TEACHER NOTES – ASTRONOMY IN THE NEWS #50

JWST HIGHLIGHTS 3

The format of this week's bulletin is different to previous ones as it will contain 3 slides of science, all showing off some results from the JWST that we haven't discussed either in these bulletins or in the Lite postings.

Slide 2: Large Galaxies in the Early Universe

After the Big Bang, the first stars did not form for millions of years. The first detection of light after the Big Bang is the cosmic microwave background radiation, which occurred at approximately 379,000 years after the Big Bang. This occurred when the hot plasma and radiation from the Big Bang cooled sufficiently that protons and electrons could combine to form hydrogen.

However, the first stars did not form until a much later time into the Universe. The time at which this occurred is referred to as the 'cosmic dawn' and is thought to have occurred a few hundred million years after the Big Bang. There are hints at when this would have occurred from both simulations and observations. Simulations of dark matter halos show that accumulations large enough to form galaxies that could spark star formation could occur at 150-250 Myr (million years) after the Big Bang, or at a redshift of z = 15-20.

This study has found a sample of large (10^{10} solar mass) galaxies in the redshift range of 7.4 – 9.1. These galaxies are not the oldest galaxies discovered in JWST observations; however, those galaxies are relatively small. The galaxies in this study are large, and as such, based on previous observations, they are unexpectedly large. As such, this tests our understanding of galaxy formation and when they began to form as they should not have accumulated as much mass by this time (500-750 Myr after the Big Bang).

The article on which this slide is based on can be found here.

A free, permanent version of the research paper can be found here:

https://arxiv.org/abs/2207.12446

IMAGES:

1. The sample of six "red" galaxies that are candidate high-mass, high-redshift galaxies. Although not many pixels across, these galaxies contain massive amounts of mass and could alter our understanding of galaxy evolution.

Slide 3: WR 124 – A Dying Star

The paths taken through the lifecycles of stars is very different depending on their initial mass. Low-mass stars, like our Sun, live a relatively sedate life. They are formed, burn through their hydrogen core and eventually end with a planetary nebula and a white dwarf. However, high-mass stars have a much more violent and energetic lifetime which spans a fraction of the time. A star like the Sun will burn for billions of years, whilst a massive star will form, live and die within half a million.

The most massive stars, as alluded to above, die a violent death in the form of a supernova. However, the path they take is also dependent on initial mass. Stars above 8 solar masses will end in supernova and will follow the basic evolutionary sequence of main sequence-supergiant-supernova. However, those above 20 solar masses will go through the Wolf-Rayet phase. WR stars are evolved massive stars that have lost their outer hydrogen and are fusing helium or heavier elements in the core. They have strong stellar winds, and this combination causes them to be both luminous and dusty.

The star in question here, WR124, is a Wolf-Rayet star on the cusp of dying. The star was observed decades ago by the Hubble Space Telescope and the star was much more star like. The fact that the stars mass loss has increased so rapidly implies that the end of the star's life has started!

The article in question can be found here:

https://www.theguardian.com/science/2023/mar/15/james-webb-space-telescope-dying-star-nasa

IMAGE:

1. WR 124 as observed by the JWST. The central star has a mass of 30 solar masses, and is surrounded by 10 solar masses of gas and dust that it has ejected.

Slide 4: Clouds on an Exoplanet

One of the major JWST science goals was to discover the makeup of the atmospheres of exoplanets. The capability of this is on display in the observations of exoplanet VHS1256-1257 b. VHS1256-1257 b is a hot Jupiter, and the spectrum has revealed water, carbon monoxide, carbon dioxide, sodium and potassium. However, further to this silicate clouds were detected, the first such detections. These clouds are detected by the presence of silicate features in the spectrum, which are indicative of small cloud particles.

The article discussing this study can be found here:

https://www.bbc.co.uk/news/science-environment-65040983

A free, permanent version of the research paper can be found here:

https://iopscience.iop.org/article/10.3847/2041-8213/acb04a

IMAGES:

1. Spectrum of exoplanet VHS1256-1257 b (in grey) with the spectrum of another exoplanet (blue) for comparison. This exoplanet doesn't have the silicate feature, emphasising the feature.