosion occurs when there is a change in the core, or centre, of a star. It happens in either binary star system or at the end of a single star's lifetime. It helps in studying the distribution of elements throughout the universe. These elements travel on to form new stars, planets and everything else in the universe. However, it does not provide evidence for expanding universe. **Hence, 4 is not correct.**
- **Therefore, option (a) is the correct answer.**