SUPERNOVA: SCIENCE & TECNOLOGY

New type of supernova detected as black hole causes star to explode

Astronomers observed a new type of supernova where a massive star's explosion was triggered by the immense gravitational pull of its companion black hole. This event is unique because it was caused by an external force rather than internal core collapse and was preceded by years of bright emissions as the black hole stripped the star's material.

Understanding Supernovae

Hydrostatic Equilibrium

A star maintains its structure and stability due to a fine balance between two opposing forces:

Gravity

An inward force, constantly trying to pull all the star's matter toward its center.

Nuclear Fusion

An outward pressure generated by the immense energy released from fusing hydrogen into helium (and later, heavier elements) in the star's core.

Supernova

A supernova is an extremely powerful and luminous stellar explosion that marks the end of a massive star's life. This event is triggered when a star depletes its nuclear fuel. Without the outward pressure from fusion, gravity wins, causing the star's core to collapse catastrophically. This rapid collapse creates a powerful shockwave that travels outward, blasting the star's outer layers into space in a spectacular explosion.

Types of Supernovae

Core-Collapse Supernova.

Occurs in massive stars that are at least eight times the mass of our Sun. When fusion ceases, the core collapses under gravity, and the outer layers are ejected. The explosion leaves behind a super-dense core remnant. A neutron star, if the original star was between 8 and 20 times the Sun's mass. A black hole, if the original star was more than 20 times the Sun's mass.

Thermonuclear Supernova

Occurs in binary star systems involving a white dwarf. The white dwarf siphons matter from its companion star, gradually increasing its own mass. When the white dwarf's mass exceeds the Chandrasekhar Limit (approximately 1.4 times the mass of the Sun), it triggers runaway nuclear fusion, causing the entire star to detonate. This type of supernova is so complete that it leaves no core remnant behind.

Understanding Black Holes

A black hole is an object in space with such an extremely high density and powerful gravitational field that nothing, not even light, can escape its pull.

Key Characteristics

It is not a solid object with a surface but a region of spacetime where matter has collapsed upon itself.

Gravitational Singularity

At the centre of a black hole is a point of infinite density where the known laws of physics (specifically, the general theory of relativity) break down. The immense gravity appears to emanate from this point.

Event Horizon

This is the theoretical "point of no return" surrounding a black hole. Any matter or light crossing this boundary is inevitably pulled into the singularity.

Historical Context

The existence of such objects was first theorized by Albert Einstein in 1915 as a consequence of his General Theory of Relativity. The term "black hole" was coined much later in the 1960s by physicist John Archibald Wheeler.

The Newly Observed Phenomenon: A Black Hole-Induced Supernova

The Setting

The event took place in a binary star system located approximately 700 million light-years from Earth. This system originally consisted of two massive stars orbiting each other.

Sequence of Events

One of the two stars ended its life cycle, exploded in a supernova, and collapsed to form a black hole. The surviving companion star, a massive star at least 10 times the mass of the Sun, continued to orbit the newly formed black hole. Over time, the star spiralled closer to the black hole. The immense tidal forces from the black hole began to distort the star and strip away its outer layers of material. Ultimately, this gravitational interaction triggered the star to explode in a supernova-like event.

Significance of the Discovery

A New Trigger Mechanism

Unlike typical supernovae, which are caused by a star's internal instabilities (running out of fuel), this explosion was directly induced by the external tidal pull of its black hole companion.

Pre-Explosion Signatures

Astronomers observed bright emissions from the system for years before the final explosion. This is believed to be the energy released as the black hole was violently stripping the star's outer hydrogen layer, offering a new way to potentially predict such events in the future.

Source: https://ddnews.gov.in/en/new-type-of-supernova-detected-as-black-hole-causes-star-to-explode/