TEACHER NOTES – ASTRONOMY IN THE NEWS #54

JWST Highlights 4

This week's bulletin is slightly different to others and is a nice way to ease into the new academy year. It is highlighting some recent news stories regarding the James Webb Space Telescope that we haven't discussed in either these or the Lite bulletins. All three slides will highlight a new result or image!

Slide 2: Ophiuchus Star-Forming Region

Stars form in the densest parts of molecular clouds. Under the force of gravity, the gas and dust collapses until the densities are high enough for fusion of hydrogen atoms to occur. As this is occurring, more and more material infalls into the young protostar. This happens via a circumstellar disc. This disc is either torus, pancake or ring-shaped. The material is accreted onto this central disc which continues to feed the central protostar as it forms. This process, for low-mass stars is very slow, lasting a few million years at a rate of between 10^{-7} and 10^{-9} solar masses per year.

The star-forming region shown here is Ophiuchus, or more specifically the Rho Ophiuchi molecular cloud. Rho Ophiuchi is one of the closet star-forming regions to the Sun, at a distance of 140 parsecs. This isn't a particularly large molecular cloud, with a mass of about 3000 solar masses, and as such is forming young stars. The JWST images shown here shows the filamentary structure of the cloud, structures down which gas flows to form new stars, as well as young stars at the centres of the disks mentioned above. These disks will be the sites of future planets and planetary systems.

The articles discussing this image can be found here:

https://www.theguardian.com/science/2023/jul/12/nasa-releases-image-of-star-forming-region-rho-ophiuchi-james-webb

https://www.bbc.co.uk/news/science-environment-66179323

Slide 3: Ring Nebula

Low mass stars end their lives with a whimper, unlike their higher-mass counterparts which explode with violent supernovae. These low-mass stars exhaust their hydrogen fuel, and this causes the core to contract. This contraction leads to an expansion of the star. However, the gravitational collapse in the core allows for the remaining hydrogen to begin burning in a shell around the core. In this time, the star will have expanded. In the Solar System, the Sun may reach the orbital radius of Earth.

Once this hydrogen is exhausted, the contraction of the core and expansion of the star restarts. The core collapse eventually causes helium burning to begin. Once the helium burning is completed, the expansion of the star continues, getting larger and larger. At this point, burning continues in shells of hydrogen and helium alternatively, with further expansion.

This begins the mass loss phase, turning the star into a planetary nebula with a core left at about half a solar mass, but in the range of 0.15 to 1.2 solar. This core will cool, leaving a white dwarf.

The image shown here is of the Ring Nebula, and the new images from the JWST show the structure of planetary nebulae in greater detail than ever seen. The cloud is wispy, with lots of internal structure and clumping. Along with this there are distinct rings, which are seen in different colours in these images, which indicates a different chemical composition.

The articles discussing these images can be found here:

https://www.theguardian.com/science/2023/aug/03/stunning-james-webb-telescope-images-show-death-throes-of-distant-star

https://www.bbc.co.uk/news/science-environment-66397231

Slide 4: Supernova 1987A

Massive stars end their lives in violent core-collapse supernovae. These events impact stars which have an initial mass of greater than 8 solar masses. A core -collapse supernova occurs when all the fuel is exhausted and the core of the star collapses. This collapse continues until it is unable to collapse any further, at which point an explosion occurs, catapulting all of the stellar envelope and material into the interstellar medium. Within the stars that go supernova, there are two evolutionary routes, again separated by mass. Those stars between 8 and approximately 30-40 solar masses leave behind a neutron star, whilst in those more massive than that, a supernova remains.

Supernova 1987A is the most recent “close by” supernova to explode. The last supernova in the Milky Way was in 1868 near the Galactic Centre. However, the most recent naked-eye observable supernova in our Galaxy was in 1604. SN 1987A is in the Large Magellanic Cloud and its recency and proximity allows for it to be studied in great detail.

The recent JWST images have revealed some new, and some previously known, features. The known features are the gas and dust released in the supernova as well as the “pearl necklace”. The “pearl necklace” is a series of small clumps of material that was ejected 20,000 years before the supernova, and which are now illuminated by the shockwave caused by the supernova.

The new features are an outer ring which is illuminated as well as two crescents that were unexpected and are found within the “pearl necklace” but outside of the dense region around the ejection point. This is, as yet, unexplained but scientists are starting to study these new images.

The article discussing this image is here:

https://www.bbc.co.uk/news/science-environment-66670705