

Q.2)

Exp) Option c is the correct answer.

All the three-phenomenon mentioned above are the predictions of Albert Einstein's General Theory of Relativity:

- **Light is affected by gravity:** This is one of the key predictions of General Relativity. Einstein proposed that massive objects, like stars and planets, warp the fabric of space-time around them. When light passes through this curved space-time, its path is bent, which gives the appearance that gravity is affecting light. This phenomenon is known as gravitational lensing and has been observed and confirmed through various experiments and observations.
- **The Universe is constantly expanding:** General Relativity provided the theoretical framework for understanding the expansion of the universe. Einstein initially introduced the cosmological constant (represented by Λ , a Greek letter lambda) into his equations to keep the universe static, as was the prevailing belief at the time. However, when the expansion of the universe was confirmed by observations, he famously referred to the cosmological constant as his “**greatest blunder**”. The theory without the cosmological constant naturally predicted an expanding universe, which is consistent with our current understanding.
- **Matter warps its surrounding space-time:** This is a fundamental idea in General Relativity. According to the theory, matter and energy cause distortions in the fabric of space-time. Massive objects, like stars and planets, create these warps in space-time, which we perceive as gravitational attraction. The more massive the object, the more it warps the surrounding space-time.

Q.3)

Exp) Option a is the correct answer.

Pair 1 is incorrect: **Cepheids**, also called Cepheid Variables, **are stars which brighten and dim periodically**. This behavior allows them to be used as cosmic yardsticks out to distances of a few tens of millions of light-years. The brighter the Cepheid, the longer its period. In fact, **Cepheids are very special variable stars because their period (the time they take to brighten, dim and brighten again) is regular**

(that is, does not change with time), and a uniform function of their brightness. That is, there is relation between the period and brightness such that once the period is known, the brightness can be inferred.

Pair 2 is incorrect: **A nebula is a giant cloud of dust and gas in space**. Some nebulae (more than one nebula) come from the gas and dust thrown out by the explosion of a dying star, such as a supernova. Other nebulae are regions where new stars are beginning to form. For this reason, some nebulae are called “**star nurseries**.”

Pair 3 is correct: **Pulsars are neutron stars**. Pulsars are rotating neutron stars observed to have pulses of radiation at very regular intervals that typically range from milliseconds to seconds. **A pulsar is the crushed core of a massive star that ran out of fuel**, collapsed under its own weight and exploded as a supernova.

Q.4)

Exp) Option b is the correct answer

A geomagnetic storm is a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding Earth. These storms result from variations in the solar wind that produces major changes in the currents, plasmas, and fields in Earth's magnetosphere.

Statement 1 is correct: Geomagnetic storm, also called magnetic storm or solar storm, is **disturbance of Earth's upper atmosphere occurs due to coronal mass ejections**—i.e., large eruptions from the Sun's outer atmosphere, or corona. Storms also result in intense currents in the magnetosphere,

changes in the radiation belts, and **changes in the ionosphere, including heating the ionosphere and upper atmosphere region called the thermosphere.**

Statement 2 is incorrect: It can last from hours to days. After which earth's magnetic field gradually starts recovering.

Statement 3 is correct: Even though rapid magnetic field variations are generated by currents in space, very real effects can be observed on the Earth's surface. **That includes voltage surges in power grids that cause blackouts.**

Knowledge Base: The other impact associated with geomagnetic storm includes:

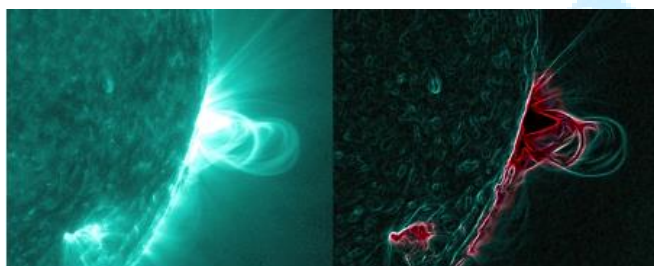
- 1) Due to heating of ionosphere is heated during storms, long range radio communication that relies on sub-ionospheric reflection can be difficult or impossible and global-positioning system (GPS) communications can be degraded.
- 2) Ionospheric expansion can increase satellite drag and make their orbits difficult to control.
- 3) During magnetic storms, satellite electronics can be damaged through the buildup and discharge of static-electric charges. Astronauts and high-altitude pilots can be subjected to increased levels of radiation.
- 4) storms also create beautiful aurora

Q.5)

Exp) Option d is the correct answer.

Option a is incorrect: The Alfvén surface (or zone) is the point past which material leaving the Sun is moving too quickly **to propagate back to the Sun itself.** The Alfvén surface marks **the transition point between the Sun's outer atmosphere, the corona, and the solar wind.**

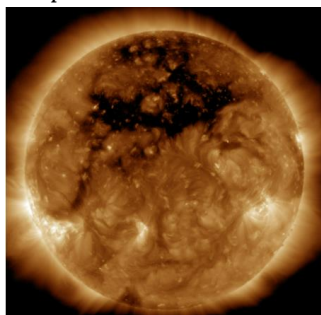
Option b is incorrect: A flux rope is kind of a magnetic structure that lies at the heart of many of the Sun's eruptions. Flux ropes form in plasmas, such as the Sun's corona, when loops of magnetic field lines connect with each other.



(Source: NASA)

Option c is incorrect: Supergranules are networks of **cells covering the Sun's visible surface** that stretch some 18,000 miles across – more than **large enough to frame two Earths side by side.** They are caused by the convection of material in the Sun.

Option d is correct: Coronal hole is a patch in Sun's atmosphere with much lower density than elsewhere. They appear like **dark splotches. Solar material escapes out of this region** at a very high-speed and leaves a dark hole near the surface of the Sun. Appearance of coronal holes is a **regular phenomenon** and they appear throughout the solar cycles. However, their duration is longer during the period of solar minimums (i.e. when sun is less active).



Q.9)

Exp) Option a is the correct answer.

Recently, NASA's Hubble Space Telescope has discovered the farthest star ever seen to date. They have nicknamed that star as "Earendel". This discovery of the most distant star was made possible by a phenomenon known as 'gravitational lensing'.

Statement a is incorrect: A gravitational lens can occur when a huge amount of matter, like a cluster of galaxies, creates a gravitational field that **distorts and magnifies the light from distant galaxies that are behind it but in the same line of sight**. The effect is like looking through a giant magnifying glass. The main effect of gravitational lensing is that it bends the light from a distant source, which can cause the object to appear distorted or magnified. **It does not reflect the light from distant objects.**

Statement b is correct: The phenomenon of gravitational lensing was **predicted to exist by Albert Einstein's General Theory of Relativity in the early 20th century**, and it was later observed in the 1920s. The theory of general relativity predicts that massive objects will bend the path of light, and this effect is known as gravitational lensing.

Statement c is correct: Gravitational lensing can be used to study the distribution of matter in the universe, including dark matter, which cannot be directly observed. By observing the distortion caused by a massive object, scientists can infer the **distribution of dark matter in the object and study the properties of distant galaxies and quasars**. This can give insight into the development of structure in the universe and how it has expanded over time.

Statement d is correct: One of the types of **gravitational lensing is microlensing**, which occurs when the lensing object is a single star or a binary star system. In this case, the light from a **background star is bent as it passes through the gravitational field of the lensing object**, causing the background star to appear brighter for a short period of time. This effect is known as a microlensing event, and can **be used to detect exoplanets and other celestial bodies that are not directly observable**. This is because the presence of a planet or other celestial body around a star can cause a small deviation in the microlensing event, which can be detected and used to infer the presence of the celestial body.

Q.22)

Exp) Option a is the correct answer

Statement 1 is correct. Solar Minimum is the period of least solar activity in the 11-year solar cycle of the Sun. During this time, sunspot and solar flare activity diminishes and often does not occur for days at a time.

Statement 2 is correct. During solar minimum, the sun's magnetic field weakens and provides less shielding from cosmic rays. It thus may cause health risks to astronauts travelling through space.

Statement 3 is incorrect. Solar minimum does not mean the non- occurrence of total solar eclipse. But, during a total solar eclipse it is possible to see clear, naked eye evidence of where the Sun is in its cycle. Totality—when the Moon completely blocks the Sun's bright disk—affords a brief view of the Sun's corona, its hot outer atmosphere.

Q.24)

Exp) Option b is the correct answer.

The International Liquid Mirror Telescope is **commissioned at Devasthal, Uttarakhand** aims to identify transient or variable objects like **supernovae, gravitational lenses, space debris, and asteroids**. It is, also, **India's first liquid telescope and the largest in Asia**.

Statement 1 is correct: The International Liquid Mirror Telescope (ILMT) has been commissioned exclusively for the astronomy. It is the **world's first telescope** of this purpose. Other previous liquid telescopes were built to track satellites or for military purposes.

Statement 2 is incorrect: The telescope is located in at the Devasthal Observatory campus of **Aryabhata Research Institute of Observational Sciences (ARIES)**, an autonomous institute under the Department of Science and Technology (DST), Govt. of India. ILMT project results from a **collaboration between** Aryabhata Research Institute of Observational Sciences (**ARIES, India**), the **Institute of Astrophysics and Geophysics (Liege University)**, the **Canadian Astronomical Institutes, University of Montreal, University of Toronto, York University, University of British Columbia and Victoria University**. Hence, the given statement is incorrect.

Statement 3 is incorrect: The instrument has a 4-meter diameter rotating mirror made up of thin film of **liquid mercury** to collect and focus light. Gallium can also be used as a reflective material, but in ILMT, mercury has been used.

Statement 4 is correct: This telescope does not revolve around any particular object like Earth or the Sun. It is **stationary** and located at an altitude of 2450 meters at the Devasthal Observatory campus of Aryabhata Research Institute of Observational Sciences (ARIES)

Q.34)

Exp) Option b is the correct answer.

Statement 1 is correct. Lagrange Points are positions in space where the gravitational forces of a two-body system like the Sun and the Earth produce enhanced regions of attraction and repulsion.

Lagrange points is a position where the gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them.

Statement 2 is incorrect. There are five Lagrange points in the Earth- Sun system where a small mass can orbit in a constant pattern.

Statement 3 is correct. Lagrange Points are positions in space where the gravitational forces of a two-body system like the Sun and the Earth produce enhanced regions of attraction and repulsion. These can be used by spacecraft to reduce fuel consumption needed to remain in position.

Statement 4 is incorrect. The L1 point of the Earth-Sun system affords an uninterrupted view of the sun and is currently home to the Solar and Heliospheric Observatory Satellite. The third Lagrange point, L3, remains hidden behind the Sun at all times, opposite Earth's orbit. For now, science has not found a use for this spot.

Q.39)

Exp) Option a is correct.

This question is based on the article “**Atmospheric pressure on surface of Pluto is more than 80,000 times less than Earth: study**” published in **PIB** on **17th Feb 2022**.

Statement 1 is correct: The 3.6m **Devasthal Optical Telescope** is a custom-built instrument of great complexity. This telescope has the **distinction of being largest telescope in India for study of celestial objects at optical wavelengths**. It is a national facility installed at Devasthal in the district of Nainital, India. It was commissioned in the year 2016 and is being maintained and operated by Aryabhata Research Institute of Observational Sciences (ARIES).

Statement 2 is incorrect: The observing time on 3.6m Devasthal Optical Telescope is apportioned as follows: **60% open time** on competitive basis to any astronomer working in an **Indian Institution**; **33% guaranteed time** for astronomers from ARIES and 7% guaranteed time for Belgian astronomers subject to the scientific merit of the proposals. About **10% of the available science time**, will be reserved as Director's Discretionary Time for allocation by the Director, ARIES.

Statement 3 is incorrect: According to a study based on observation from **Devasthal Optical Telescope**, Pluto's atmospheric pressure on its surface is 80,000 times less than that on Earth.

The study **confirms earlier findings** that Pluto suffers from **intense seasonal episodes** because of a large depression on Pluto known as **Sputnik Planitia**.

Q.46)

Exp) Option b is correct.

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.

Statement a is correct. While dark matter attracts and holds galaxies together, **dark energy repels and causes the expansion of our universe**. Dark energy is a form of material that has an **inverse gravity, repelling matter** that comes close to it. In short, dark matter slows down the expansion of the universe, while dark energy speeds it up.

Statement b is incorrect. Dark energy is a repulsive force, a sort of anti-gravity that drives the universe's ever-accelerating expansion.

Dark energy is the far more dominant force, **accounting for roughly 68 percent** of the universe's total mass and energy.

Dark matter makes up 27 percent.

And the rest – a measly 5 percent is all the regular matter we see and interact with every day.

Statement c is correct. Dark matter works like an attractive force – a kind of cosmic cement that holds our universe together. This is because dark matter does interact with gravity, but it doesn't reflect, absorb, or emit light. **The dark matter interacts with the universe only through its gravity.**

Statement d is correct. The **velocity of rotation for spiral galaxies depends on the amount of mass** contained in them, But the outer arms of the Milky Way are **rotating much too fast** to be consistent with the amount of matter that we know exists in them.

Such fast rotation is possible **only when there is more mass**, and that extra mass is believed to come from **dark matter**.

The Milky Way rotates at a whopping 130 miles (210 kilometers) per second, but a new study has found that dark matter has slowed the rotation of spinning bar at the center by at least 24% since its formation nearly 14 billion years ago.

Astrophysicists have long suspected that the spinning bar at the center of our galaxy is slowing down.

Q.51)

Exp) Option a is the correct answer.

Statement 1 is incorrect. Wolf-Rayet stars are highly luminous objects and one of the hottest kinds of stars. The surface temperature of WR stars is a thousand times more than the Sun. They are massive stars. Further, they have completely lost their outer hydrogen.

Statement 2 is incorrect. A supernova is a powerful and luminous stellar explosion. A supernova is the biggest explosion that humans have ever seen. Each blast is the extremely bright, super-powerful explosion of a star. A supernova is the explosion of a star. It is the largest explosion that takes place in space. Supernovas are often seen in other galaxies. But supernovas are difficult to see in our own Milky Way galaxy because dust blocks our view. Further, a supernova happens where there is a change in the core or center of a star.

Statement 3 is correct. Neutron stars are formed when a massive star runs out of fuel and collapses. A neutron star is the collapsed core of a massive supergiant star, which had a total mass of between 10 and 25 solar masses, possibly more if the star was especially metal-rich. Except for black holes, and some hypothetical objects (e.g. white holes, quark stars, and strange stars), neutron stars are the smallest and densest currently known class of stellar object

Q.57)

Exp) Option c is the correct answer.

Statement 1 is correct: Coronal holes are regions on the sun's surface from where fast solar wind gushes out into space.

Statement 2 is correct: These fast solar wind streams sometimes interact with earth's magnetic field, creating what's called a geomagnetic storm. This can expose satellites to radiation and interfere with communications signals.

Statement 3 is correct: Because they contain little solar material, they have lower temperatures and thus appear much darker than their surroundings. These coronal holes can cause a solar storm on Earth as they release a complex stream of solar winds.

Statement 4 is incorrect: Coronal holes appear as dark areas in the solar corona in extreme ultraviolet (EUV) and soft X-ray solar images. The phenomenon is typically invisible to the human eye.