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| **Astrophysics** | IB Physics Content Guide |

# Big Ideas

* A variety of measurements from earth can be used to calculate the distance of stars and galaxies
* The scale of our universe is so vast that we need to define new units to help conceptualize its overall size
* It is possible to measure the emission or absorption spectrum of a star to determine its composition
* The properties of stars can be organized into a chart and used to predict the future life cycles

# Content Objectives

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| 1 – The Scale of Astrophysics |  |
| I can describe the relative scale of the solar system |  |  |  |
| I can identify the defining characteristics required for a celestial body to be a planet  |  |  |  |
| I can define a light year (ly) as a unit of distance in terms of meters |  |  |  |
| I can define the meaning of one astronomical unit (AU) |  |  |  |
| I can relate degrees and seconds as units of angular measurement |  |  |  |
| I can describe the meaning of 1 parsec as a unit of distance |  |  |  |

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| 2 – Stellar Quantities |  |
| I can describe the phenomenon of stellar parallax and how it can be used to measure distance |  |  |  |
| I can calculate distance in parsecs of a nearby star when given the parallax angle in arc seconds |  |  |  |
| I can compare the definitions of brightness and luminosity |  |  |  |
| I can conceptually describe the relationship between a star’s brightness and distance from viewer |  |  |  |
| I can calculate the brightness of a star with a known luminosity and distance |  |  |  |
| I can describe how different stars can appear the same brightness on earth |  |  |  |
| I can use Wien’s Displacement Law to mathematically relate peak wavelength and temperature |  |  |  |
| I can use Stefan-Boltzmann’s Law to mathematically relate luminosity, radius and temperature  |  |  |  |

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| 3 – H-R Diagrams and Stellar Spectra |  |
| I can place a star on an axis showing luminosity vs temperature |  |  |  |
| I can describe the organization of the Hertzsprung-Russell Diagram |  |  |  |
| I can use the main sequence to calculate the distance of a star from its wavelength and brightness |  |  |  |
| I can proportionally relate a star’s luminosity to its mass |  |  |  |
| I can identify the chemical makeup of a star from its absorption spectrum |  |  |  |

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| 4 – Evolution of Stars |  |
| I can predict the relative life span of a star based on its type |  |  |  |
| I can explain the process of stellar equilibrium and how the temperature affects size  |  |  |  |
| I can describe the life cycle of a low mass star like the Sun and plot it on an H-R Diagram |  |  |  |
| I can describe the nature and formation process of a white dwarf star |  |  |  |
| I can define the Chandrasekhar Limit as the maximum mass of a core that can become a white dwarf |  |  |  |
| I can define the Oppenheimer-Volkhoff Limit as the maximum mass of a neutron star |  |  |  |
| I can predict the fate of a star based on its mass |  |  |  |

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| 5 – The Expanding Universe |  |
| I can describe the nature of Cephid Variables |  |  |  |
| I can use a table to relate the luminosity and period of a Cephid Variable |  |  |  |
| I can outline the process that results in a Type IA Supernova |  |  |  |
| I can describe the value of a “standard candle” in making measurements about distance |  |  |  |
| I can use wavelength shift to calculate the relative speed of an object |  |  |  |
| I can describe the important discovery that Hubble made when analyzing redshift of distant stars |  |  |  |
| I can relate the distance of an object to its relative velocity using the Hubble Constant |  |  |  |
| I can calculate redshift based on the expansion of the universe |  |  |  |

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| 6 – The Beginning and The End |  |
| I can describe the different methods to find the distances of objects based on magnitude |  |  |  |
| I can use Hubble’s constant to estimate the age of the universe |  |  |  |
| I can outline the steps in the Big Bang |  |  |  |
| I can describe the CMB and why it is important evidence of the Big Bang |  |  |  |
| I can provide the peak wavelength and average temperature of the CMB |  |  |  |
| I can describe the current theory about the expansion of the universe |  |  |  |

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| **Astrophysics** | Shelving Guide |

# The Scale of Astrophysics

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| Unit Conversion | Definition |
| 1 light year (ly) =  |  |
| 1 parsec (pc) =  |  |
| 1 astronomical unit (AU) =  |  |

# Stellar Quantities

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| --- | --- |
| Brightness | Luminosity |
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| --- | --- | --- | --- | --- |
|  | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Distance |  |  |  | $$d \left(parsec\right)= \frac{1}{p (arc-second)}$$ |
| Parallax Angle |  |  |  |
| Brightness |  |  |  | $$b=\frac{L}{4πd^{2}}$$ |
| Luminosity |  |  |  |
| Max Wavelength |  |  |  | $$λ\_{max}T=2.9×10^{-3} m K$$ |
| Temperature |  |  |  | $$L=σAT^{4}$$ |
| Surface Area |  |  |  | $$σ=5.67×10^{-8} W m^{-2} K^{-4}$$ |

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| Describe the process of Stellar Parallax: |

# H-R Diagrams and Life Cycle of a Star

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| Label the Following:* Main Sequence
* White Dwarfs
* Red Giants
* The Sun
* Line representing the life cycle of our sun
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| Chandrasekhar Limit | Oppenheimer-Volkhoff Limit |
|  |  |
| Sun Like Stars (< 1.5 Mʘ)⬇ | Huge Stars (1.5 – 3 Mʘ)⬇ | Giant Stars (> 3 Mʘ)⬇ |

# The Expanding Universe

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| Standard Candles | Evidence for Expanding Universe |
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|  | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Redshift |  | --- |  | $$z=\frac{∆λ}{λ\_{0}}≈\frac{v}{c}$$ |
| Change in Wavelength |  |  |  |
| Original Wavelength |  |  |  | $$z=\frac{R}{R\_{0}}-1$$ |
| Relative Velocity of Source |  |  |  |
| Speed of Light |  |  |  | $$v=H\_{0}d$$ |
| Current Scale Factor |  | --- |  |  |
| Scale Factor when Emitted |  | --- |  | $$c=3.00×10^{8} m s^{-1}$$ |
| Hubble’s Constant |  |  |  | $$H\_{0}≈ $$ |

# The Big Bang

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|  | Peak Wavelength | Temperature |
| Cosmic Microwave Background Radiation |  |  |

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| Describe why the CMB is evidence of the Big Bang: |