



Dark Matter Shapes Galaxies

For Prelims: Dark Matter, Large Hadron Collider, dark energy, Black Hole

For Mains: Dark Matter, Dark energy, Black Hole, Expansion of Universe

Why in News

Recently, scientists investigating how the **shape of dark matter** affects the motion of stars in the centre of some galaxies (stellar bars) have found that **out-of-plane bending** can be explained through **dark matter halos in barred galaxies**.

- Out of plane bending of the bar in **barred galaxies** is a rare violent bar thickening mechanism known as **buckling**.
- A **dark halo** is the inferred halo of invisible material (dark matter) that permeates and surrounds individual galaxies, as well as groups and clusters of galaxies.

Note

- A barred spiral galaxy is a spiral galaxy with a central bar-shaped structure composed of stars.
- For example, the Milky Way is a disk galaxy made up of stars moving in circular orbits around the center in a flattened disk, with a dense collection of the stars at the center called the bulge.
 - These bulges can have shapes ranging from nearly spherical to as flat as the galaxy disk. The Milky Way has a flat boxy or peanut-shaped bulge in its center.
 - Such bulges are formed due to thickening of the stellar bars in galaxies.
- One of the violent thickening mechanisms is buckling, where the bar bends out of the plane of the galaxy disk.
- **Stellar bar:** A bar-shaped accumulation of stars in galaxies.

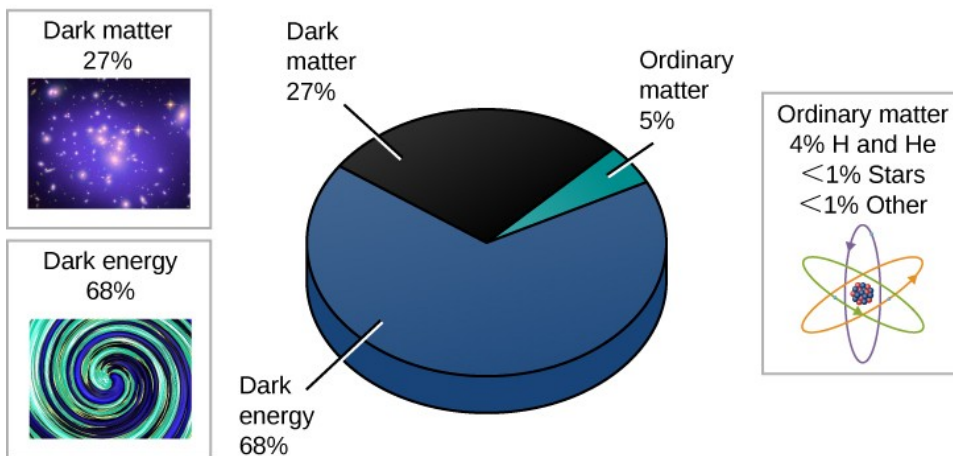
Key Points

- **About Dark Matter:**
 - Dark matter, though never detected, is believed to be present in the entire universe.
 - It is presumed that primordial black holes, those that were formed in the early age of the universe, are a source of dark matter. It was **proposed by Professor Stephen Hawking**.
 - It is believed that combined with dark energy, it makes up more than **95% of the universe**.
 - Its **gravitational force** prevents stars in our **Milky Way** from flying apart.
 - However, attempts to detect such dark matter particles using underground experiments, or accelerator experiments including the world's largest accelerator, the **Large Hadron Collider (LHC)**, have failed so far.
- **Dark Matter Presence in the Universe:**

- **Laws of gravity** expect us to see stars closer to the center of galaxies rotating faster than the stars on the edge.
 - However, in most galaxies, **the stars closer to the center and the stars at the edge of the galaxies take almost the same time to make one revolution.**
- This implied that something **invisible and enveloping the galaxies** was giving an extra push to the outer stars, speeding them up.
- This entity has remained as one of the unresolved puzzles in cosmology since the 1930s. **It was named 'Dark Matter'.**
- The material is considered to be a 'matter' since it has gravitational attraction and it is **'dark' because it does not seem to interact with light** (or any part of the electromagnetic spectrum).
- **Dark Matter and Dark Energy:**
 - While dark matter attracts and holds galaxies together, dark energy repels and causes the expansion of our universe.
 - Despite both components being invisible, a lot more is known about dark matter, since its existence was suggested as early as the 1920s, while **dark energy** wasn't discovered until 1998.
- **About Dark Energy:**
 - The **Big Bang** occurred nearly 15 billion years ago and expanded.
 - Earlier, astronomers believed that eventually the expansion of the Universe will slow down because of gravity and it will recollapse.
 - However, data from the **Hubble Telescope** suggested that the Universe's expansion is accelerating.
 - The astronomers theorize that the faster expansion rate is due to a mysterious, dark force or energy that is pulling galaxies apart.
 - The term 'dark' is used to denote the unknown.
 - The following diagram reveals changes in the rate of expansion since the universe's birth 15 billion years ago.

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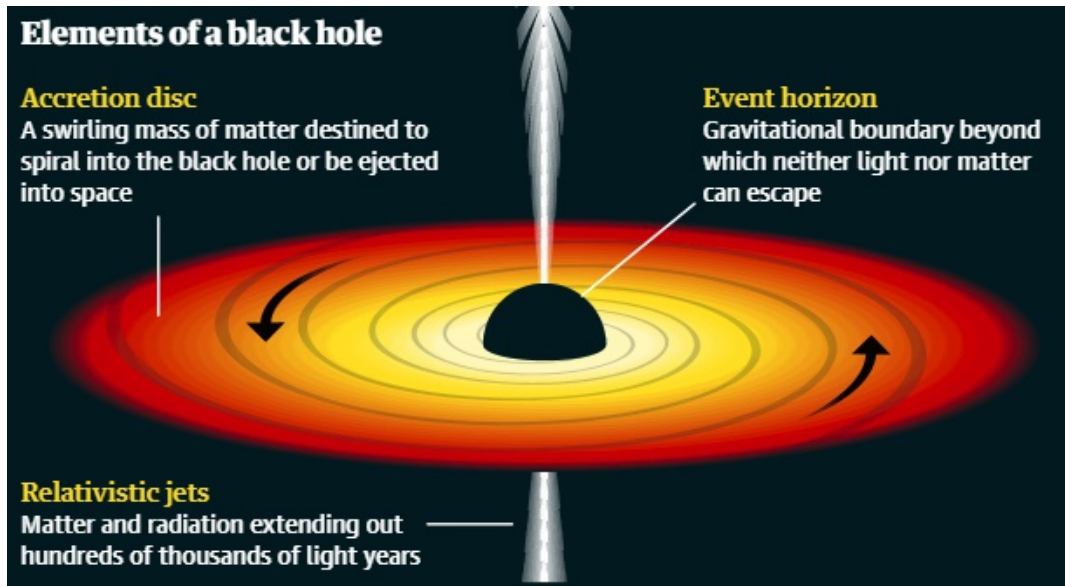
Composition of the Universe



Black Holes

- It refers to a point in space where the matter is so compressed as to create a gravity field from which even light cannot escape.
- The concept was theorized by Albert Einstein in 1915 and the term 'black hole' was coined in the mid-1960s by American physicist John Archibald Wheeler.
- Usually, the black holes belong to two categories:
 - One category ranges between a few solar masses and tens of solar masses. These are thought to form when massive stars die.
 - The other category is of supermassive black holes. These range from hundreds of thousands to billions of times that of the sun from the Solar system to which Earth belongs.
- In April 2019, the scientists at the Event Horizon Telescope Project released the **first-ever image of a Black Hole** (more precisely, of its shadow).

- The Event Horizon Telescope is a group of 8 radio telescopes (used to detect radio waves from space) located in different parts of the world.
- **Gravitational waves** are created when two black holes orbit each other and merge.



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