TEACHER NOTES – ASTRONOMY IN THE NEWS #42

JWST IS OPERATIONAL: FIRST RESULTS

The bulletin is going to be slightly different this week and isn't going to contain a few of the usual components. There will be no background science or activity since I am highlighting some of the stunning early images from the James Webb Space Telescope that were released since the last bulletin before the summer break, along with no curriculum information. These changes are for this bulletin only.

There are a large number of articles that addressed these images, which are listed here, along with a couple from my host institution, the Armagh Observatory and Planetarium.

https://www.bbc.co.uk/news/science-environment-62122859

https://www.theguardian.com/science/2022/jul/12/james-webb-telescope-promises-a-glimpse-of-the-birth-of-the-universe

https://www.theguardian.com/science/2022/jul/11/nasa-james-webb-telescope-ancient-galaxy-images

https://www.bbc.co.uk/news/science-environment-62140044

https://www.bbc.co.uk/news/science-environment-62259492

https://www.theguardian.com/science/2022/aug/22/jupiter-james-webb-space-telescope-images-nasa

https://www.bbc.co.uk/news/science-environment-62641866

https://www.theguardian.com/science/2022/aug/24/james-webb-telescope-gives-a-stunning-look-at-galaxies-far-far-away

https://www.theguardian.com/science/2022/aug/25/webb-telescope-zooms-in-on-planet-beyond-our-solar-system

https://www.theguardian.com/science/2022/sep/01/historic-james-webb-images-show-exoplanet-unprecedented-detail

https://armaghplanet.com/first-images-from-webb-telescope-reveal-unseen-universe.html

https://armaghplanet.com/webb-reveals-cosmic-cliffs-a-glittering-landscape-of-star-birt.html

Slide 2: Extragalactic and Cosmology

Image 1 (Left): SMACS 0723

The galaxy cluster, SMACS 0723. This deep field image of the cluster of galaxies shows the power of the JWST. This cluster, which is located at a distance of 4.6 billion lightyears, is a gravitational lens. A gravitational lens is when a very massive foreground object, in this case the galaxy cluster, causes a curvature in the spacetime, and as such the path of the light from background objects is bent around the foreground object.

Examples of this in this image can be seen with the objects that look very long and thin. These are background galaxies, possibly at distances of 13 billion years, and there are mirror images within the field as the light has travelled to us along multiple different lensed paths.

Future work on JWST will be spectral surveys of these distant galaxies to determine the nature of the first galaxies in the Universe, hinting at how these objects formed in the early lifetime of the cosmos.

Image 2 (Right): Stephan's Quintet
This galaxy cluster is relatively close compared to that in the previous image at a distance of "only" 290 million lightyears. This cluster, Stephan's Quintet is a compact galaxy group containing five galaxies, as the name implies. Four of these galaxies are interacting with each other and will eventually merge to form one single galaxy.

Slide 3: Star Formation and Interstellar Dust

Image 1 (Top): Carina Nebula
The Carina Nebula is a star-forming region relatively close to the Sun, at a distance of 7,500 lightyears. This image in the infrared shows the gas and dust from which a new generation of stars will form. This gas and dust isn't visible in the optical light, where in fact it blocks the light from the background stars. However, in the infrared this dust is visible since it absorbs this background light and emits it in these wavelengths. The denser regions, indicated by the darkest areas of the gas and dust are where this cloud has started to collapse under gravity, and will form new stars. The evidence for these new stars can also be seen by the plumes of gas that look like bullet tracks. These are protostellar jets, the jets that are produced from a forming star.

Image 2 (Bottom): The Southern Ring
This image is of a planetary nebula, one of the final stages in the death of a star which has a mass of less than 8 solar masses. When a red giant star has expelled its atmosphere due to the core not having sufficient gravity to hold the outer layers of the star, the core that is still burning becomes exposed. This core emits large amounts of ultraviolet radiation which energises these outer layers, giving the structures that are observed here. These structures play an important role in enriching the chemical environment of galaxies, and put vast amounts of heavy metals into the ecosystem, which form future molecular clouds and then future generations of stars.

Slide 4: Exoplanets and Jupiter

Image 1 (Left): Direct imaging of an exoplanet
The star HIP 65426 has a system of planets. The planet, HIP 65426b has become the first to be observed directly with this facility. This image shows the planet in four different infrared wavebands: 3.3, 4.44, 11.4, and 15.5 μm, respectively. The location of the star is indicated by the cartoon star, and was subtracted in the image processing stage. This planet is a large planet, at least 6 times larger than Jupiter and at a large distance from the central star (100

times further from the star than Earth is from the Sun), which is a perfect combination to allow for separation in the image of star and planet.

Image 2 (Top Right): Spectrum of WASP-96b

This is the spectrum of the exoplanet WASP-96b, and is a demonstration of the exciting science that is possible with the JWST. This spectrum, specifically, is of the atmosphere of this planet and the exciting result from this is the detection of the presence of water in the atmosphere. The peaks that are detected are at the wavelengths you would expect water, as confirmed with the blue line which is the best-fit chemical model to the observed detections. This planet is not expected to host life since it is too close to the parent star. However, future exoplanet studies may find planets which have atmospheres similar to Earth and that are found in the Goldilock's Zone for habitable planets.

Image 3 (Bottom Right): Jupiter

The final image in this showcase if of a familiar Solar System object, the planet Jupiter. This image is a composite image of four JWST wavelengths combined in such a way to highlight the features. The giant storm and the bands of clouds in the atmosphere are very visible, along with the Northern and Southern lights at the poles. I recommend the students look up the other images of the planet, as in those images the moons are also visible along with the rings around the planet.