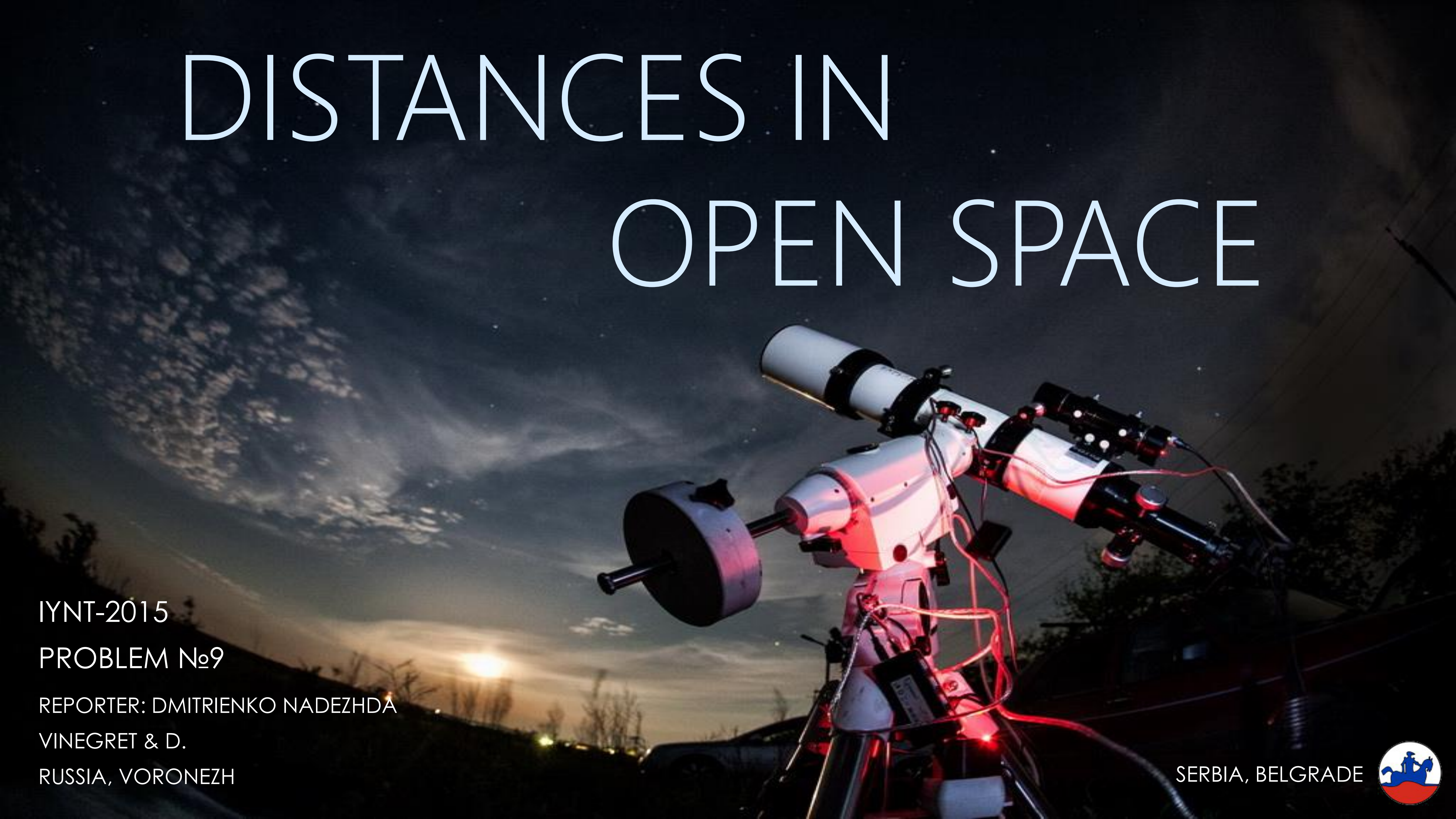

# DISTANCES IN OPEN SPACE

IYNT-2015

PROBLEM №9


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# Problem



How do astronomers measure distances between the planets of the Solar System, between the stars in our Galaxy, or between the galaxies? Determine the distance between the two space objects of your choice.

# Purposes



- Determine which units denominate the distances in space
- Identify methods of measuring this cosmic values
- Try to find out some distances

# Units

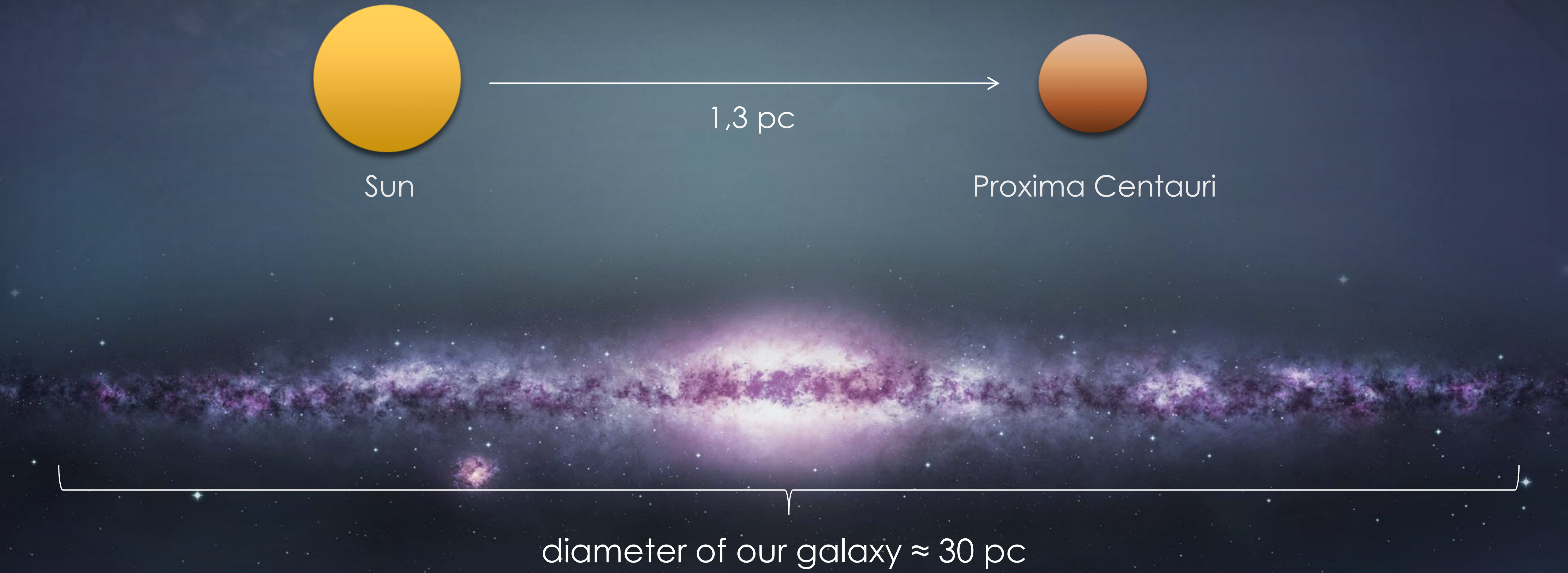


**AU (astronomical unit)** ≈ 150 million km


Neptune – 30 AU
The radius of Solar System – 50 AU
Nearest star (Proxima Centauri) – 268 000 AU! It means that sometimes the AU is too small, if we want to go beyond the solar system.

# Units

**pc (parsec)** = 206000 au



# Units



**light-year (l.y.)** ≈ 0.3 pc ≈ 63241 au ≈ 800 billion km

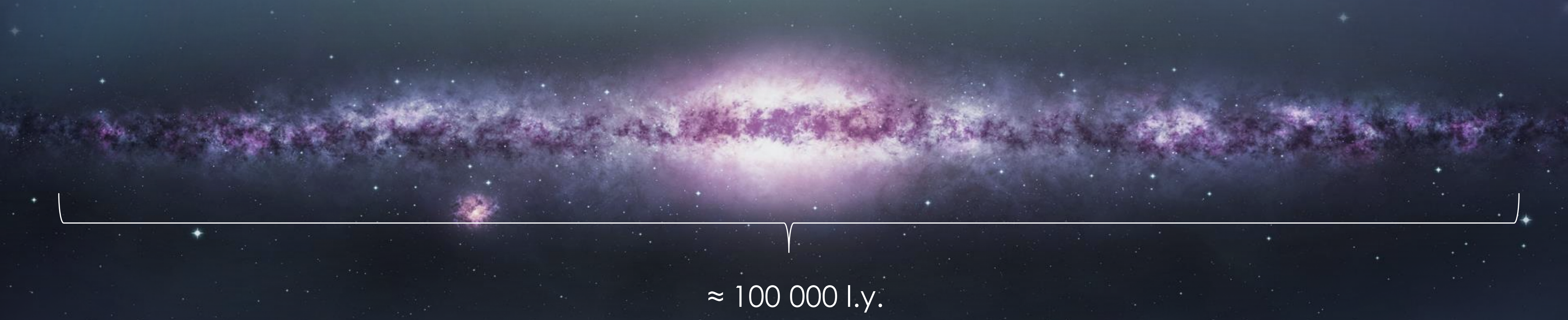
300 000 km/s

800 000 000 000 000 km/year

# Units



**light-year (l.y.)** ≈ 0.3 pc ≈ 63241 au ≈ 800 billion km

# Units



**light-year (l.y.)** ≈ 0.3 pc ≈ 63241 au ≈ 800 billion km

≈ 2 500 000 l.y.

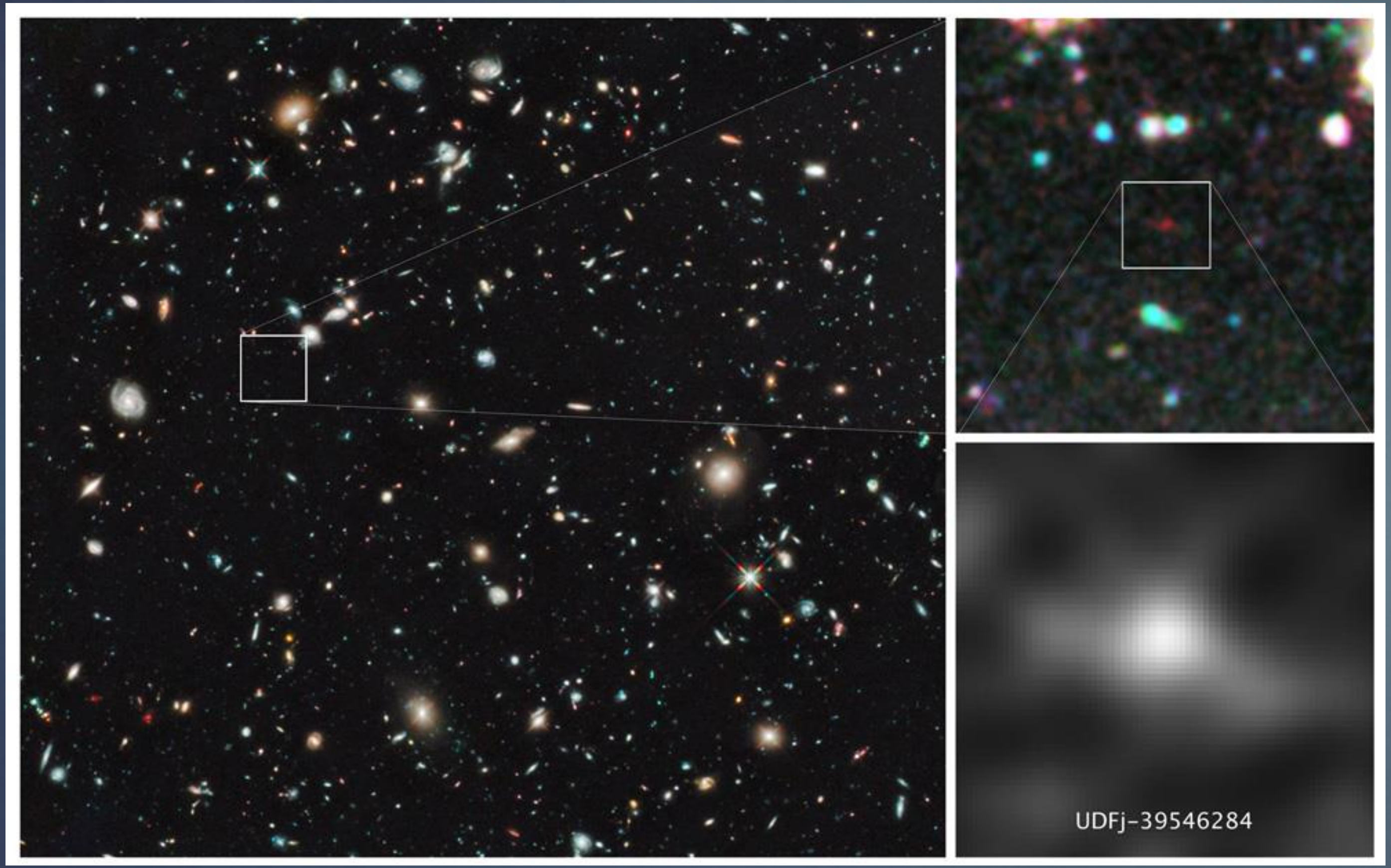
Andromeda Galaxy

≈ 29 350 000 l.y.

# Units



**light-year (l.y.)** ≈ 0.3 pc ≈ 63241 au ≈ 800 billion km




Hubble Space Telescope image

≈ 13 400 000 000 l.y.

# 1. A short distances



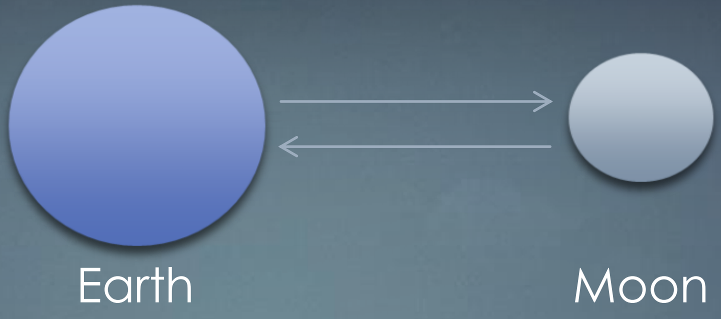
from Earth to planets in Solar System: radiolocation

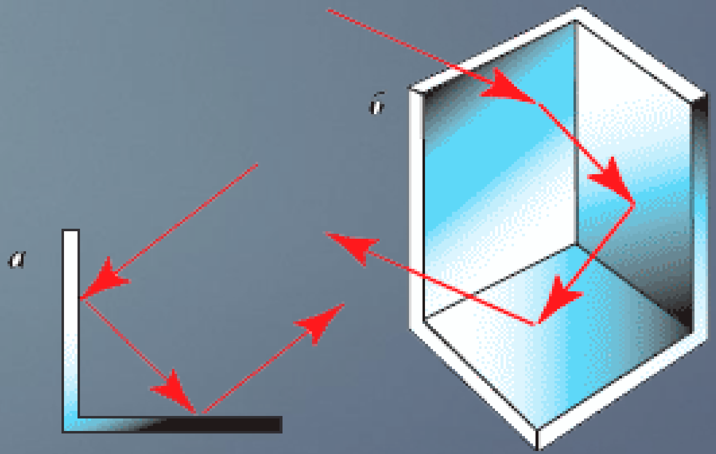
# 1. A short distances

from Earth to planets in Solar System: radiolocation

# 2. A short distances

distance from Earth to Moon was measured by laser ranging

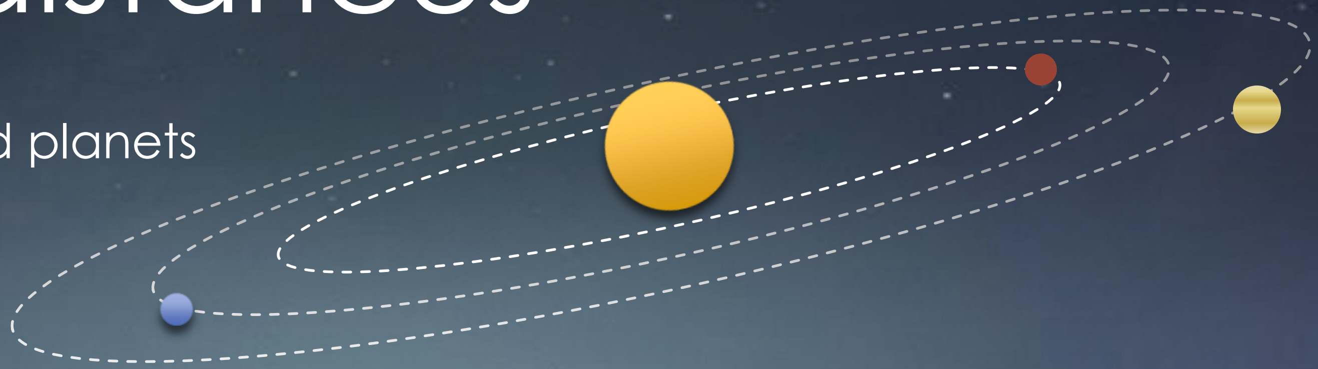



corner reflector

# 3. A short distances

distances between Sun and planets

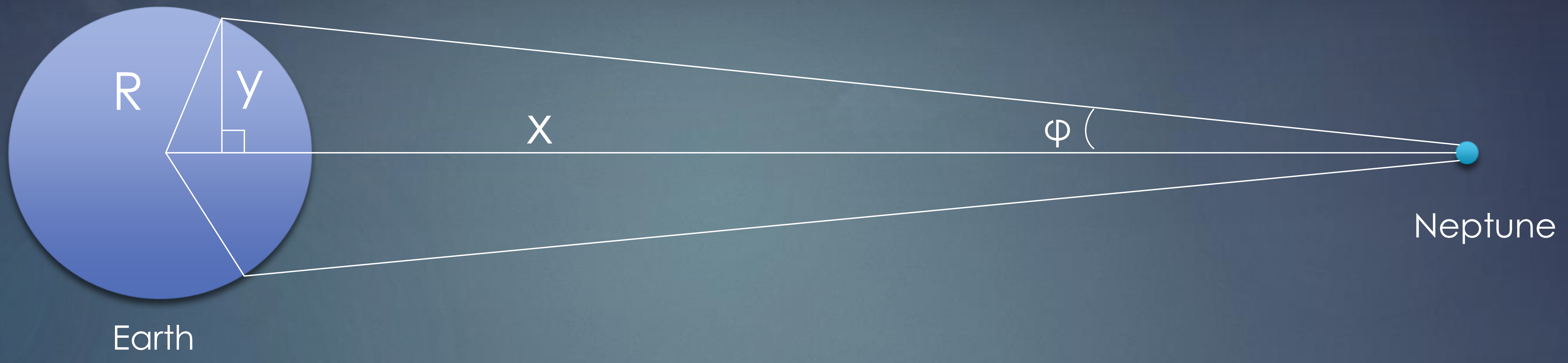


third Kepler's law: $$\frac{T^2}{r^3} = \frac{4\pi^2}{GM} \longrightarrow r = \sqrt[3]{\frac{T^2 GM}{4\pi^2}}$$

Подписать обозначения

# 4. Trigonometric parallax

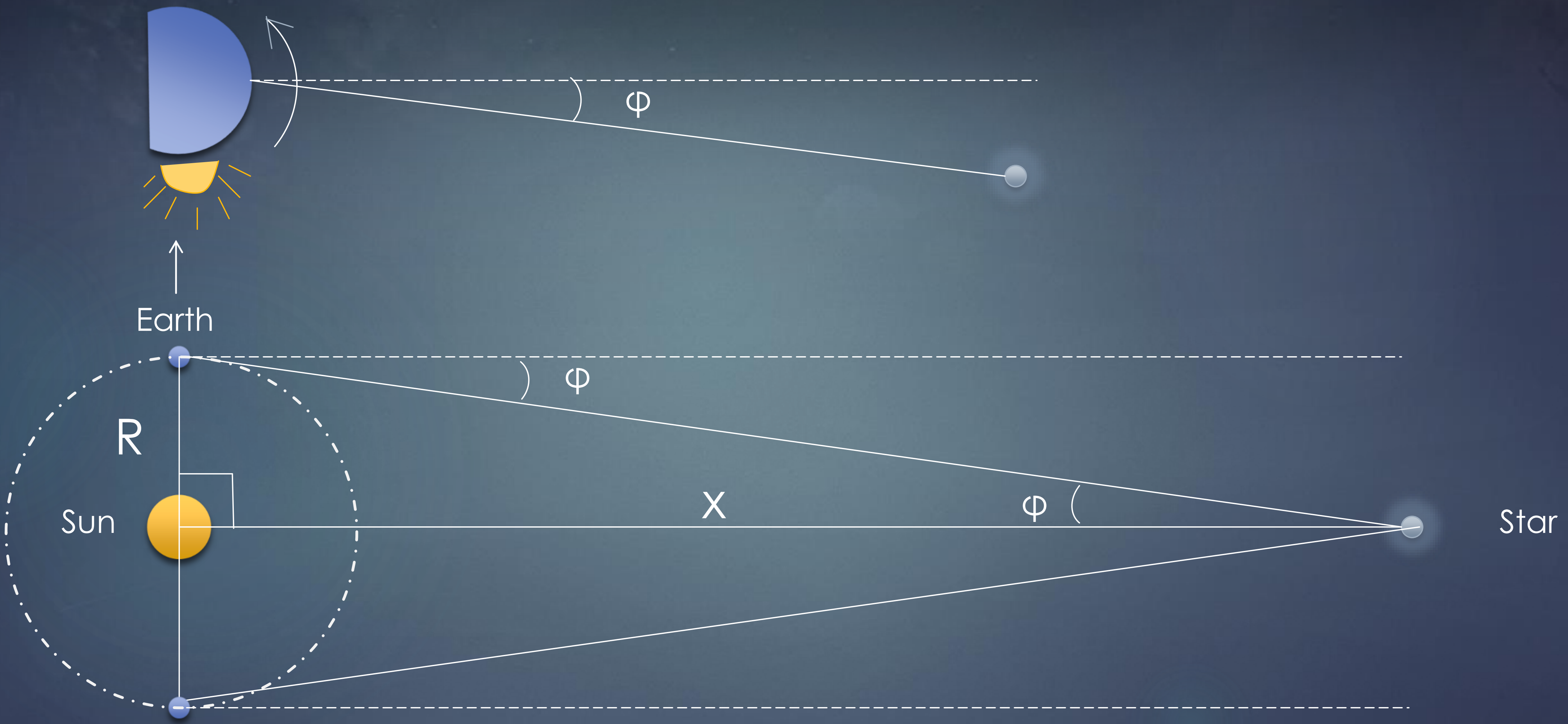





$$\begin{cases} y = R\sin\alpha \\ tg\varphi = \dfrac{y}{x} \end{cases} \longrightarrow x = \frac{R\sin\alpha}{tg\varphi}$$

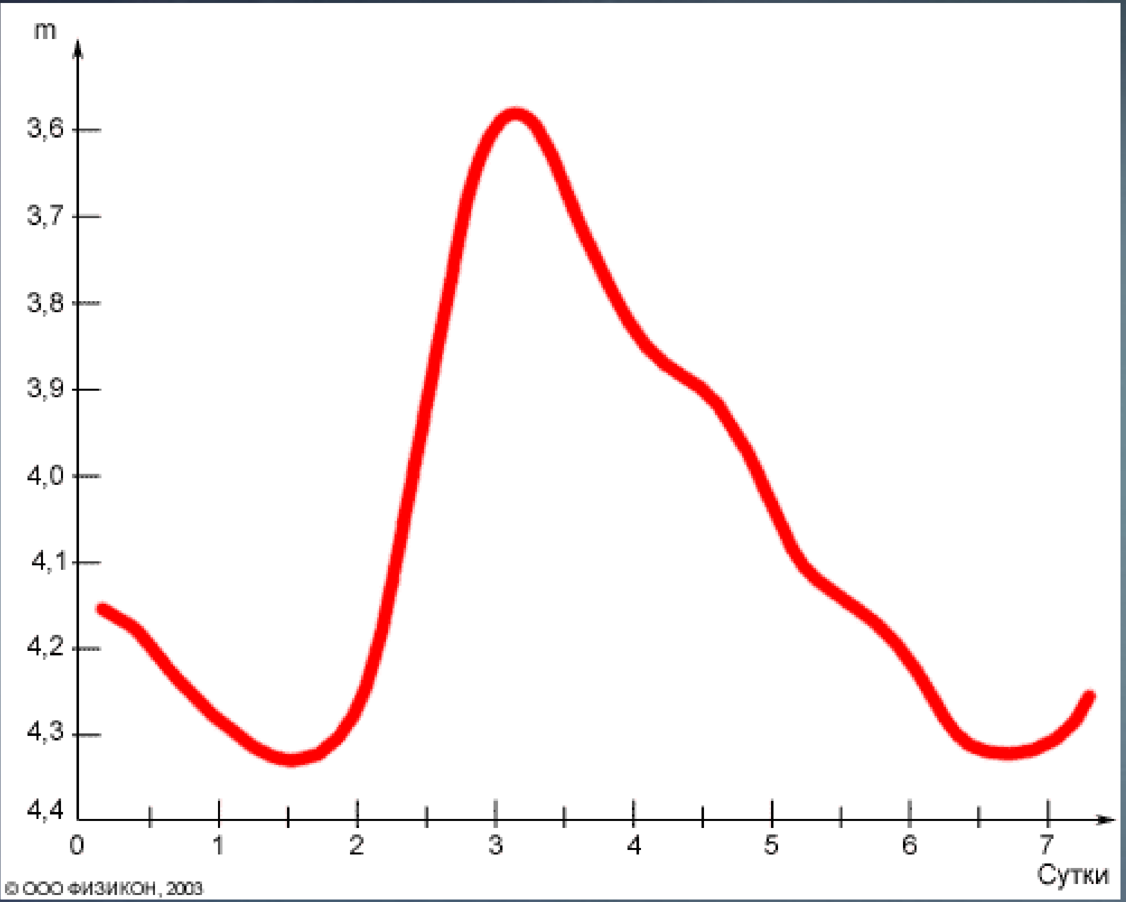
# 5. Trigonometric parallax

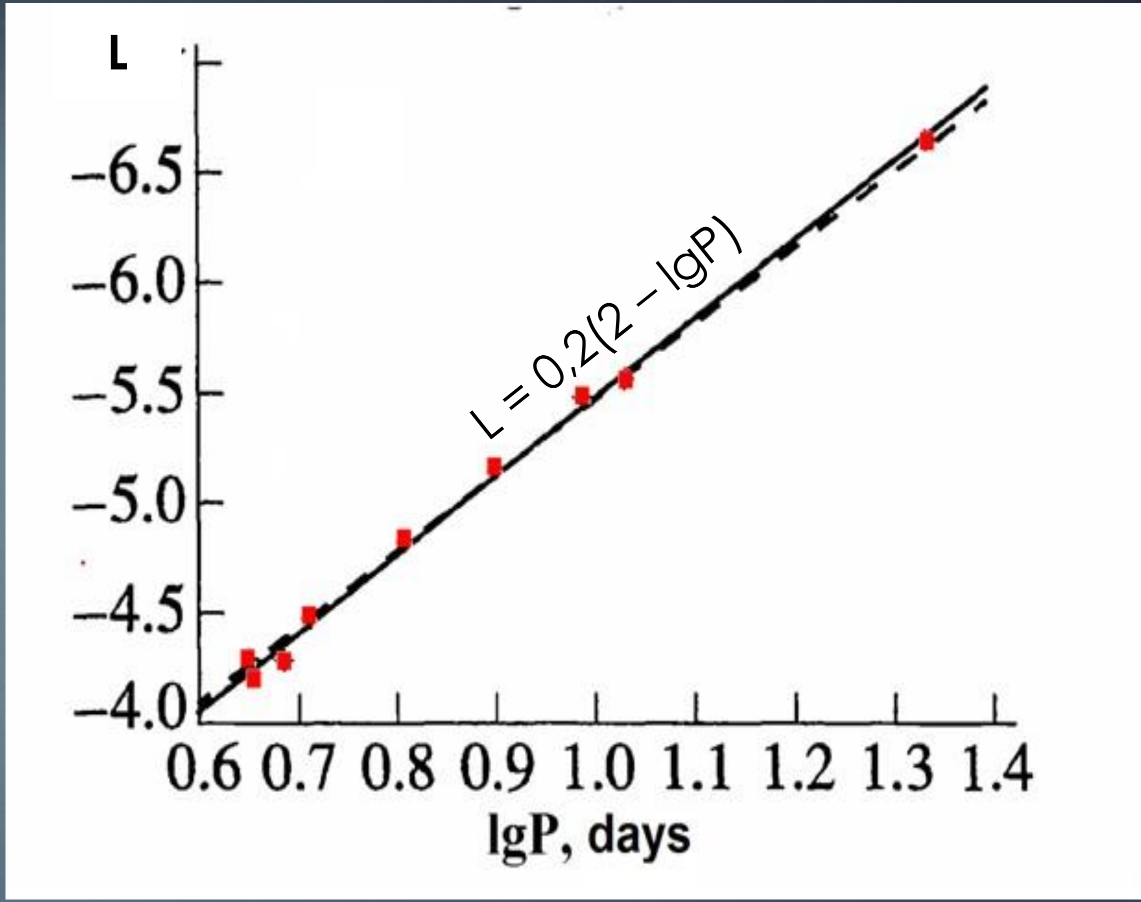




# 6. Cepheid variable






m – apparent magnitude
t – time, days

L – luminosity
P – period, days
M – absolute magnitude

# 6. Cepheid variable



$$L = 0{,}2(2 - \lg P)$$

$$\lg(L) = 0{,}4\,(M_{\odot} - M)$$

$$\lg(R) = 0{,}2\,(m - M) + 1$$

→ If we know P and m, we can calculate R

# 7. Doppler effect (redshift)



Hubble's law:

$$v = Hr$$

$$\begin{cases} v = Hr \\ v = \dfrac{\Delta\lambda c}{\lambda_0} \end{cases} \longrightarrow r = \frac{\Delta\lambda c}{\lambda_0 H}$$

# Calculations the distances:



| Practice | Theory |
|---|---|
| 0,37 | 0,38 |
| 0,70 | 0,72 |
| 0,98 | 1,00 |
| 1,50 | 1,52 |
| 5,10 | 5,20 |
| 9,32 | 9,58 |
| 18,94 | 19,20 |
| 29,71 | 30,10 |

# Conclusions:



1. We give examples of units which used in space.
2. We describe a several ways to measure distances.
3. We use one of these methods to calculate the distance to space objects and compared them to the actual distance.

# Thanks for attention!