Physics in Universe's Youth

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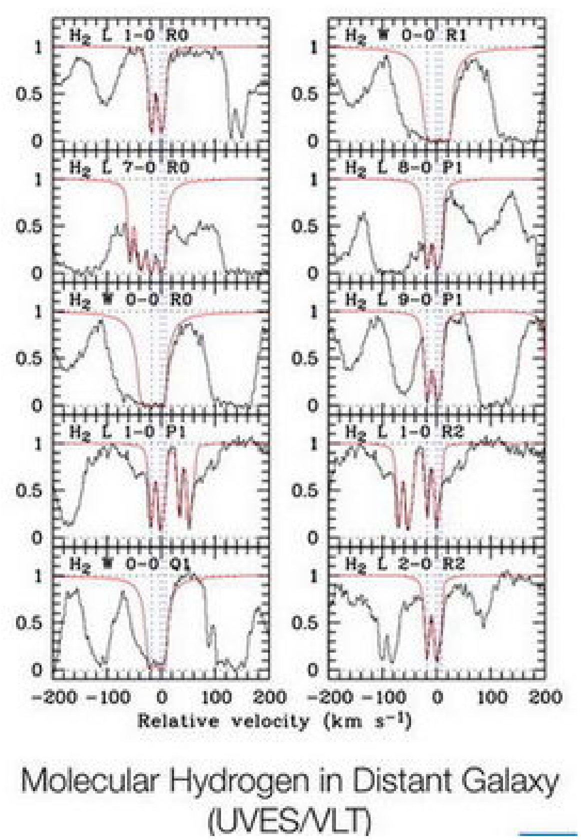

Molecular Hydrogen in Distant Galaxy.

Using a quasar located 12.3 billion light-years away as a beacon, a team of astronomers detected the presence of molecular hydrogen in the farthest system ever, an otherwise invisible galaxy that we observe when the Universe was less than 1.5 billion years old, that is, about 10% of its present age. The astronomers find that there is about one hydrogen molecule for 250 hydrogen atoms. A similar set of observations for two other quasars, together with the most precise laboratory measurements, allows scientists to infer that the ratio of the proton to electron masses may have changed with time. If confirmed, this would have important consequences on our understanding of physics.

"Detecting molecular hydrogen and measuring its properties in the most remote parts of the Universe is important to understand the gas environment and determine the rate of star formation in the early Universe", said Cédric Ledoux, lead-author of the paper presenting the results.

Although molecular hydrogen is the most abundant molecule in the Universe, it is very difficult to detect directly. For the time being, the only way to detect it directly in the far Universe is to search for its telltale signatures in the spectra of quasars or gamma-ray burst afterglows. This requires high spectral resolution and large telescopes to reach the necessary precision.

A team of astronomers, comprised of Cédric Ledoux (ESO), Patrick Petitjean (IAP, Paris, France) and Raghunathan Srianand (IUCAA, Pune, India), is conducting a survey for molecular hydrogen at high redshift using the Ultraviolet and Visible Echelle Spectrograph (UVES) at ESO's Very Large Telescope. Out of the 75 systems observed up to now, 14 have firm detection of molecular hydrogen. Among these, one is found having a redshift of 4.224.

While using the 12.3 billion light-years distant quasar PSS J 1443+2724 as a beacon, the astronomers detected several features belonging to an unseen galaxy having a redshift of 4.224. In particular, many lines from molecular hydrogen were found, breaking the record for the detection of this element in the farthest object in the Universe. This also implies that the gas in this galaxy must be rather cold, about -90 to -180 degrees

Celsius.

In addition, several lines from 'metals' are also seen, allowing the researchers to deduce the amount of various chemical elements.

"From the abundance of Nitrogen observed, we argue that it had to be produced in the late stage of the life of 4 to 8 solar mass stars," said Patrick Petitjean. "Thus, star-formation activity must have formed at least 200 to 500 million years before we are observing the galaxy, that is, when the Universe was about one billion years old".

If the galaxy went through a phase of intense star-formation activity, it is now, at the time of the observations, in a rather quiescent state.

"These observations demonstrate the possibility to perform these studies at the highest redshift with ESO's VLT", said Raghunathan Srianand. "In particular, the possibility to observe the interstellar medium of distant galaxies revealed by using gamma-ray bursts as beacons will boost this field in the near future."

A similar set of accurate measurements of molecular hydrogen lines was made by the astronomers with UVES on the VLT towards two others quasars, Q 0405-443 and Q 0347-383.

This set of data allowed the scientists to compare the ratio of the mass of a proton to that of an electron in molecular hydrogen as it is now and how it was about 12 billion years ago. To this aim, they performed extremely accurate measurements of spectral lines of hydrogen molecules in the laboratory and compared the results with the same lines observed in the spectra of these quasars. This finding is reported in the April 21 issue of *Physical Review Letters* ("Indication of a cosmological variation of the proton-to-electron mass ratio based on laboratory measurement and reanalysis of H_2 spectra", by E. Reinhold et al.).

These measurements show that the mass ratio of the proton and the electron may have changed, becoming 0.002% smaller in the past twelve billion years. Albeit such a change may look tiny, it would have important consequences on our understanding of physics. The scientists stress however that their result is just an 'indication', not yet a 'proof' and that it should be confirmed by further measurements, both astronomical and in the laboratory.

Source: ESO