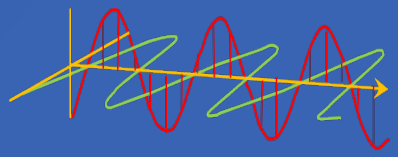
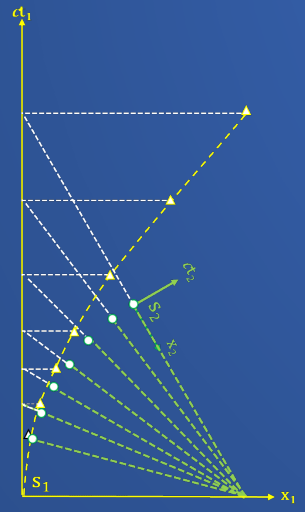
The Velocity Triangle and the Accelerating Universe





CS-AAPT Spring 2025

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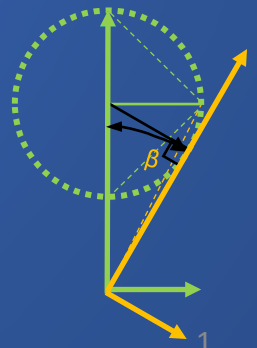
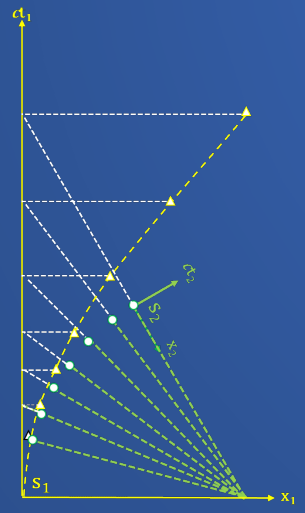


What is the Accelerating Universe?



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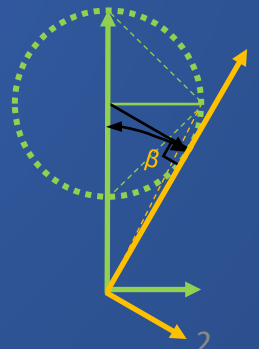
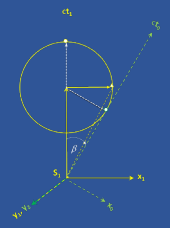
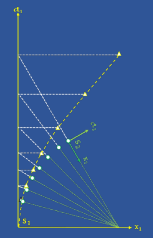
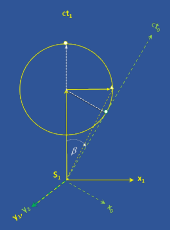




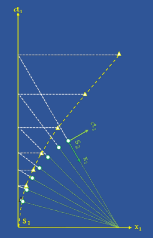
HUBBLE EXPANSION



- DEVELOPED BY EDWIN HUBBLE IN THE 1920's
  - Used Cepheid Variable Stars
  - Measured Distances to 46 Galaxies Up To ~326 Million Light Years
  - Observed Doppler Shift of Characteristic Spectra due to Velocity Proportional To Distance *($V=h_0 s$)*
  - Hubble Factor H Was Determined to be ~1/T, the Age of the Universe
- ESTIMATES VARIED FROM 50-75 km/Mpc TO ABOUT 1975, NOW ABOUT 67 TO 75

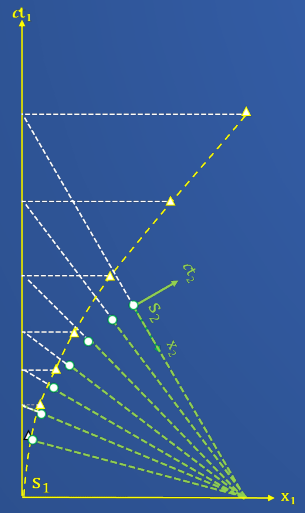


EXPANDING UNIVERSE



- SUPERNOVA COSMOLOGY PROJECT & HIGH-Z SUPERNOVA SEARCH TIME, @1998
  - Determined that the Most Distant Bodies are Receding at an Accelerating Rate, Rather than Proportional To Distance
  - Compatible with Friedmann's 1922 Derivation of Expanding Universe from the Einstein General Field Equations
  - Augmented by Dark Energy (λ) and Cold Dark Matter (CDM) (Both by Definition Unobservable) in the λ CDM Model to Account for the Redshifts Observed.

LET's GO FROM THE SIMPLE TO THE COMPLEX



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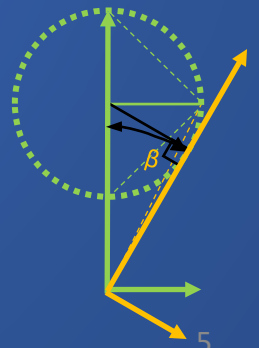
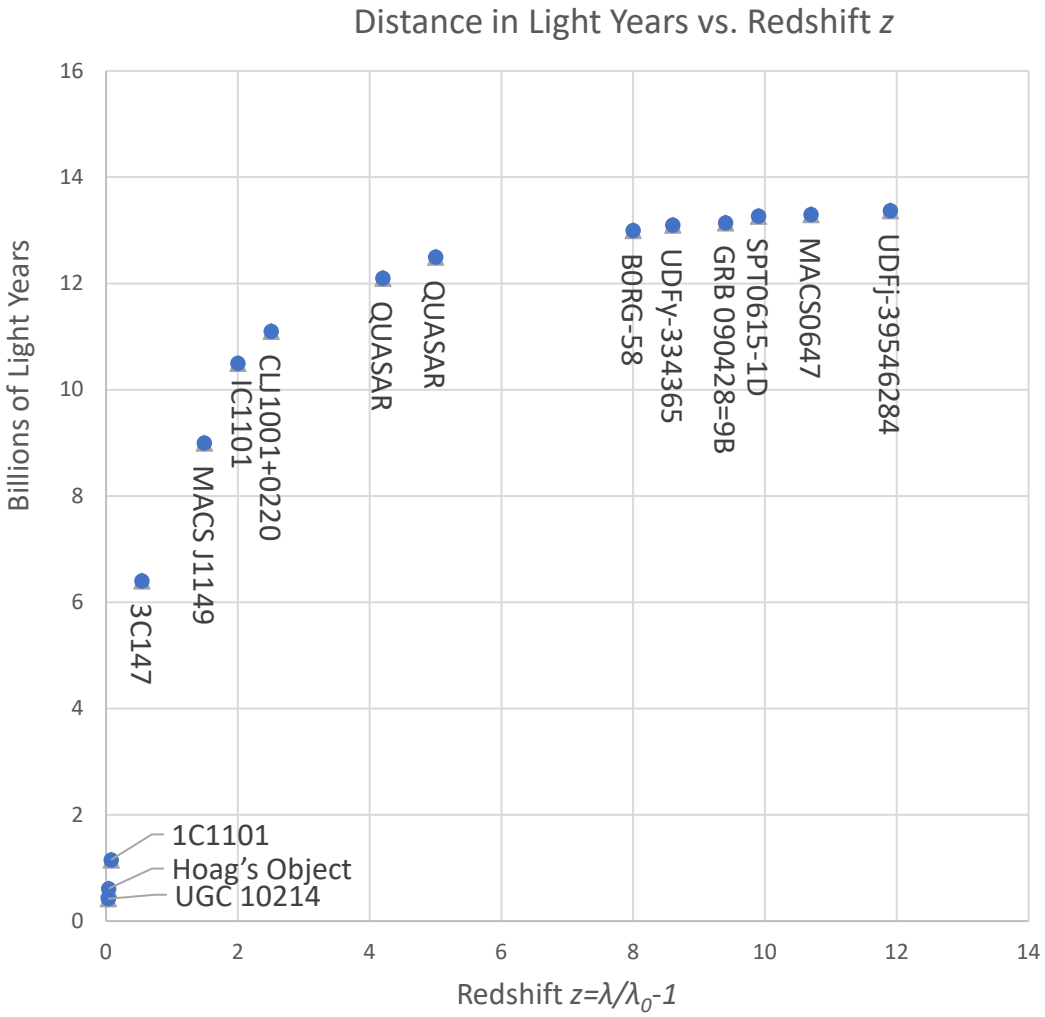
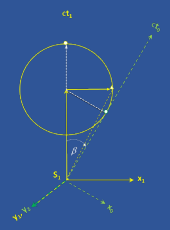


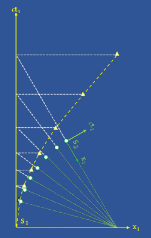
EXPANDING UNIVERSE

Galaxy	Redshift z	Measured Distance, Gly
UDFj-39546284	11.900	13.370
MACS0647-JD	10.700	13.300
SPT0615-JD	9.900	13.270
GRB 090429B	9.400	13.140
UDFy-33436598	8.600	13.100
BoRG-58	8.000	13.000
Quasar	5.000	12.500
Quasar	4.200	12.100
CL J1001+0220	2.506	11.100
DE516C2nm	1.998	10.500
MACS J1149	1.490	9.000
3C 147	0.545	6.400
1C101	0.078	1.154
Hoag's Object	0.041	0.612
UGC 10214	0.031	0.4200





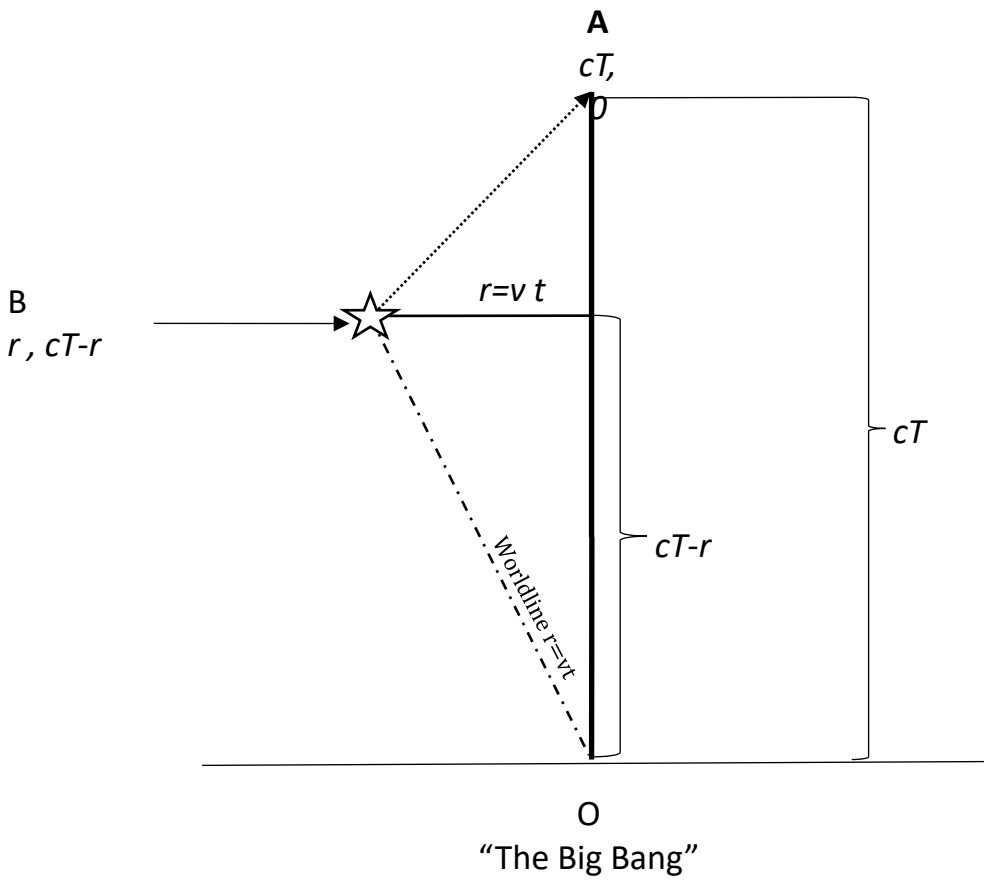
TIME-SPEED DISTANCE SOLUTION



- RESTRICT OURSELVES TO MEASUREMENTS USING OUR OWN RULERS AND CLOCKS

- NEITHER SPECIAL NOR GENERAL RELATIVITY AFFECT OUR OWN MEASUREMENTS

TIME-SPEED DISTANCE SOLUTION

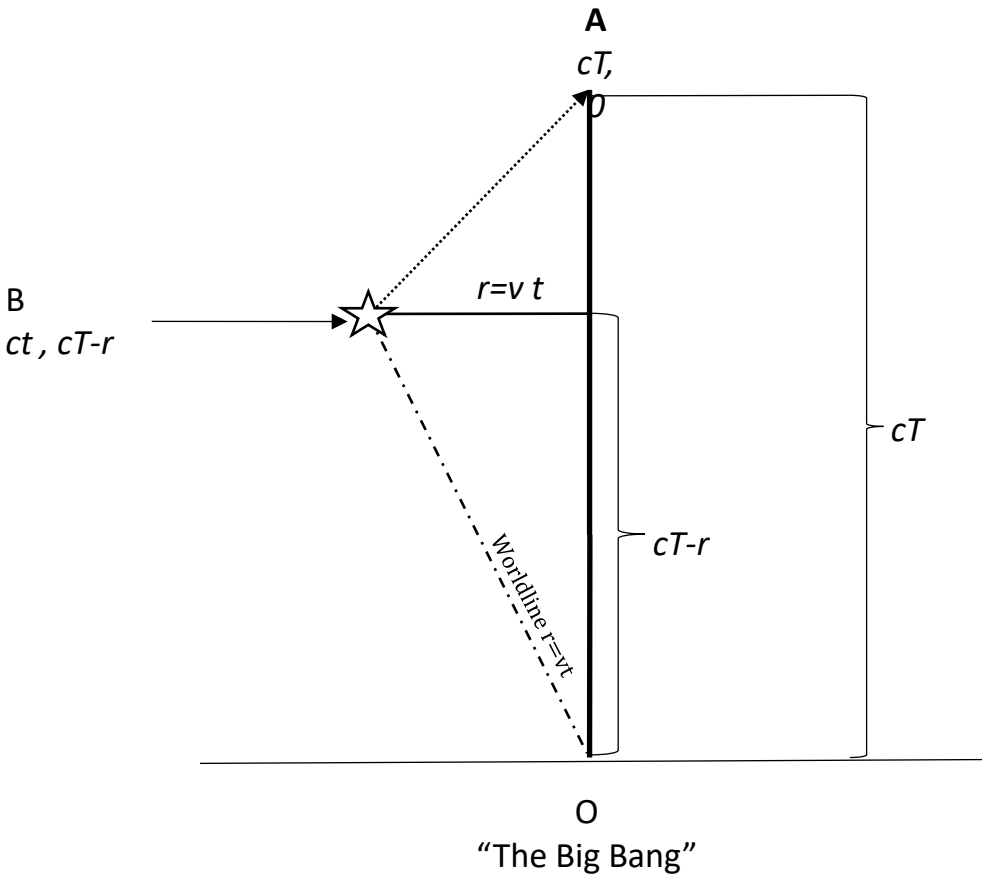


- *cT*=AGE OF THE UNIVERSE, MEASURED ON EARTH
- STAR OBSERVED AT A. @TIME=*cT*
- STAR MEASURED AT B, @RADIUS *r*, @ *cT-r*
- VELOCITY *v/c=r/(cT-r)*

VELOCITY TENDS TO c AS r TENDS TO cT/2

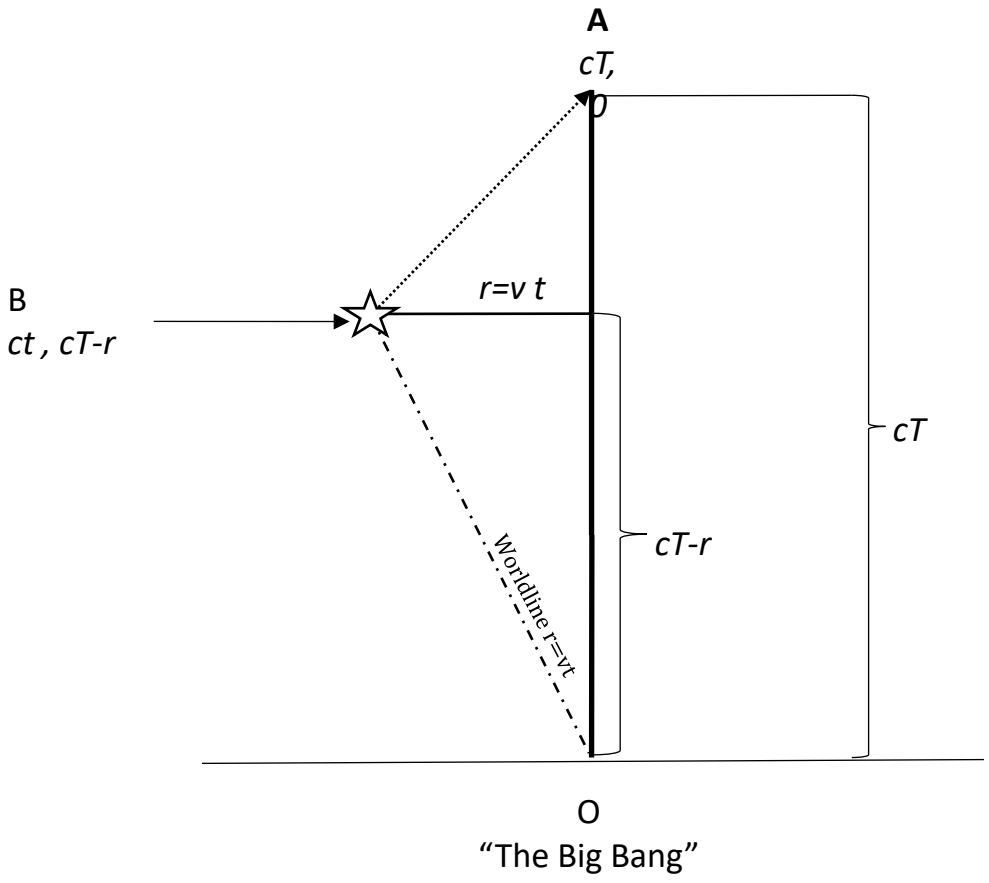
THEREFORE, THE AGE OF THE UNIVERSE IS TWICE THE DISTANCE TO THE MOST REMOTE OBSERVABLE BODY: @27.6gy

AGE OF UNIVERSE



- *cT*=27.6 YEARS, AS MEASURED ON EARTH
- MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY.
  - Rajendra Gupta, University of Ottawa
  - "Tired Light" Losing Energy in Transit
  - Time-Varying Coupling Constants
- "Methuselah Star" HD 140283
  - @200 ly from Earth
  - Estimated 14-15 Billion Years Old.

HUBBLE PARAMETER

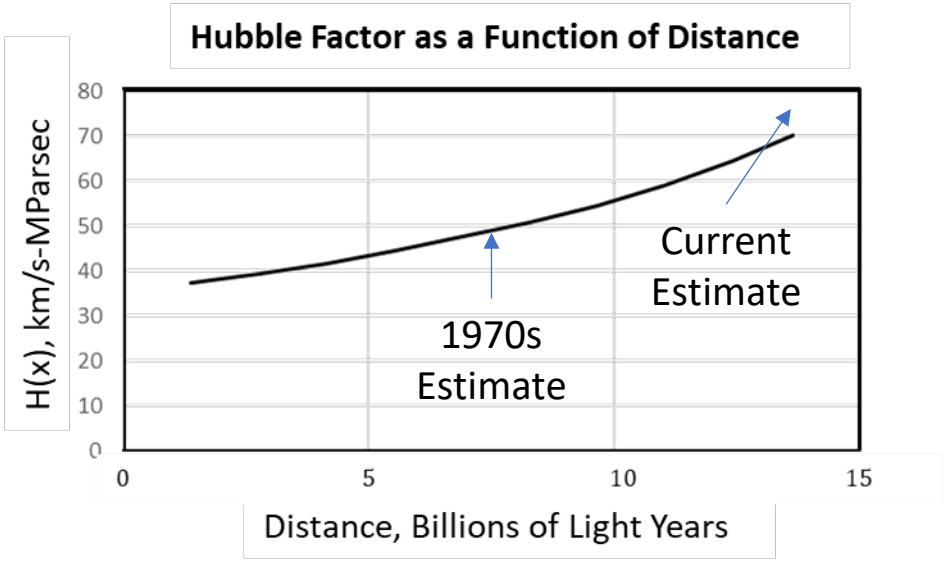


- HUBBLE PARAMETER

$$H(r)=1/(cT-r)$$

$$v/c=r\cdot H(r)$$

VALIDATING THE HUBBLE MODEL



HUBBLE PARAMETER
$H(r)=1/(cT-r)$
(percent of c per light year)

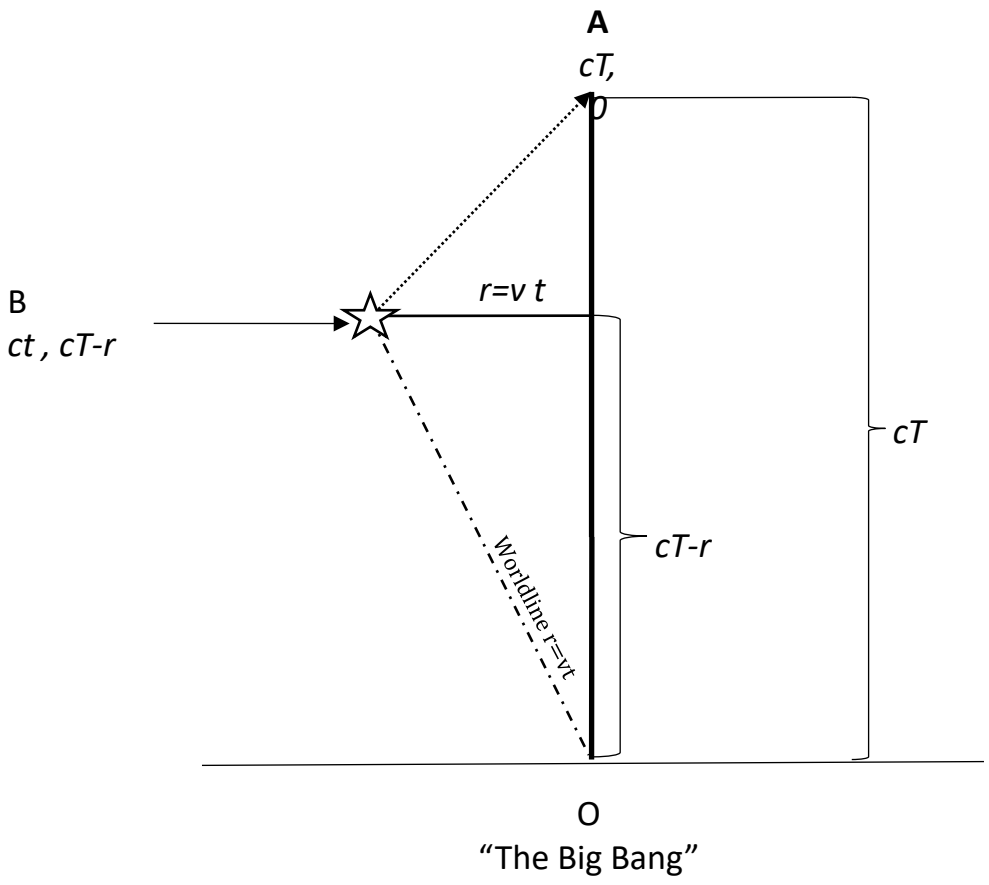
$cT=27.6 \times 10^9$ *light years*

Multiply by

$c=300x10^3$ km/sec
$3.26x10^6$ light-years/megaparsec

for conventional Hubble units (kilometers per second per megaparsec)

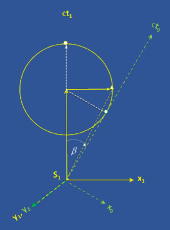
REDSHIFT vs DISTANCE



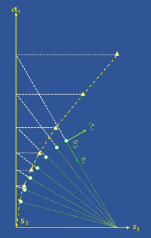
- HUBBLE PARAMETER
  $H(r)=1/(cT-r)$
- $v/c=r\cdot H(r)$
- RELATIVISTIC DOPPLER SHIFT

$$\lambda/\lambda_0 = \sqrt{\frac{1+v/c}{1-v/c}} = \frac{1}{\sqrt{1-2r/cT}}$$

$$z = \frac{\lambda-\lambda_0}{\lambda_0} = \lambda/\lambda_0 - 1$$



REDSHIFT vs DISTANCE



Galaxy	Redshift z	Measured Distance, Gly	Velocity Triangle Distance
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UDFy-33436598	8.600	13.100	13.650
BoRG-58	8.000	13.000	13.630
Quasar	5.000	12.500	13.417
Quasar	4.200	12.100	13.290
CL J1001+0220	2.506	11.100	12.667
DE516C2nm	1.998	10.500	12.265
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3C 147	0.545	6.400	8.019
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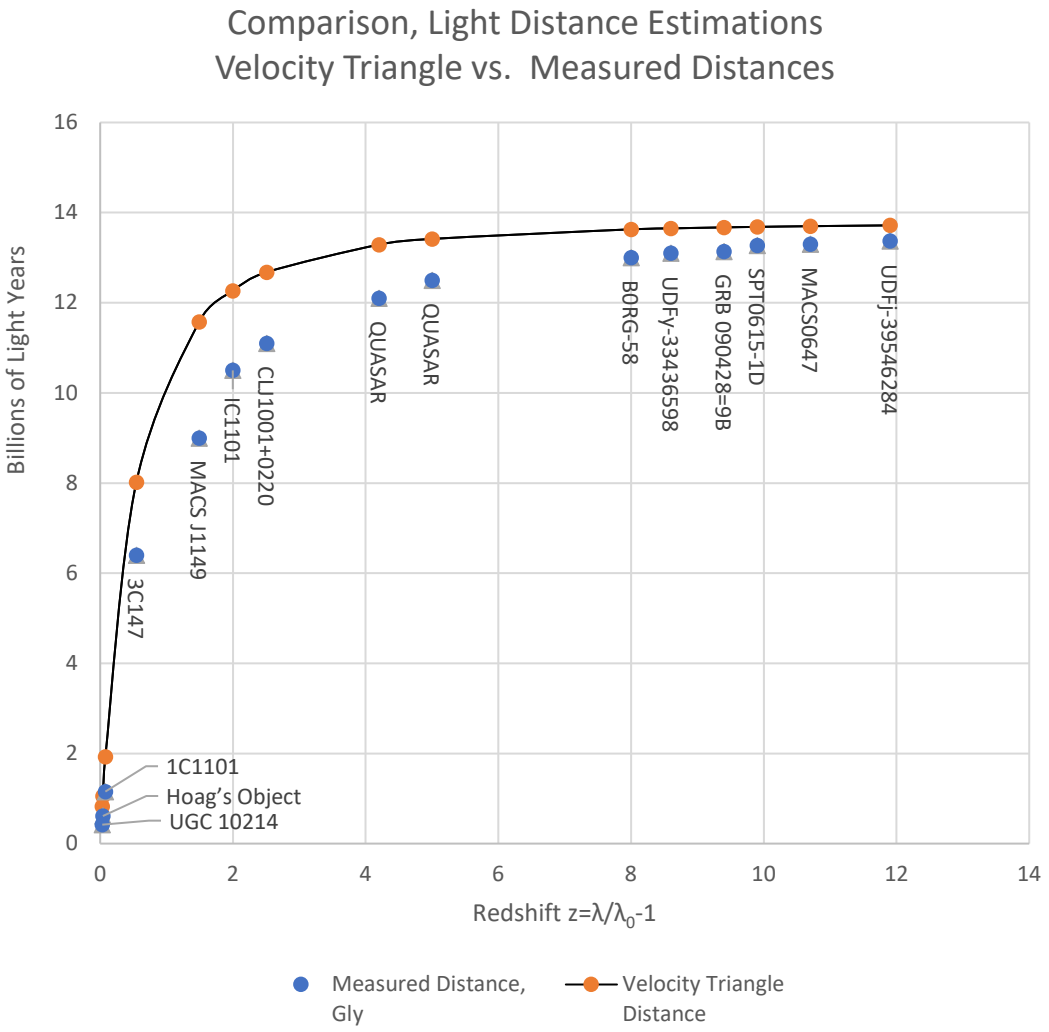
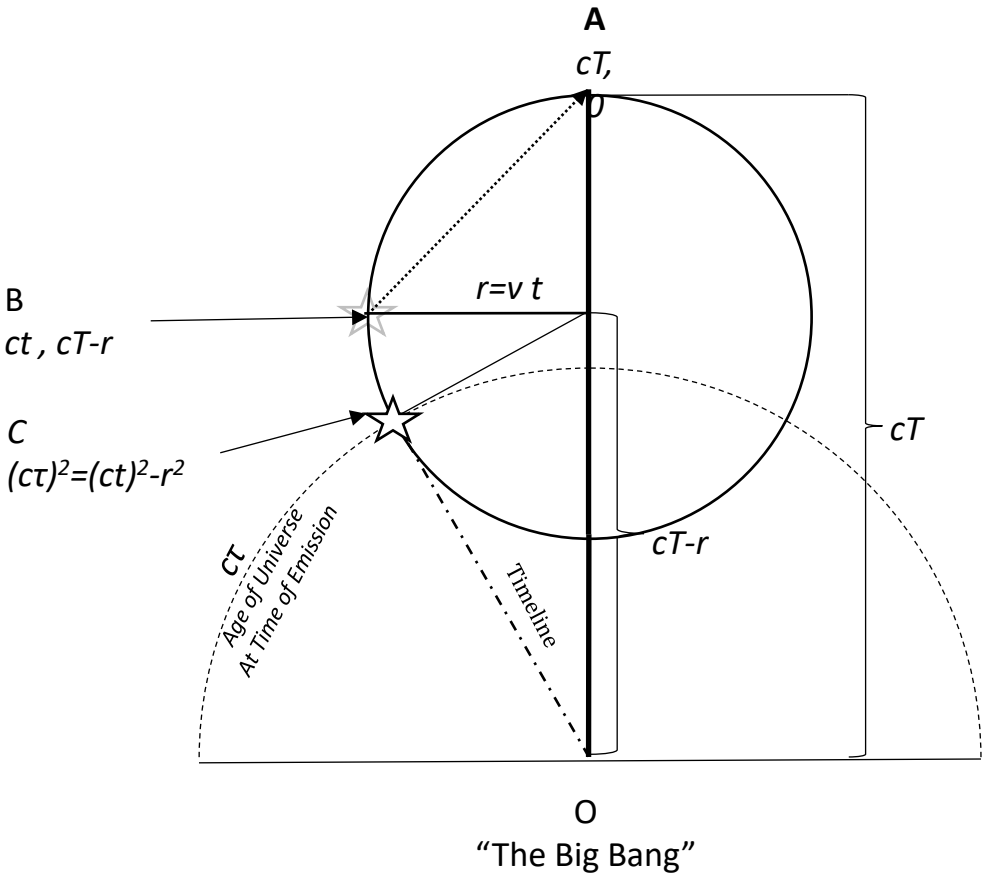


GALACTIC AGES



- HUBBLE PARAMETER

$$H(r)=1/(cT-r)$$

$$v/c=r\cdot H(r)$$

- RELATIVISTIC DOPPLER SHIFT

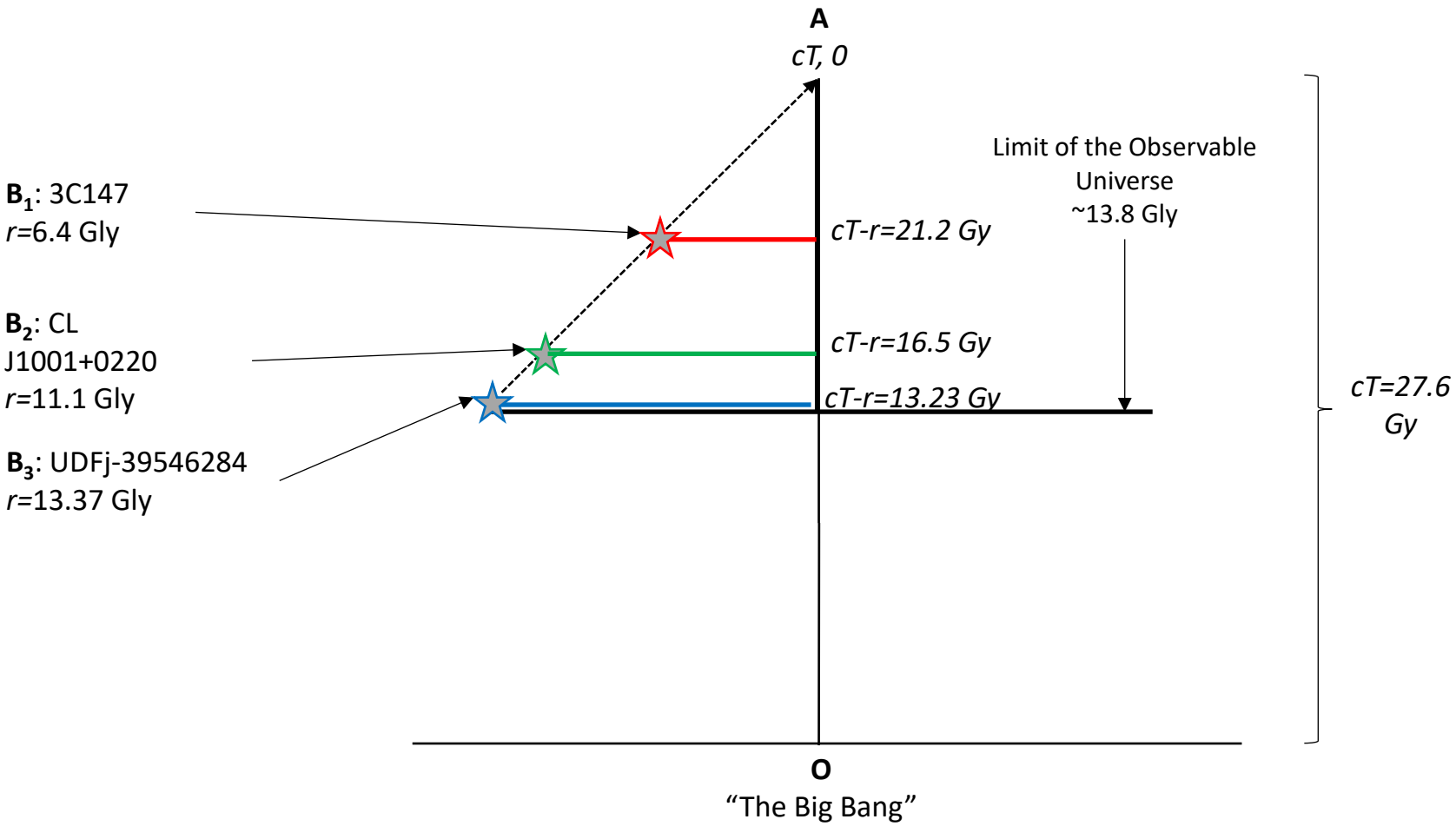
$$\lambda/\lambda_0 = \frac{1}{\sqrt{1-2r/cT}}$$

- PROPER TIME OF TRANSMISSION AT C

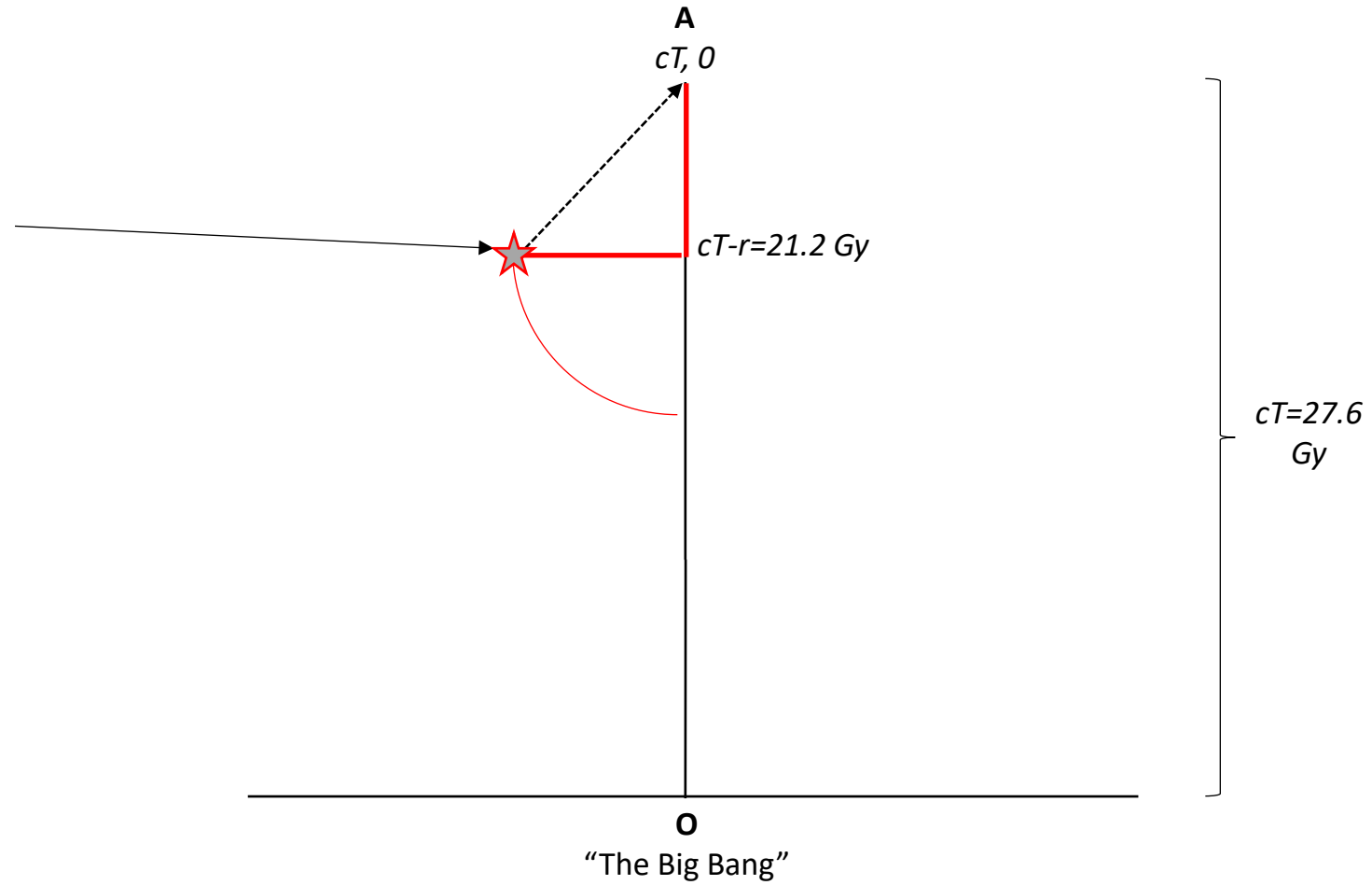
$$c\tau = \sqrt{(cT-r)^2 - r^2}$$

$$= cT\sqrt{1-2r/cT}$$

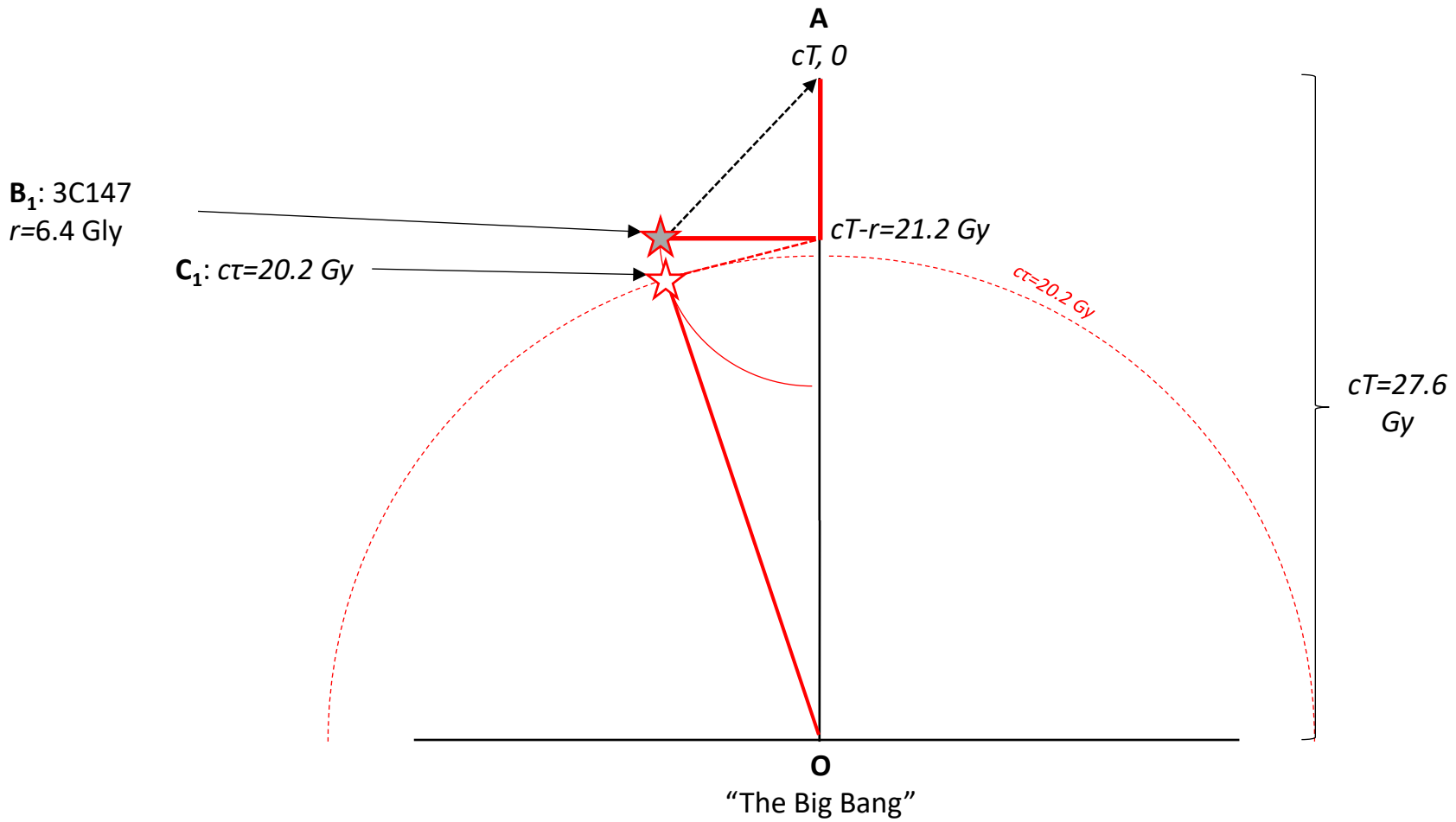
GALACTIC AGES



GALACTIC AGES



GALACTIC AGES



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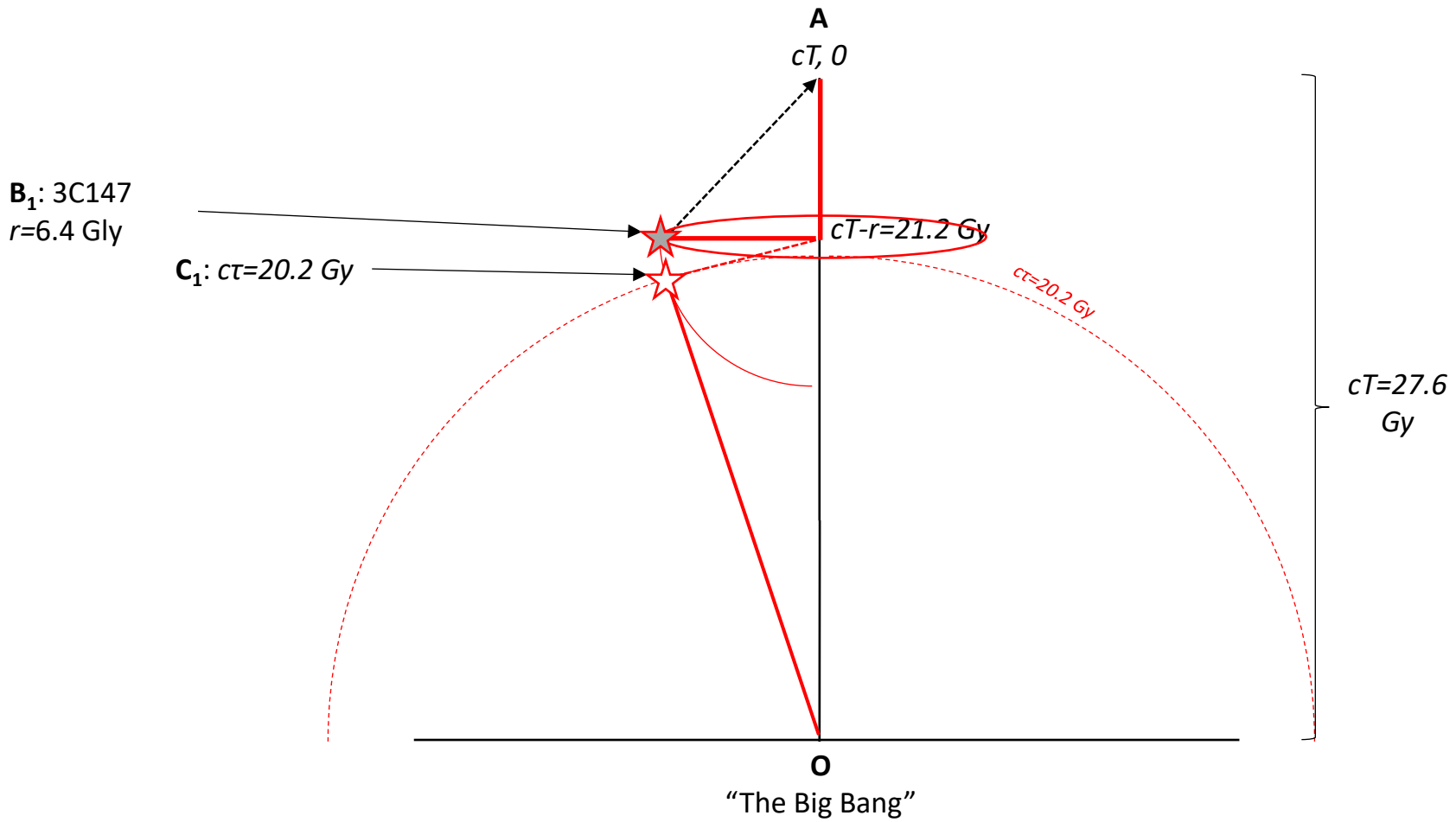

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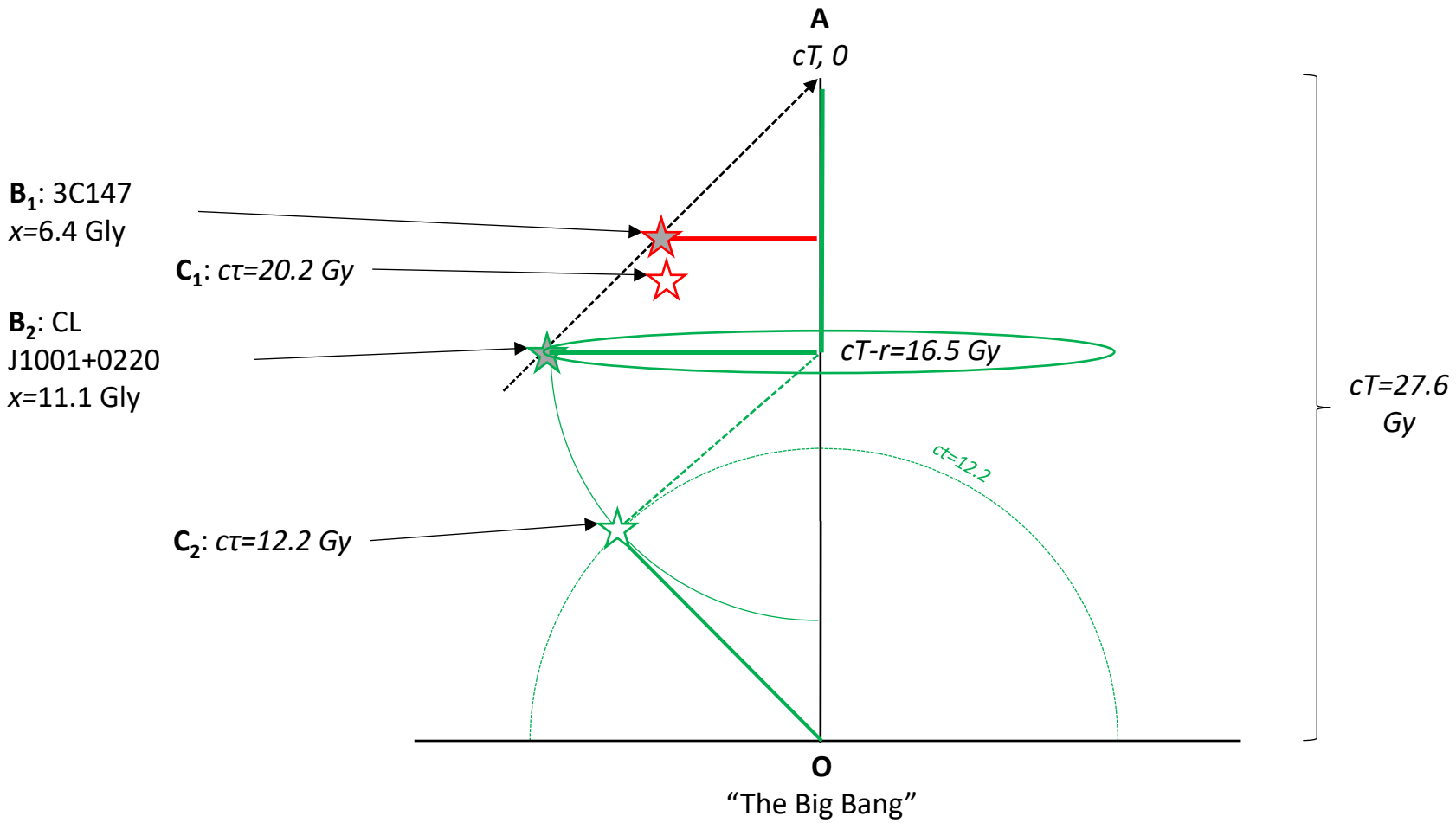

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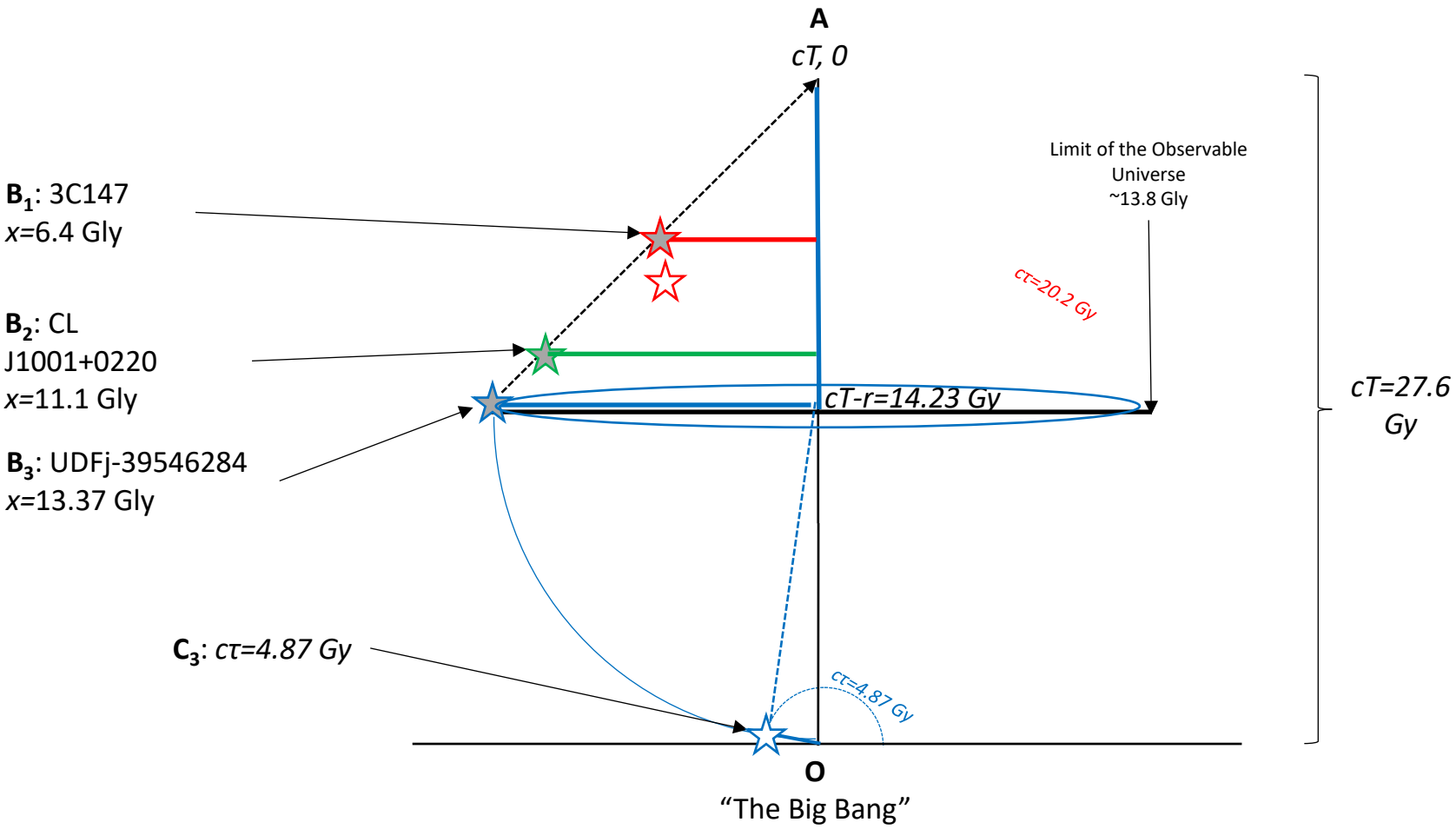
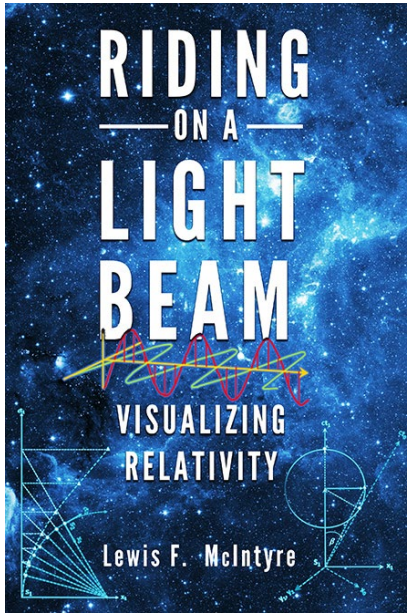


SUMMARY

- **SIMPLE MODEL: SURPRISINGLY GOOD RESULTS WITHOUT INVOKING GENERAL RELATIVITY AND DARK MATTER /ENERGY.**
- **UNIVERSE EXPANDING IN THE DIRECTION OF LOCAL TIME**
- **BIG BANG MAPS TO A SPHERE SURROUNDING US, RATHER THAN A POINT BEHIND US, AS IT DOES FOR ALL OTHER BODIES IN THE UNIVERSE.**
- **MATTER EQUALLY DISTRIBUTED AROUND US: GRAVITY DOES NOT ACT TO SLOW EXPANSION.**



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