VICTORIA UNIVERSITY WELLINGTON
TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

The Search for the Hidden Hydrogen

A VICTORIA UNIVERSITY OF WELLINGTON SCIENCE TEACHING RESOURCE

WHAT'S THE PROBLEM?

Today stars are being born at a rate of millions per year. However, at its peak over eleven billion years ago, there were twenty times as many stars being formed.

This presents something of a puzzle to astronomers. With more fuel being trapped in stars that live for billions of years, astronomers should expect to see the amount of hydrogen in the universe change with the rate of star formation. Instead, what they found is that the amount of hydrogen has been largely unchanged over billions of years.

- *How can astronomers figure out how much hydrogen there was in the universe at different times throughout its history?*

WHY IS HYDROGEN SO IMPORTANT?

Hydrogen is the main fuel of stars. Hundreds of thousands of years after the 'Big Bang', when the universe had cooled enough to let matter form, hydrogen was first. As the universe continued to expand, hydrogen came together to form gigantic clouds of gas. In these clouds, gas slowly collapsed upon itself, building pressure and heat until eventually two hydrogen atoms fused together to make helium. Energy released from this fusion sparked the next two hydrogen atoms to fuse, and the next, until a chain reaction formed that ignited the cloud into a proto-star.

LOOKING IN THE RIGHT PLACES

Victoria University of Wellington astronomer, Dr Stephen Curran, may have found the answer to this problem.

While stars are hot, the hydrogen clouds in which they are born needs to be very cold for them to collapse under their own gravity, only ten degrees above absolute zero. This cold hydrogen cannot be detected with optical telescopes, the main technique astronomers use to measure the amount of gas in the universe. Radio telescopes, on the other hand, are able to detect this colder gas.

- *Why do you think hydrogen clouds need to be very cold for them to become stars?*
- *What is it about radio telescopes that lets us detect colder hydrogen?*

By taking the observations of radio telescopes and comparing them with those of optical telescopes, Dr Curran has discovered that the amount of cold hydrogen in the universe has followed a similar pattern to that of stars being formed. Dr Curran is confident that his discovery will be confirmed when the Square Kilometre Array, the largest radio telescope on the planet, is completed in 2020.

- *Why do you think it's useful for astronomers to use different measurement techniques?*
- *What is the difference between a radio telescope and an optical telescope?*

CAPITAL THINKING. GLOBALLY MINDED.
MAI I TE IHO KI TE PAE

Exploring the Stars

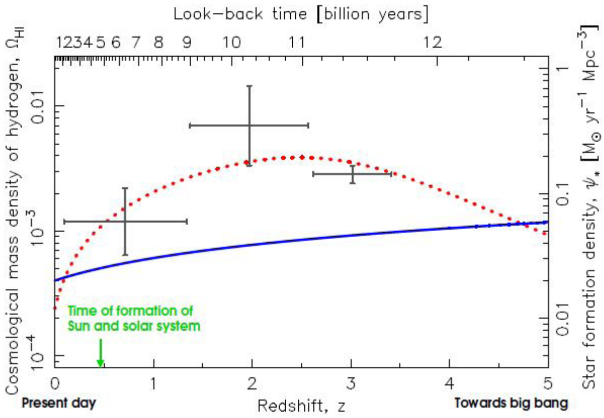
WHERE'S THE HYDROGEN

Hydrogen clouds can be difficult to find throughout the universe because they don't emit much radiation, unlike stars and other very hot objects. To find them, astronomers look at the light coming from distant quasars (incredibly bright disks of gas orbiting a supermassive black hole). When light travels through clouds of hydrogen, some photons hit the hydrogen atoms and are absorbed, only to be emitted again at a lower wavelength. This light can then be analysed by astronomers who use it to figure out the density and temperature of the cloud.

- *Why do you think radio telescopes might be able to detect more hydrogen gas than optical telescopes?*

Below is a graph showing the relationship between the rate of stellar formation and the density of hydrogen in the observable universe. See if you can answer the following questions:

- *What is redshift? Why do you think they use it in this graph?*
- *Why do you think the units for 'Look-back time' aren't evenly spread out?*
- *What do the three crosses (error bars) represent?*



The evolution of the cosmological mass density of neutral hydrogen (sold blue curve) and the star formation density (broken red curve). There is little relation between these, although the fraction of cold gas (the binned data shown as error bars) trace the star formation.

CHECK OUT THE ARTICLE

https://arxiv.org/pdf/1708.03024.pdf

The potential of tracing the star formation history with H I 21-cm in intervening absorption systems, SJ Curran, Astronomy & Astrophysics 606, A56