Time Dilation in Early Universe

For Prelims: **Quasars**, Big Bang, Einstein's Theory of Relativity.

For Mains: Time Dilation in Early Universe.

Why in News?

A recent study has utilized observations of **Quasars**, intense black holes to demonstrate time dilation in the early universe.

- The researchers **examined the brightness of 190 quasars across the universe**, dating back approximately **1.5 billion years after the** Big Bang. By comparing the brightness of these ancient quasars to those existing today, they discovered that certain fluctuations that occur in a specific duration today occurred **five times more slowly in the earliest quasars.**

What are the Key Highlights of the Study?

- **Slower Passage of Time in the Past:**
  - The continual expansion of the universe accounts for the **slower passage of time in the past** compared to the present.
  - The time **passed approximately one-fifth** as quickly as it does today. The observations stretch back to about 12.3 billion years ago, when the universe was roughly a tenth its present age.
    - According to Einstein's general theory of relativity, time and space are interconnected, and since the Big Bang, the universe **has been expanding in all directions.**
- **Previous Observations:**
  - Scientists had previously documented time dilation dating back around 7 billion years based on **observations of supernovas, stellar explosions.**
  - By studying these explosions from the past, **they found that events unfolded more slowly from the perspective of our present** time due to the known time it takes for today's supernovas to brighten and fade.

What is the Significance of the Study?

- This research highlights the intricate **nature of time and its interplay with the expansion of the universe.**
- By continuing to explore distant objects and phenomena, scientists hope to gain further understanding of the concept of time and its potential implications, **including the possibility of time travel and advanced propulsion systems like warp drives.**

What are Quasars?

- **About**:

- Quasars, which are incredibly bright objects, served as a "clock" in the study. They are supermassive **black holes**, **millions to billions of times more massive than the sun**, located at the centers of galaxies.
- These black holes draw matter towards them through **strong gravitational forces, emitting powerful radiation** and high-energy particle jets, while surrounded by a glowing disk of matter.

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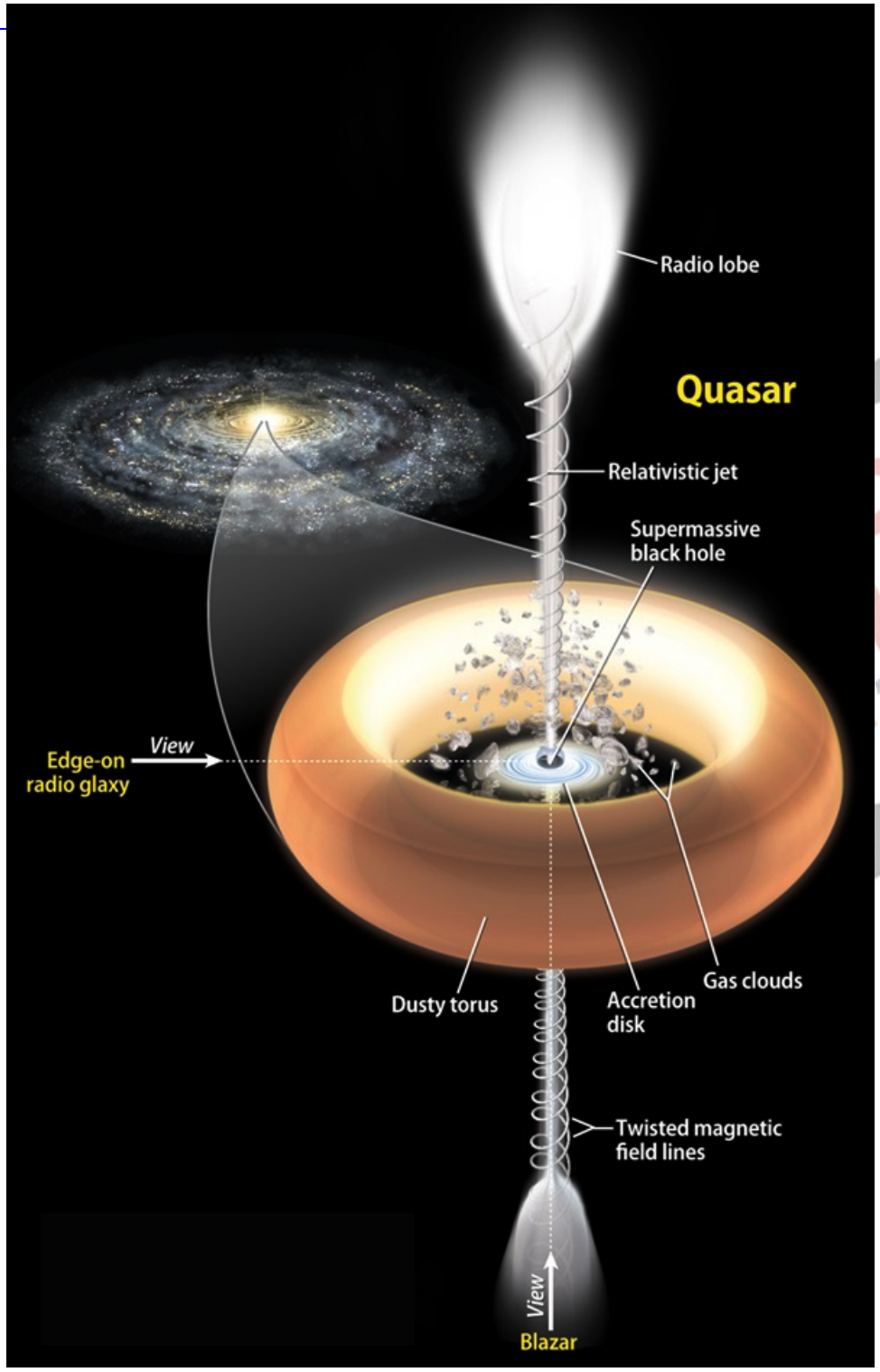

- **Significance of Quasars in Examining Time Dilation:**
  - Quasars provide an **advantage over individual stellar explosions** because their brightness remains **observable from the early stages of the universe.** The fluctuations in quasar brightness reveal **statistical properties and time scales that can be used to measure the passage of time.**

What is Time Dilation?

- Time dilation is a phenomenon in **physics that occurs due to differences in relative motion or gravitational fields.** It is a consequence of Einstein's theory of relativity, both the special theory of relativity and the general theory of relativity.
- In the special theory of relativity, time dilation occurs when **two observers are in relative motion to each other.**
- According to this theory, time is not **absolute but is relative to the observer's frame** of reference.
- When objects move relative to each other at speeds close to the speed of light, time appears to pass more slowly for the moving object compared to the stationary one.
- This means that time is dilated or stretched out for the moving object from the perspective of the stationary observer.

UPSC Civil Services Examination Previous Year Question (PYQ):

Q. Consider the following phenomena: (2018)

1. Light is affected by gravity.
2. The Universe is constantly expanding.
3. Matter warps its surrounding space-time.

Which of the above is/are the prediction/predictions of Albert Einstein’s General Theory of Relativity, often discussed in media?

(a) 1 and 2 only
(b) 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans: (d)

Source: TH