TEACHER NOTES – ASTRONOMY IN THE NEWS #40
GAIA DATA RELEASE 3

Slide 2 – Background Science: Parallax and Gaia

The Gaia satellite launched in 2013 with a number of science goals, but the major one was to map billions of astronomical objects in 3D. These objects, primarily stars, but also include planets, asteroids, comets, and quasars in extragalactic systems.

Gaia used the method of parallax to measure the position of these objects. As the Earth moves around the Sun, the apparent position of stars will move in relation to the background objects. This relative movement can be measured, and since you know this angle, along with the distance the Earth has moved in the time (these measurements are usually taken 6 months apart), you can then use trigonometry to calculate the distance. Image 1 on this slide gives a demonstration of this. Since the angles are usually small (of the order micro arcseconds), the approximation below can be used:

$$d = \frac{1}{p}$$

Where d is the distance in units of parsecs, and p is the parallax angle measured in arcseconds. Of course, the true calculation would use the tangent function, but this can be omitted for such small angular deviations.

To ensure accurate measurements, Gaia was observing each star approximately 70 times.

IMAGES:

1. (Top) Illustration of the parallax method, in fact showing the derivation of the unit of the parsec (parallax of one second). The Earth moves around the Sun, and over 6 months produces a baseline of 2 astronomical units (AU). The apparent motion of the star compared to the background gives an angle, and this angle can be used to produce a distance. The angle of 1 arcsecond (1/3600th of a degree) gives a distance of 1 parsec or 3.26 lightyears or 3.09 x10^{16} m.
2. (Bottom) Artist's impression of the Gaia satellite in orbit with background stars.

Slide 3: Gaia Data Release 3

The third data release of the Gaia mission contains an incredible amount of information for astronomers to utilise in their research goals. This data set contains the distances for almost 2 billion sources. This data release also contained the spectra for a large number of objects, and this information can be used to determine the temperatures, masses and chemical compositions of the stars.

The data contains 1.8 billion stars within the Milky Way. Of these 1.8 billion stars, 1.5 billion are classified as according to type, 10 million were found to be variable stars, whilst 813,000 binary star systems are also found. Within the Solar System, 156,000 asteroids were found along with the chemical composition for 60,000 of these. For extragalactic studies, 1.9 million quasars are included in the data release, along with 2.9 million galaxies.

The articles that this resource is built on can be found here:

https://www.bbc.co.uk/news/science-environment-61791271

https://www.theguardian.com/science/2022/jun/13/gaia-probe-reveals-stella-dna-and-unexpected-starquakes

More details, along with the media kit containing the press release can be found here: https://www.esa.int/Science_Exploration/Space_Science/Gaia/Gaia_data_release_3_media_kit

IMAGES:

1. (Top left) Radial Velocities: The measured velocities, relative to Earth of 30 million objects in the Milky Way. This velocity, the speed at which the object is moving away, is called the radial velocity. The bright areas are moving away from us, whilst the dark areas are towards us. The Magellanic Clouds are the bright spots in the lower right, whilst the tiny dots are globular clusters.
2. (Top right) Interstellar dust: By measuring the positions of the stars, the Gaia mission has also mapped the material that lies between the stars, the gas and dust from which future stars will form. The positions as well as the extinction from this dust, Gaia has mapped the absorption of starlight from the interstellar medium.
3. (Bottom left) Radial Velocities and proper motion: This is the velocity field in the Milky Way for 26 million stars. The blue areas are where stars are, on average, moving towards us, whilst red areas are the regions where this motion is away from us. The lines are the motion of the stars on the sky.
4. (Bottom right) Chemical map: The spectra of the stars observed by Gaia allow for the chemical composition to be determined. The measure of the amount of metals (i.e. elements heavier than hydrogen) is called the metallicity. The Sun has a high metallicity, indicating it formed from the gas and dust put back into the Universe following the explosion of a previous star via a supernova. This image displays the metallicity with the redder stars richer in metals, i.e., solar-like.

Slide 4 – Activity: Demonstrating parallax

The parallax method can be demonstrated using nothing more than your eyes and your thumb.

Full details of the experiment can be found here:

http://www.phy6.org/stargaze/Sparalax.htm

The student should choose a distant landmark and point towards it with their thumb up on their extended arm. Close one eye and line up the thumbnail with the landmark. Then, swap which eye is open and note where the thumbnail now lines up. By estimating the distance between the landmark and this new position, the distance to the landmark can be calculated as 10 times this!

GCSE Specifications:

Specification	Knowledge Point
Pearson Edexcel Astronomy	7.6, 11.9, 13.10, 13.11, 13.12

A-Level Physics Specifications:

Specification	Knowledge Point
Pearson Edexcel Physics	157
OCR Physics A	5.5.3(a,b,c)