Exotic substance in our galaxy?

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Our Universe is full of mysteries; the enigmatic dark matter and dark energy, mystifying particles, obscure elements—all of these add up to the puzzle the Universe poses. Now, researchers from the Raman Research Institute (RRI), Bangalore and Lebedev Physical Institute, Moscow, Russia have identified a new piece to this puzzle closer to home. In a study published in the journal *Astrophysical Journal Letters*, the researchers have interpreted spectral data taken from the Sloan Digital Sky Survey (SDSS), and have pointed at the possible presence of exotic elements in our galactic halo, the roughly spherical component of our galaxy that extends beyond the primary, visible part.

High school physics tells us that when light passes through a prism, it splits up into different colours that make up the spectrum of the light we see. A light spectrum is a vital tool in astronomy as it provides a window into the processes that are putting out the light, as well as the medium through which that light passes. When light from a star or a galaxy passes through (relatively) cold gas on its way to us, atoms in the gas absorb specific frequencies of light, producing gaps in the observed spectrum known as absorption lines. These lines are unique for each element and therefore help astronomers identify the composition of stars and intervening gas.

In 2017, researchers from the University of Arizona, USA analysed spectra of more than 700,000 galaxies in the Sloan Digital Sky Survey (SDSS) dataset,

which contains data from 15 years of observations made by an automated telescope that scans the sky. They discovered absorption lines at a wavelength of 6565 Angstroms (10 billion Angstroms is 1 metre), that were produced when light from the distant galaxies passed through gases in our galaxy. Based on the wavelength of the absorption lines that were characteristic of hydrogen, the researchers claimed to have detected hydrogen gas in our galactic halo. Furthermore, the strength of the absorption lines indicated the presence of a large quantity of hydrogen gas that would have helped account for the matter that is known to exist but has not been detected so far.

When Prof. Shiv Sethi of RRI, the lead author of this study, and his colleagues heard about this result, they attempted to model it. The idea was to construct a model of the interstellar medium (ISM) - the space between stars in our galaxy that would show how the newly observed hydrogen gas could exist alongside the other, known components of the ISM and how they would interact.

The researchers found a surprising result. “We realised it could not be modelled because from what we know of the ISM, such a line cannot arise,” explains Prof. Sethi. Producing a hydrogen line with the same strength as was observed would require a sky brightness at ultraviolet frequencies (higher frequencies than visible light) that is much greater than what is seen. As an alternative, the researchers investigated whether the line could have been produced by carbon, nitrogen or oxygen which are the most abundant elements in the ISM after hydrogen and helium. But their calculations showed that the absorbing cloud would have to be larger than the halo of our galaxy thereby ruling out this possibility too.

“Somebody observes something, and we (theorists) usually explain it. But here, it is different - the entire paper was that we could not explain it. Proving a result wrong is hard. It is rare in astronomy,” quips Prof. Sethi.

The researchers argue that the absorption lines could have been produced by complex molecules known as Polycyclic Aromatic Hydrocarbons (PAH). PAHs are organic compounds containing carbon and hydrogen with the carbon atoms arranged in rings. Laboratory measurements of the spectra of PAHs like pyrene and naphthalene have shown that they produce spectral lines that are close to the observed wavelength of 6565 Angstroms. Using this information, the researchers identify some possible compounds that could have produced the observed absorption lines, but they cannot definitively determine the compound that may be responsible.

PAHs have been detected in the disc of our galaxy, the atmosphere of Saturn’s moon Titan and elsewhere in the Universe. They are of particular interest

because they are thought to be the starting material for the earliest forms of life.

"In Astronomy, we see all kinds of exotic phenomena," concludes Prof. Sethi. However, he cautions that a group of researchers in the US have corresponded with him, and suggested that the observational result may have come about as a result of "calibration errors". He adds, "We are not sure, and this issue may take some time to be resolved."