

CEPHEID VARIABLES

Nayan Telrandhe

171006007

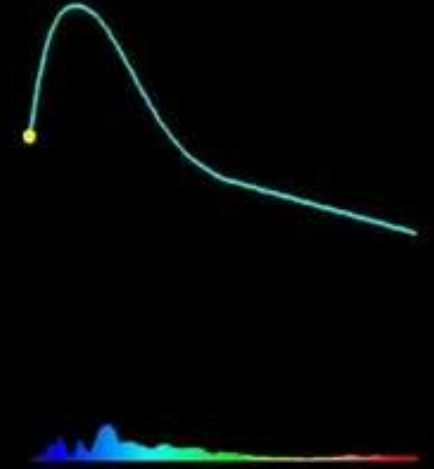
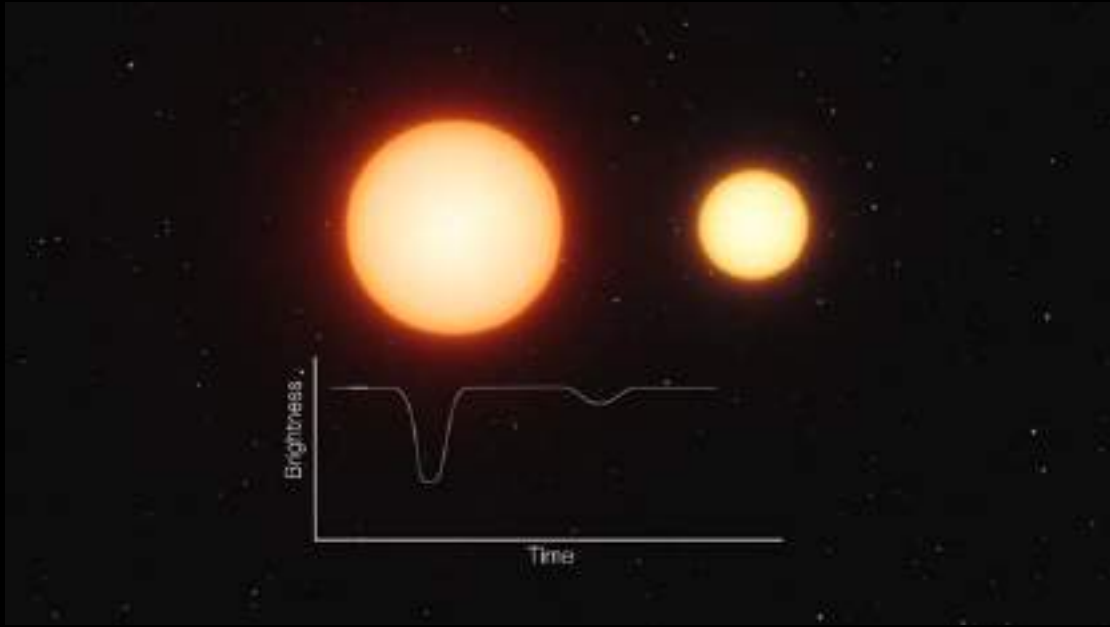
B.Sc. (Hons.) Physics

PY1680 Seminar Presentation

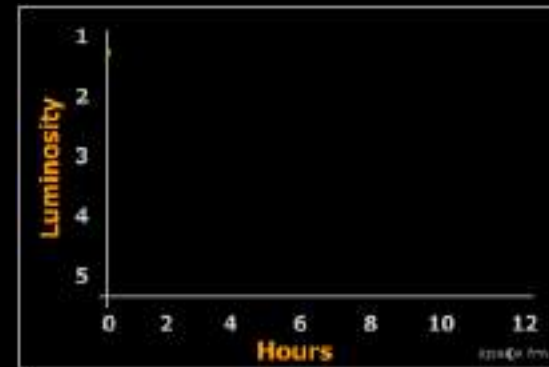
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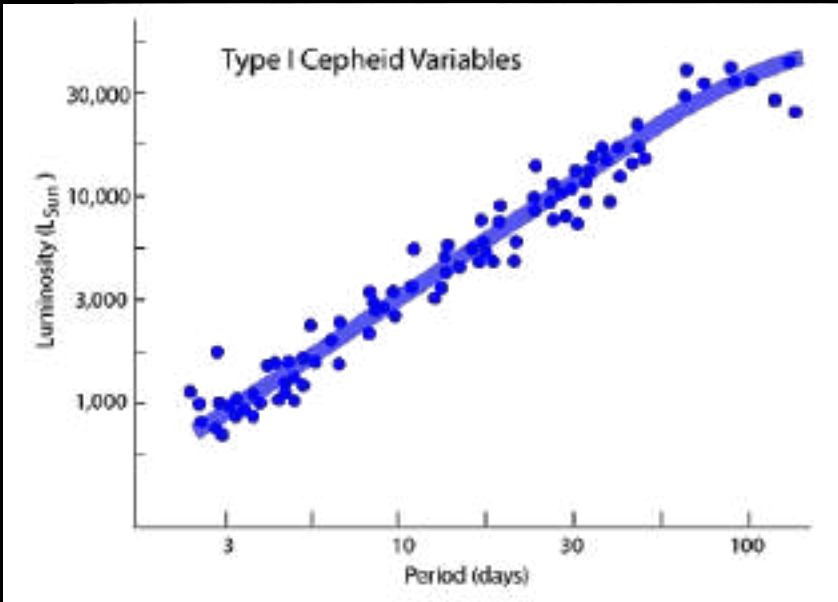
- What are Cepheid Variables ?
- What makes them interesting ?
- Their Physical Structure
- What they can be used for ?
- They changed our picture of the Universe and surrounding
- Uncertainties





- Variable Stars apparently vary their brightness.
- Like Eclipsing binaries, Supernovae, Novae and Cepheids.
- Eclipsing binaries and Cepheids are **periodic variables**.
- Cepheids show an increase in brightness in short period of time followed by relatively longer period of decrease.

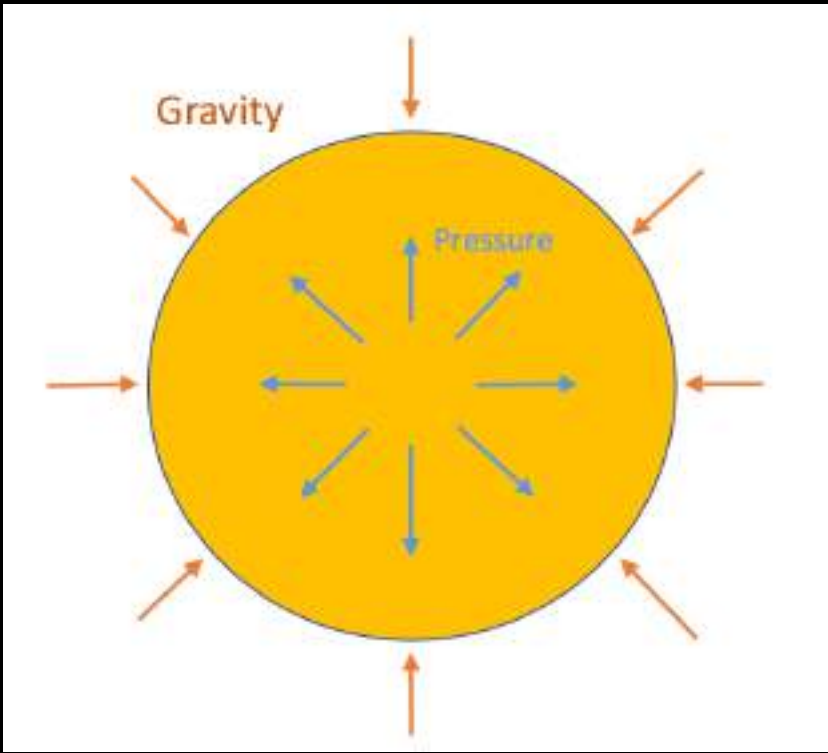




- Henrietta Swan Leavitt found that apparently there exist a Linear relationship between the Luminosity of these variables and their Time period of variability.
- If we know the Time period of a Cepheid it's Luminosity or total energy emitted by it can be found.

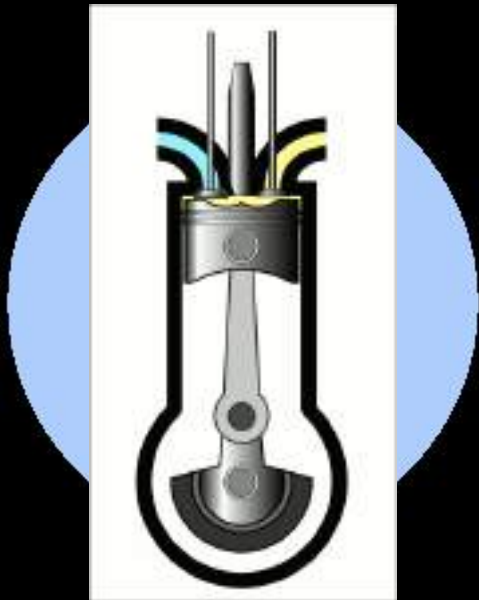
$$I(\text{Intensity observed}) \propto \frac{L (\text{Luminosity of source})}{D^2(\text{Distance from source squared})}$$





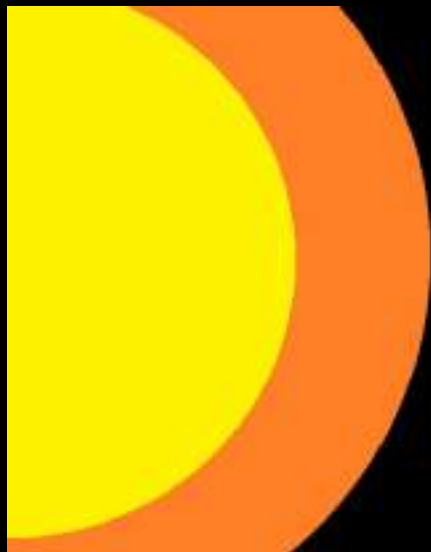
- Hydrostatic Equilibrium – There’s a balance between Thermal Pressure and star’s weight.
- This makes most of the stars stable.
- Stars undergo instabilities during their lifetime.

- Arthur Eddington - Cepheids as **Heat Engines**.
- Cepheids pulsate radially.
- Varying diameter and heat flow producing Pulsations.



“Possibly during the pulsation, variations of the transparency, which governs the flow of heat, might cause the engine to be fed in the required manner”

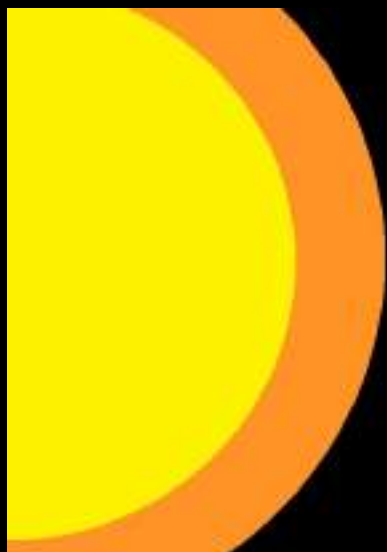




Cool upper star layers
fall under gravity

- Arthur Eddington in his paper later ascribed this valve mechanism to Hydrogen.
- Baker & Kippenhahn (1962), Cox (1963) and Zhevakin (1963) later suggested Doubly ionized Helium being the major reason.

*“Doubly ionized Helium is more
opaque than singly ionized Helium”*



Much of the
gravitational
potential energy goes
in ionization thus
decreasing
transparency or
increasing opacity



Radiation is trapped
and there's build up
pressure due to
increase in
temperature. Leading
to expansion giving
burst of radiation.

- Their role as Standard Candles along with Type Ia Supernovae.
- High Luminosity.
- Distance measurements of farther objects over parallax.

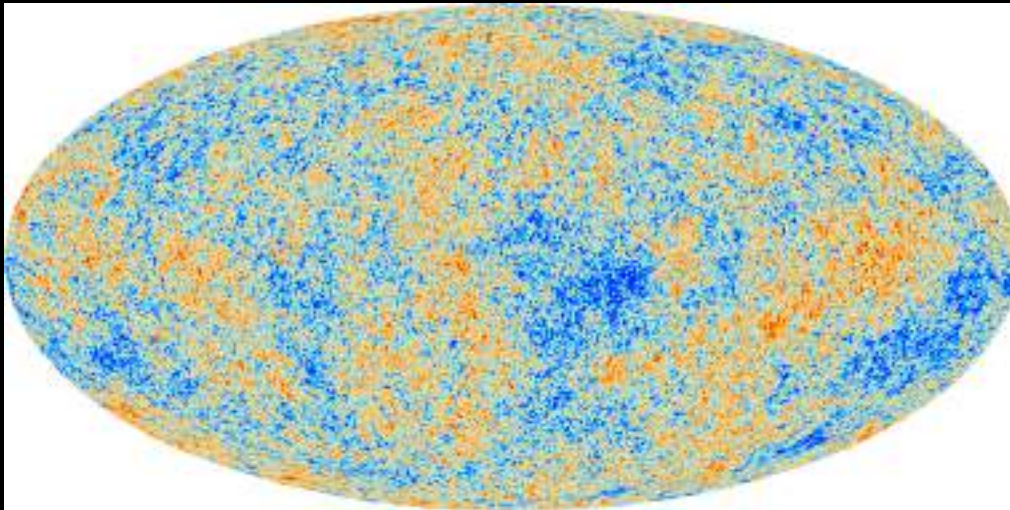


$$v \propto D$$

- Edwin Hubble observed Cepheids in Andromeda.
- Spiral nebulae were actually galaxies and were farther.
- Hubble's discovery of Expanding Universe.
- Matter distribution.
- Measurements for Cosmological parameters.
- Knowledge to make us doubt and wonder.

Uncertainties

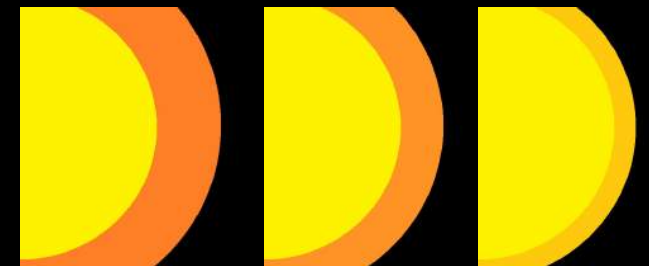
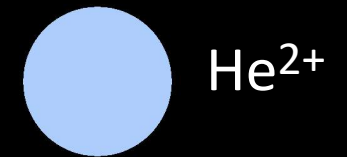
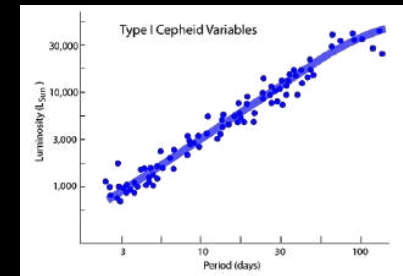
- Precise Calibration to know which Luminosity value relates to which value of time period.
- Distance determination for farther objects requires better Telescopes. (HST reach app. 30Mpc)
- Uncertainties in determination of value of Hubble Constant.



Light echoes (created due to variability) from RS Puppis (a Cepheid variable) propagate through its reflection nebula
Credit: HST

Summary

- Cepheids vary in brightness.
- Rapid increase followed by a hump.
- Linear relationship between Luminosity and period of pulsation.
- Eddington's valve mechanism and Doubly ionized Helium.
- Doubly ionized Helium is more opaque than singly ionized Helium.
- Useful for distance measurement.
- Changed our picture of Universe and surrounding.
- Uncertainties with Calibration and more.



“The scientist does not study nature because it is useful to do so. He studies it because he takes pleasure in it, and he takes pleasure in it because it is beautiful. If nature were not beautiful it would not be worth knowing, and life would not be worth living. ”

- Poincare

THANK YOU

References and Credits

https://en.wikipedia.org/wiki/Cepheid_variable and related Articles.

<https://arxiv.org/ftp/arxiv/papers/1504/1504.02713.pdf> “The Secret Lives of Cepheids”

<https://www.aavso.org/>