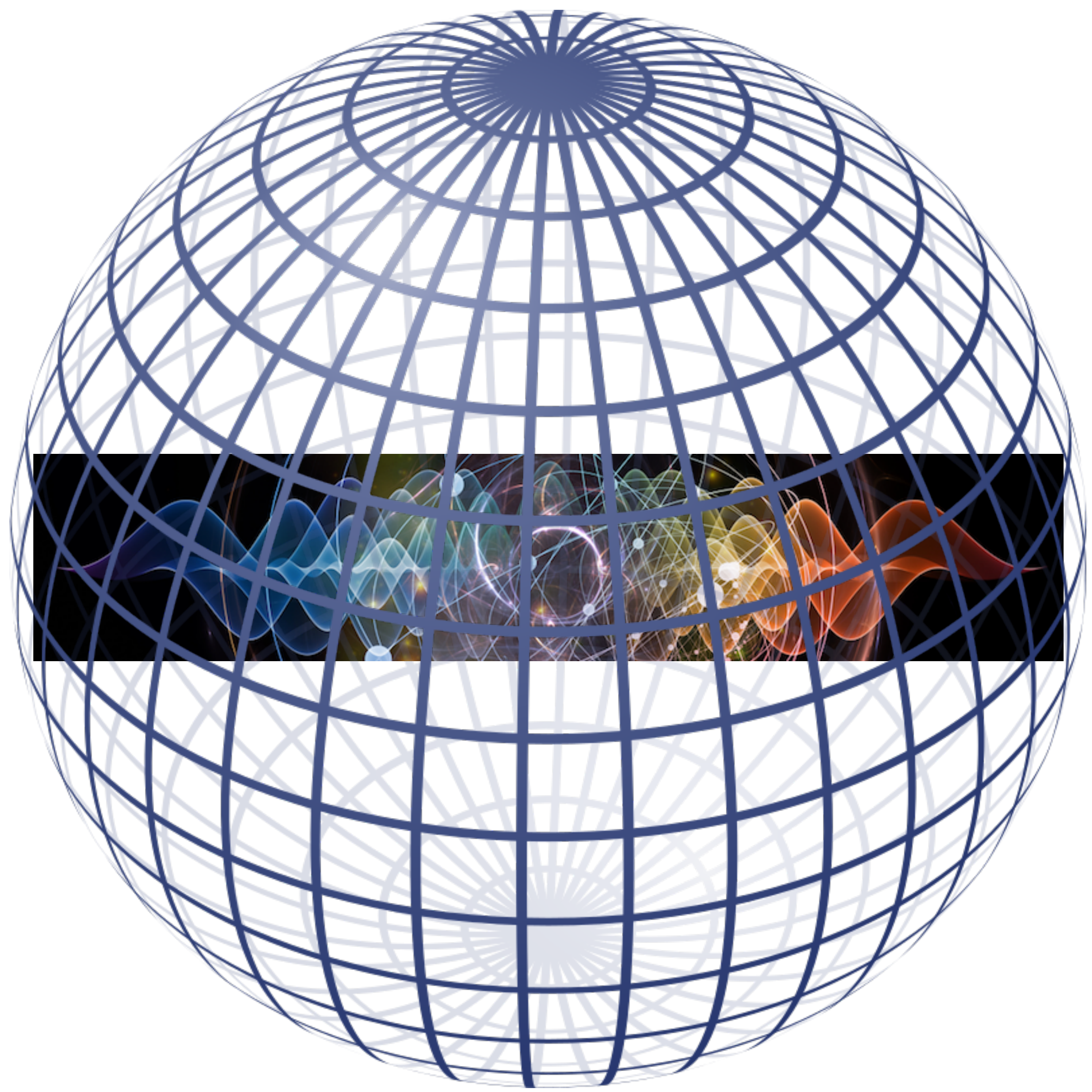
Cosmology

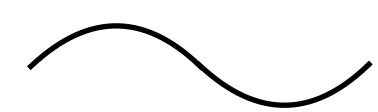
A combination of Mathematics, Physics, and Philosophy

$$a^2 + b^2 + c^2 = d^2$$



$$E = mc^2$$

$$e^{i\theta} = \cos(\theta) + i\sin(\theta)$$



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Cosmology

Outline:

Observations:
- Trigonometry
- Parallax
- Optics
- Doppler
- Redshift
- Advanced methods

Theory:
- Philosophy
- Mathematics
- Physics
- Current picture
- Components
- Baryon Acoustic Oscillations

Stellar objects:
- Planets
- Stars
- Galaxies
- Supernovae
- Quasars
- Black holes
- Hawking radiation
- Actionic field-particles

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Stellar objects:
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- Black holes (BH)
- BH radiation
- Actionic field-particles

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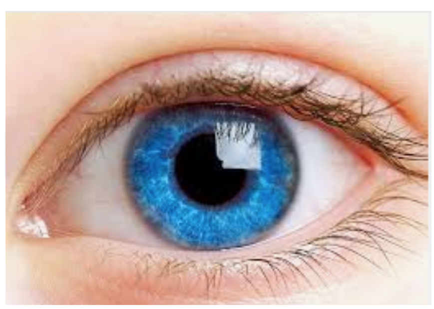
Observations in Astronomy and Cosmology

Using

Trigonometry

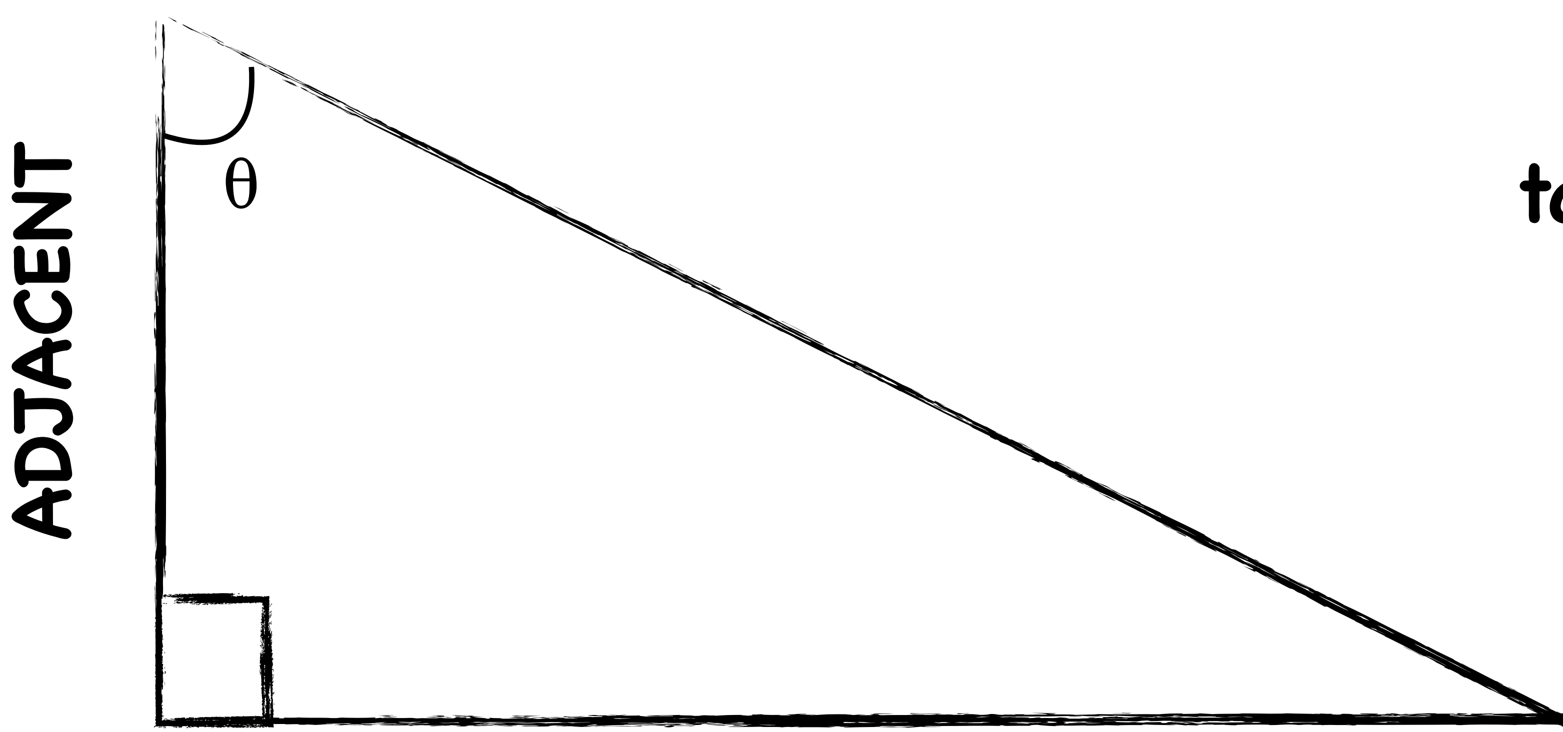


Optics

Advanced methods

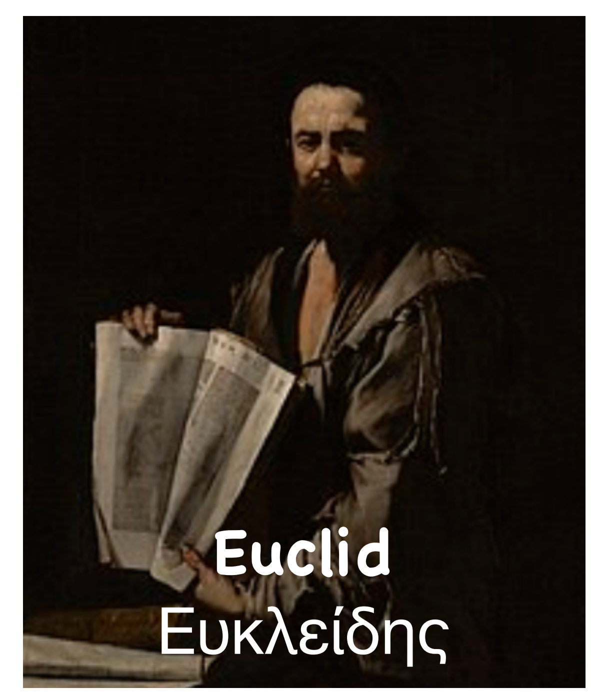
Observations in Astronomy and Cosmology

Following trigonometric methods



$$\tan(\theta) = \frac{\text{OPPOSITE}}{\text{ADJACENT}}$$

Ancient Egyptians, Babylonians, Indians and Greeks

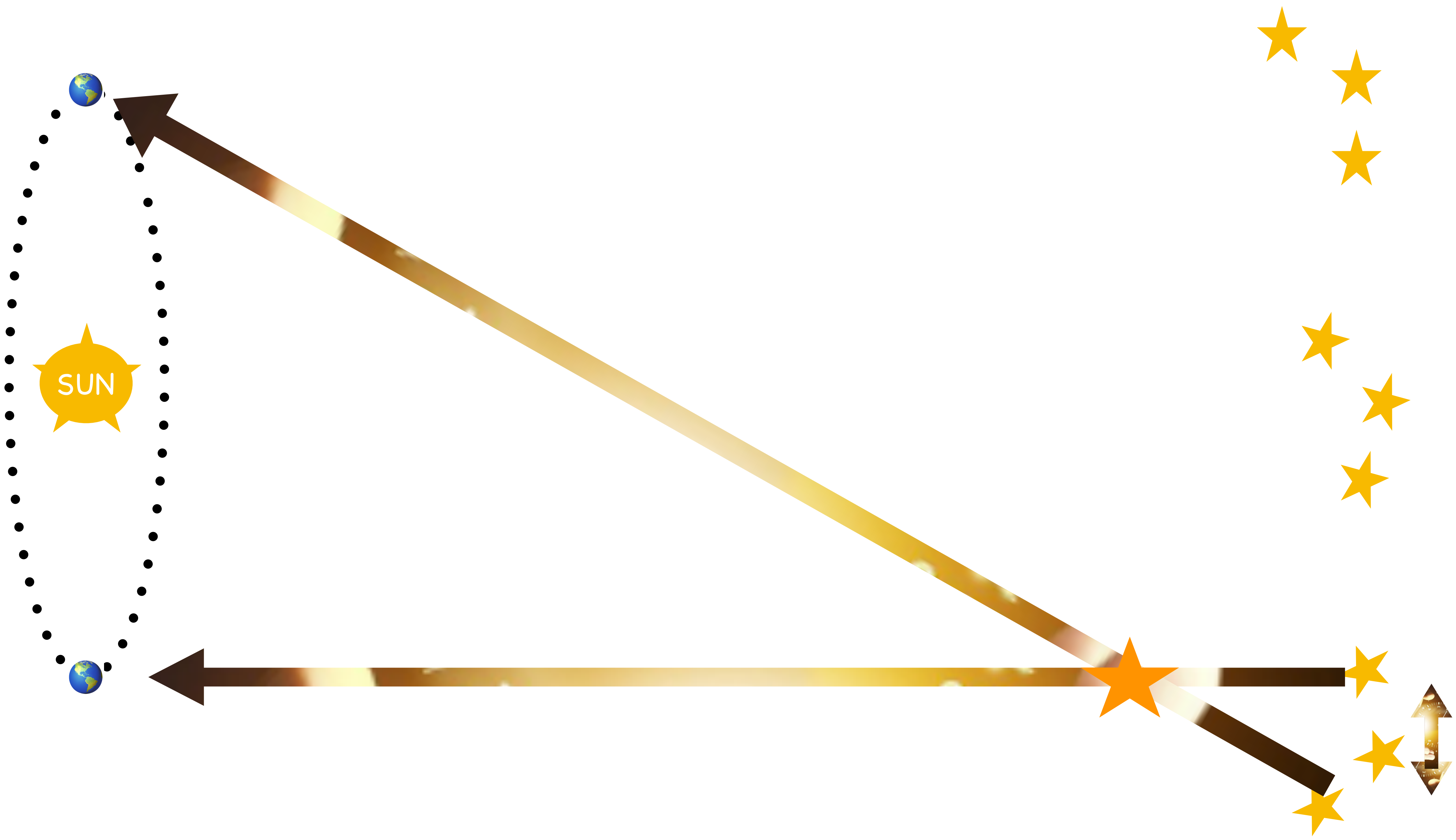


Parallax effect

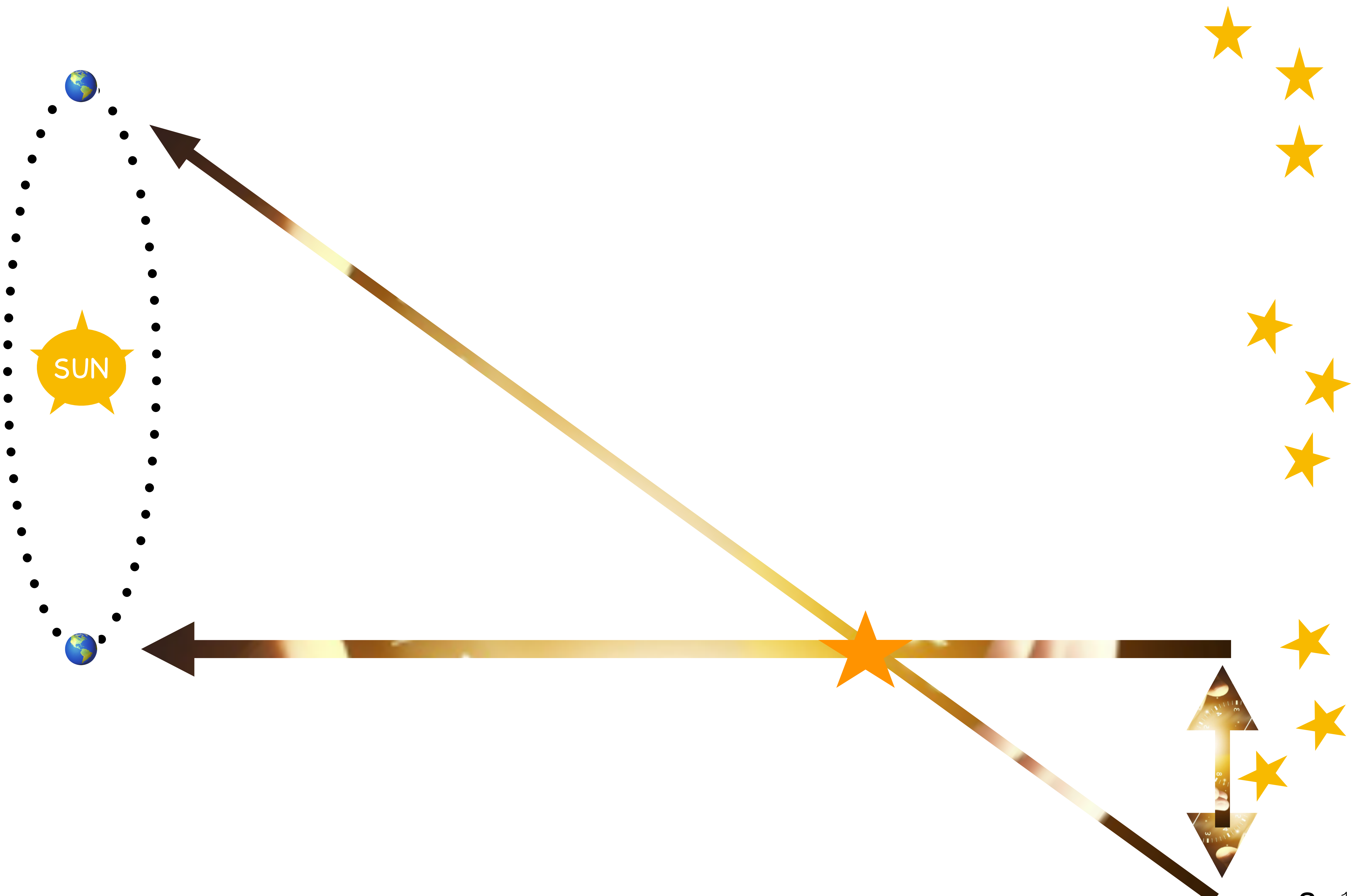
After 6 months

Parallax effect

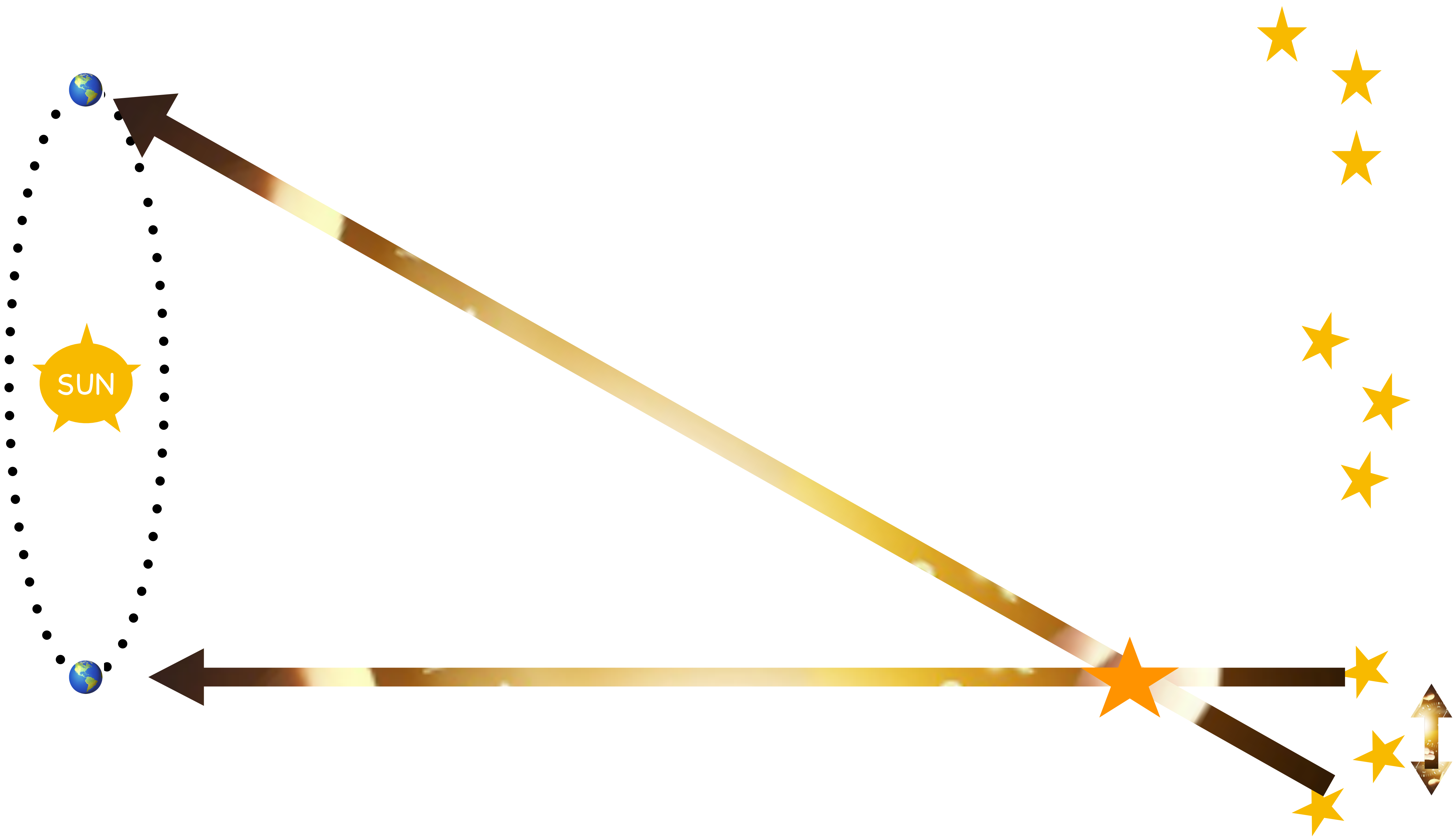
Parallax effect



Parallax effect

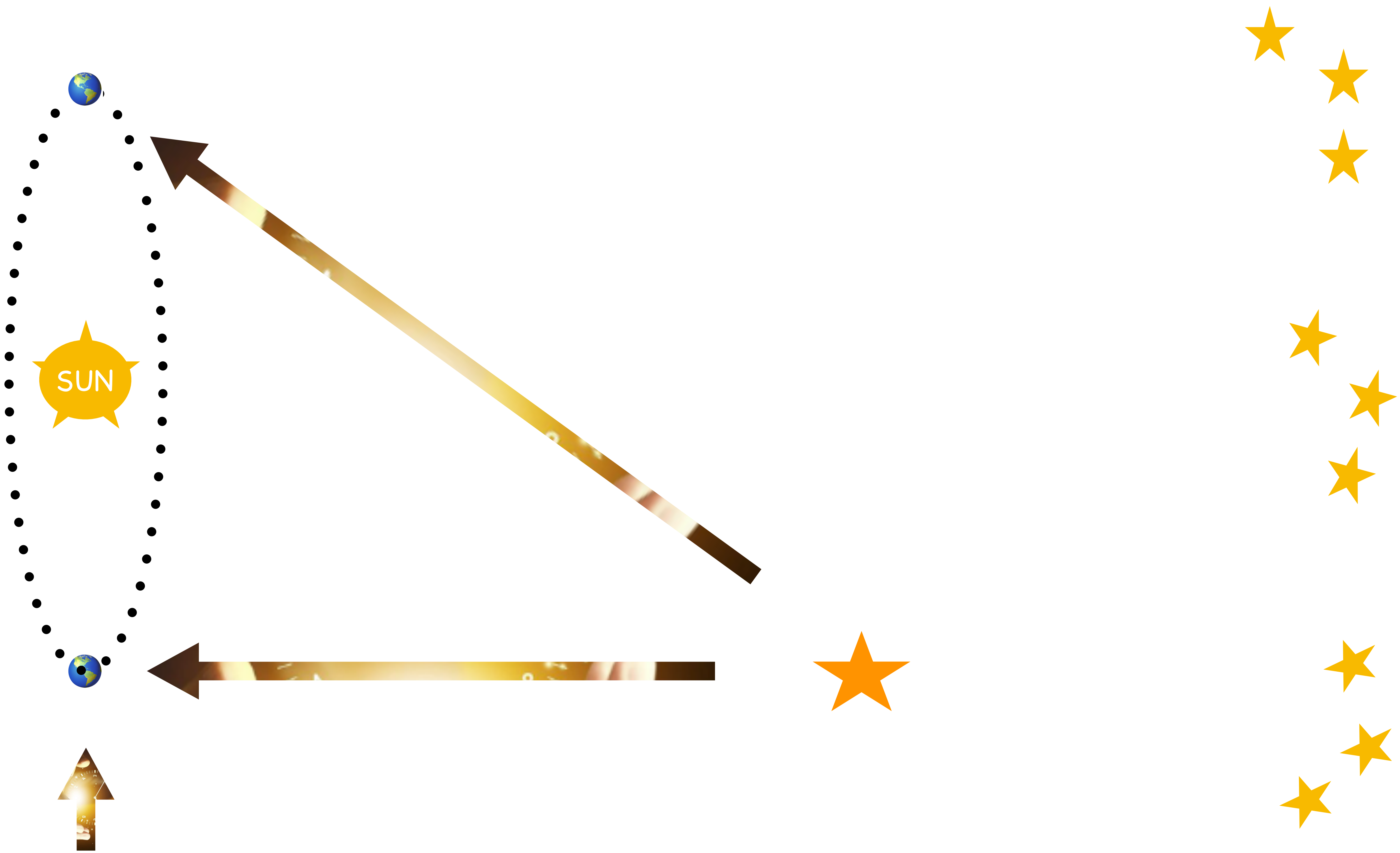


Parallax effect



Parallax effect

After 6 months



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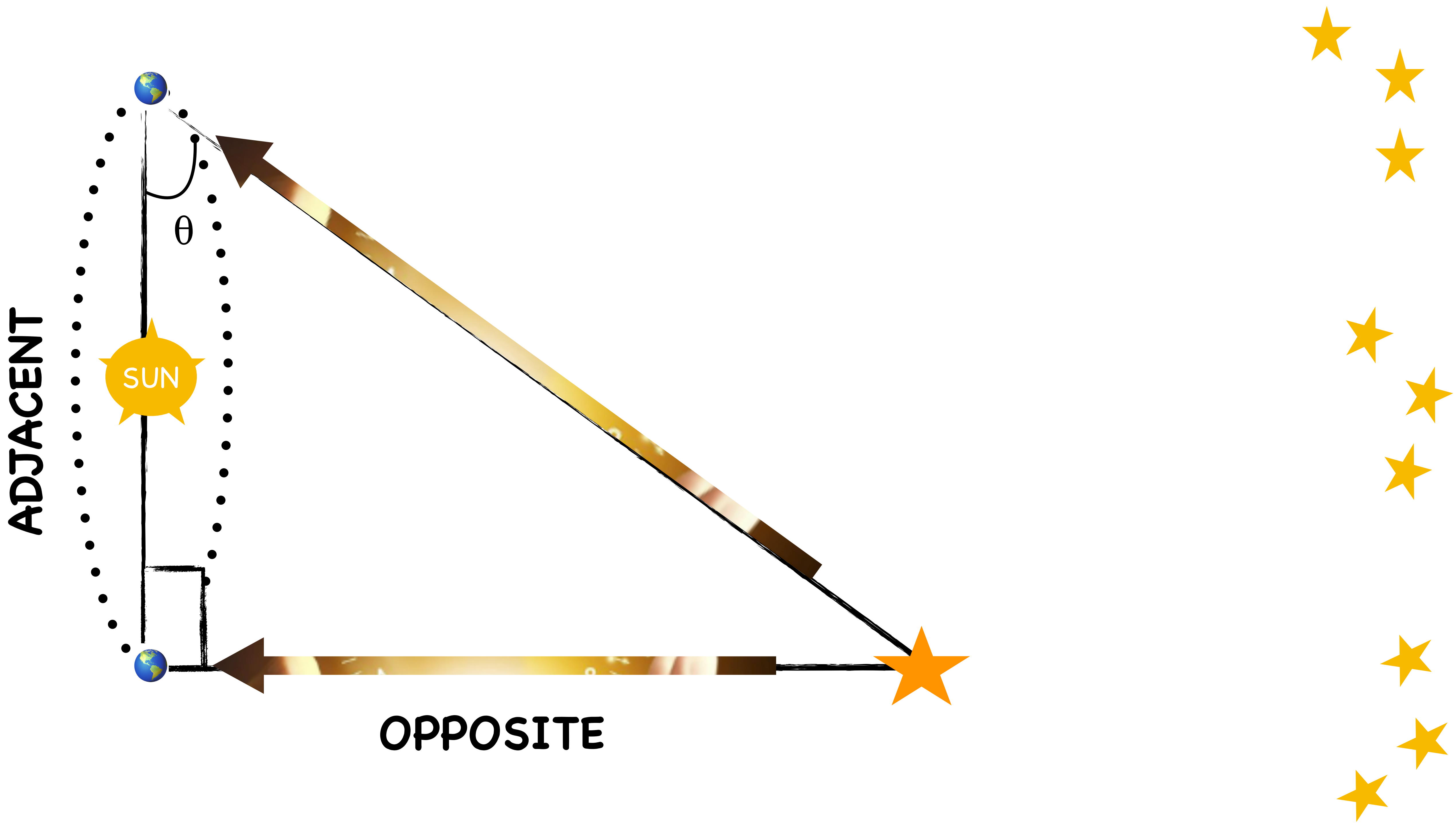
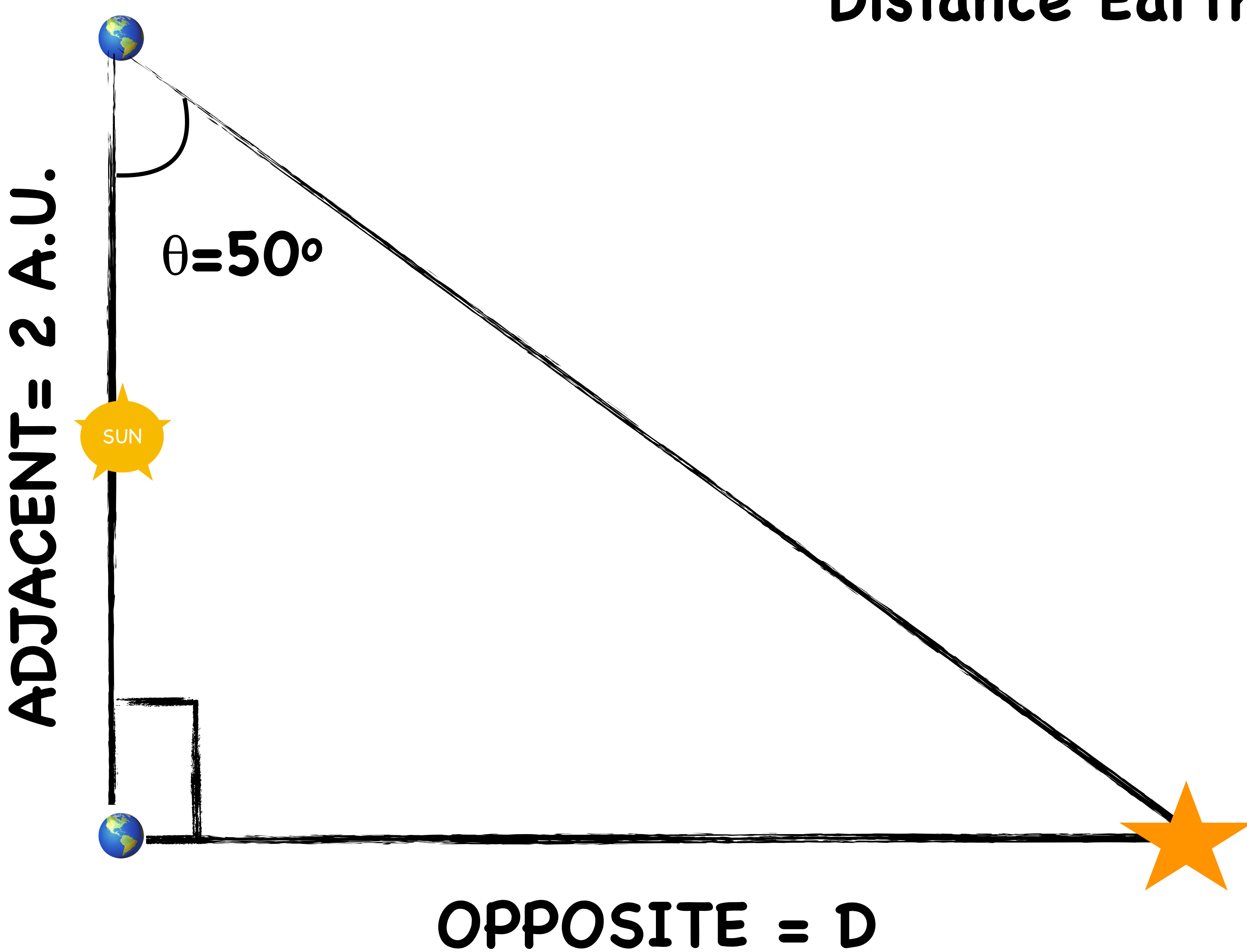
Parallax effect



Parallax effect



Distance Earth to Sun = 1 A.U.

$= 1.5\times10^{11}$m

$$\tan(\theta) = \frac{\text{OPPOSITE}}{\text{ADJACENT}}$$

$$\tan(50^{o}) = \frac{D}{2\ \text{A.U.}}$$

$$D = \tan(50^{o})\ 2\ \text{A.U.}$$

$$= 1.2\ (2)\ \text{A.U.}$$

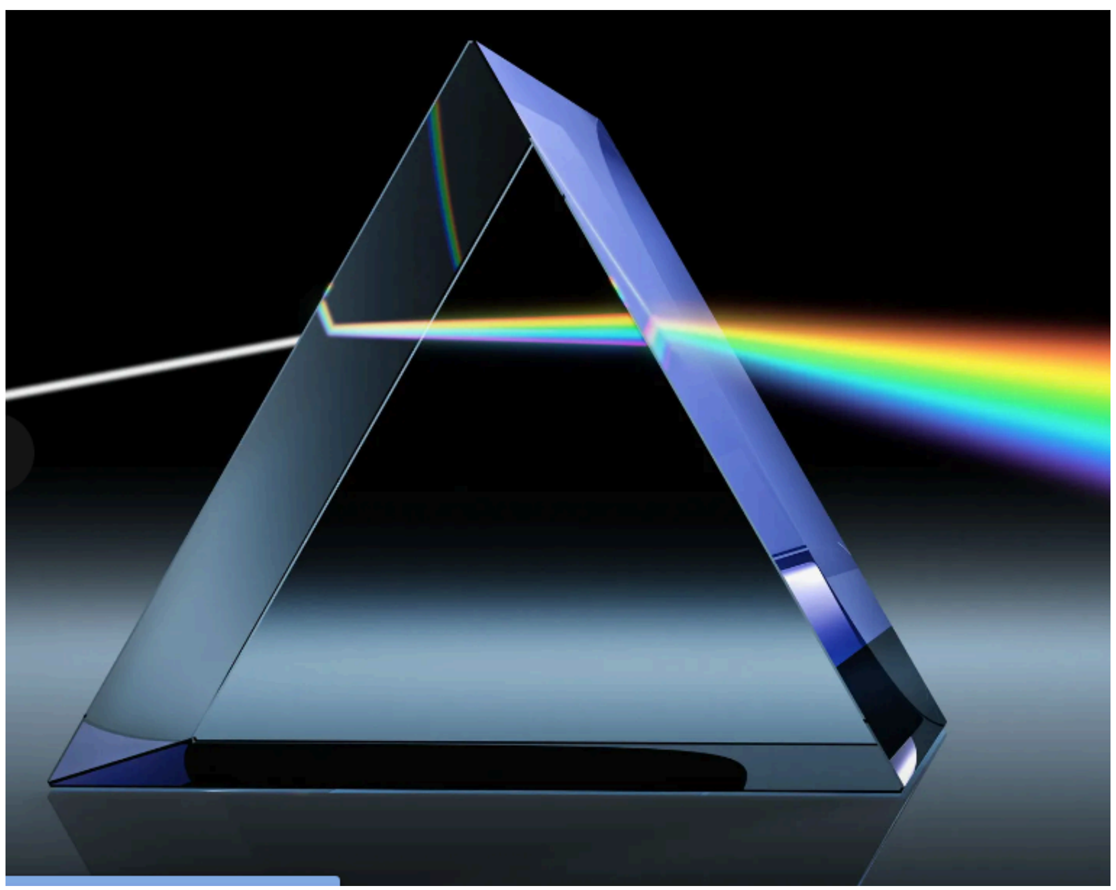
$$= 2.4\ \text{A.U}$$

D = 2.4 A.U.

D = 4×10^{11} m

Observations in Astronomy and Cosmology

Following optic methods of analysing light spectrum by



Refraction of white light

(I.Newton 17th c.)

Observations in Astronomy and Cosmology

Following doppler effect by

Given

c = velocity in medium

v_o = observer velocity

v_e = emitter velocity

f_o = observer frequency

f_e = emitter frequency

$$f_o = \frac{c \pm v_o}{c \pm v_e} f_e$$

(Doppler 19th c.)

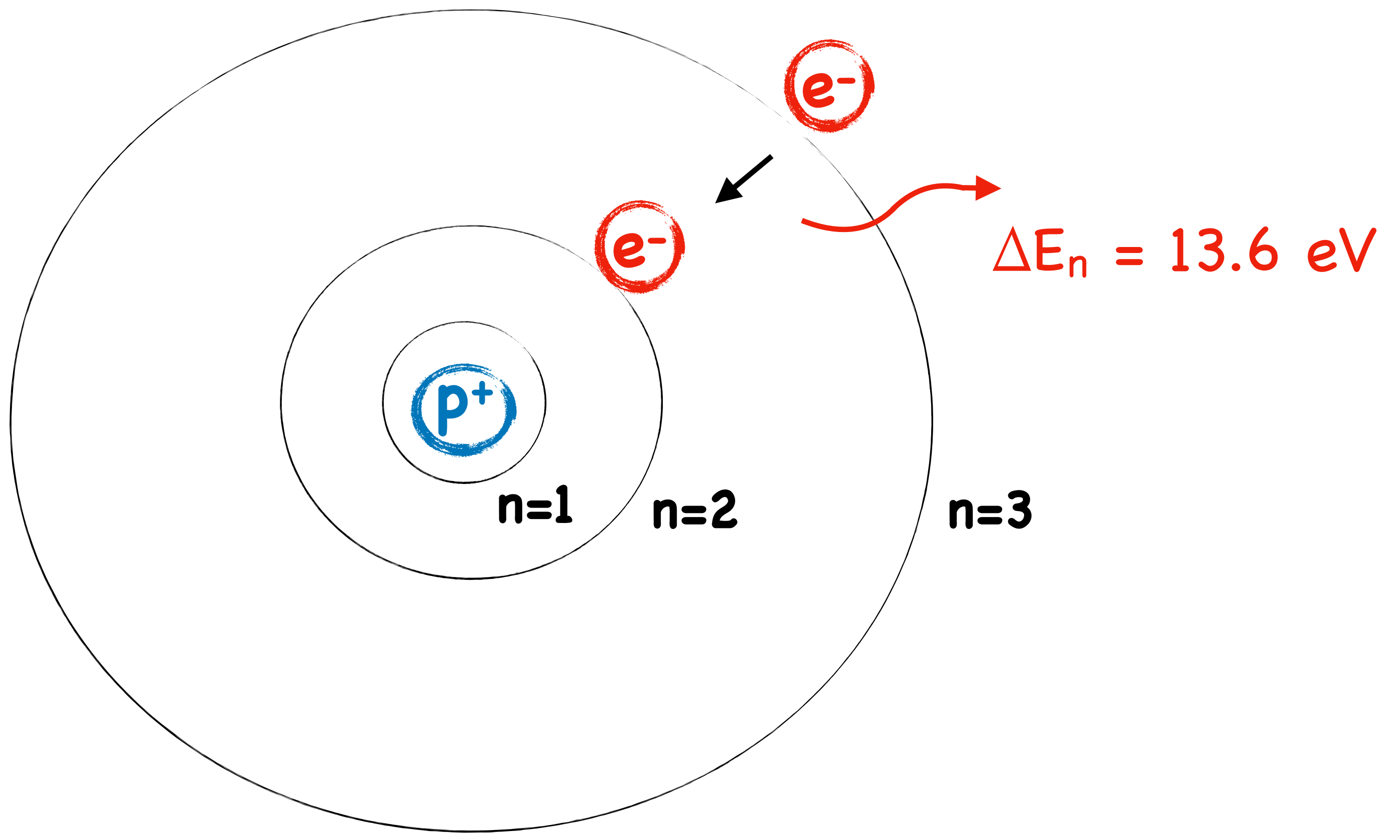
In case of stationary observer

$$\frac{f_e}{f_o} = 1 + \frac{v_e}{c} = \frac{\lambda_o}{\lambda_e}$$

Ch.Whisky 2007 (modified)

Emission Line identification effect

Hydrogen Atom:



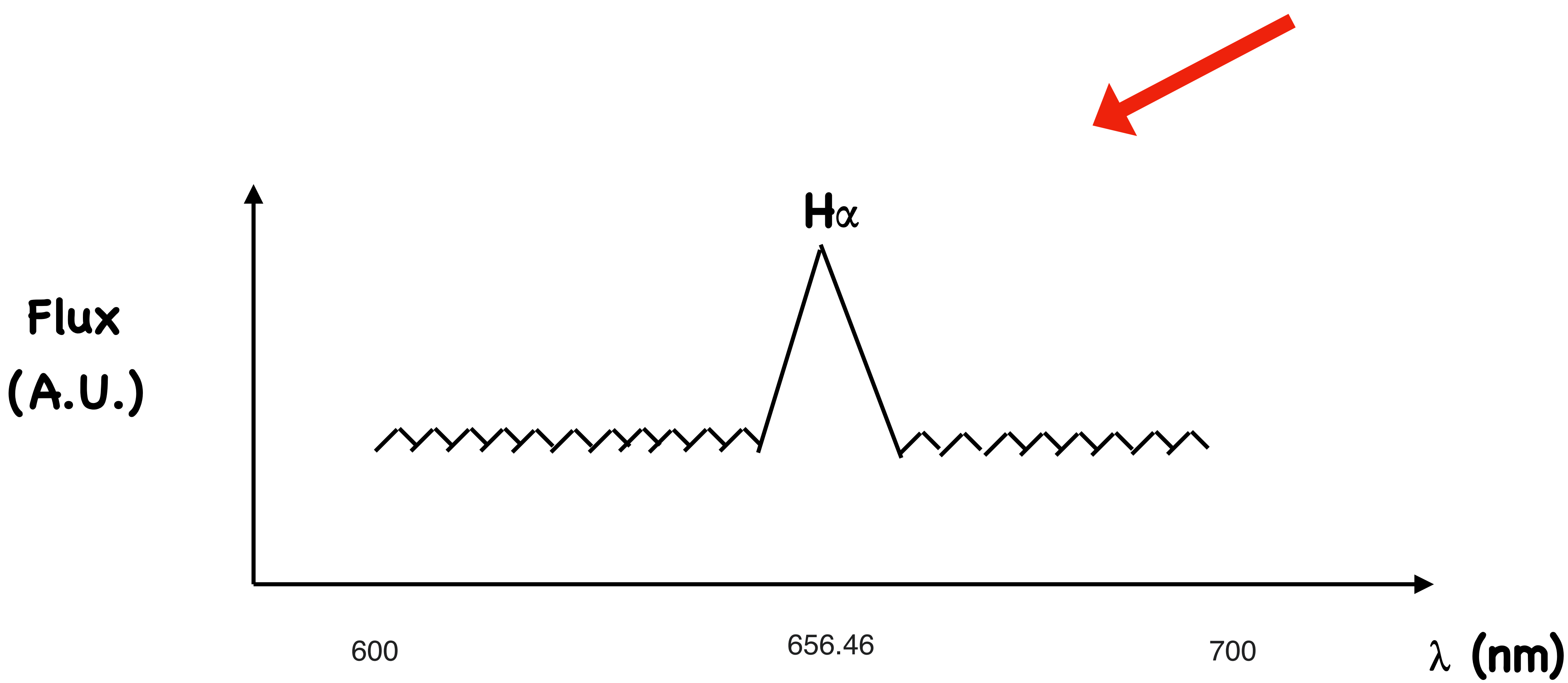
Quantum Mechanics suggests that during electron energy transition from level n=3 to n=2, there is energy emission of $\Delta E_n = h/\lambda = 13.6$ eV $= 22 \times 10^{-19}$J, where, λ=656.46 nm which results to Hα photon emission

The four visible hydrogen emission spectrum lines in the Balmer series. The red line at far-right is H-alpha

Wiki Ha

Emission Line identification effect

The four visible hydrogen emission spectrum lines in the Balmer series. The red line at far-right is H-alpha



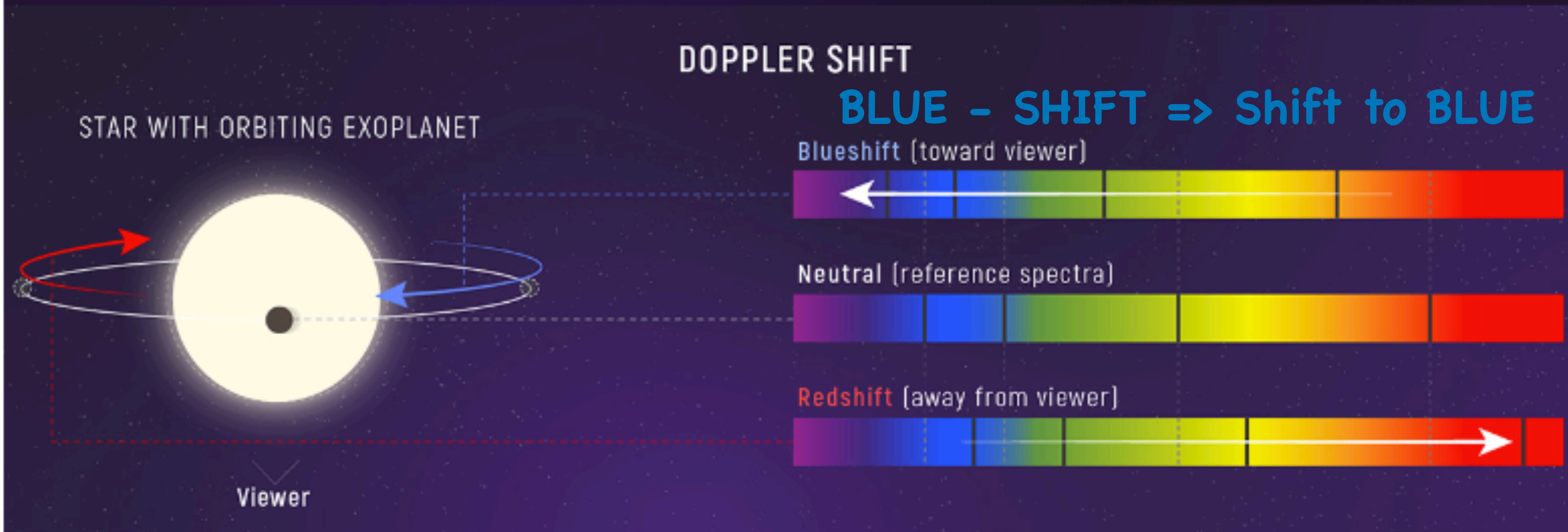
Wiki Ha

Emission Line identification effect

Redshift

is the shift of a nominal wavelength to large values (redder)

Main colour Emission line wavelength, λ

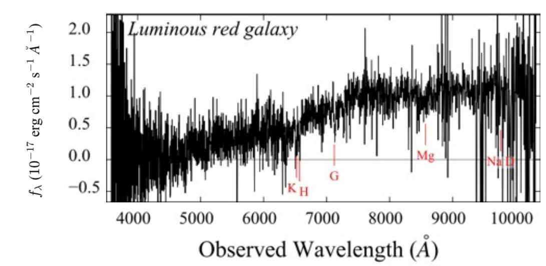


RED - SHIFT => Shift to RED

Webb

Observations in Astronomy and Cosmology

Spectroscopy (spectra + scopy)
observe the light flux patterns from (distant) objects
emission line identification



Light flux = energy per wavelength
patterns = specific emission lines

Compare with emission lines from elements
in the laboratory in earth (our reference)
and learn about

Chemical composition

Velocity/Distance

Time

Emission Line identification effect

Given

- v_{rec} = recession velocity
- c = speed of light in vacuum ~ 3×10^8 m/s
- λ_o = observed wavelength
- λ_e = emitted wavelength (reference)

$$\text{Redshift, } z = \frac{v_{rec}}{c} = \frac{\lambda_o}{\lambda_e} - 1$$

Webb

Hubble discovery: $v_{rec} = H_0 D$

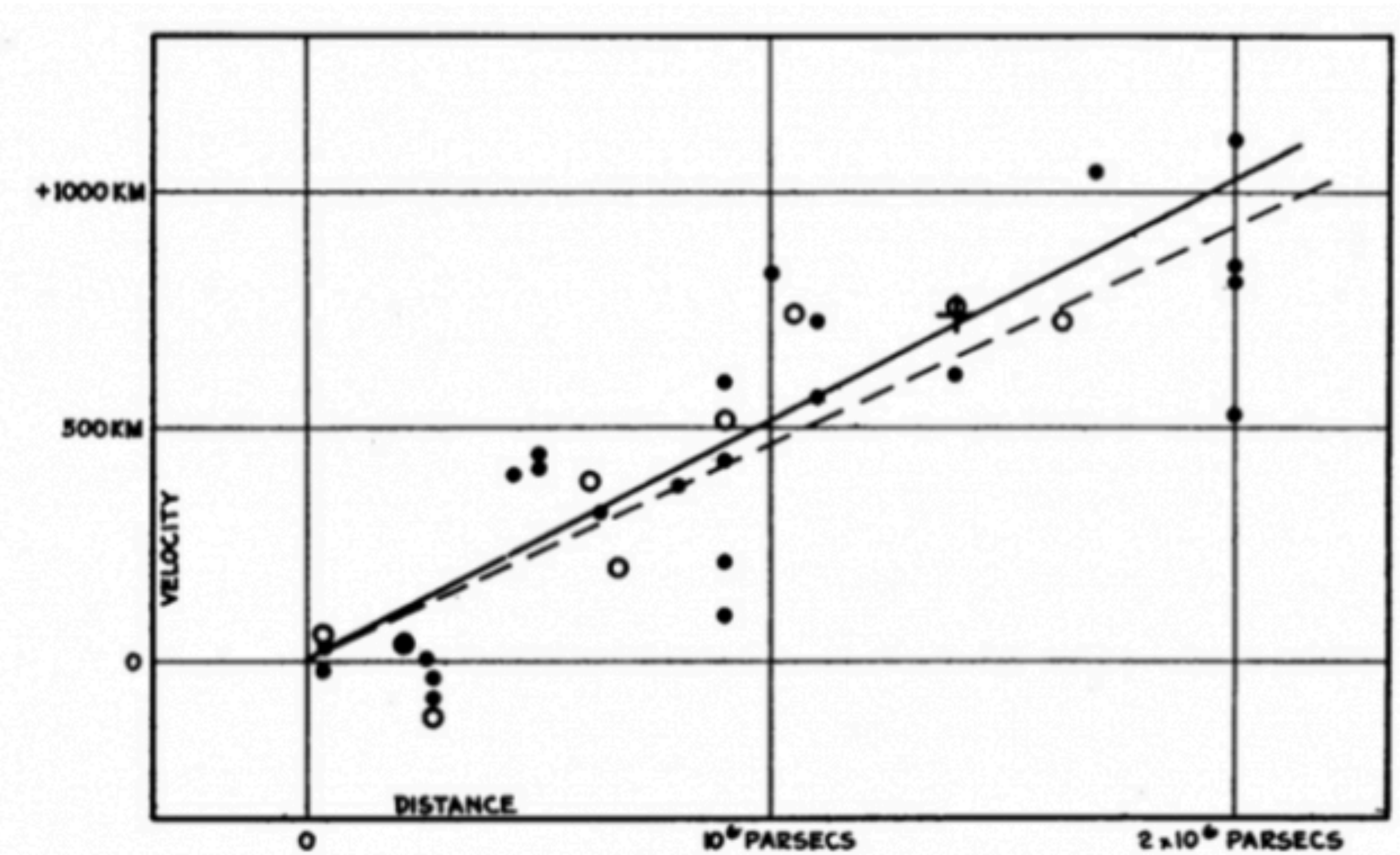


FIGURE 1
Velocity-Distance Relation among Extra-Galactic Nebulae.

The spatial space of the Universe is expanding

H_0 = 70 km/s/Mpc, where 1Mpc = 3×10^{19}km

$H_0 = 2 \times 10^{-18}\ s^{-1} \Rightarrow t_H = H_0^{-1} = 0.5 \times 10^{18}\ s = 10^{10}$yr

From wavelength, λ => redshift, z => distance, D

$$z = \frac{\lambda_o}{\lambda_e} - 1$$

$$z = \frac{v_{rec}}{c} \Rightarrow v_{rec} = cz$$

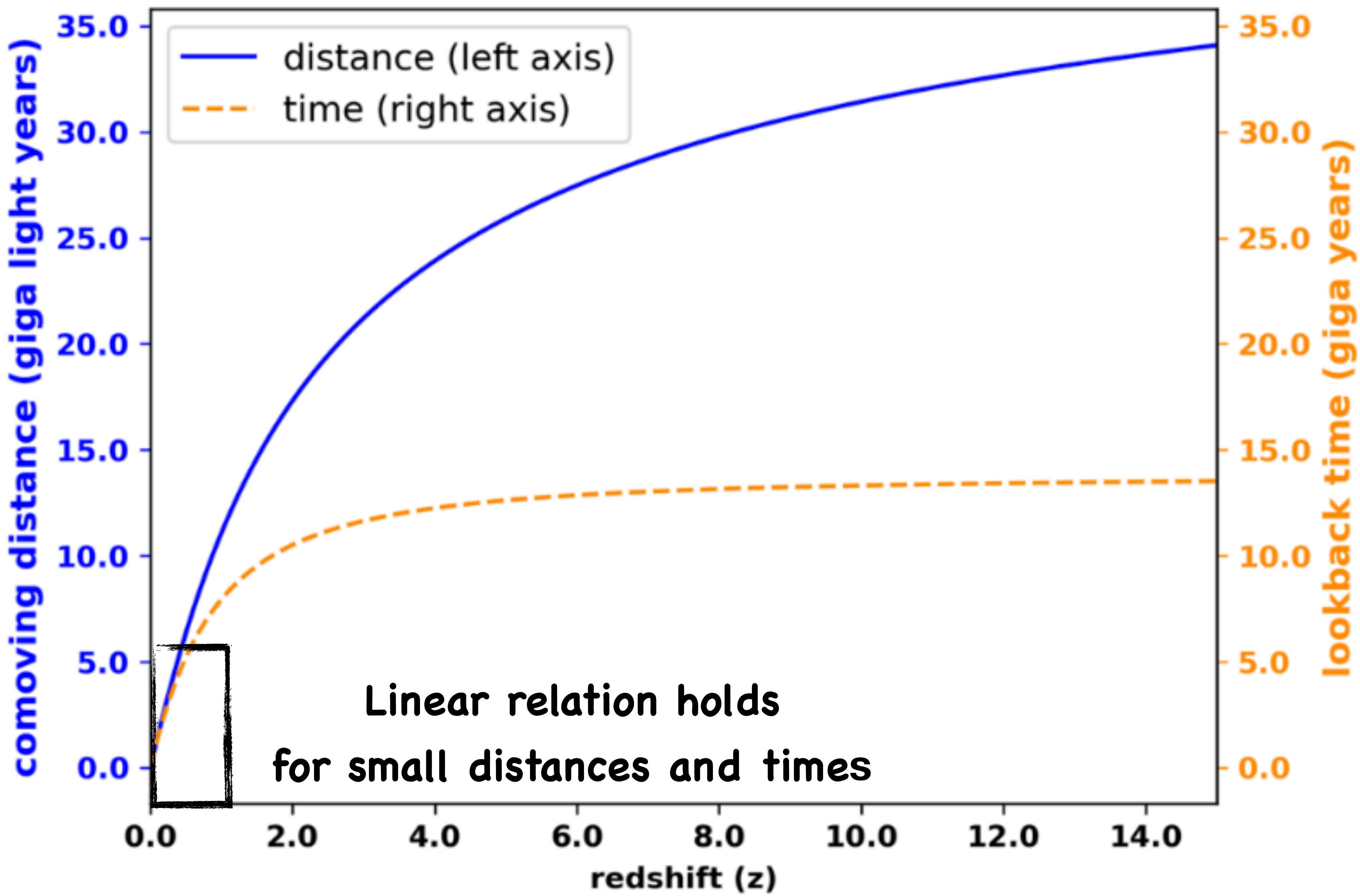
$$v_{rec} = H_0 D$$

Linear relation

$$\boxed{D = \frac{c}{H_0} z}$$

From wavelength, λ => redshift, z => distance, D, or loopback time, T

using advanced methods and models



From wavelength, λ => redshift, z => distance, D

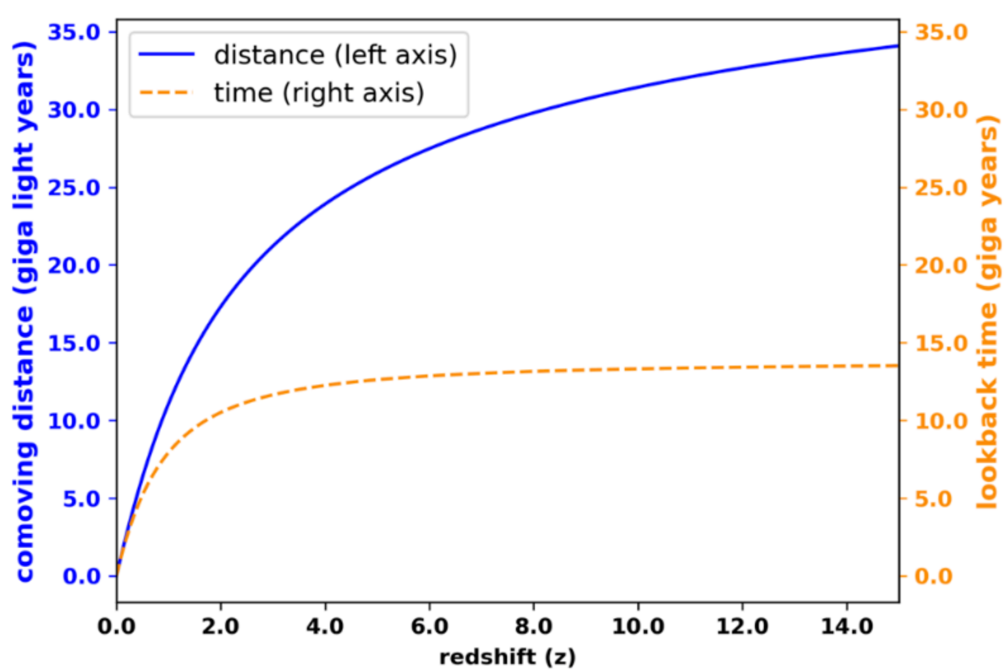
using advanced methods and models

$$H_0 = 70\ \mathrm{km/s/Mpc} \quad \text{Expansion rate, from Sn, CMB, and LSS}$$

$$\Omega_{\mathrm{m}} = 0.3 \quad \text{Dark and Baryonic matter, from CMB}$$

$$\Omega_{\mathrm{D.E.}} = 0.7 \quad \text{Dark Energy, from Sn, CMB, and LSS}$$

$$D(z_\star) = \lim_{z \to z_\star} \frac{c}{H_0} \int_0^z \frac{dz'}{\sqrt{(1+z)^3 \Omega_{\mathrm{m}} + \Omega_{\mathrm{D.E.}}}}$$



From wavelength, λ => redshift, z => lookback time, T

using advanced methods and models

$H_0 = 70\ \mathrm{km/s/Mpc}$ Expansion rate, from Sn, CMB, and LSS

$\Omega_\mathrm{m} = 0.3$ Dark and Baryonic matter, from CMB

$\Omega_\mathrm{D.E.} = 0.7$ Dark Energy, from Sn, CMB, and LSS

$$T(z_\star) = \lim_{z \to z_\star} \frac{1}{H_0} \int_0^z \frac{dz'}{(1+z')\sqrt{(1+z)^3\Omega_\mathrm{m} + \Omega_\mathrm{D.E.}}}$$