TEACHER NOTES – ASTRONOMY IN THE NEWS #48

JWST HIGHLIGHTS

The format of this week's bulletin is different to previous 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: Neptune

Neptune is the most outer planet within our Solar System, and is the smallest of the giants but is the third most massive at a relative mass of 17 times greater than that of Earth. Along with Uranus, it is an ice giant and made primarily of heavier elements. However, the atmosphere of the planet is hydrogen and helium.

Neptune was not discovered "by eye" but by predictions based on mathematical modelling, with confirmation via telescope occurring later. Later observations have found 14 moons orbiting the planet, with Triton by far the largest.

The scientific investigation of Neptune is limited due to its distance from Earth, and its small size. Therefore, space telescopes have increased our understanding of the planet, with Voyager visiting in 1989, followed by observations by the Hubble Space Telescope (HST) and James Webb Space Telescope (JWST).

Some observational features of Neptune are the blue colour, caused by methane in the upper atmosphere, with faint rings also detected. Neptune also has a very active weather system, with the strongest sustained winds in the Solar System at 600 m/s (1,300 mph).

The JWST observations look significantly different, as this methane absorbs at infrared wavelengths, but shows different bands of emission that could maybe different cloud properties, as well as similarities with other giant planets.

The result on this slide was discussed in the following articles:

https://www.bbc.co.uk/news/science-environment-62984658

https://www.theguardian.com/science/2022/sep/21/neptune-and-its-rings-shown-in-striking-new-light-by-webb-telescope

IMAGES:

1. (Left) JWST observations of Neptune with Triton appearing more star like. Neptune's other moons are visible, along with the rings.
2. (Right) Evolution of the observations of Neptune, from Voyager to HST to the new infrared observations from JWST.

Slide 3: Globular Clusters at high redshift

Globular clusters are collections of stars but beyond this, out knowledge of them is very low. Their formation mechanisms, and when this happened, is not known. The Milky Way has many globular clusters and the majority of them, along with those in nearby galaxies, are very old. Their ages, in fact, correspond to formation at a redshift of z=5, or 12.5 gigayears ago. The error bar on these measurements is quite large though and could span from z=3 to z=6.

Some of the first images released from the JWST were deep cosmological images, displaying evidence of gravitational lensing. Within this image, one such lensed galaxy appears multiple times, and in each mirror, there are globular clusters present as red point sources. The galaxy, at a redshift of z=1.378, is lensed by a foreground galaxy cluster at z=0.39. By modelling the spectra and colours of these globular clusters, it is aged to have formed at a redshift greater than z=9, which would be in the first 500 million years of the Universe, which is when reionisation of the Universe occurred, and the initial phases of galaxy assembly.

The result on this slide was discussed in the following article:

https://www.bbc.co.uk/news/science-environment-63090818

The research article that this is based on can be found here:

https://iopscience.iop.org/article/10.3847/2041-8213/ac90ca

IMAGES:

1. (Top) Wide image of the SMACS 0723 lensing image. One such lensed object is a galaxy that contains multiple globular clusters.
2. (Bottom) Zoomed-in image of the lensed galaxy with the apparent globular clusters visible in all versions.

Slide 4: Pillars of Creation

The Pillars of Creation were first observed by the HST and are located in the M16 nebula. This region hosts an open cluster of stars, along with star-forming gas and dust which is actively forming stars. It is this gas that is observed in these images. The darker regions are where new protostars are currently forming. The gas and dust, especially when viewed in the optical wavelengths with HST, block the light from the background stars, whilst in the infrared we can start to see through them.

In the optical, they are illuminated by the young massive stars that have formed to the side of them. The ultraviolet radiation given off from these young stars is the cause of these pillars as it is eroding the gas cloud, and may disrupt the star-forming process.

The result on this slide was discussed in the following articles:

https://www.bbc.co.uk/news/science-environment-63319814

https://www.bbc.co.uk/news/science-environment-63431578

IMAGES:

1. (Left) Optical image from HST.
2. (Middle) New JWST image of the Pillars of Creation from the near-infrared wavelength regime.
3. (Right) JWST image from the mid-infrared regime. These wavelengths show the filamentary structures where stars are forming. The truly densest regions are highlighted, and are the darkest structures in the pillars. These densities are required to form stars.