

The background of the slide is a deep blue and black starry night sky. A prominent, glowing red nebula is visible in the upper central region, with some blue and white stars scattered throughout the field of view.

Calibrating the Cepheid Period-Luminosity Relation

Presentation for NM Space Grant
Ryan Campbell

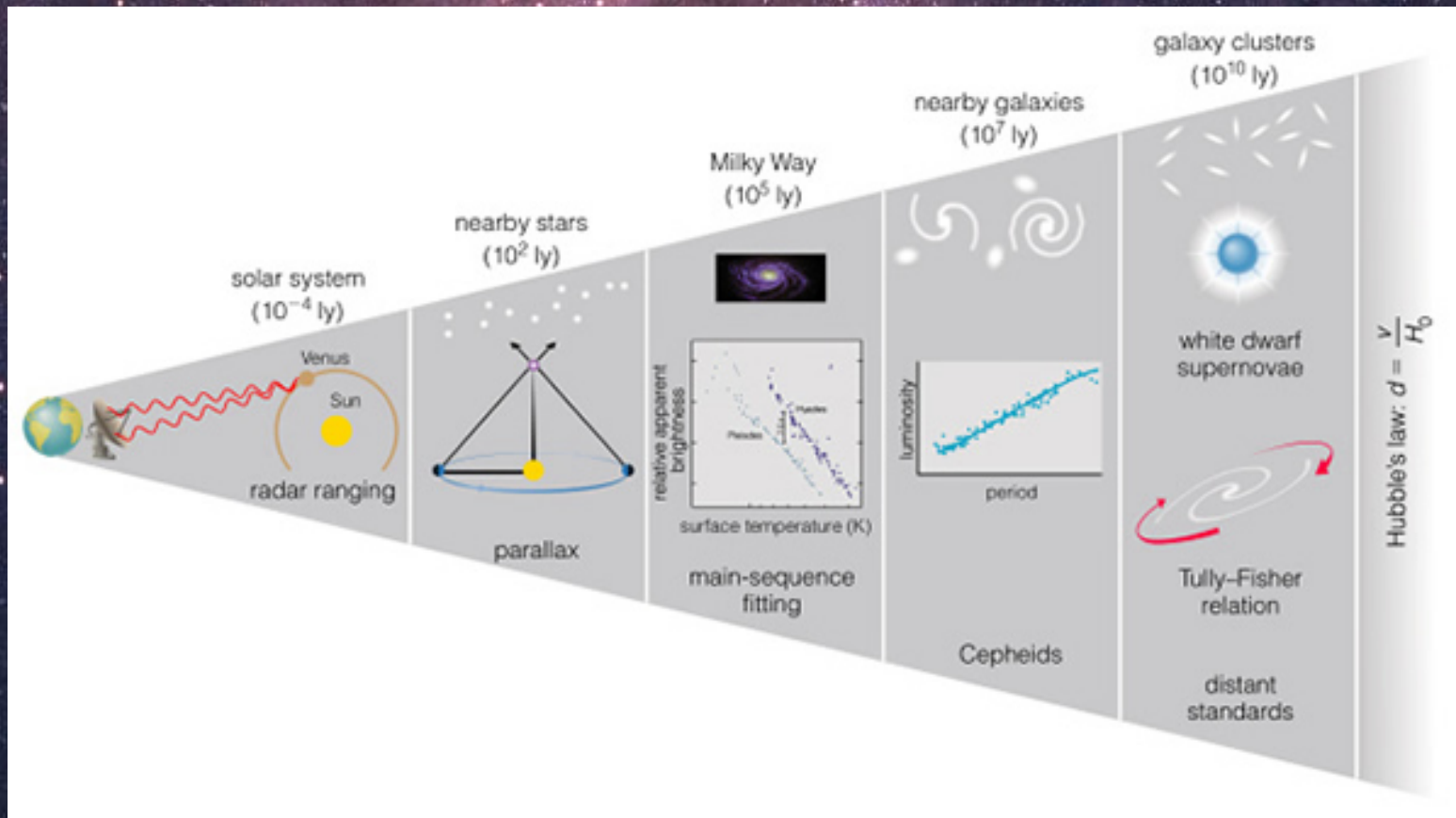
Overview

- *Getting an Idea of where we are-* The distance scale ladder
- **Cepheids:** A General Primer
- **Our Project**
- **Results**

The Distance Scale Ladder

- Distance=Big Problem!!
- Distance Scale Ladder
 - Each step requires accurate calibration of step before it.
 - Currently, the largest error is in the calibration of **Cepheids**.

The Distance Scale Ladder



The Distance Scale Ladder

- Solar System-
 - Radar Ranging
- Stellar Neighborhood
 - Parallax
- “Intermediate”:
 - Cepheids
- Galaxies:
 - Tulley-Fisher, Faber-Jackson
- Extragalactic-
 - Hubble’s Law

Radar Ranging

- Bounce radar off mirrors/Probes
- Radar waves travel at speed of light.
- How long does a response take?
- Very accurate but only works for places we have already gone.

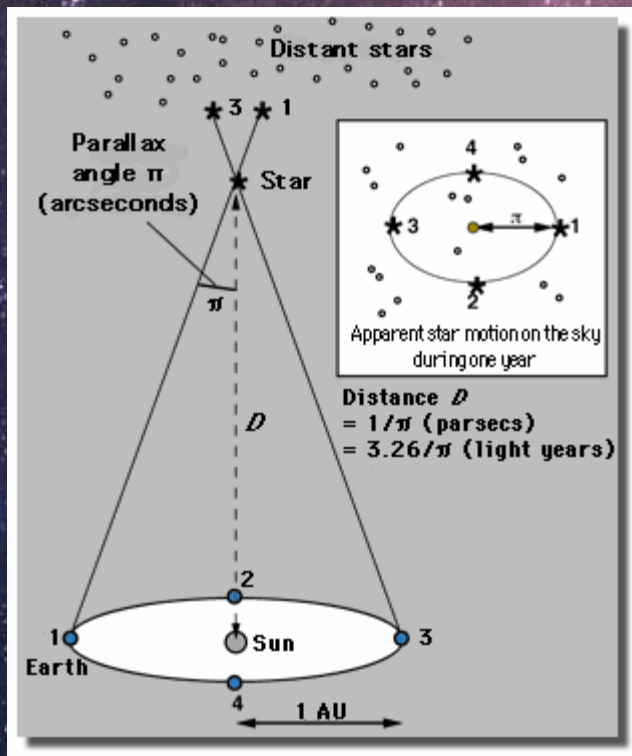


Ummm... Pretty far.

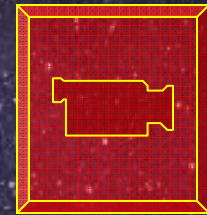
Hey, How far are you?



Parallax



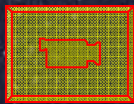
- “Apparent Motion”
- Nearby stars move more than those very far away
- Accurate calibration requires very accurate angular measurements
- Must take very small motion of distant stars into account
- Doesn't work for $p < .1$ ma



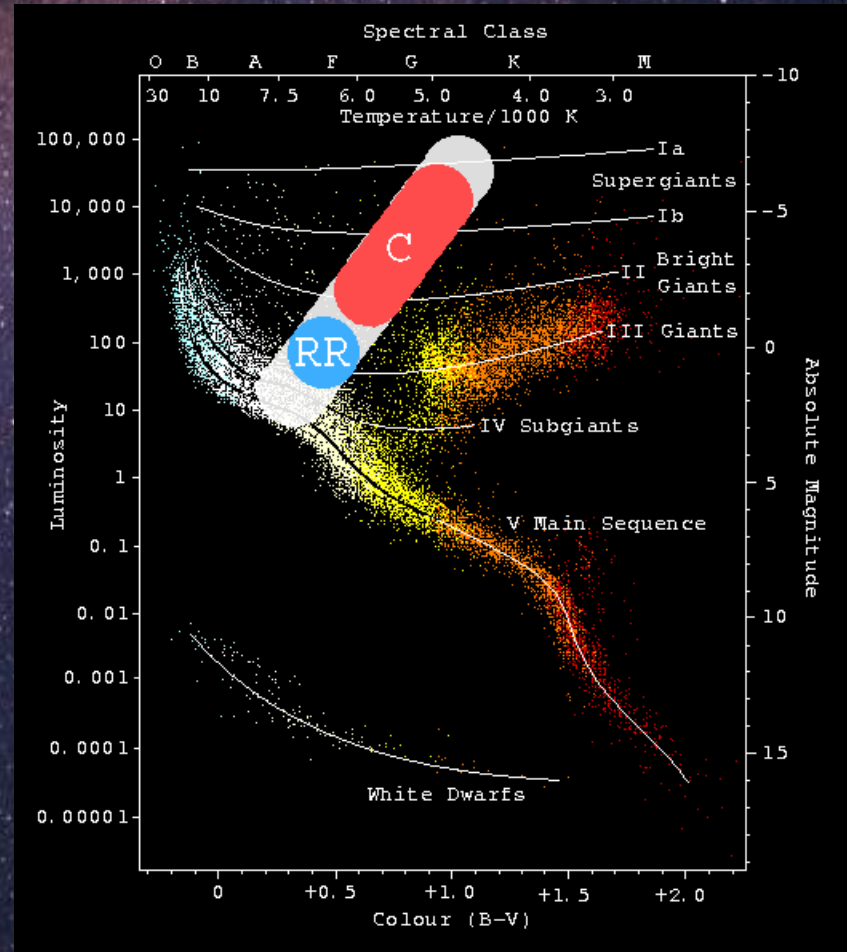
Parallax Movie

Cepheids

- How far to nearby galaxies?
- “Cepheids”
 - Horizontal branch
 - Instability Strip
- They Pulsate in size and brightness
 - He+ partial ionization zone; Like a piston



Cepheid Pulsating



Cepheids Cont.

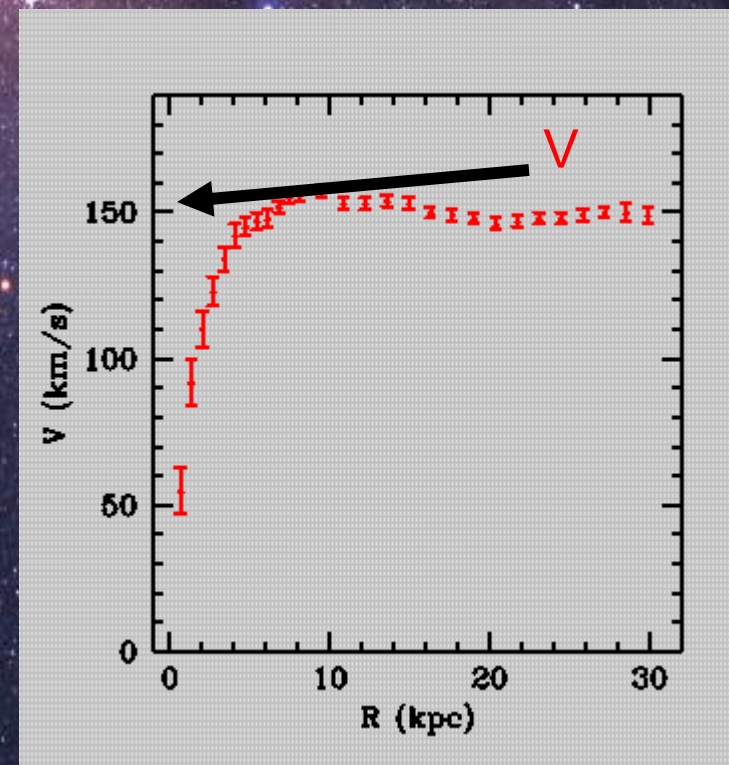


Henrietta Swan
Leavitt

- Period tied to luminosity
 - 2 Types: Classical and W Virginis
- Current P-L Relation:
- $M_v = -2.8 \log P - 1.43$
 - Needs an independent measurement to Cepheid to calibrate.
 - Considerably off

Tully-Fisher & Kin

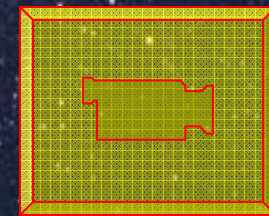
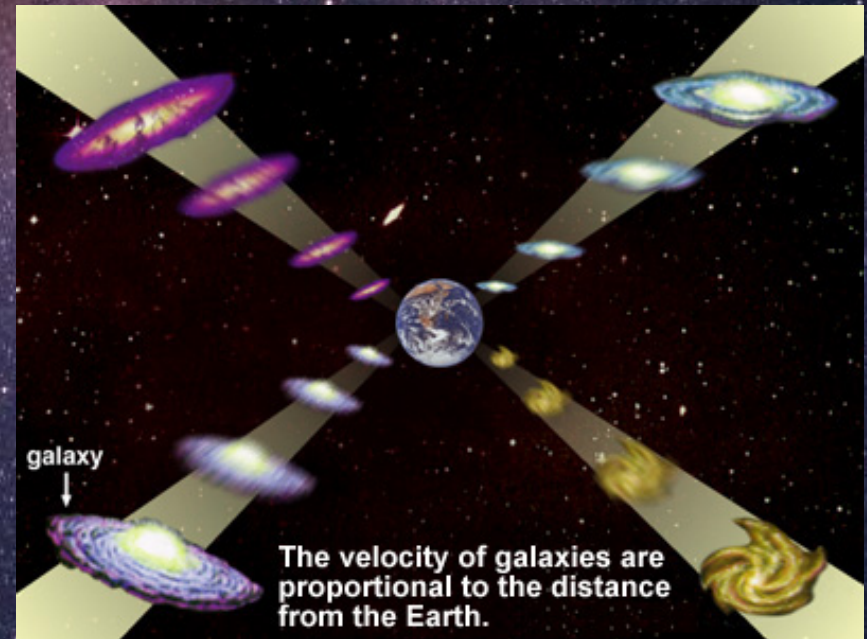
- T-F: $L \propto V^4$
 - For Spiral Galaxies
 - More massive galaxies move faster and are brighter
- Faber-Jackson:
 - $L \propto \sigma^4$, where σ is the velocity dispersion
 - For elliptical galaxies.
 - More massive Es are more “stirred up”
- These relations calibrated via P-L relation



Rotation Curve: A way to determine galactic distance

Hubble's Law

- The universe is expanding
 - Everything is redshifted (it's moving away from us)
- Like a balloon, the further away the Faster something expands
 - $V=H_0D$, H_0 = Hubble's Constant
 - $T_{\text{universe}} \sim 2/(3H_0)$.
- Once again may be miscalibrated



Expanding Universe

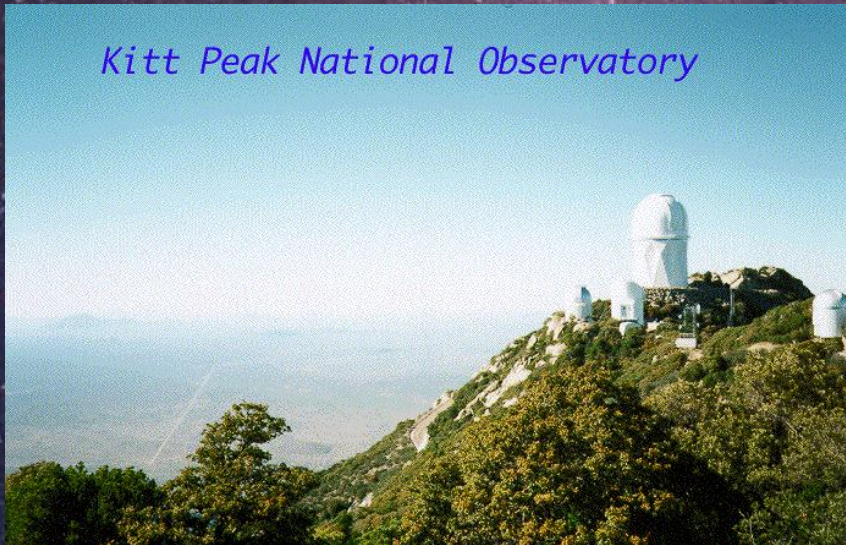
Big Project

- **HST** - Measures 10 Variables with FGS over 110 orbits.
- Measures the magnitude zero point: The average magnitude @ $\log P=0.73$, that of δ Cephei.
- Expect accuracy within 0.03 mag (1- σ certainty)



Hubble Space Telescope

Our Portion



Kitt Peak National Observatory

Kitt Peak National Observatory

- Observe standards in Cepheid-star fields with KPNO 4.1 and 2.1 meter telescopes.
- 6 Star fields observed, each with 6-8 stars.
- From each obtained Spectral type, V & K Magnitude, Zero Point, A_v , Distance, and Parallax angle
- U. Texas now working on final results for Cepheids

Results For one Field: FF Aql

Name	Sp. Ty.	V	K	Mv	Av	<D(Pc)>	<P(ma)>
FF Aql				0.69			
Ref 2	K2III	14.17	10.32	0.50	1.39	2914	0.343
Ref 3	K3V	14.16	11.46	6.72	0.00	290	3.461
Ref 4	K3V	13.68	11.17	6.72	0.00	242	4.125
Ref 5	G7V	14.93	12.63	5.32	0.68	610	1.639
Ref 6	F2V	15.10	13.18	2.70	1.22	1715	0.583
Ref 7	K2III	15.23	11.14	0.50	1.51	4418	0.226

Conclusion

- Distance scale ladder one major fundamental problem in astronomy
 - Cepheids are the Major “Break in the Ladder”
 - Impacts as far ranging as cosmology
- Reduced standard fields for 6 cepheids
- Now awaiting results from U. Texas
- Should calibrate P-L zero point to 0.03 mag.

Up Next For Me

- My research is transitioning to the study of Polars.
 - Binary stars with bad tempers. (=HUGE Explosions) and GIGANTIC Magnetic Fields
- My Thesis will be a joint observational/Theoretical campaign
 - Get spectra for a lot of these objects
 - Model their spectra & system geometries



Polars! These Guys are so Cool.

The End

Thanks so Much, Guys!

