

Finding A Relation
Between Galactic Redshift
and Radial Distance

Mathematical Association of America
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B.S. Physics

B.S. Civil Engineering

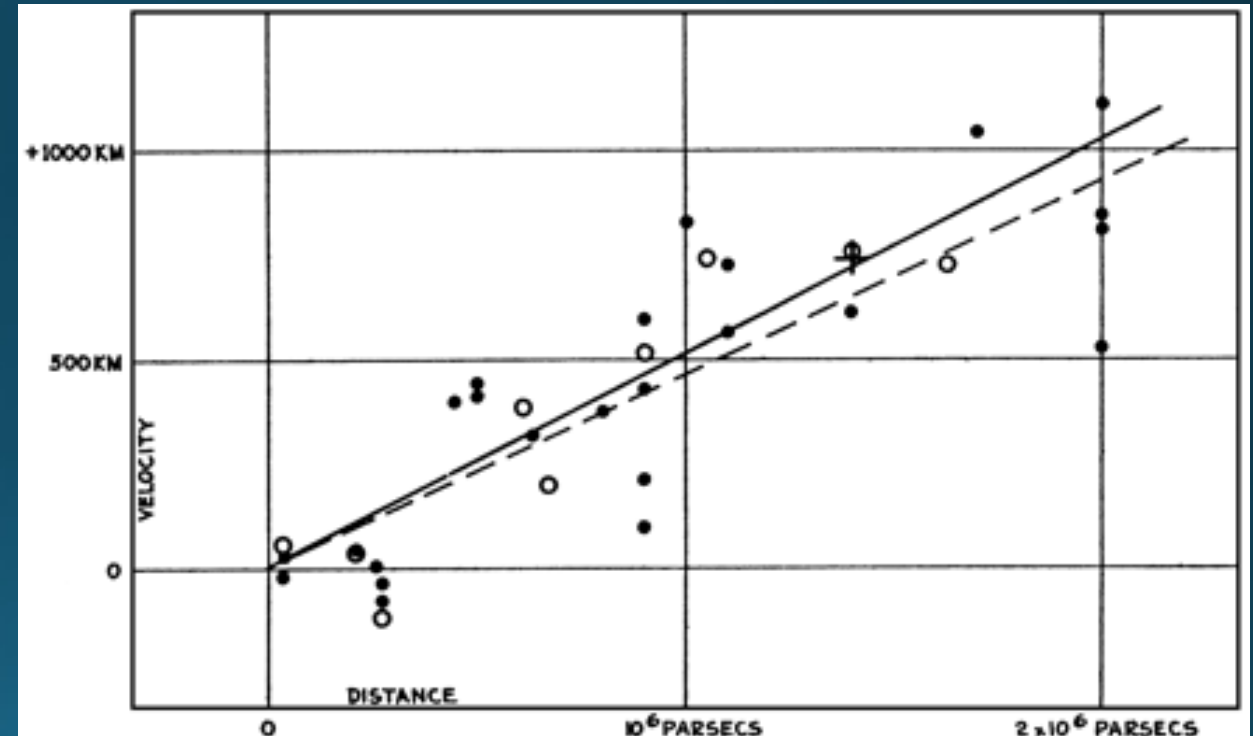
Under the Direction of

Dr. Adam Fritsch

Measuring a Relation between Radial Distance and Recessional Velocity

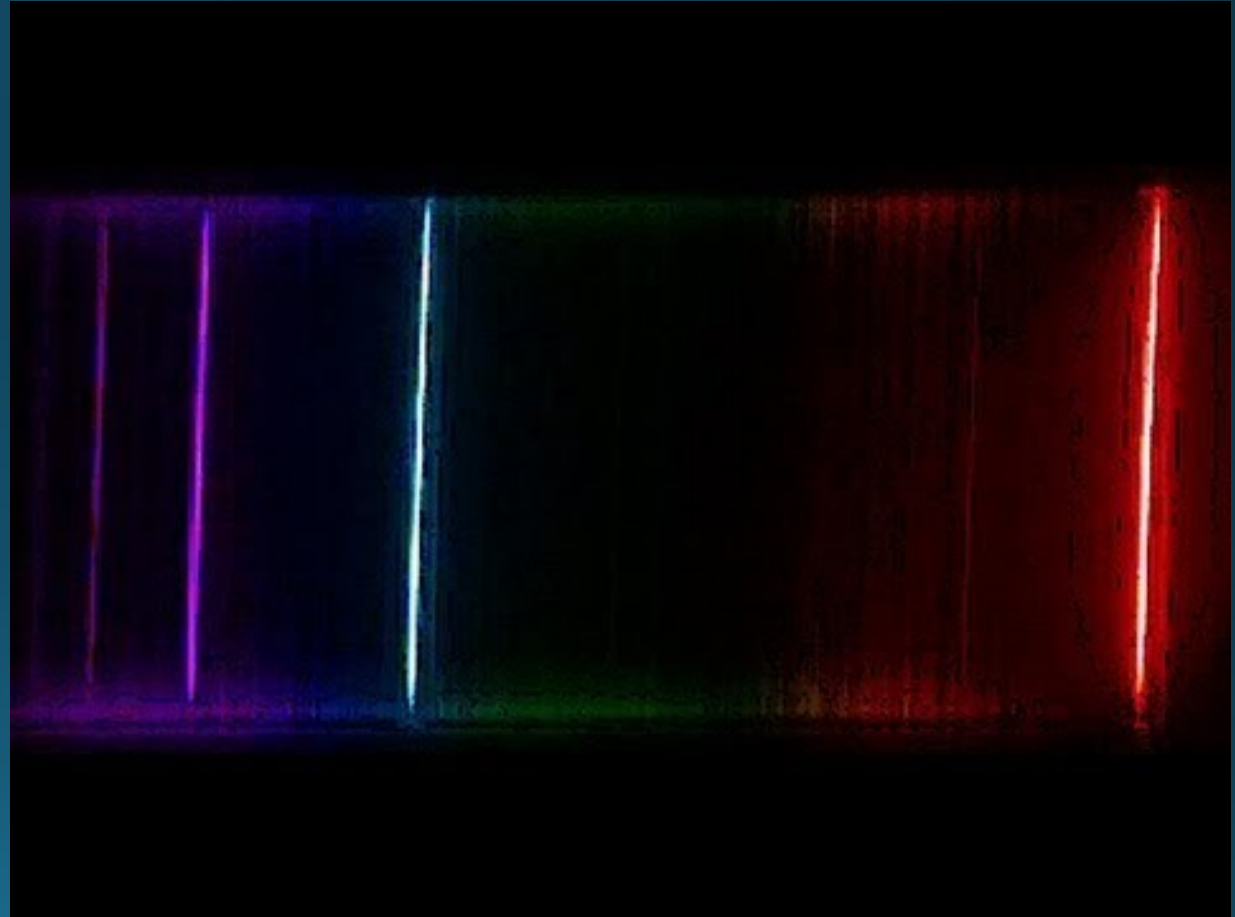
Objective:

- Attempt to replicate results of Edwin Hubble's 1929 survey of recessional velocity and radial distance
- Experimentally determine value of Hubble Constant
- Complete research and analysis with equipment available to any undergrad program



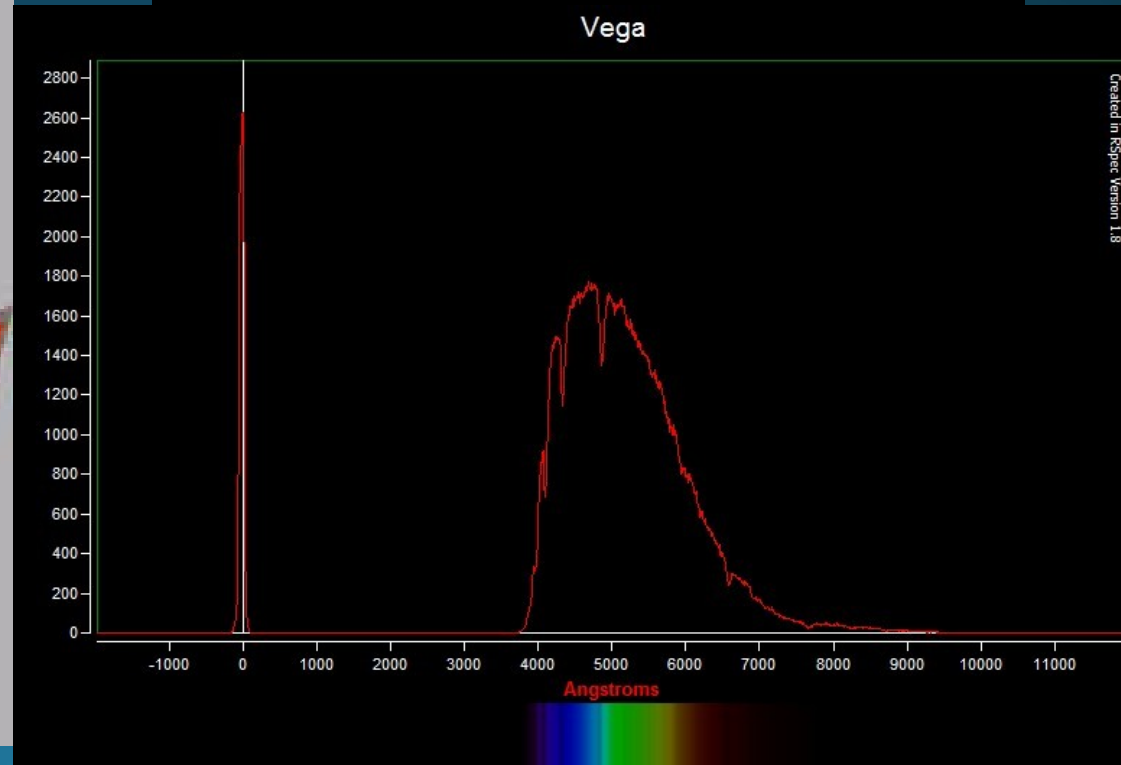
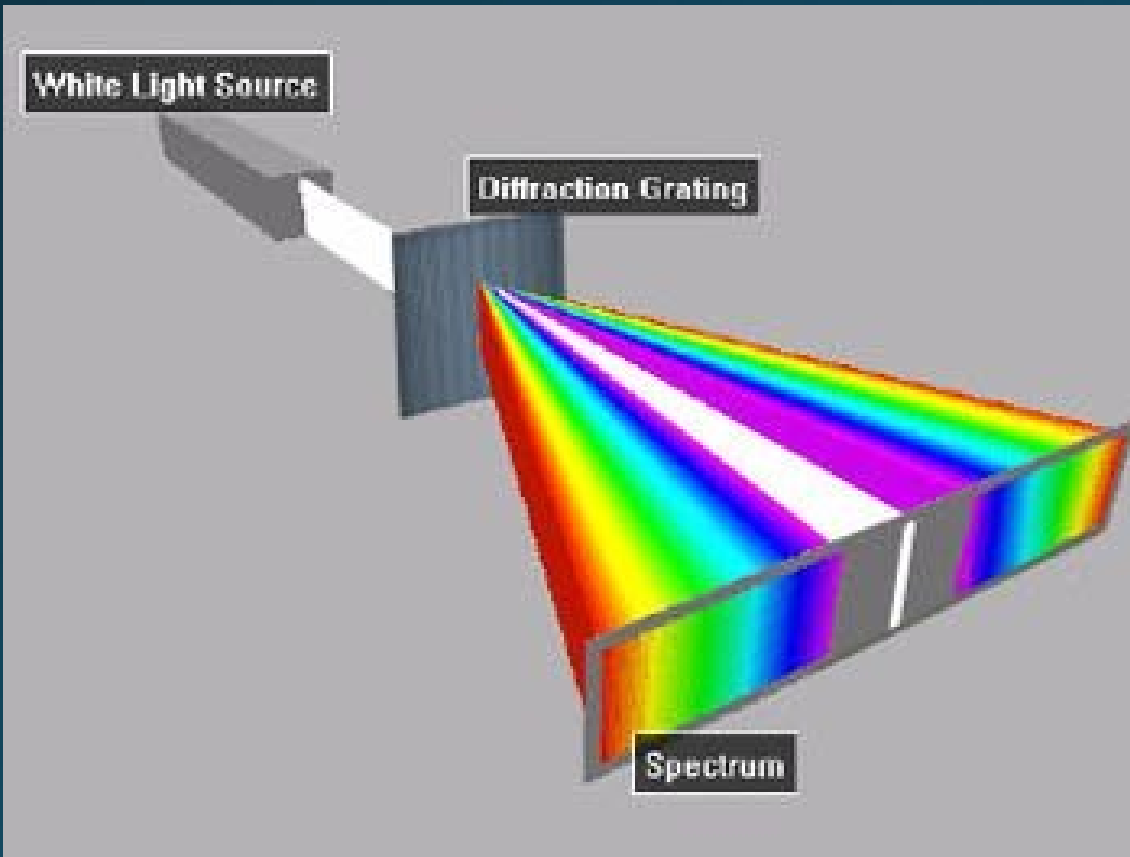
Measuring Velocity

- Doppler Effect Red/Blue Shift
- Receding objects demonstrate Red Shift
- Approaching objects demonstrate Blue Shift
- By measuring Red Shift we can determine Recessional Velocity



Measuring Red Shift

- Diffraction Grating
- Calibrated on known source



Measuring Distance

- A Much more complex task
- Two methods
 - Parallax
 - Std Candle
- Both require very sensitive equipment and facilities
- Out of the scope of this project

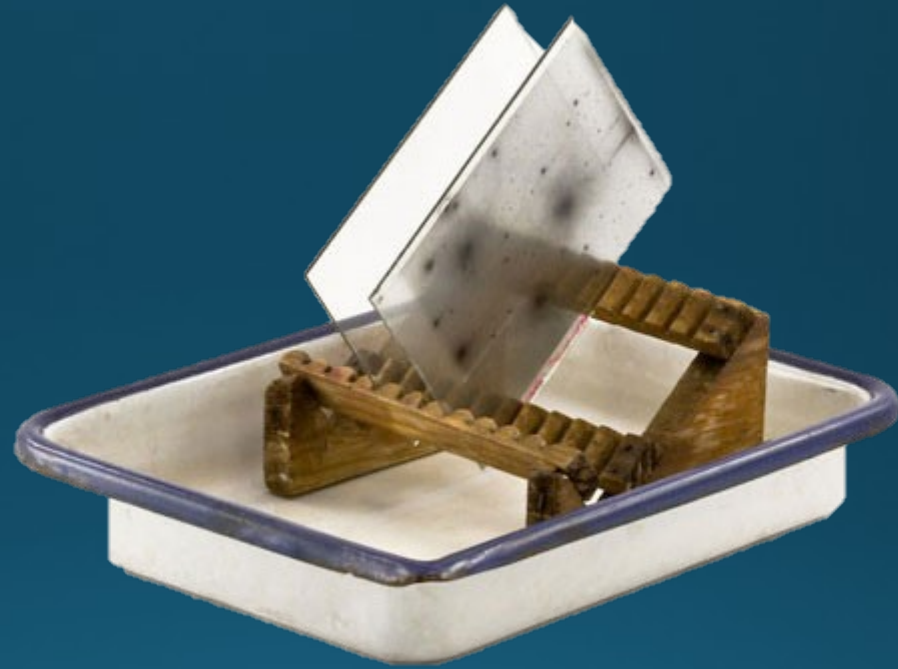
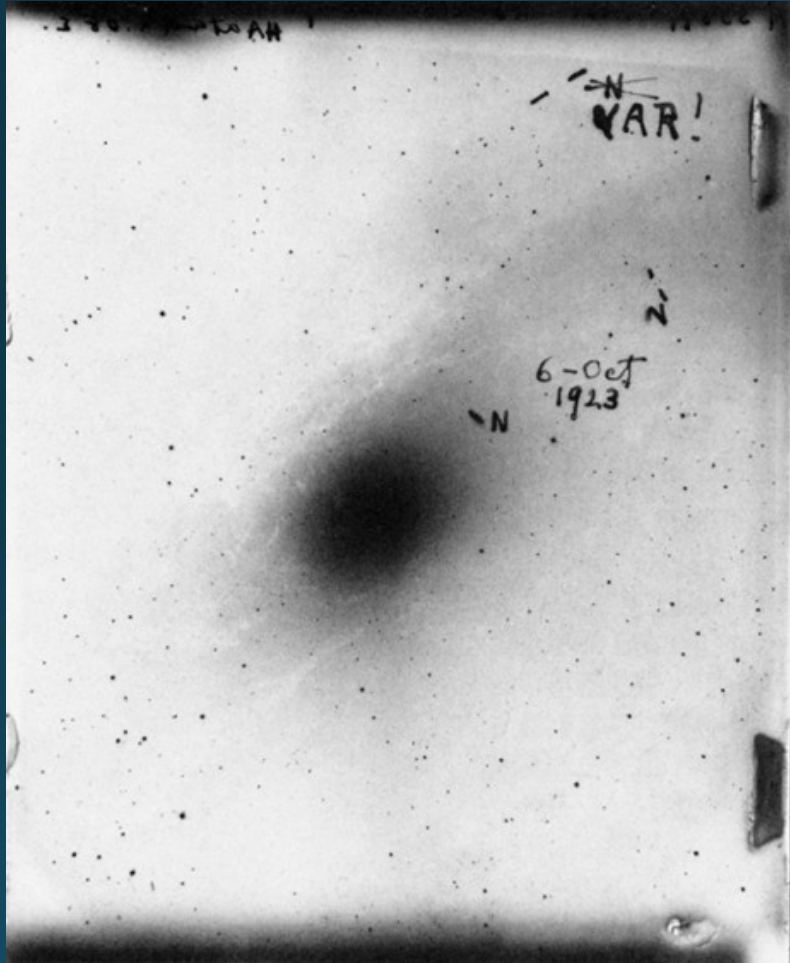
Measuring a Relation between Radial Distance and Recessional Velocity

How is this Possible

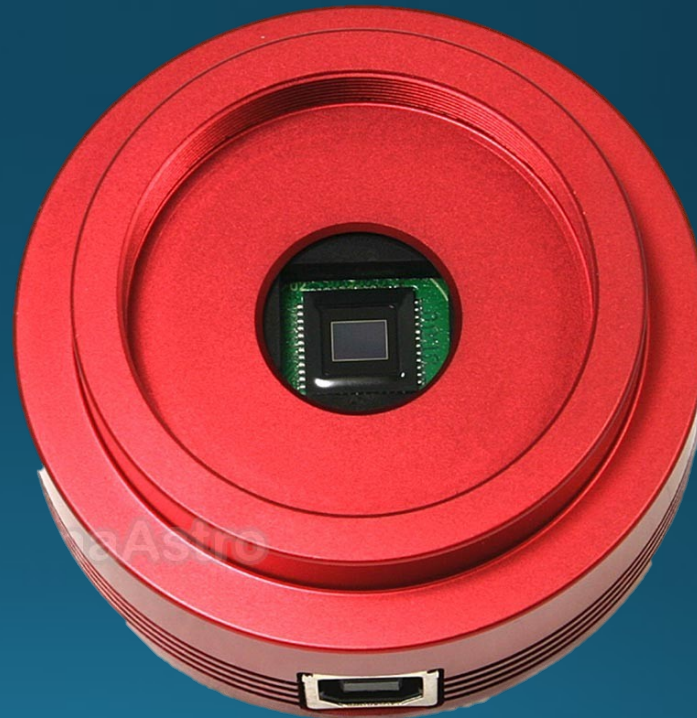
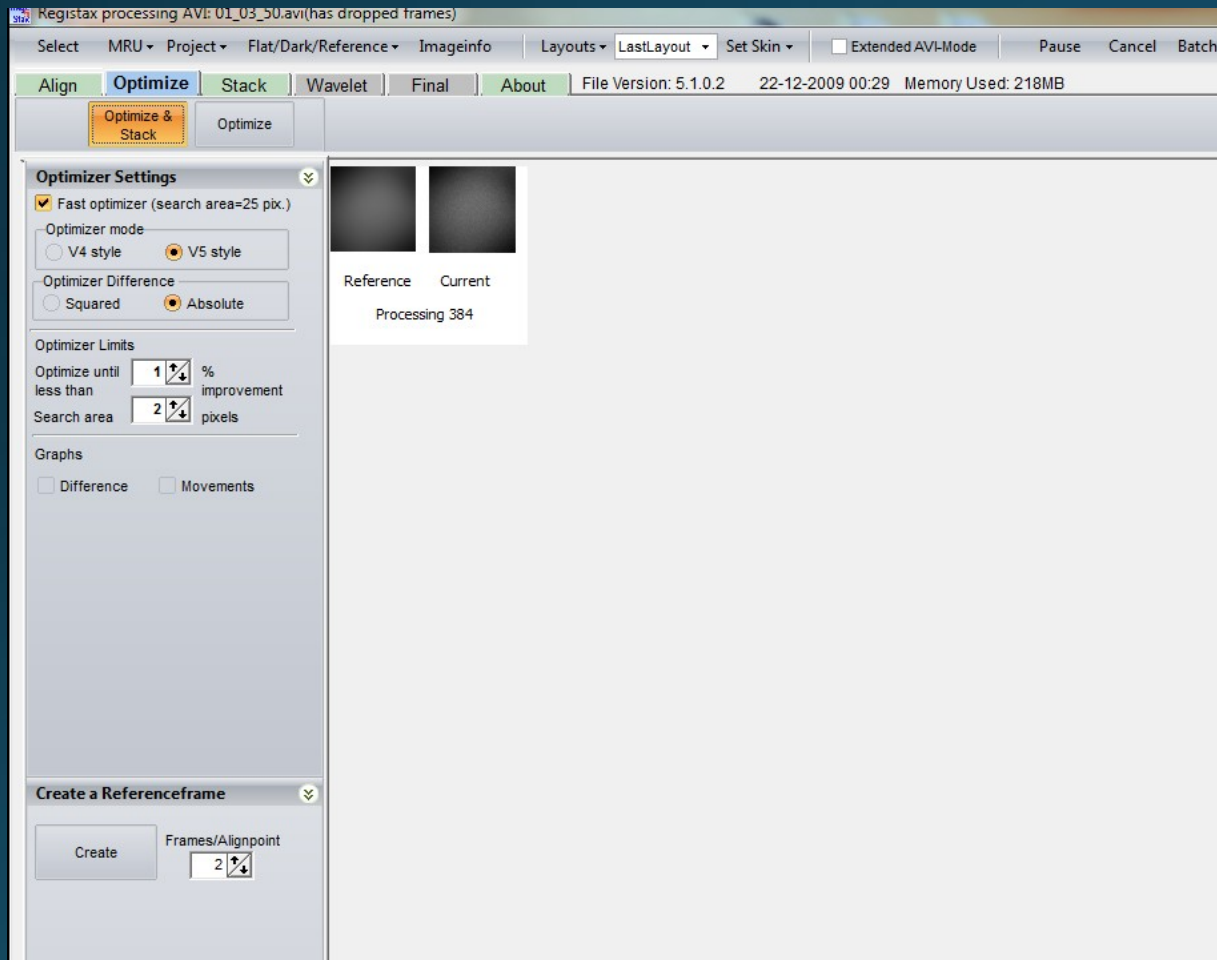
- Hubble in 1929
 - 100x more light gathering
 - Limited to long exposure photography on glass plates
- Thurston in 2017
 - 1% of the light gathering capability, over 100x more computational power
 - Can take and stack thousands of short exposure images



Glass Photographic Plates



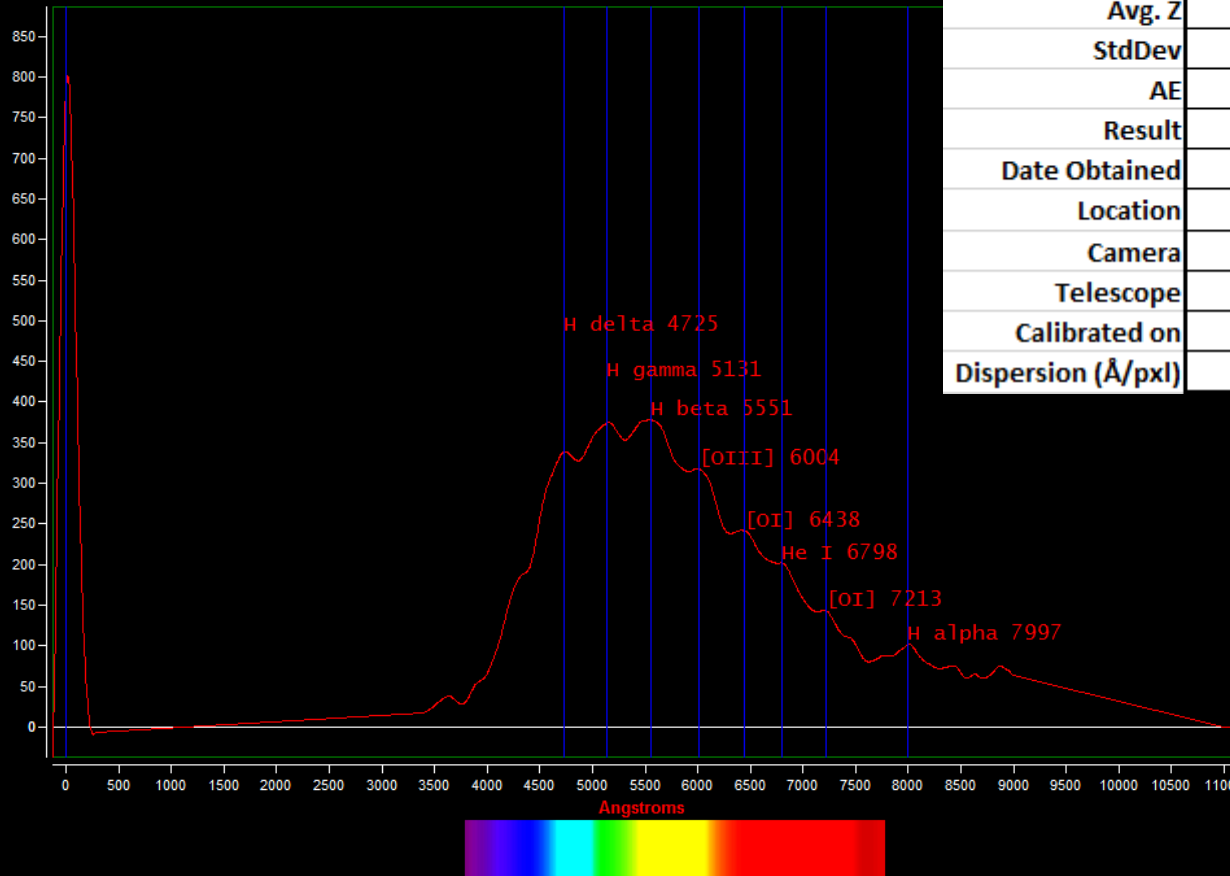
Digital Stacking



Measuring a Relation between Radial Distance and Recessional Velocity

First Usable Data

Quasar 3c273 Spectrum



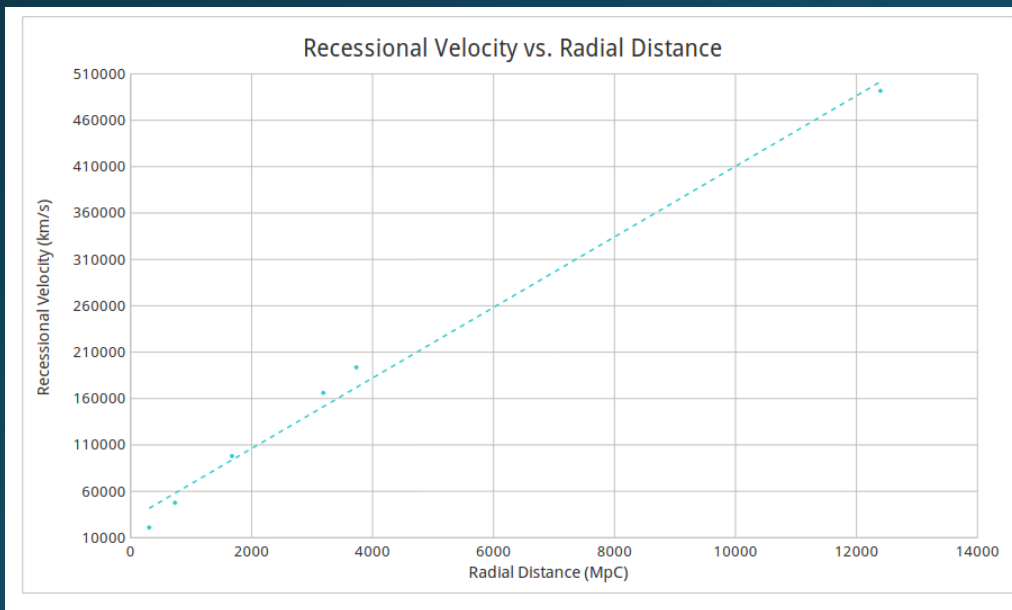
3c273								
Emission Line	H α	H β	H γ	H δ	[OIII]	[OI]	[OI]	He I
Measured λ (Å)	7997	5551.9	5131.8	4725.7	6004.7	7213.7	6438.8	6798.2
Resting λ (Å)	6562.8	4861.3	4340.5	4101.7	5007	6363.78	5577.33	5875.64
Z	0.218535	0.142061	0.182306	0.152132	0.199261	0.133556	0.154459	0.157014
Avg. Z	0.16741553							
StdDev	0.029635939							
AE	0.020536658							
Result	.17 \pm .02							
Date Obtained	5/29/2017							
Location	Spokane (Residential)							
Camera	ZWO ASI 120MM							
Telescope	10" f/5 Newtonian							
Calibrated on	Vega							
Dispersion (Å/pxl)	8.3							



Measuring a Relation between Radial Distance and Recessional Velocity

Data

- 3 day expedition to Darling Lake, ID
- 6 pulsars imaged
- 700 – 12000 Mpc (NASA/IPAC Extra Galactic Database Luminosity Distance)



3c273													Markarian 205						
Emission Line	H α	H β	H γ	H δ	[OIII]	He II	[OI]	Ne II	H α	H β	H γ	H δ	He	H ζ	[OI]	He I			
Measured λ (Å)	7423.7	5596.4	5067.6	4707.7	6040.7	5390.9	6462.8	4357.8	7121	5135.5	4510.7	4403.4	4279.6	4170	6667.6	4909.1			
Resting λ (Å)	6562.81	4861.33	4340.47	4101.74	5007	4685.7	5577.33	3766.26	6562.8	4861.33	4340.47	4101.74	3970.07	3889.05	6300.3	4471.48			
Z	0.131177	0.151208	0.167523	0.147732	0.206451	0.1505	0.158762	0.157063	0.085055	0.056398	0.039219	0.073544	0.077966	0.072241	0.058299	0.097869			
Avg. Z													0.0700740130587057						
StdDev													0.0183370354483053						
AE													0.00648312105617738						
Result													.159 \pm .015						
Date Obtained													5/29/2017						
Location													Spokane (Residential)						
Camera													ZWO ASI 120MM						
Telescope													10" f/5 Newtonian						
Calibrated on													Vega						
Dispersion (Å/pxl)													8.34						
Distance (Mpc)*													734						

MS 12186+7522										2XMM J122048.3+751806						
Emission Line	H β	H γ	H δ	He	H ζ	H η	He I	He II	Ne II	Ne II	Ne II	[OII]	[OII]			
Measured λ (Å)	8040.1	7129.8	6840.9	6646.4	6385.3	6113	7396.5	7729.9	5074.8	5547	7729.8	7152.1	6518.9			
Resting λ (Å)	4861.33	4340.47	4101.74	3970.07	3889.05	3835.38	4471.48	4685.7	1916.08	2085.47	2955.73	2733.29	2445.54			
Z	0.653889	0.642633	0.667804	0.674127	0.641866	0.593845	0.65415	0.649679	1.648532	1.659832	1.615192	1.616663	1.665628	#DIV/0!	#DIV/0!	#DIV/0!
Avg. Z													1.64116949642258			
StdDev													0.0238543906381092			
AE													0.0106680078057293			
Result													.646 \pm .020			
Date Obtained													6/25/2017			
Location													Darling Lake, ID			
Camera													ZWO ASI 120MM			
Telescope													10" f/5 Newtonian			
Calibrated on													Vega			
Dispersion (Å/pxl)													8.34			
Distance (Mpc)*													3732			

2XMM J122134.8+750916										2XMM J122350.9+752227						
Emission Line	H α	H β	Ne II	H δ	H ζ	C II	[OI]	Ne II	H β	H γ	He	[OII]	Ne II	Ne I	[OII]	[OII]
Measured λ (Å)	8762.7	6486.7	4759.3	5419.3	5085.4	6842.1	8152.9	6075.7	7585.2	6799.5	6213.4	6547.5	5845.8	5613.5	5149.1	4990.9
Resting λ (Å)	6562.8	4861.33	3574.61	4101.74	3889.05	5145.16	6156.77	4569.06	4861.33	4340.47	4101.74	4185.45	3727.11	3520.47	3287.47	3134.72
Z	0.335208	0.334347	0.331418	0.32122	0.30762	0.329813	0.324217	0.329748	0.560314	0.566535	0.514821	0.564348	0.568454	0.594531	0.56628	0.592136
Avg. Z													0.55489429279761			
StdDev													0.0226054442139212			
AE													0.00799223144769894			
Result													.327 \pm .006			
Date Obtained													6/25/2017			
Location													Darling Lake, ID			
Camera													ZWO ASI 120MM			
Telescope													10" f/5 Newtonian			
Calibrated on													Vega			
Dispersion (Å/pxl)													8.34			

Measuring a Relation between Radial Distance and Recessional Velocity

Results

- Better than expected precision
- Does not agree with Planck Satellite Mission
- Should refine with cosmologically corrected distance measurements

H (km/s/MpC)	
Results	50 ± 3
Range	47 to 53
Accepted	67.74*
Agree?	No

*Planck Satellite Mission

