Dark Energy

Why in News

Recently, an international team of researchers made the **first direct detection of dark energy.** The experiment named **XENON1T,** is the **world's most sensitive dark matter experiment** and was operated deep underground at the **INFN Laboratori Nazionali del Gran Sasso in Italy.**

- Dark energy is the mysterious form of energy that makes up about **68% of the universe,** and has intrigued physicists and astronomers for decades.

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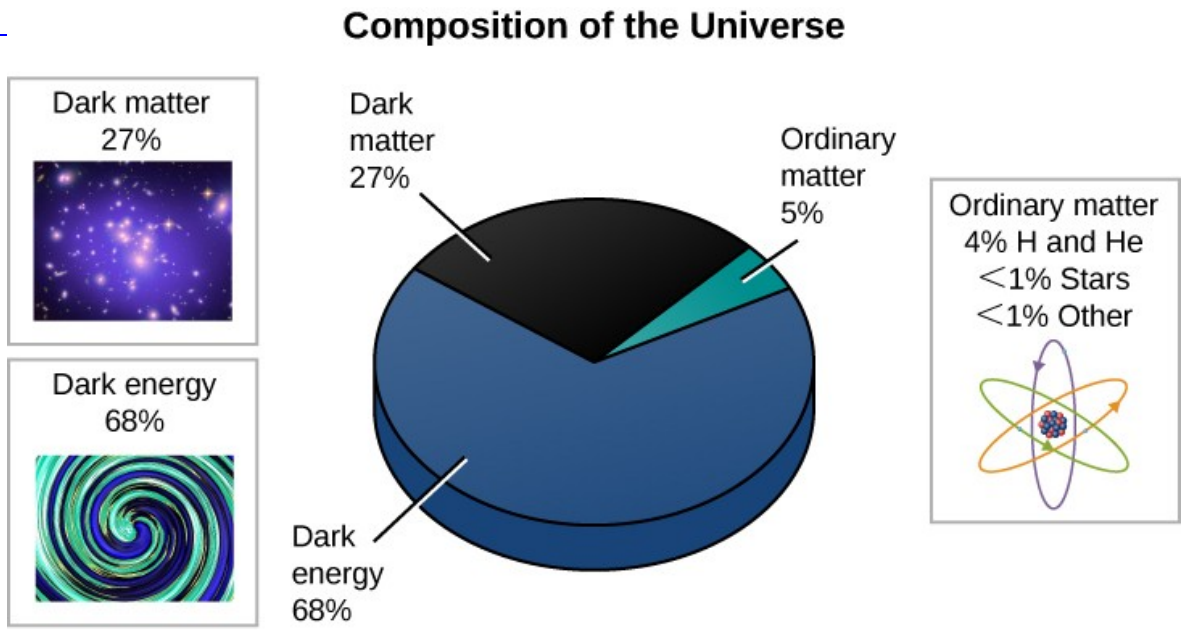
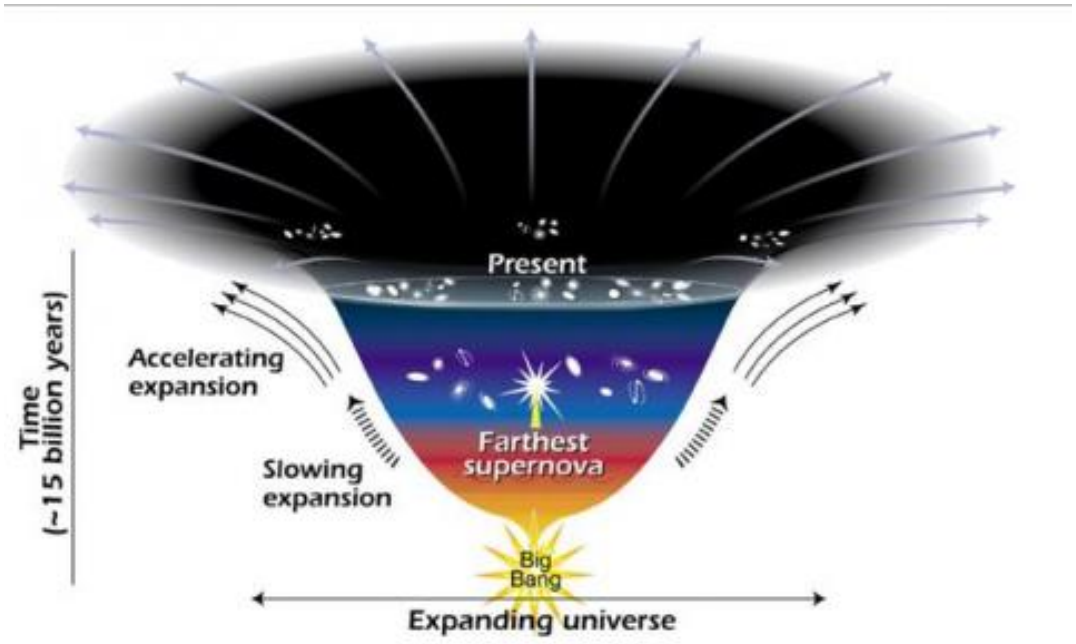


Key Points

- **About the Experiment:**
  - The XENON1T is a dark matter research project, operated at the **Italian Gran Sasso National Laboratory.**
  - It is a deep underground research facility featuring increasingly ambitious experiments aiming to detect dark matter particles.
  - The experiments aim to detect particles in the form of **Weakly Interacting Massive Particles (WIMPs)** by looking for rare interactions via nuclear recoils in a **liquid xenon target chamber.**
- **Other Dark Matter and Energy Experiments:**
  - **LUX-Zeplin** – a next generation dark matter experiment located at the Sanford Underground Research Facility, US.
  - **PandaX-xT** – project at China Jinping Underground Laboratory.

- **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.



- **Possible Explanations of Dark Energy:**
    - **Property of Space:** Albert Einstein was the first person to realize that empty space is not nothing.
        - One version of **Einstein's gravity theory,** the version that contains a **cosmological constant,** implies that "empty space" can possess its own energy.
        - Because this energy is a property of space itself, it would not be diluted as space expands. As more space comes into existence, more of this energy-of-space would appear. As a result, this form of energy would cause the universe to expand faster and faster.
    - **Quantum Theory of Matter:** Another explanation for how space acquires energy comes from the **quantum theory of matter.**
        - In this theory, "empty space" is **actually full of temporary ("virtual") particles that continually form and then disappear.**
    - **Fifth Fundamental Force:** There are four fundamental forces in the universe, and

speculative theories have proposed a **fifth force** – something that can't be explained by the four forces.

- To hide or screen this fifth force, many models for dark energy use special mechanisms.
- Some theorists have named this **"quintessence," after the fifth element of the Greek philosophers.**

◦ However, **none of the theories have been proved.** Due to this, Dark energy has been noted as "the most profound mystery in all of science".

Note

- The Four Fundamental Forces of Nature are Gravitational force, Weak Nuclear force, Electromagnetic force and Strong Nuclear force.

Fundamental Force Particles

Force	Particles Experiencing	Force Carrier Particle	Range	Relative Strength*
Gravity acts between objects with mass	all particles with mass	graviton (not yet observed)	infinity	much weaker ↓
Weak Force governs particle decay	quarks and leptons	W^+, W^-, Z^0 (W and Z)	short range	
Electromagnetism acts between electrically charged particles	electrically charged	γ (photon)	infinity	
Strong Force** binds quarks together	quarks and gluons	g (gluon)	short range	much stronger

Source: IE