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| **Lesson Number: 28.11** |
| **Lesson Title: Distance ladder and Quasars** |
| **Specification Reference** | **3.9.3.2, 3.9.3.3** |
| **Learning Objectives** |
| Red shift *v* = *Hd*Simple interpretation as expansion of universe; estimation of age of universe, assuming *H* is constant.Qualitative treatment of Big Bang theory including evidence from cosmological microwave background radiation, and relative abundance of hydrogen and helium.Quasars as the most distant measurable objects.Discovery of quasars as bright radio sources.Quasars show large optical red shifts; estimation involving distance and power output.Formation of quasars from active supermassive black holes. |
| **Opportunities for Assessment** |
| Discussion of parallax, spectroscopy and supernova |

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| **Starter:** | Slide #1 asks the main question of the lesson – how do we measure the distance to objects in space? |
| **Main:** | Slide #2 recaps parallax from previous lessonSlide #3 recaps the calculation for luminositySlide #4 introduces the idea of Cepheid variables – link back to the work on the HR diagram and the instability stripSlide #5 recaps supernovae as a standard candleSlides #2 - #5 are about creating a distance ladder or calibration tool for Edwin Hubble; whilst not specifically examined on the A-Level course it is essential pupils understand *how* the Hubble constant was calibratedSlides #6 - #7 explain the link between red-shift and the Hubble constant – possible research / homework can be to obtain data on quasar redshift and plot a graph to find the Hubble constantSlide #7 also mentions the CMB (covered at GCSE) and begins the link between the evidence and the theory of the big bangSlide #8 explains how the abundance of Hydrogen and Helium support the big bang theory - <http://hyperphysics.phy-astr.gsu.edu/hbase/astro/hydhel.html> is an excellent resource to set for students to researchSlides #9 - #10 describe quasars – A research homework could be on looking at the link between active radio galaxies, quasars and blazars |
| **Plenary:** | Slide #11 is a summary |

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| **Homework:** | Research of Edwin Hubble, Henrietta Leavitt, Cepheid variables, Quasars |
| **Differentiation / Extension / S&C** |
| Linking Quasars to the evolution of the universe; quasars linked to active galaxies; research the black hole in the Milky Way |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Formula and gradients | Edwin Hubble used a distance ladder created by other scientists to calibrate his workHenrietta Leavitt did sterling work but is not as famous as her male counterparts; link to women in science and history and sexism in historical astronomy |
| **RESOURCES:** |
| None |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| None |

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Slide #1 – By Jared Smith <https://www.flickr.com/photos/jaredsmith/176375861>

Slide #4 - Taken before 1921 (year of death), Public Domain, <https://commons.wikimedia.org/w/index.php?curid=1491349>

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