MeerKAT discovers a distant galaxy has very large hydrogen atoms

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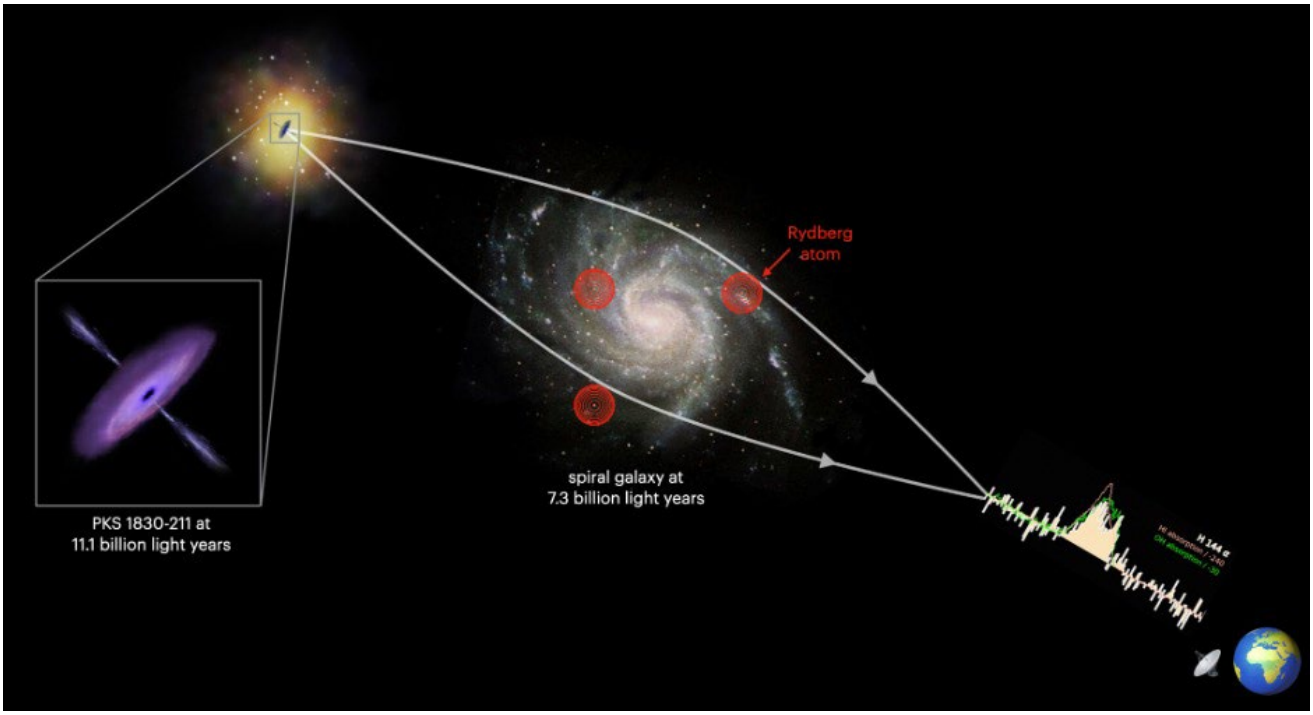

While using the MeerKAT radio telescope to study a distant galaxy towards PKS 1830-211, scientists discovered something unexpected: gas clouds made up of some of the largest hydrogen atoms in the universe, Rydberg atoms. It is the first time scientists observed these hydrogen atoms in a distant galaxy. What's more, they believe the large atoms are spread throughout the galaxy in ionized interstellar gas clouds. The discovery could help researchers to understand the nature and evolution of interstellar gas in galaxies and how Rydberg atoms are formed in space. An article reporting this discovery was recently published in the Astrophysical Journal. *Image credits: ESA + K. Emig*

Located in the constellation Sagittarius, PKS1830-211 is a very distant quasar 11.1 billion light years away (redshift 2.5). However, it is one of the brightest radio sources in the sky since the high-power jet from its super massive black hole is pointed directly at Earth. PKS 1830-211 is a hot spot for studying astrochemistry in the universe. The light from PKS 1830-211 passes through a foreground galaxy 7.3 billion light years distant (redshift 0.89) on its way to Earth, illuminating molecular chemistry in the spiral arms of the foreground galaxy. This rare alignment has allowed the large Hydrogen atoms to be observed.

A *Rydberg atom* refers to an atom with an electron in a high energy state. Radio light amplifies the Rydberg atoms. Under just the right conditions, the atoms become naturally occurring lasers, and light becomes brighter at the radio wavelengths emitted by the atoms. Finding just the right conditions for this to occur in distant galaxies has been a long standing mystery. But next-generation radio telescopes observing the Universe at cm to meter wavelengths are making it possible for the first time.

The South African MeerKAT radio telescope is currently the most sensitive radio telescope observing at these wavelengths. Large surveys that cover the sky using wide bandwidth receivers have high enough precision to look for spectral fingerprints from many wavelengths simultaneously. The MeerKAT Absorption Line Survey (MALS; https://mals.iucaa.in/) is one such survey which observes at 18 to 52 cm wavelengths. Because MALS is targeting the brightest radio sources in the sky, it is currently the

most sensitive survey for detecting absorption signatures from hydrogen atoms (in the ground state) and molecules like OH – and unexpectedly, also the large Rydberg atoms.

Using the MALS survey, scientists found 44 fingerprints from Rydberg atoms. Hydrogen Rydberg atoms are used to study the physical and dynamic structures in a galaxy 7.3 billion light years away towards PKS 1830-211. The Rydberg atoms could be coming from large clouds of gas that are ionized by the radiation from young massive stars. These atoms tell us that interstellar gas in this galaxy is much more dense than what is found in the Milky Way. They give a new way to observe our Universe and possibly study the evolution of interstellar gas in galaxies over cosmic time. They could also help us to understand how interstellar gas drives and inhibits the activity of super massive black holes.

Reference: Emig, K.L., Gupta, N., Salas, P., Muller, S., Balashev, S.A., Combes, F., et al: 2023, Discovery of Hydrogen Radio Recombination Lines at z=0.89 towards PKS 1830-211, ApJ, 944, 93