MISSING DARK MATTER - GEOGRAPHY

NEWS: Astronomers at the **Indian Institute of Astrophysics (IIA)** have uncovered new insights into the strange absence of dark matter in the **distant galaxy NGC 1052-DF2**, an **ultra-diffuse galaxy.**

WHAT'S IN THE NEWS?

Indian Institute of Astrophysics (IIA)

- The **Indian Institute of Astrophysics (IIA)** is one of India's leading research institutions in the field of **astrophysics** and **space sciences**.
- It operates under the **Department of Science and Technology (DST)**, Government of India, and is recognized globally for its significant contributions in areas such as **solar physics**, **stellar astronomy**, and **galaxy formation**.
- The institute is a key player in advancing **cutting-edge studies** on various cosmic phenomena and plays an active role in **international collaborations** on large-scale **space-based and ground-based observatories**.
- IIA is involved in research aimed at understanding the fundamental forces of nature through **observational and theoretical astrophysics**.

Galaxy NGC 1052-DF2

- **NGC 1052-DF2** is a peculiar galaxy that has drawn considerable attention due to its **large size** combined with **extremely low surface brightness**.
- The galaxy is characterized by a **sparse distribution of stars**, which makes it significantly less luminous compared to typical galaxies, despite its large radius.
- The **total dynamical mass** of NGC 1052-DF2 is estimated to be less than **340 million solar masses**, almost matching its **stellar mass**, which is around **200 million solar masses**.
- **Solar mass** refers to the mass of our Sun and is the standard unit used in astronomy for expressing the mass of stars and other astronomical objects.
- A striking feature of NGC 1052-DF2 is its **deficiency of dark matter**, which sets it apart from most galaxies such as the **Milky Way**, where dark matter makes up the bulk of the mass. This discovery suggests that the galaxy's mass is made almost entirely of visible stars.

Significance of the Discovery

- **Challenging Dark Matter Paradigms**: The discovery of NGC 1052-DF2 challenges the established theories that **dark matter** is necessary for galaxy formation and structural integrity. Traditionally, dark matter is believed to play a crucial role in the formation of galaxies by providing the gravitational force required to hold galaxies together.

- **Questioning Dark Matter's Role in Galaxy Formation**: The galaxy's near absence of dark matter raises important questions about the conditions required for galaxy formation. It provides a unique case study suggesting that some galaxies may evolve and maintain structural integrity without significant dark matter content, requiring reevaluation of existing theories in astrophysics.

- **Insights into Galaxy Formation**: The study of NGC 1052-DF2 offers new insights into the **diversity of galaxy formation processes**. It indicates that there may be alternative mechanisms or models that can explain the formation and evolution of galaxies with low or no dark matter.

What is Dark Matter?

- **Definition**: **Dark matter** is a form of matter that cannot be directly observed because it **does not emit, absorb, or reflect light**. This invisibility makes it extremely difficult to detect using conventional methods that rely on electromagnetic radiation (such as light, radio waves, or X-rays).

- **Presence in the Universe**: Dark matter is believed to constitute about **27% of the universe's total mass-energy content**. Despite being invisible, it is inferred to have a significant **gravitational influence** on galaxies, clusters of galaxies, and the large-scale structure of the universe.

- **Role in Galaxies**: Dark matter plays a critical role in the **gravitational binding** of galaxies, helping to hold them together. Without dark matter, galaxies would not have enough mass to prevent stars from flying off due to their high velocities.

- **Research on Dark Matter**: While dark matter cannot be detected directly, scientists study its effects indirectly through **gravitational lensing** (the bending of light by dark matter) and **galaxy rotation curves** (which show discrepancies in the expected rotation speed of galaxies). Various experiments, including those at **CERN** and **Xenon1T**, aim to detect dark matter particles directly, but no definitive evidence has been found yet.

Dark Matter & Dark Energy :

Dark Matter

●Hypothetical non-baryonic matter that doesn't interact with light or EM radiation.
● First inferred in 1933 by Zwicky via galaxy cluster dynamics.
●Galactic rotation curves in 1970s indicated its presence in invisible halos.
●Not made of baryons, antimatter, MACHOs, or black holes.
● Likely candidates include WIMPs like axions, neutrinos, and neutralinos.
●Comprises ~27% of the universe; detected through gravitational effects.

Dark Energy:

●Hypothetical energy responsible for the accelerated expansion of the universe.
● Makes up ~68% of the universe's total energy.
●Possible explanations:
○Cosmological constant (Einstein)
○Quantum vacuum energy
○ Quintessence (dynamic energy field)
○ Modified gravity theories
●Observed via supernovae, CMB, and large-scale structure studies.

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