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WHAT ARE EXOPLANETS, AND WHAT IS ‘DARK’ MATTER?

Relevant for: Geography | Topic: The Earth and the Solar System

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. The scientists were awarded for discoveries that added “new perspectives on our place in the universe”.

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. It is an extrasolar planet.

Nicolaus Copernicus (1473 – 1543) was the first to put the Sun at the centre, with planets like earth moving around it. This was literally an earth-shaking theory, because before that, people imagined the earth to be at the centre of the universe. The Copernican revolution was followed by the Italian philosopher Giordano Bruno in the sixteenth century and later Sir Isaac Newton shattering the uniqueness of the Sun’s position by predicting that many stars could have planets orbiting them. But were they all like our world? How far were they? No one knew. But that was when people started searching for and imagining worlds other than our own.

51 Pegasi b was the first exoplanet to be discovered by Mayor and Queloz in December, 1995. The delay was due to the lack of good telescopes or a suitable method. Indirect methods that used slight wobbling in the orbits of binary stars or variations in the brightness of isolated stars – none yielded correct results and was rejected by the astronomy community.

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. Incidentally, the Madras observatory later evolved into the Indian Institute of Astrophysics.

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, which is why it was given the name Dimidium, meaning one-half. It orbits its star in just four days. It is unlikely that we can survive that.

According to the NASA exoplanet archive, as of October 10, 2019, there are 4,073 confirmed

exoplanets. This webpage hosts one of the archives that has such lists and data. Today, there are not just ground-based telescopes but space missions that search for exoplanets, such as the Kepler Space Telescope.

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 transparent, allowing light to pass through it. This ancient afterglow of the Big Bang, the remnants of which still can be observed, is known as the cosmic microwave background (CMB). The universe continued to expand and cool and its present temperature is close to 2 kelvin. That is, approximately minus 271 degrees Celsius.

Microwaves have wavelengths in the range of millimetres which has been long compared to visible light. The CMB consists of light in the microwave range because the expansion of the universe stretched the light so much. Microwave radiation is invisible light. The CMB was detected first in 1964, winning for its discoverers a Nobel Prize in 1978.

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.

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. This is because it does not interact with light. About 25% of the mass of the universe is made up of dark matter. Scientists have set up large experiments across the world to capture traces of dark matter particles.

In 1998, it was discovered that the universe is expanding and that this expansion was gaining speed or accelerating. There had to be an "invisible" energy that was driving this. Calculations showed that this dark energy – so called because it did not interact with the observed mass – makes up about 70% of the universe.

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