TEACHER NOTES – ASTRONOMY IN THE NEWS #36

JWST IS FULLY ALIGNED

Slide 2 – Background Science: JWST is Aligned

The James Webb Space Telescope (JWST) launched on Christmas Day, much to the excitement of astronomers across the world. Since that launch, the JWST has gone through a rigorous testing regime to allow astronomers to be confident that the telescope is working as it should. All of this deployment testing was occurring as it moved to its orbit position at the second Lagrangian (L2) on the other side of the moon. This orbital position means that if there is a fault, it will be unable to be fixed, unlike the Hubble Space Telescope.

The primary mirror is made up of 18 segments, and each of these segments need aligning to provide a smooth curvature to the whole structure. This process involves using small motors attached to each segment, called actuators. This was often movements many times smaller than the width of a human hair. Once this was complete, alignment across all instruments was ensured, with iteration on alignment required. The images from all instruments of this final alignment is shown on the slide. The next step will be to commission the instruments by observing well-known astronomical objects. This will allow the JWST team to know how much of the light entering the instrument reaches the detector.

IMAGES:

1. (Top Left) A cartoon of the fully deployed JWST, and as it will look as it makes observations. The segmented primary mirror is visible, with the fully extended sunshield.
2. (Bottom Left) Fully aligned images from all JWST instruments. This demonstrates that the mirrors are all correctly aligned, with much better performance than expected.
3. (Right) Video of two images of the Large Magellanic Cloud, one taken by Spitzer, one taken by JWST. These two images are at almost identical wavelengths. Spitzer is 8 μm and JWST is with the MIRI instrument at 7.7 μm. This image shows the improvement with the increased resolution of the JWST.

Slide 3: Galaxies Over Time

This is the third Astronomy in the News bulletin to discuss the JWST, following on from AITN #26 and #32. In each of these bulletins, I used this slide to introduce some of the expected science from the facility. There are four broad areas of science and we have discussed two of them (Early Universe and Other Worlds), and this week I will discuss Galaxies Over Time.

Some of the key questions that this area of science, Galaxies Over Time, will try to answer are: how galaxies are formed; what gives them their shape; and how do the central black holes influence their galaxies.

Galaxies, and in particular massive ones, have usually undergone at least one major merger since they formed, including the grand design spirals like the Milky Way. The Universe is made up of a web of dark matter. Dark matter is an invisible form of matter, that gravity interacts with. This web attracts the matter we can see (galaxies and stars) and as such when smaller objects are attracted into the nodes of this web, they begin to grow as more material is attracted.

It is thought that the interaction of stars and galaxies with the dark matter produced the galaxies we have seen today. By using the JWST to look back at galaxies in the early Universe, these galaxies can be compared to those in the present day, allowing theories to be confirmed on how galaxies have grown and evolved throughout the lifetime of the Universe. Spectral observations will determine which elements are in the early Universe and comparisons with the present galaxies will show the chemical evolution of the Universe, determine how elements heavier than hydrogen were formed and how this proceeded across time.

The article that this resource was built on can be found here:

https://www.bbc.co.uk/news/science-environment-61268680

IMAGES:

1. (Left) NGC 6052, a pair of colliding galaxies as imaged using the Hubble Space Telescope. As with all colliding galaxies, they are so sparse that although the galaxies are colliding, the stars are unlikely to do so.
2. (Right) Hubble Tuning Fork of galaxies, showing the classifications of galaxies. Ellipticals are classified with the E# symbol, with a larger number indicating the ellipticity. E0 galaxies are almost spherical, whilst E7 are very elliptical. Spiral galaxies are split into two classifications, with S# and SB# where the "B" indicates barred galaxies. The # is replaced by "a", "b", or "c" where the tighter wound spirals have the lower letter. A further classification is given for lenticular galaxies S0, which is the join between ellipticals and spirals. It was originally thought that this diagram was a evolutionary sequence, but this is no longer thought to be the case.

Slide 4 – Activity: How far away is the LMC?

The new image of the Large Magellanic Cloud, the LMC, is shown again on this slide. The activity this week is to both determine the angular resolution of this image and determine the distance to the LMC.

The waevelength of this image is 7.7 µm, and this gives a resolution of 0.07 parsecs. Can the students use the Rayleigh criterion to first determine the angular resolution of the jWST at this wavelength, using the primary mirror size of 6.5 m. Using this, you should obtain an angular resolution of 0.30". Then using trigonometry, the angular resolution and the resolution in parsec, you should obtain a distance of ~ 48,000 kiloparsecs.

GCSE Specifications:

Specification	Knowledge Point
Pearson Edexcel Astronomy	6.1, 7.6, 11.9, 11.19, 11.20, 11.22, 13.10, 13.30, 13.31, 13.32, 15.5, 15.6, 15.7

A-Level Physics Specifications:

Specification	Knowledge Point
OCR Physics A	5.5.3(a)
AQA Physics	3.9.1.4,