

Unravelling the secrets of the universe

How the **Physics** Nobel winners answered some of the age-old questions

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The story so far: On Tuesday, October 8, the royal Swedish Academy of Sciences announced that the Nobel Prize in Physics would go to three people: One half of it would be shared by Michel Mayor and Didier Queloz of the University of Geneva, for discovering for the first time a planet outside our solar system orbiting a Sun-like star; the other half would go to James Peebles, Princeton University, for his contribution to physical cosmology.

What are exoplanets? Since when have people been looking for them? The word planet is a general term that describes any celestial body that moves around a star. Well, there are also “rogue” planets that do not orbit stars. An exoplanet is a planet outside our solar system.

What were Indian astronomers doing?

The very first, significant “false alarm” came from no place other than Chennai, then known as Madras. Captain William Stephen Jacob who was the director of the Madras Observatory (The East India Observatory at Madras) from 1849 to 1858, made this “finding” in 1855.

He was studying the binary star (a pair of stars that orbit each other) named 70 Ophiuchi and noticed a slight difference in the orbital motions of the pair. He attributed this to the presence of a planet orbiting them. He published this result in the Monthly Notices of the Royal Astronomical Society.

His findings were corroborated by astronomer Thomas Jefferson Jackson See who even deduced that the planet would take 36 years to orbit the stars. Sadly, however, both of their calculations were later shown to have mistakes. This story is narrated in the book *Worlds Beyond Our Own*, by Prof. Sujan Sengupta, of the Indian Institute of Astrophysics, Bengaluru.

What kind of a planet is 51 Pegasi b? Is it habitable?

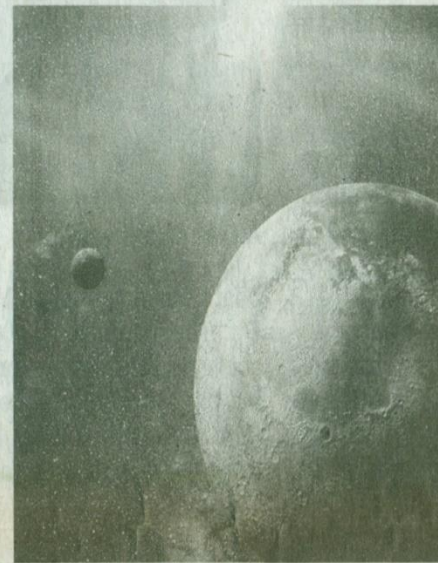
The constellation Pegasus has a star 51 Pegasi which is some 50 light years away from earth. On October 6, 1995, the prize-winning duo discovered a planet orbiting it. It was named 51 Pegasi b, as per astronomical conventions. It is a gas giant, about half the size of Jupiter. It orbits its star in just four days. It is unlikely that we can survive that.

How many such exoplanets have been discovered? Who maintains a list of exoplanets?

According to the NASA exoplanet archive, as of October 10, 2019, there are 4,073 confirmed exoplanets. This webpage (<https://bit.ly/2oCPPrp>) hosts one of the archives that has such lists and data.

Why did James Peebles get the Prize?

In the beginning was the Big Bang, about 13.8 billion years ago. No one knows much about the earliest states of the universe, but theories hold that it was a compact, hot and opaque particle soup. About 400,000 years after the Big Bang, the universe expanded and cooled to a few thousand degrees Celsius. This caused it to become



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Many questions, like how old is the universe, what is its fate, how much matter and energy does it contain, can be answered by studying the variation of the cosmic microwave background

ground (CMB). The universe continued to expand and cool and its present temperature is close to 2 kelvin. That is, approximately minus 271 degrees Celsius.

Peebles realised that measuring the CMB's temperature could provide information about how much matter had been

created in the Big Bang. He also saw that the release of this light played a role in how matter could form clumps creating what we now see as galaxies. This was a major breakthrough.

This discovery by Peebles heralded a new era of cosmology. Many questions — how old is the universe? What is its fate? How much matter and energy does it contain? These could be answered by studying the variation of the CMB. The news release of the Nobel academy describes these variations as wavelets on the sea surface — small from a distance but significant when close.

What is Peebles' role in understanding dark matter? For that matter, what is 'dark' matter?

By measuring the speeds of rotating galaxies, scientists were able to see that a lot of mass needed to be there that would hold the galaxies together with the strength of their gravitational attraction. Before Peebles intervened, the missing mass was attributed to neutrinos. Peebles instead said this is due to a hitherto unknown type of “dark” matter particles. However, while they could “see” a portion of this mass, a large part of it could not be seen. Hence the mass missing from view was named “dark” matter. It is to be understood that in this case “seeing” is not being used in the sense that the matter in question is very far away and hence cannot be seen. It means that even though this matter is all around us, close as well as far away, we only feel it through its gravity, but we cannot see it through other interactions.