The Hypothesis of Dark Energy

Why in news?

The Dark Energy Spectroscopic Instrument (DESI) aims to uncover clues about dark energy by mapping the universe in three dimensions.

Dark Energy Spectroscopic Instrument (DESI)
• It is a scientific research instrument for conducting spectrographic astronomical surveys of distant galaxies. • **Location**- The DESI is retrofitted onto the Mayall Telescope on top of Kitt Peak in the Sonoran Desert, US. • **International collaboration**- Over 900 researchers, including a team from the *Tata Institute of Fundamental Research in Mumbai*, are involved in this global project • **Goal**- To measure the effect of dark energy on the expansion of the universe. • **3D map**- By obtaining optical spectra for tens of millions of galaxies and quasars, DESI constructs a 3D map spanning the nearby universe to a staggering 11 billion light years. • **Components-** Focal plane and a bank of spectrographs. • **Focal plane-** DESI houses an impressive array of 5,000 fiber-positioning robots which work together to precisely position optical fibers on celestial objects, allowing for efficient spectroscopic observations. • **Spectrographs-** DESI employs a bank of spectrographs that receive light from the fibers, it analyze the spectra of galaxies and quasars, providing valuable information about their composition and other properties.

What is dark energy?

- Everything we see - the planets, moons, galaxies, organisms - makes up less than 5% of the universe.
- Dark energy is an invisible, repulsive energy that counteracts the gravitational attraction between matter, it causes the Universe's expansion to accelerate.
- **Discovery-**The existence of dark energy was inferred from observations of distant supernovae in the late 1990s, these observations revealed that the expansion of the Universe was accelerating, contrary to expectations.
- **Cosmic expansion**- Dark energy is responsible for the cosmic acceleration observed in the expansion of the Universe, it dominates the energy content of the Universe, accounting for about 68% of its total energy density.
- **Baryon Acoustic Oscillations (BAO)**- Scientists use baryon acoustic oscillations as a "standard ruler" to study dark energy, these oscillations are imprints left in the distribution of galaxies due to sound waves in the early Universe.
- Despite its importance, dark energy remains one of the greatest mysteries in astrophysics, hence its origin, nature, and behavior are still not fully understood.

Dark Matter	Dark Energy

Dark matter is a hypothetical form of matter thought to account for approximately 85% of the matter in the universe.	Dark energy is an unknown form of energy that is hypothesized to permeate all of space, tending to accelerate the expansion of the universe.
It is the second largest constituent of the universe, 27% of the universe is dark matter.	It is the single largest constituent of the universe, 68% of the universe is dark energy.
Dark matter works like an *attractive force* that holds our universe together.	Dark energy is a *repulsive force* that causes the expansion of our universe.
It interacts with normal matter like gravity.	There is no interaction with normal matter.
Xenon1T is designed to detect dark matter.	Euclid mission will study dark energy and dark matter.

What are the key highlights of the new 3D map by DESI?

- **Unprecedented data-** DESI has captured light from 6 million galaxies, some dating back 11 billion years to create most detailed map of the universe yet.
- **Study dark energy**- DESI examines dark energy's impact on cosmic expansion, using baryon acoustic oscillations (BAO) as a "standard ruler."
- **Precision in expansion-** The experiment has achieved better than 1% precision in measuring the Universe's expansion, enhancing our understanding of cosmic evolution.
- **Measured expansion rate-** The team has measured the universe's expansion rate at 68.5 km/s per megaparsec, which could provide insights into the nature of dark energy.
- **Mystery of dark energy-** The map has led to measurements of the universe's expansion with unprecedented accuracy, suggesting that dark energy may *not be constant* over time, challenging the standard model.
- **Scientific surprise**- The vast empty spaces between stars and galaxies have been measured to be expanding at an accelerating pace, despite the countervailing force of gravitation that has the effect of pulling things together.
- **Hypothesis-** Scientists have been unable to find any explanation for this rapid expansion, and have been forced to hypothesis that there must be some "dark" energy causing this expansion.
- **Future insights-** With 4 more years of data collection, DESI may reveal changes in dark energy over time, refining our cosmological model.

Quick facts

XENON1T
• It is the world's most sensitive dark matter experiment. • **Operation-** It is operated deep underground at INFN Laboratori Nazionali del Gran Sasso, *Italy*. • **Objective-** It have been designed to *directly detect dark matter*, by searching for signs of dark matter 'hitting' ordinary matter.
Euclid mission

• **Objective-** To understand the evolution of the Universe by looking at the light emitted from galaxies 10 billion years ago.
• **Euclid Telescope**- It was launched by *European Space Agency* from Cape Canaveral in Florida.
• **Cosmology survey mission**- It is optimized to determine the properties of dark energy and dark matter on universal scales.
• The telescope will also focus on gleaning more information on *dark energy and dark matter* and will scan more than 1/3rd of the sky.

References

1. Indian Express- New map of universe
2. Xenon experiment- Xenon1T