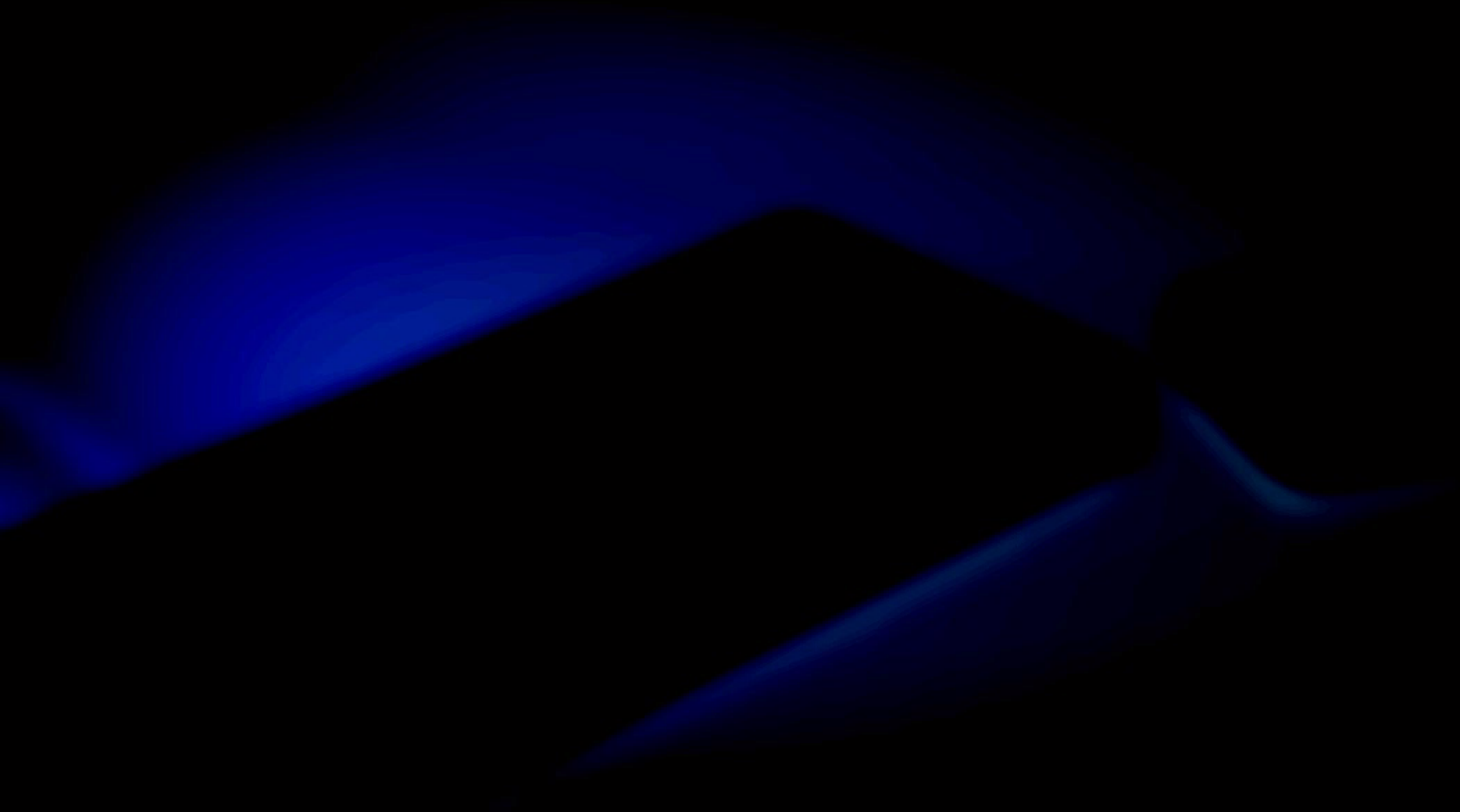
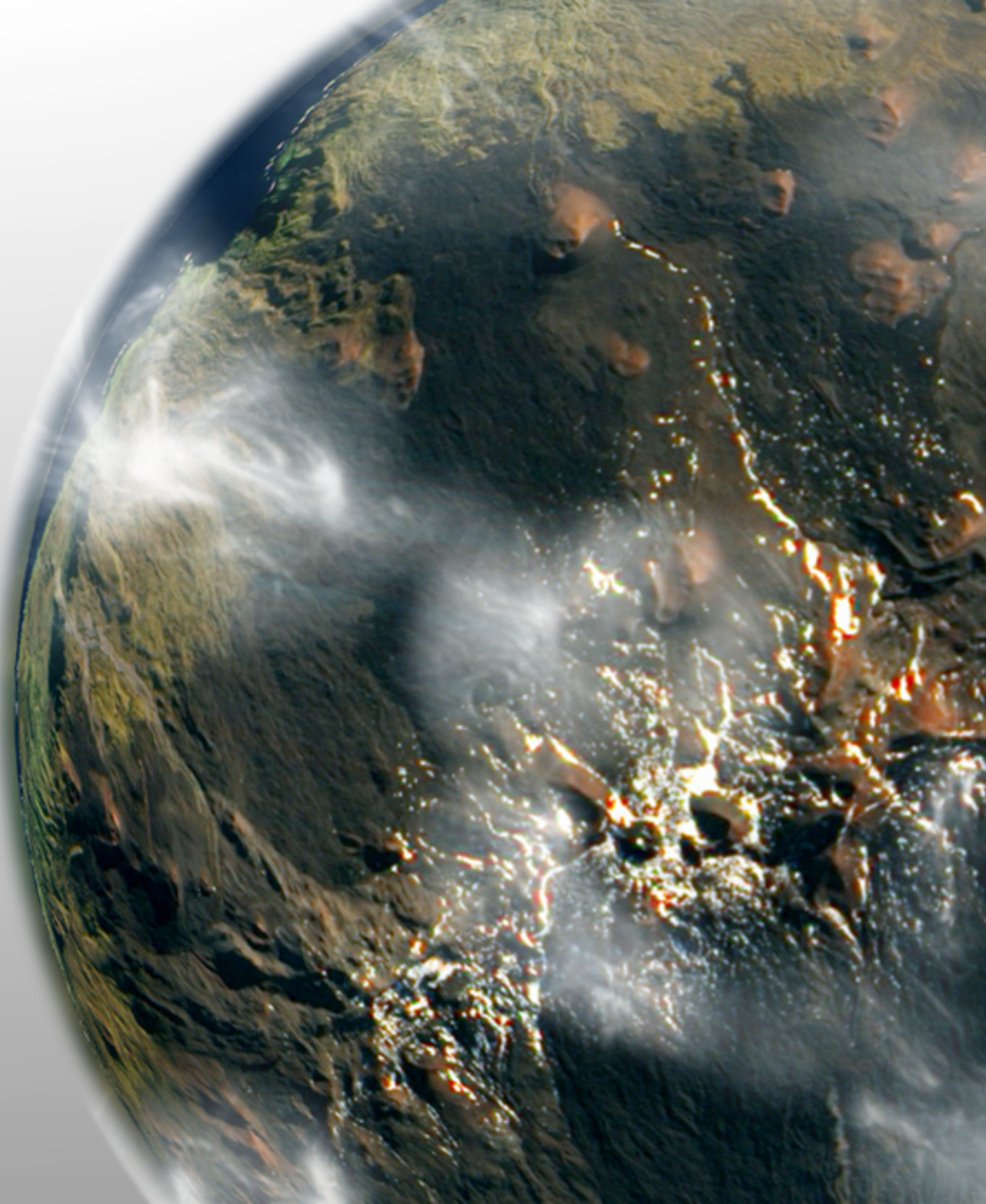


Astronomical Observatory "N. Copernicus"
Varna - 2017

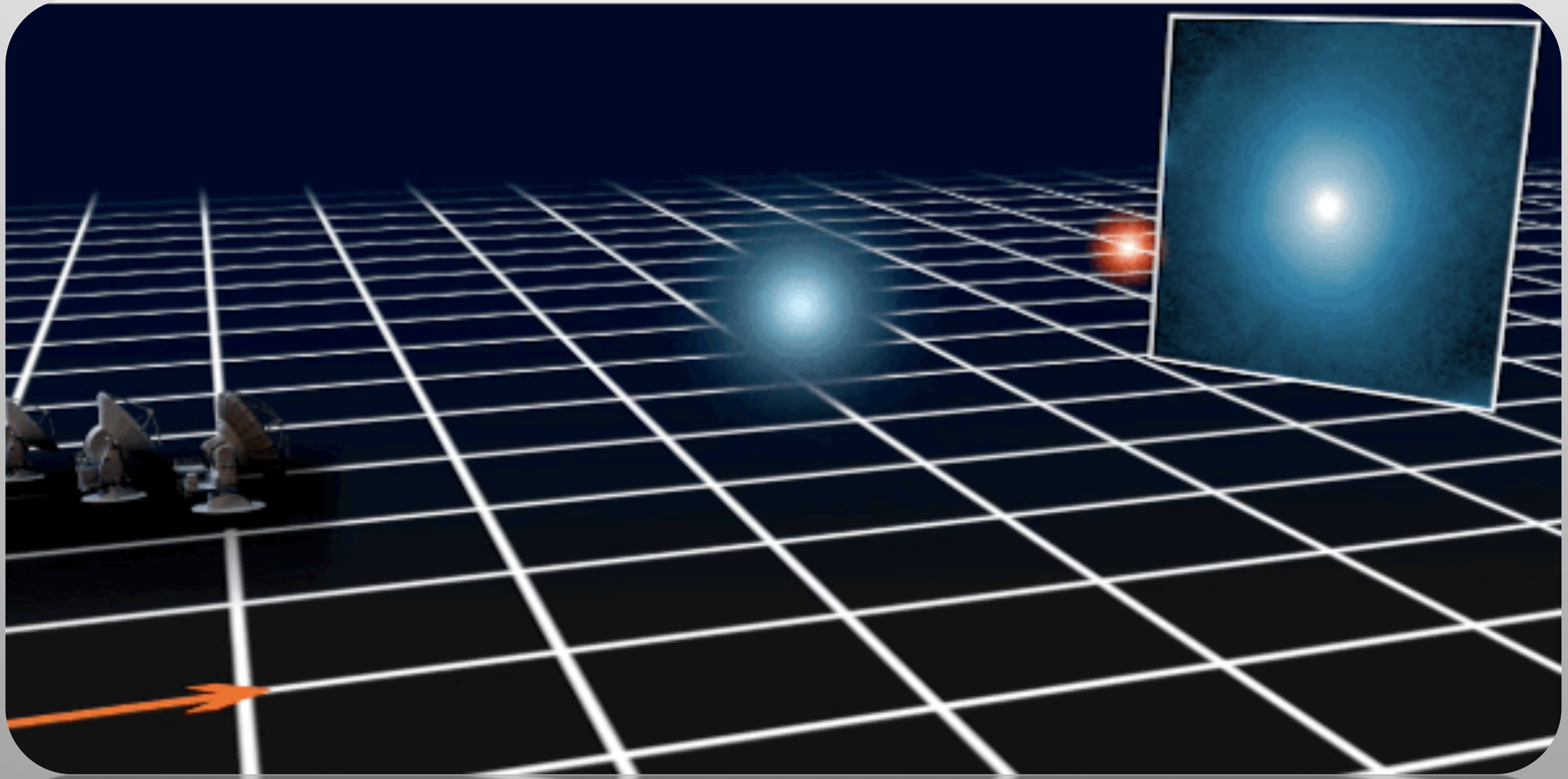
GRAVITATIONAL TELESCOPE

Katerina Bakhtigaliyeva, Zdravko Slavov, Feodor Konomaev
Teacher: Mrs. Eva Bozhurova
With the special support of Mr. Geoffrey Landis ("NASA John Glen Research Center")

Content



What is a gravitational lens?



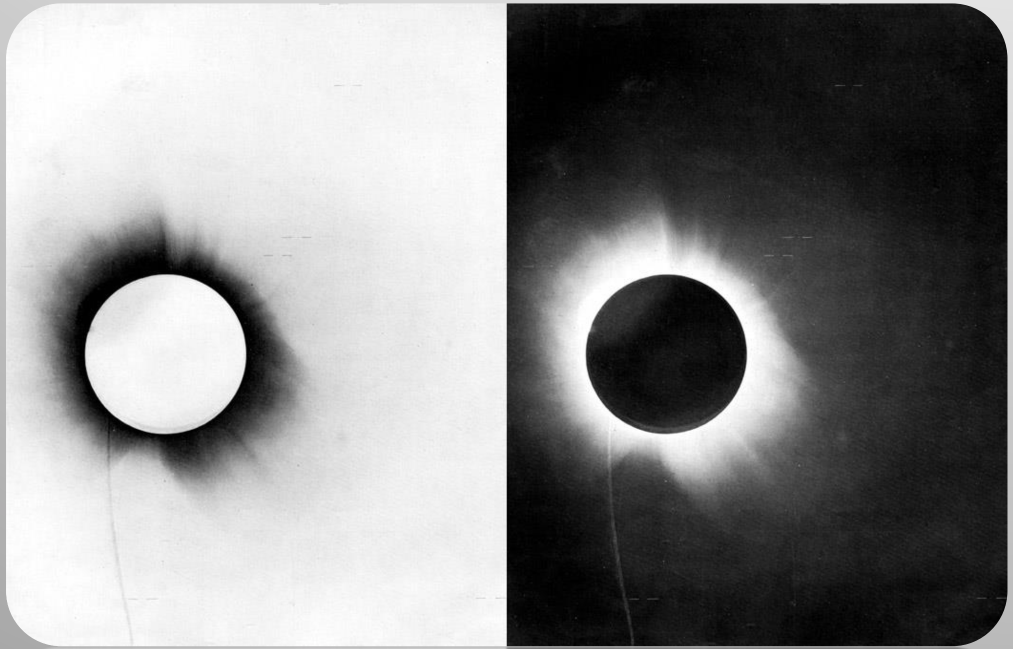
The Discovery of the Phenomenon

Henry
Cavendish
(1731 – 1801)

Johann Georg von
Soldner
(1776- 1833)

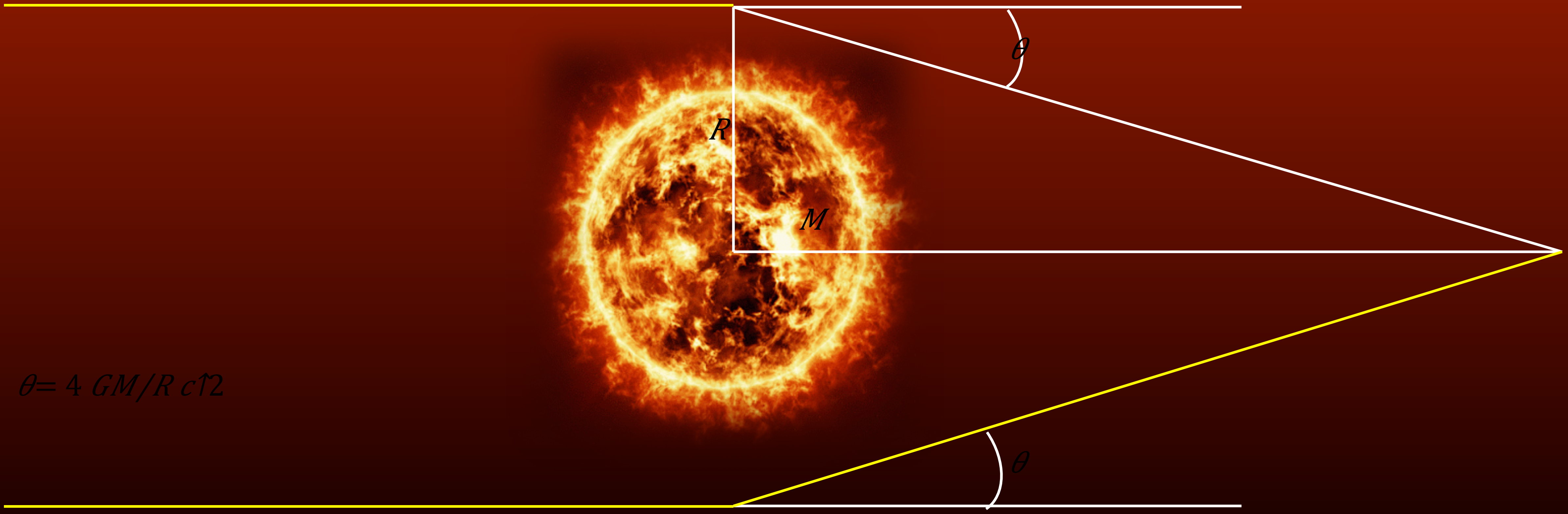
Albert Einstein
(1879 - 1955)

The Observation of the Solar Eclipse 29.05.1919



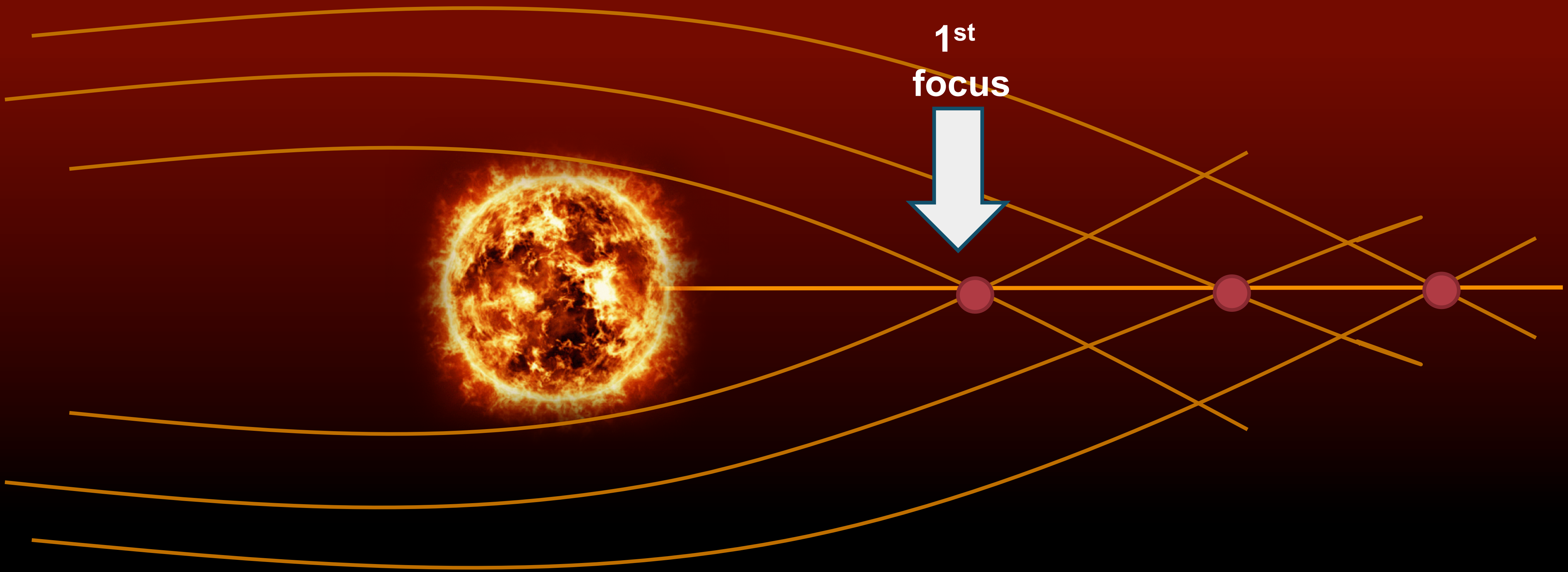
Gravitational lens effect

- Bending of the light



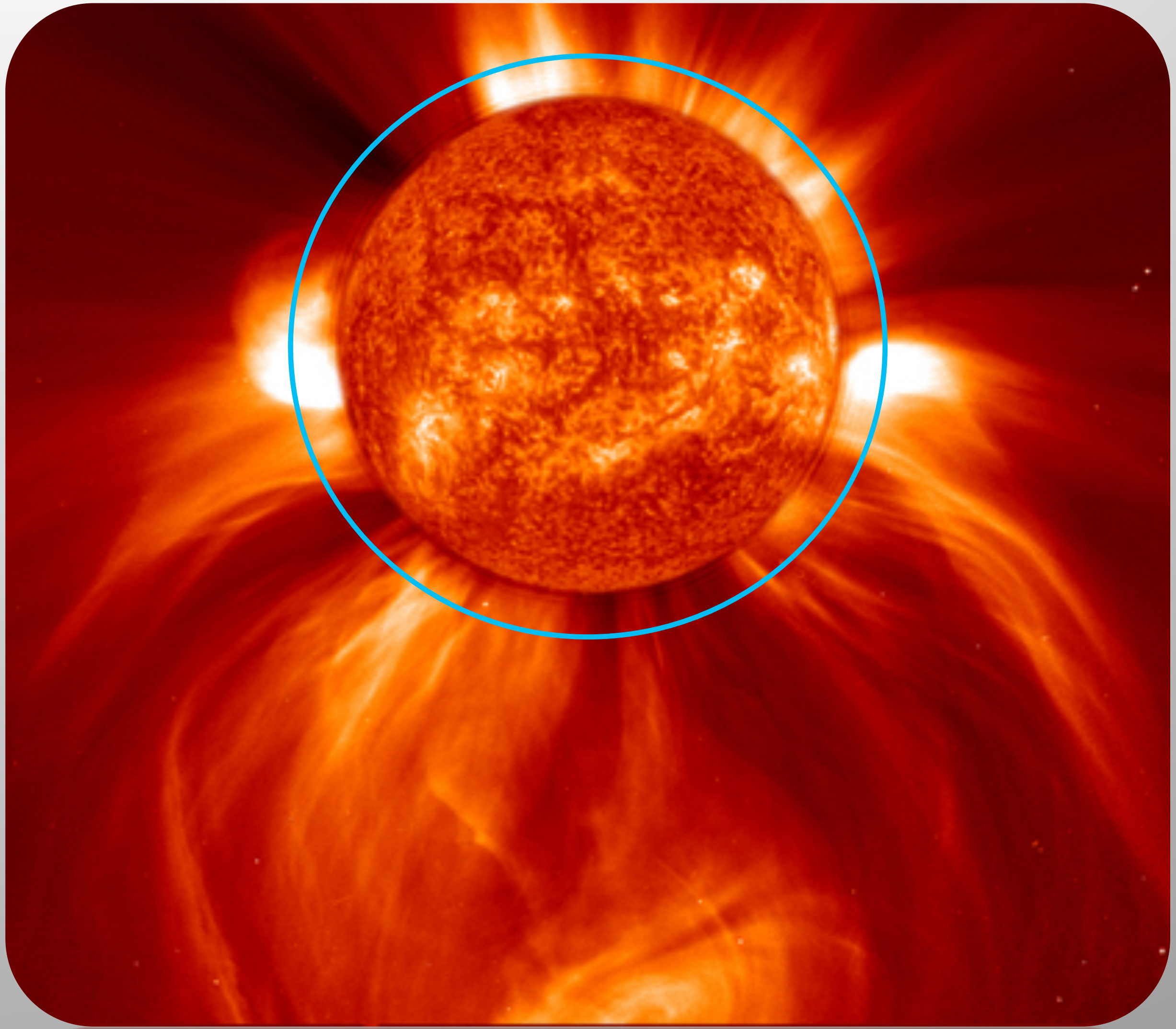
$\theta = 4\,GM/R\,c^2$

- Line of focuses

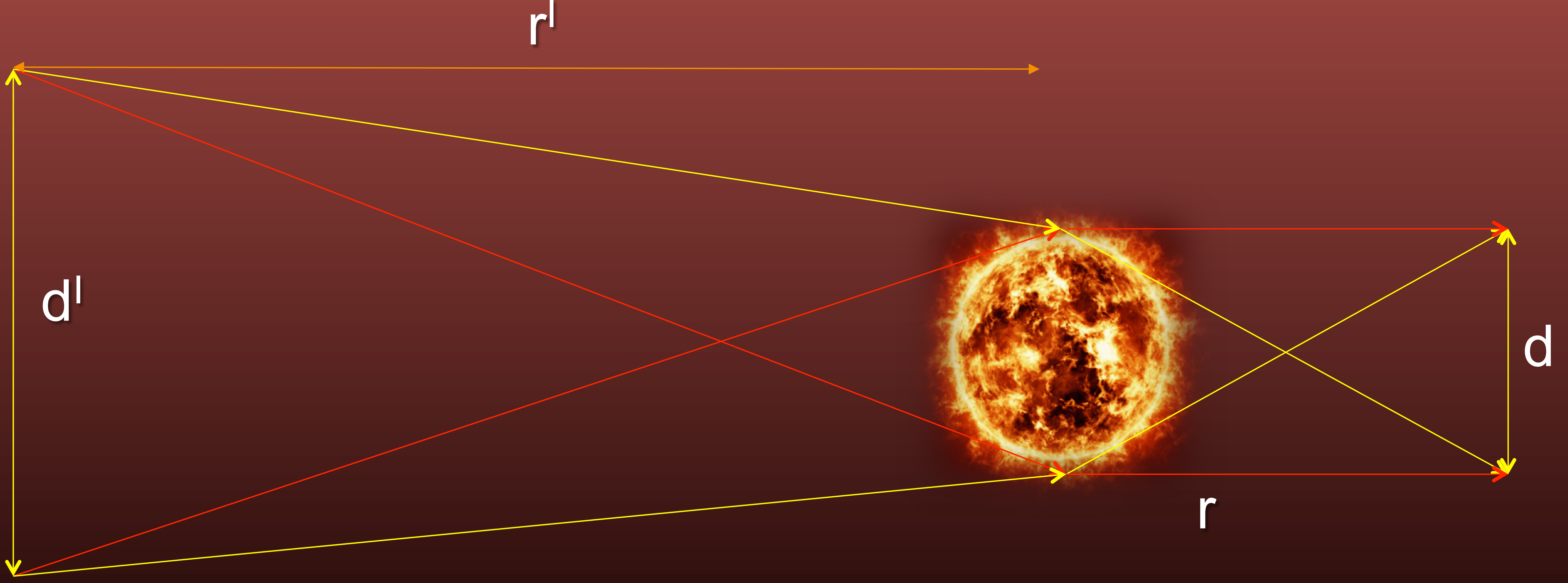


Parameters and capabilities of the gravity telescope

- First Focus - 784 AU



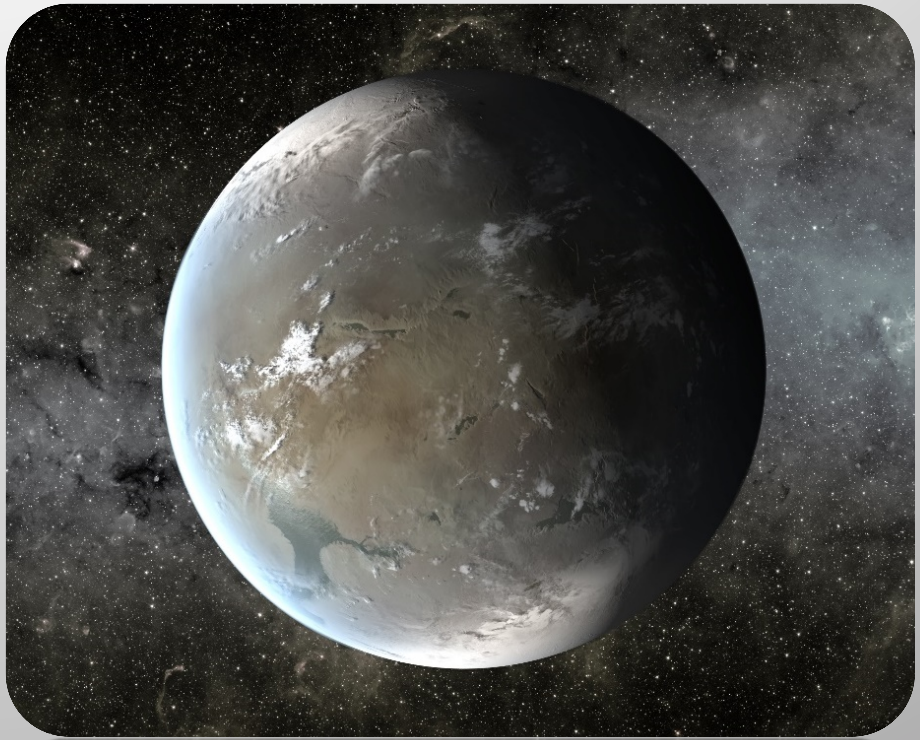
Scheme of a gravitational lens



Using the formula $d^{l}/r^{l} = d/r$ we can determine the diameter of the planet's image obtained with the solar gravitational lens.

The scale of the image

Andromeda Galaxy: r^{l} = 780 000 pc

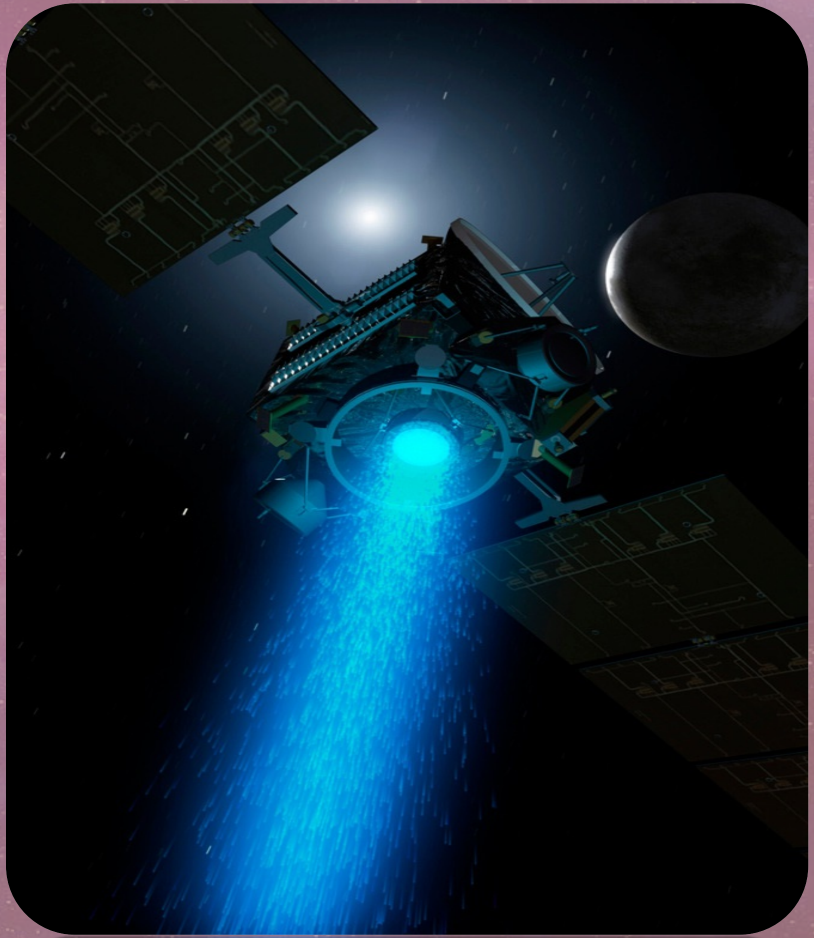


Earth like exoplanet: d=6cm
(image on the matrix)

Transportation

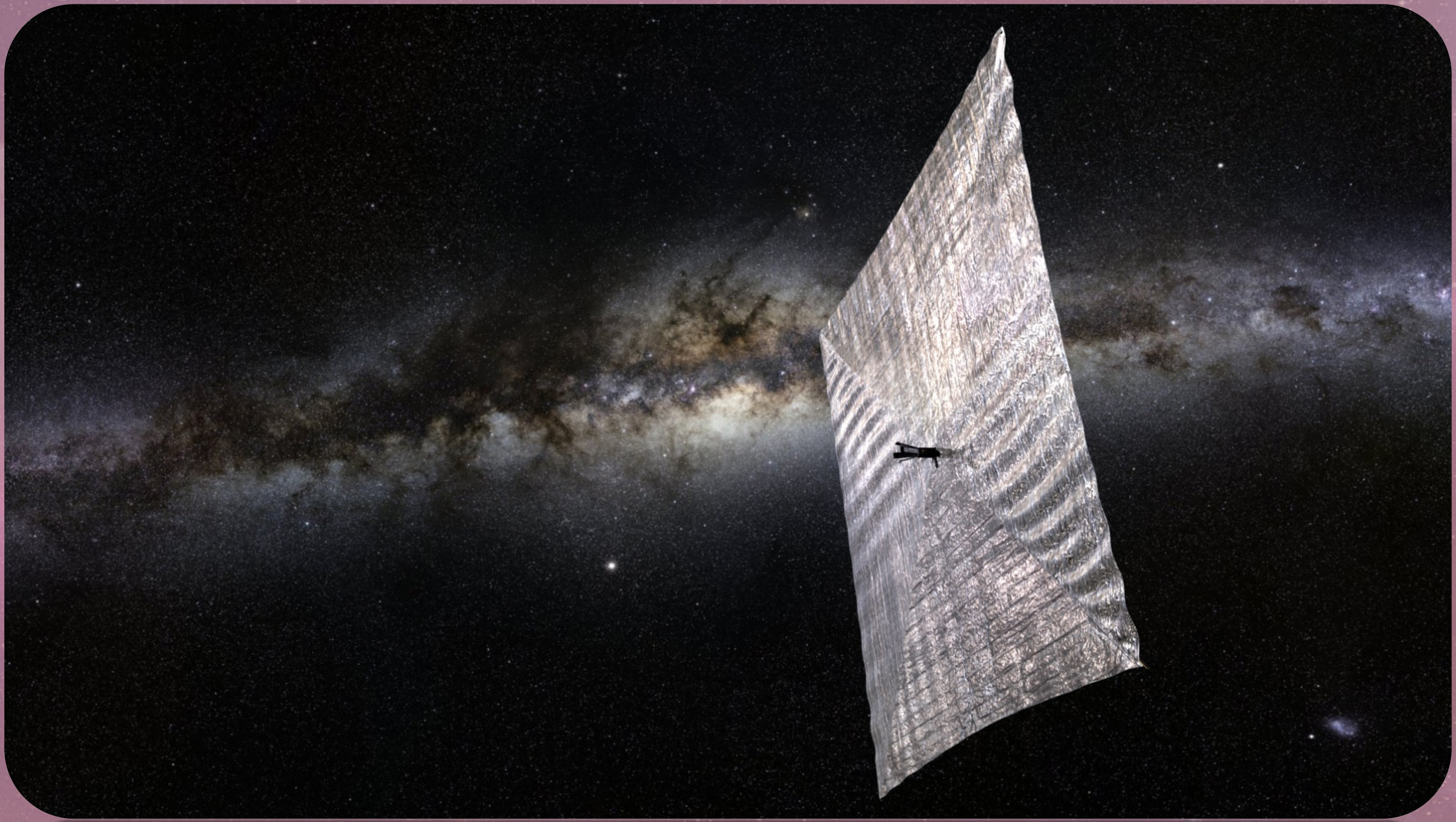
- The most popular method of traveling in space is through jet engines:

- Another more efficient method would be an ion motor:



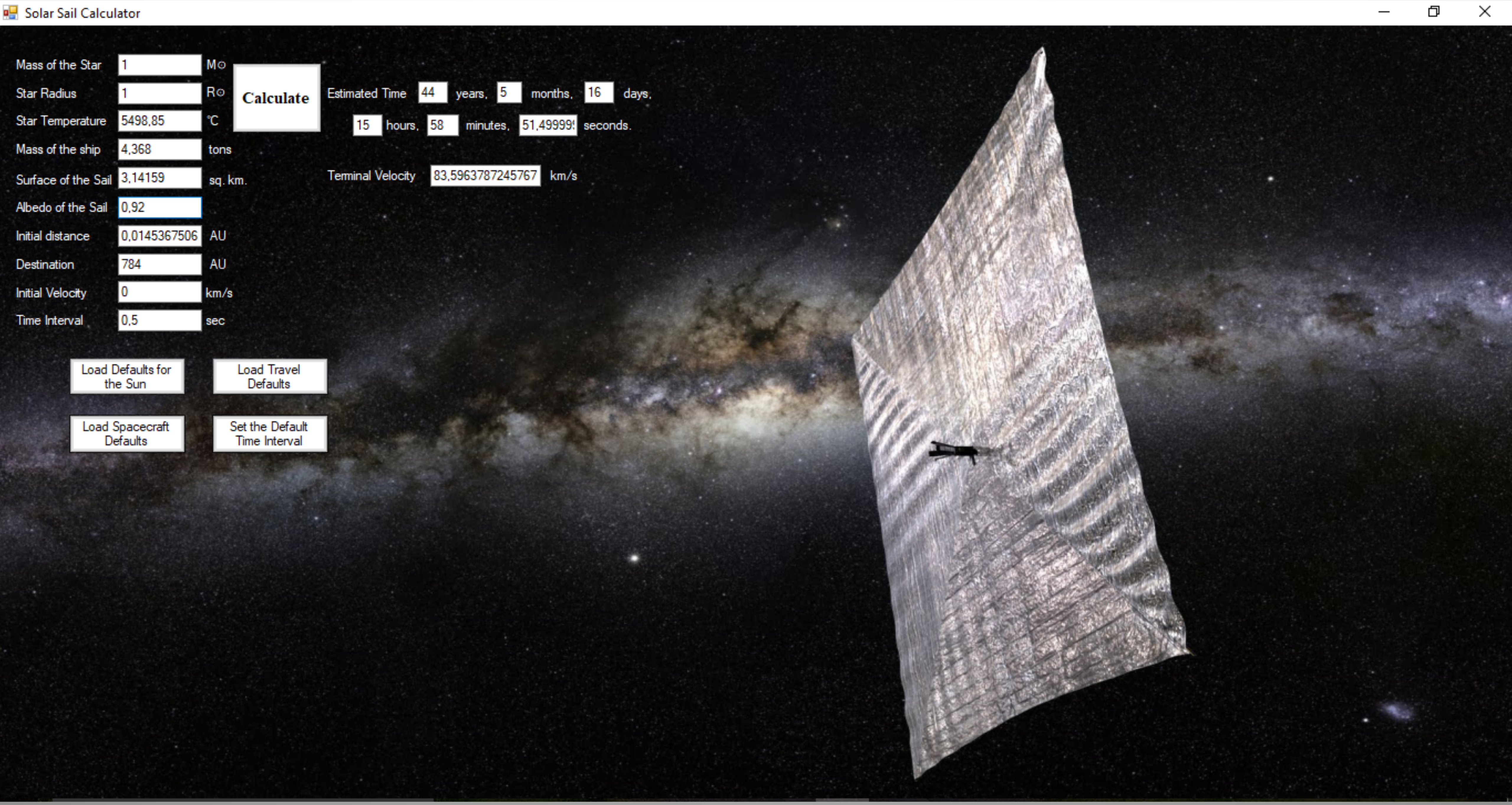
Transportation

- **Solar sail**

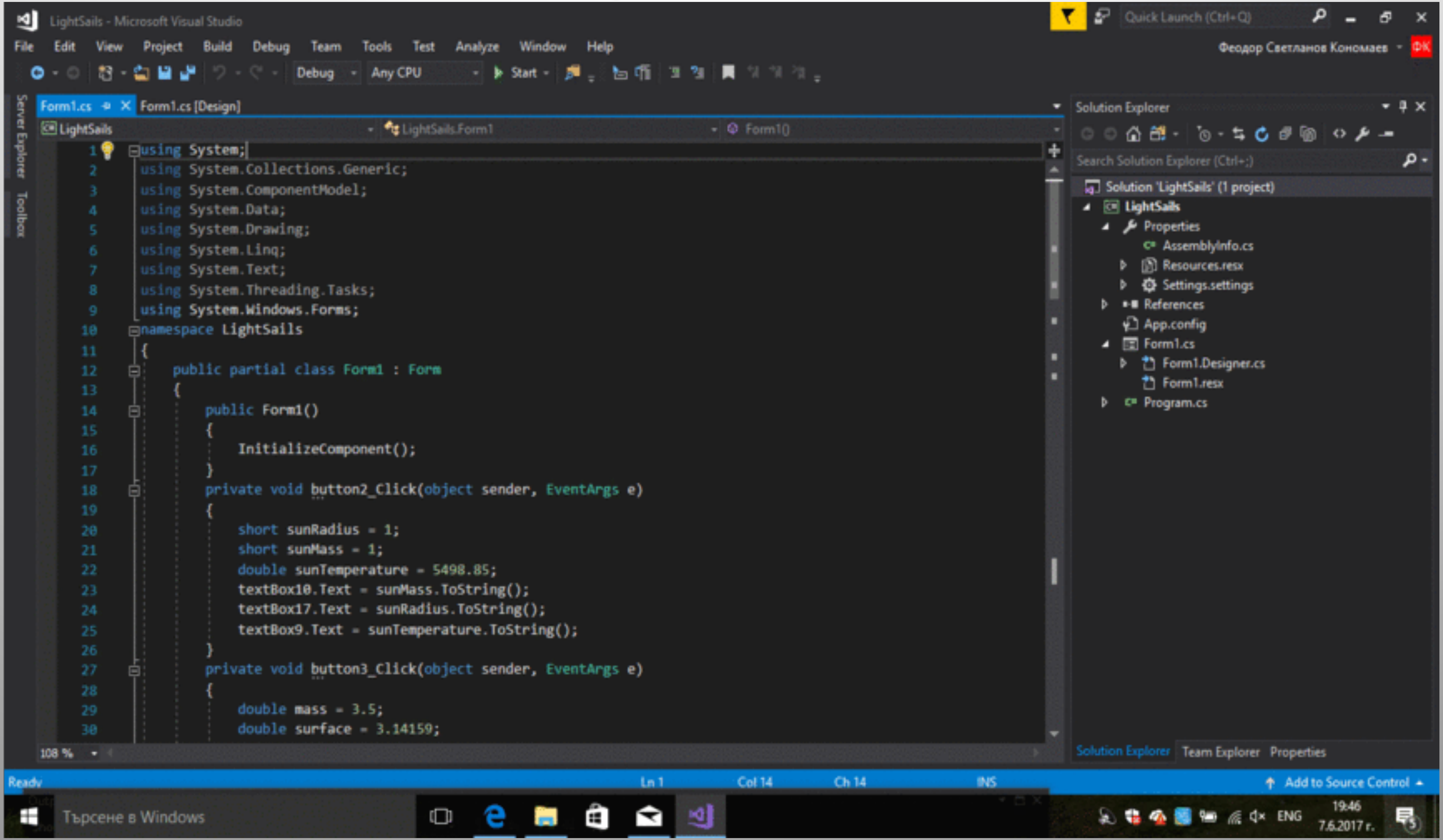


Used Formulae for Light Pressure

- $E = \frac{L_{SUN}.S}{4\pi r^2}$
- $\varepsilon = p.c$
- $m.a = F_{rad}\ ;\ F_{rad} = \frac{\Delta P}{\Delta t}$
- $F_{GR(gravitational\ force)} = \frac{GM_{SUN}m}{r^2}$


Solar Sail Calculator
Mass of the Star
1
M⊙
Star Radius
1
R⊙
Star Temperature
5498,85
°C
Mass of the ship
4,368
tons
Surface of the Sail
3,14159
sq. km.
Albedo of the Sail
0,92
Initial distance
0,0145367506
AU
Destination
784
AU
Initial Velocity
0
km/s
Time Interval
0,5
sec
Calculate
Estimated Time
44
years,
5
months,
16
days,
15
hours,
58
minutes,
51,49999
seconds.
Terminal Velocity
83,5963787245767
km/s
Load Defaults for the Sun
Load Travel Defaults
Load Spacecraft Defaults
Set the Default Time Interval

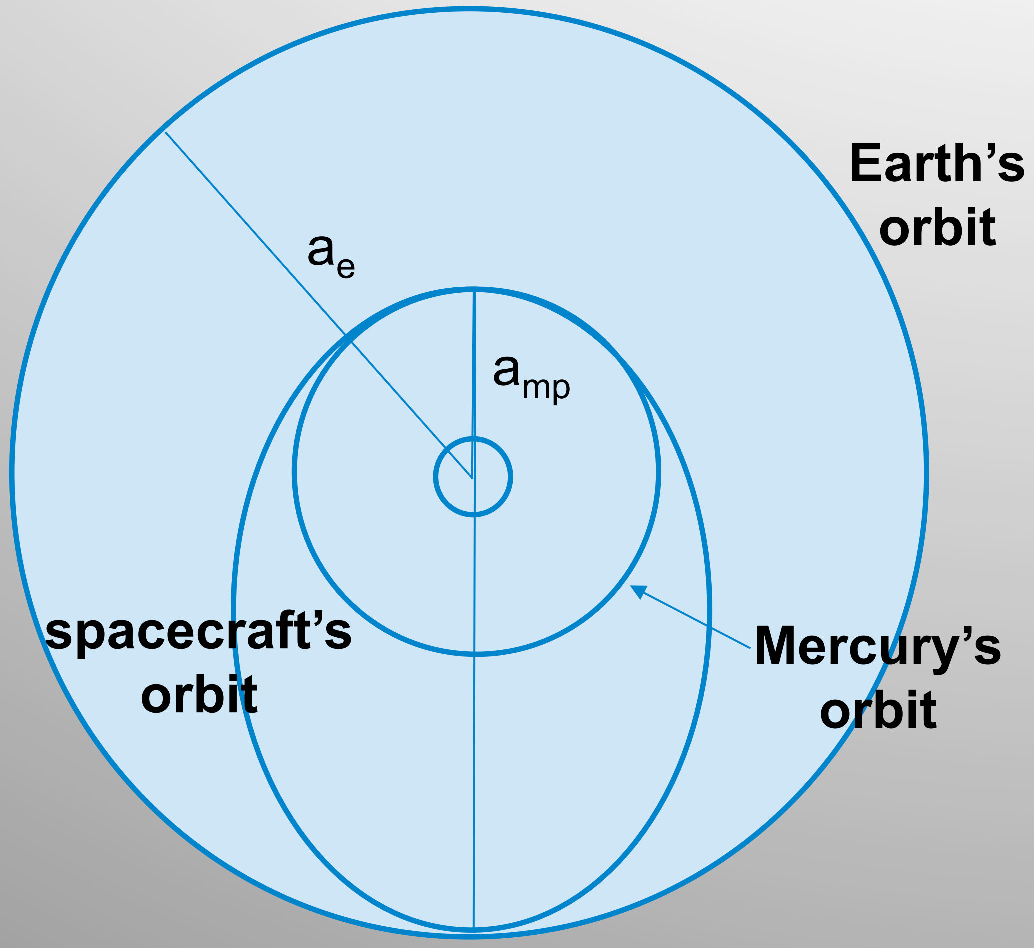
Program Code

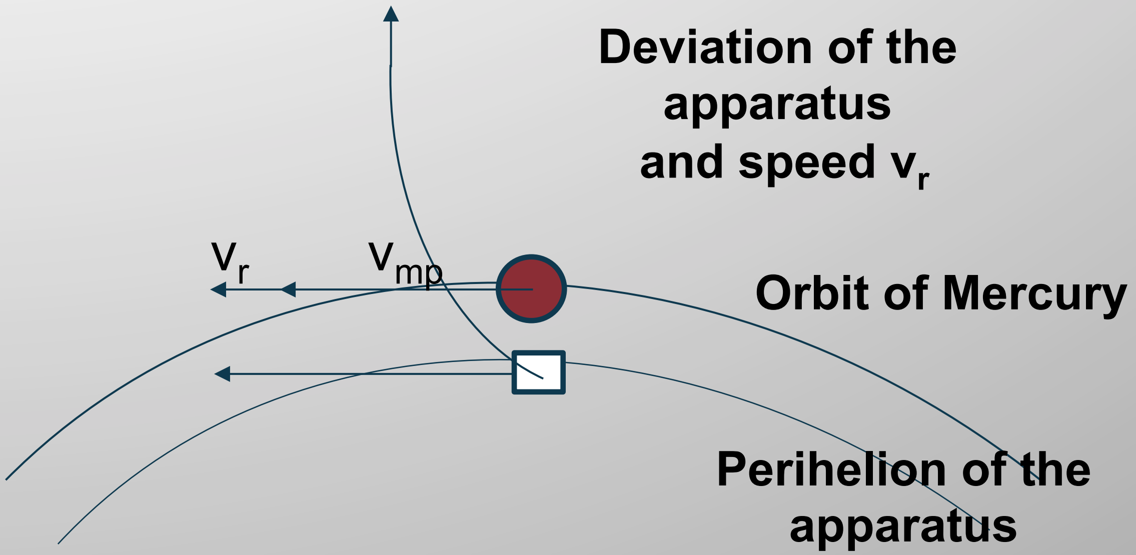


Mercury Slingshot

Our goal is to use the effect of the gravity slingshot and to achieve an even higher initial velocity.

Mercury Slingshot Scheme





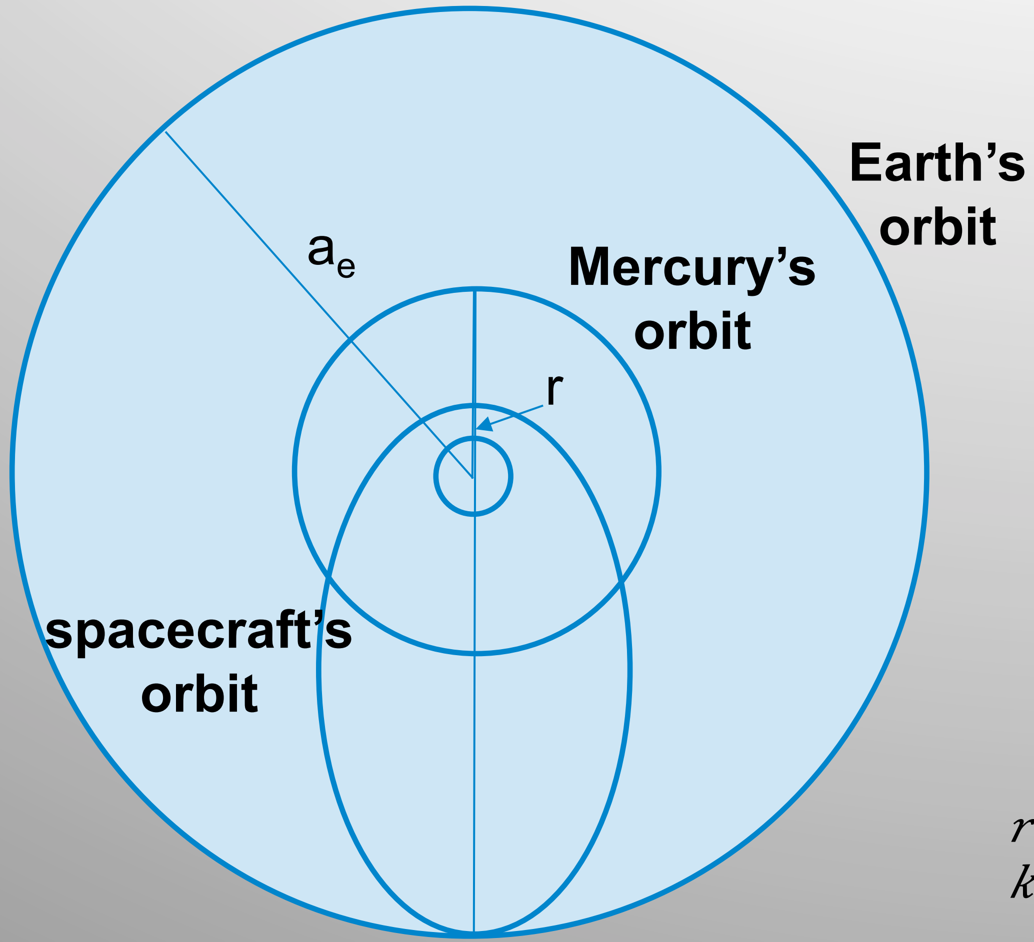
Used Formulae for The Mercury Slingshot

- Mass - 4300 kg
- Surface of the sail - 3,14159 sq.km
- Albedo of the sail - 0.92
- Minimum distance from the Sun - 0.02207 AU

- $V_{mp} = \sqrt{G . \frac{M_0}{a_m}} . \sqrt{\frac{1+e_m}{1-e_m}}$
- $v_x = \sqrt{G . \frac{M_0}{a}} . \sqrt{\frac{a_e}{a_m} . (1-e_m)}$
- $a = a_e + a_m . (1-e)/2$

Time to travel
186 years 2 months 9 days

Closer approach to the Sun



Magnesium sail

Minimal distance – bellow melting point of Mg

$r=R_0 T_0^2 \sqrt{1-A}/2\varepsilon /T^2=10410213,863\ km=0,0695$

Time to travel

95 years 8 months 29 days

Magnex sail

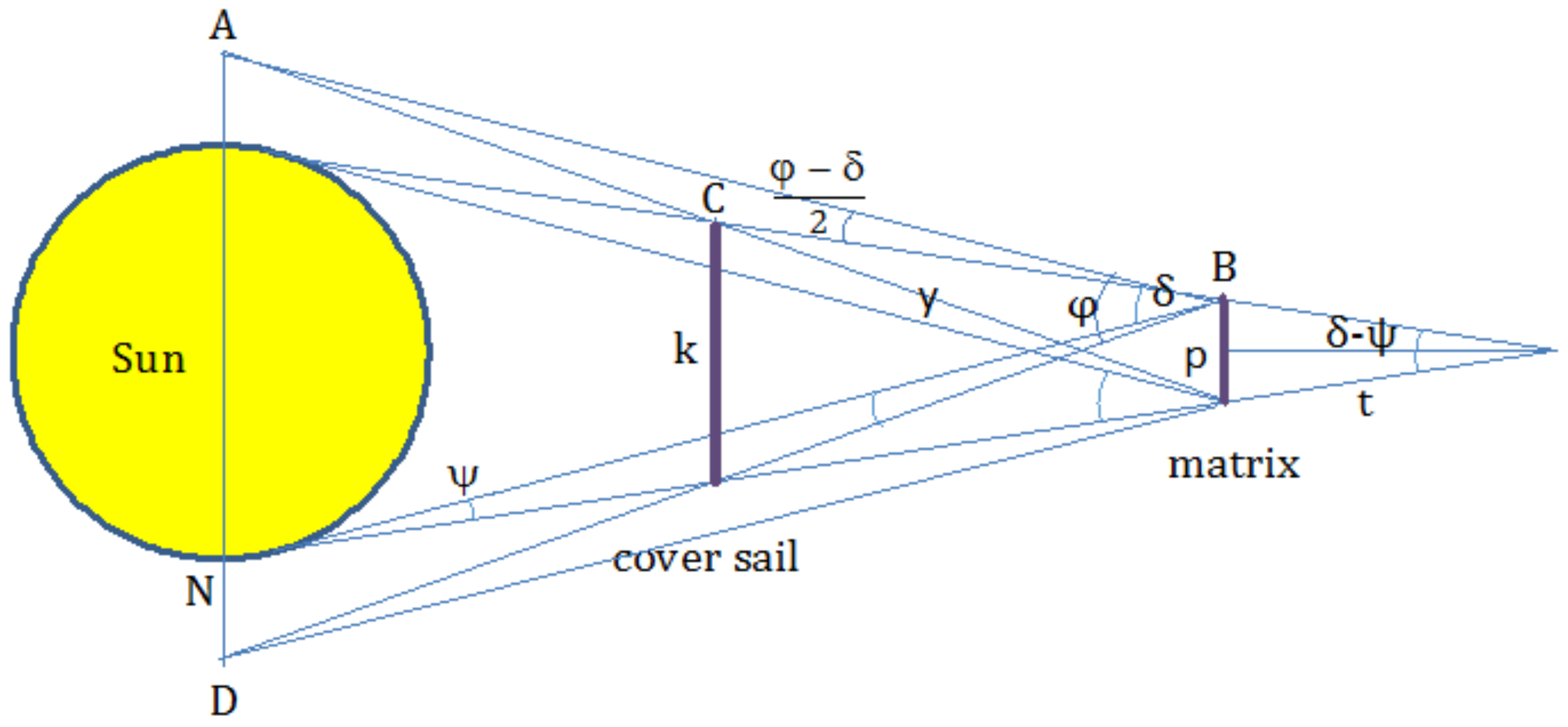
Minimal distance – bellow melting point of silica aerogel

$r_1 =R_0 T_0^2 \sqrt{1-A}/2\varepsilon_1 /T_1^2 =1640570,3921\ km=0,0109665246\ AU$

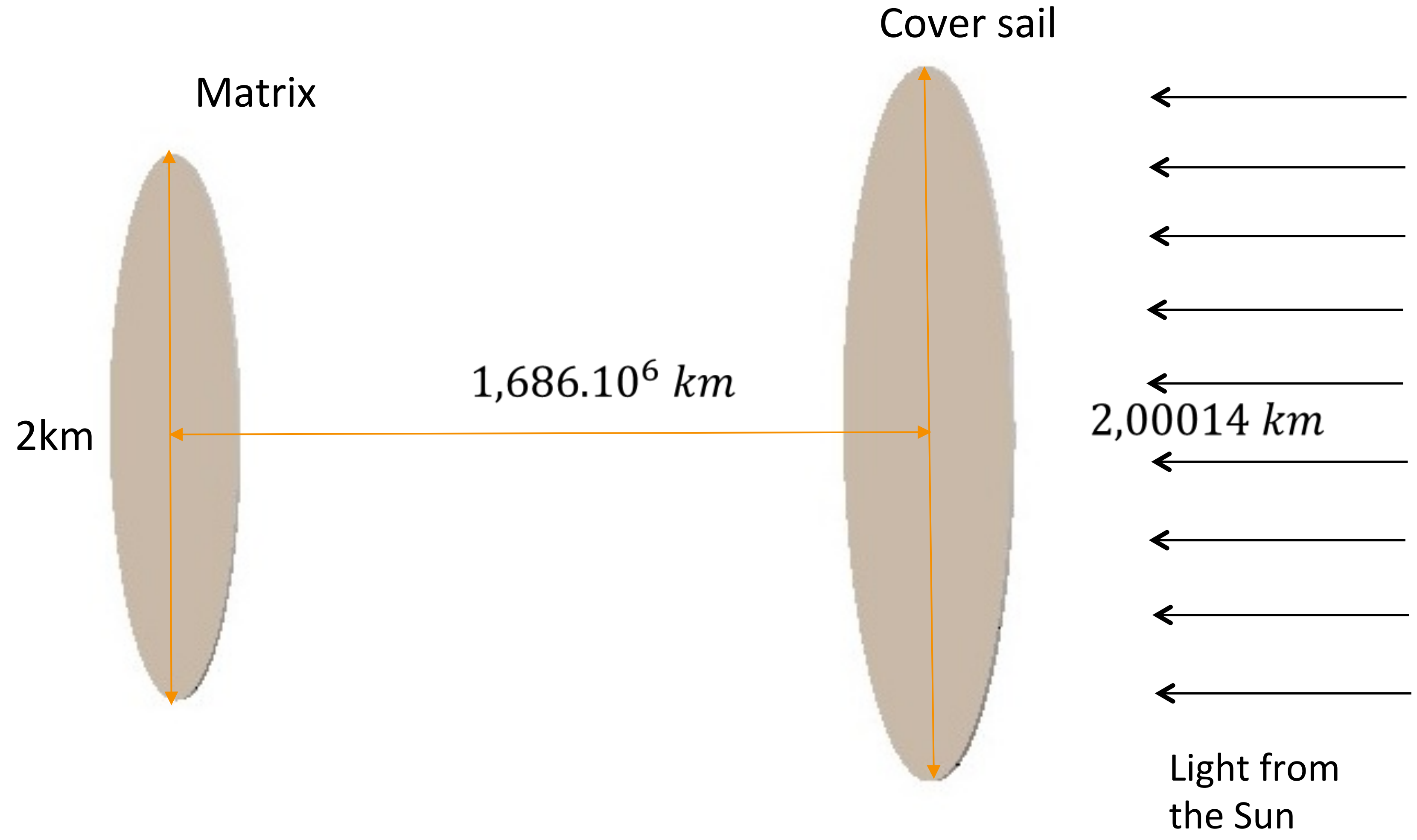
Time to travel

37 years 11 months 29 days

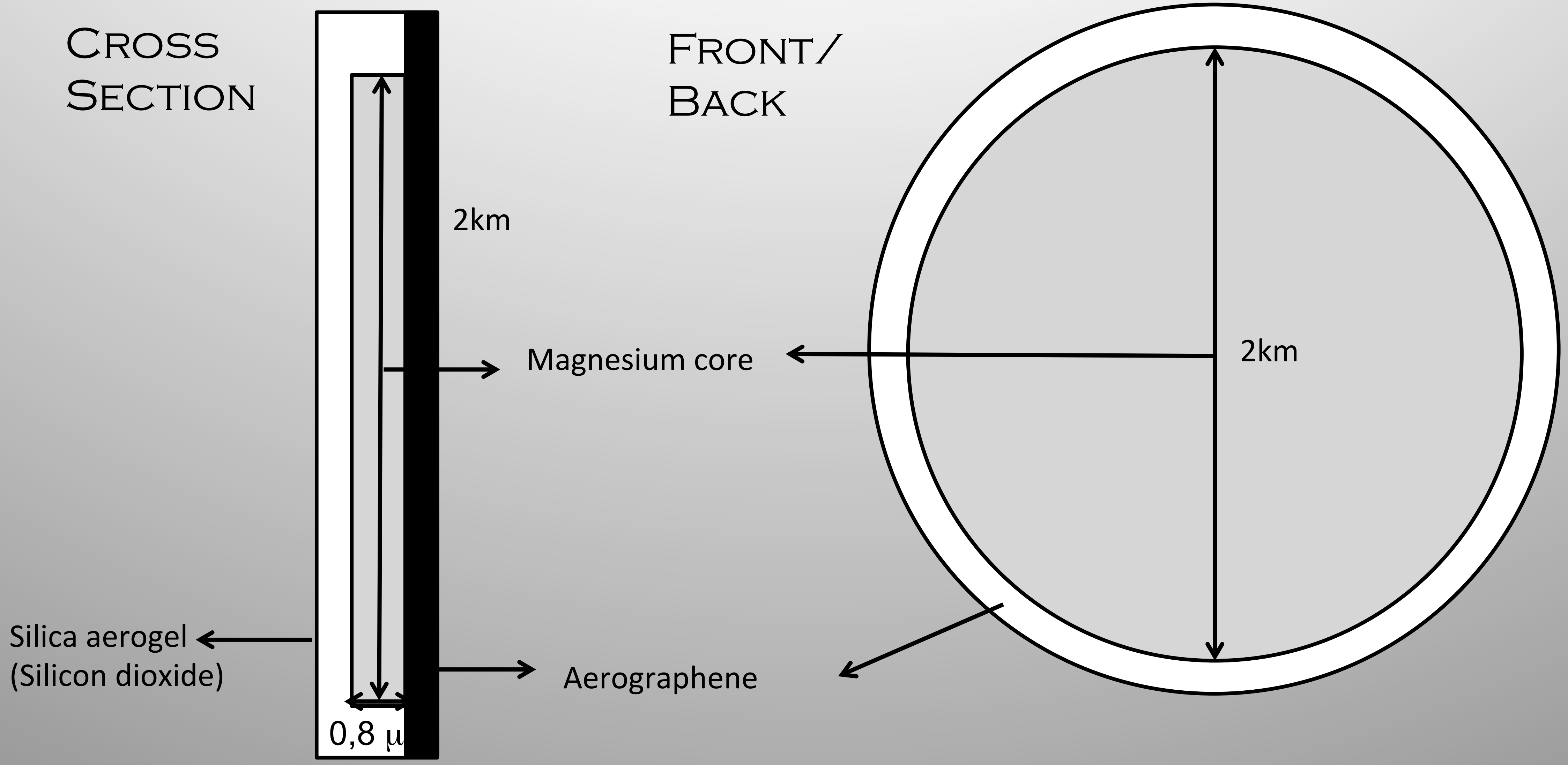
General scheme of the telescope



Positions of the matrix and cover sail

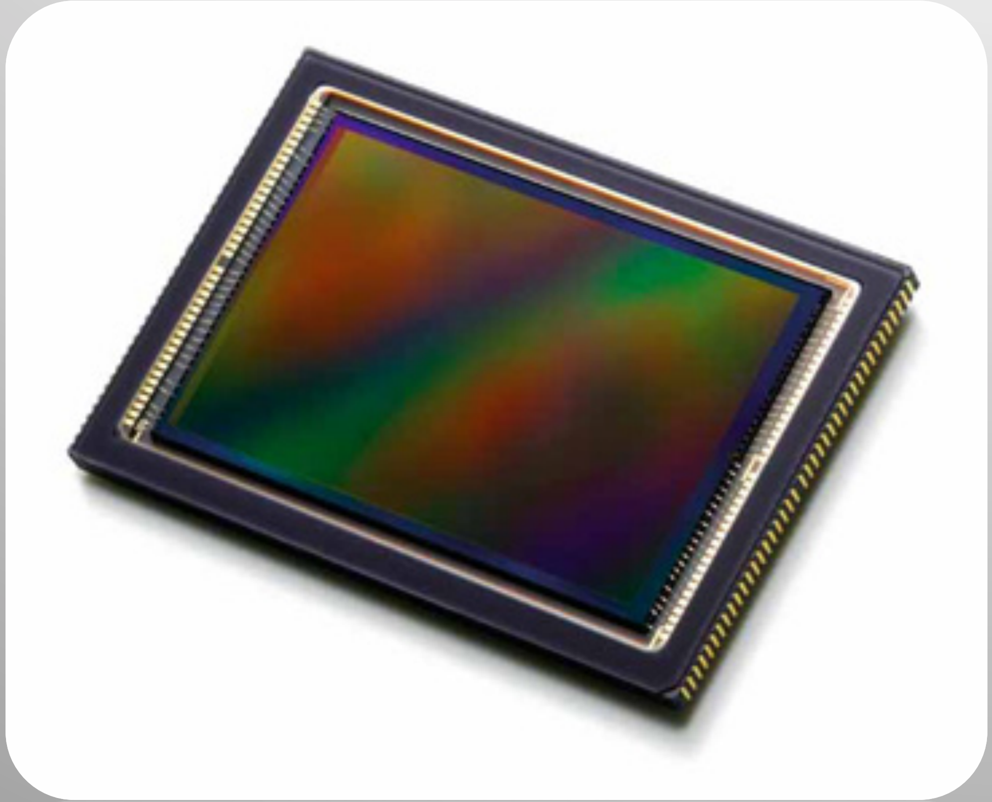


Characteristics of the Sail



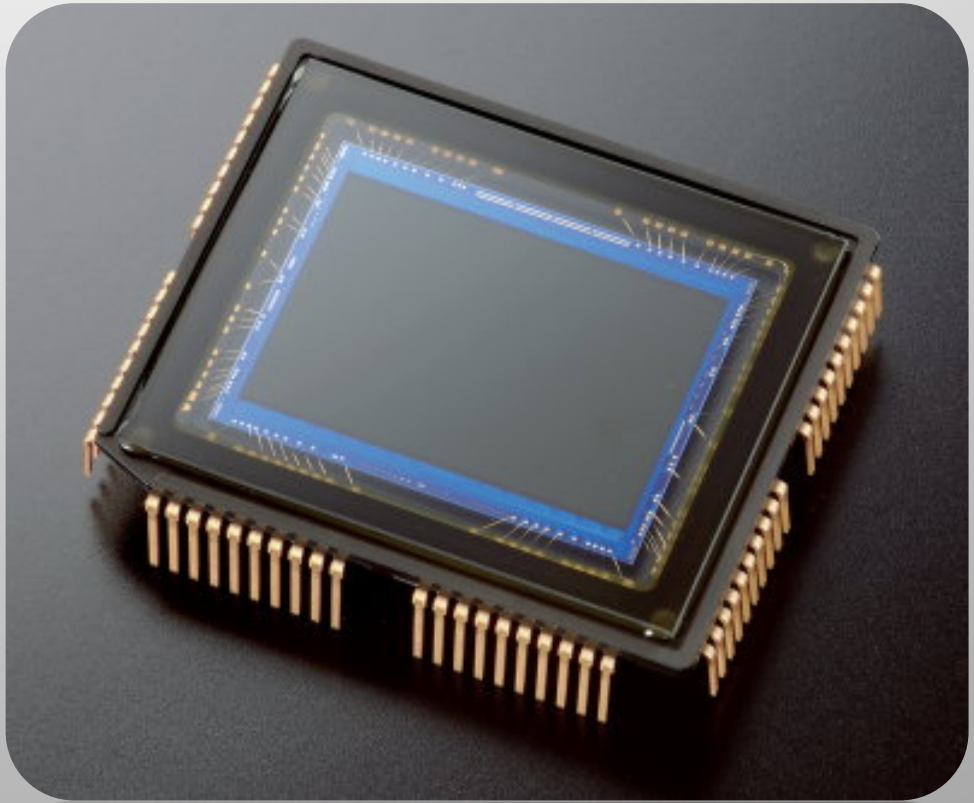
Characteristics of the Matrix

CMOS Technology



Every single pixel is being read individually.

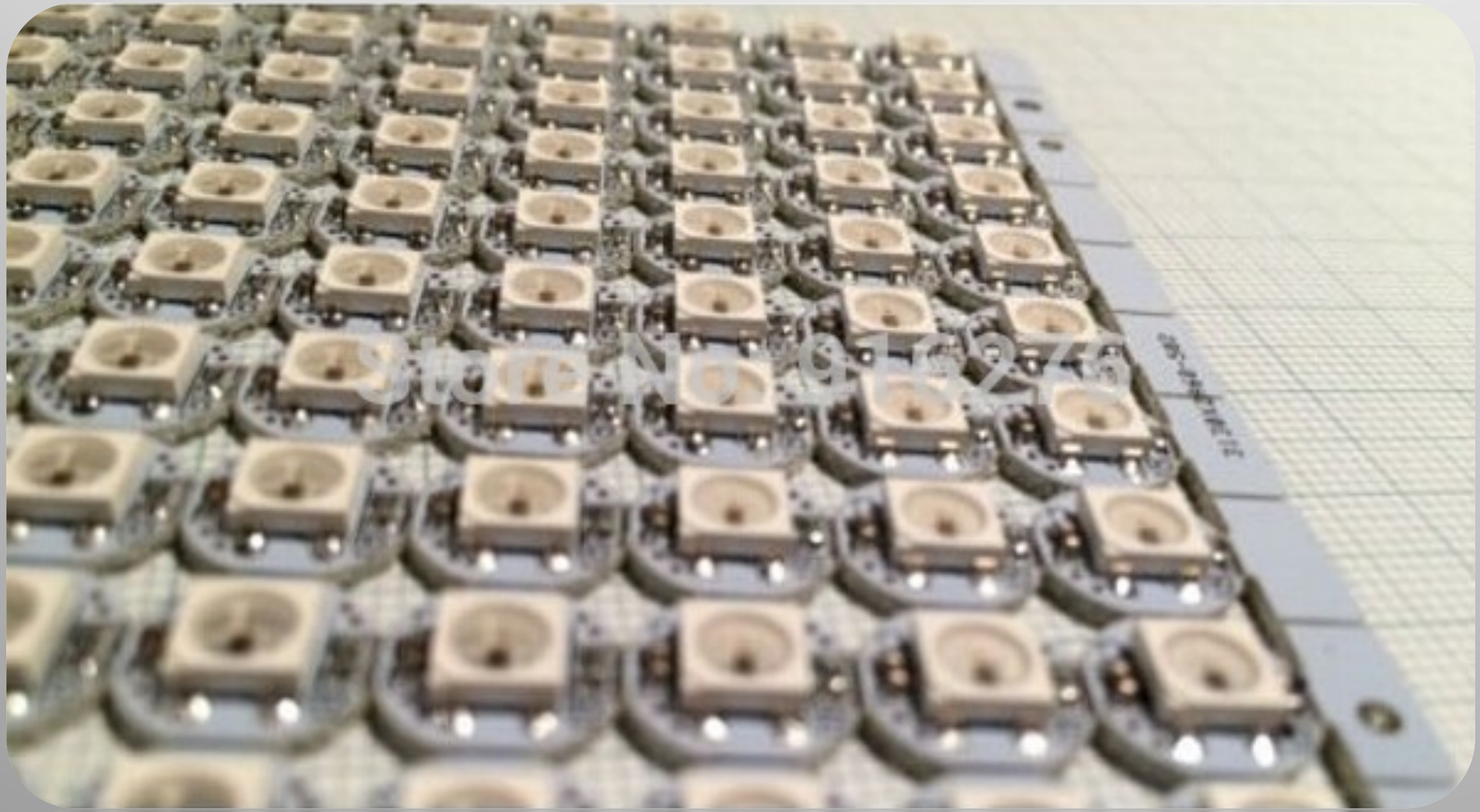
CCD Matrix



Every row of pixels is being read simultaneously.

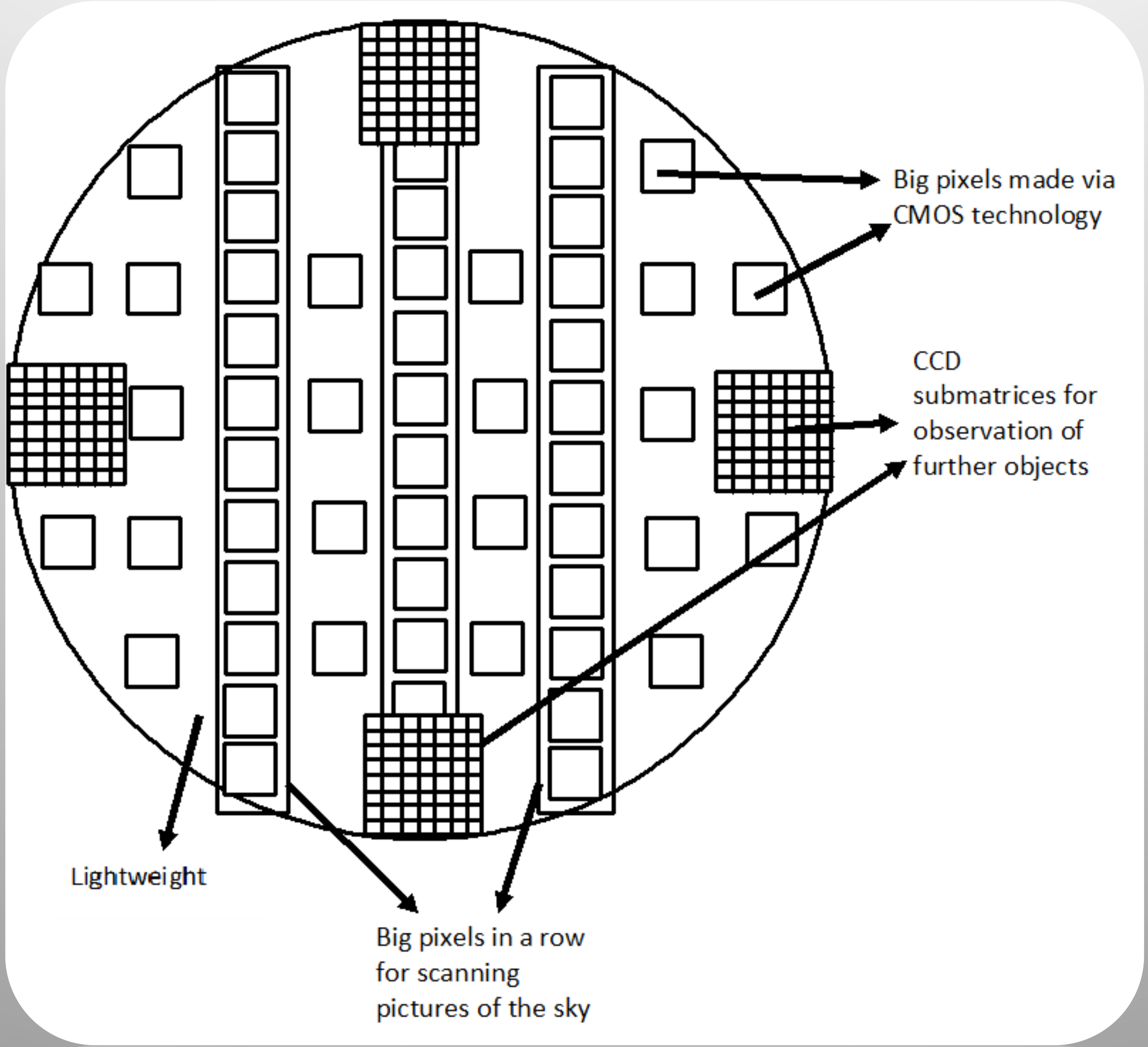
Larger but Thinner Pixels

The pixels of the matrix would be with similar sizes.



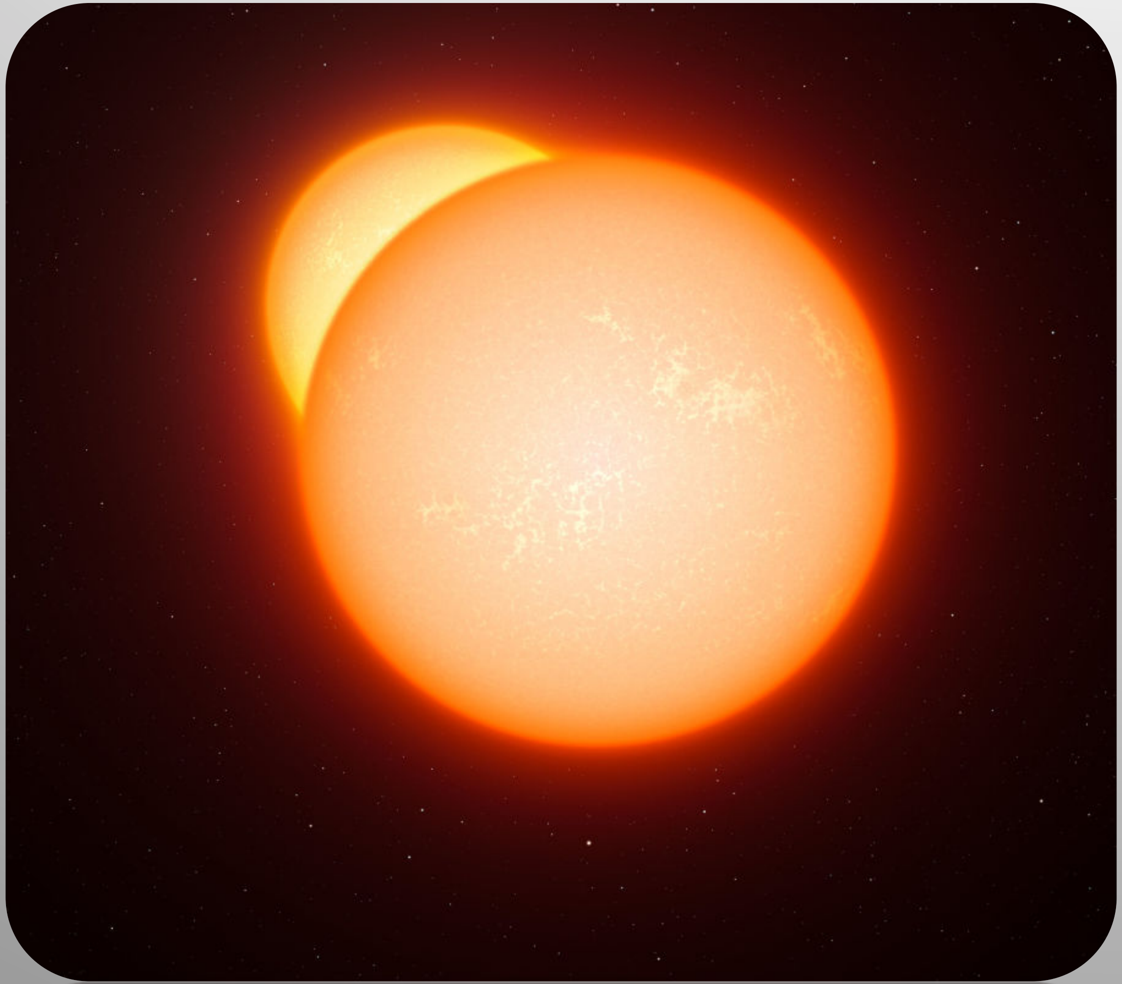
Probable appeal of the future pixels.

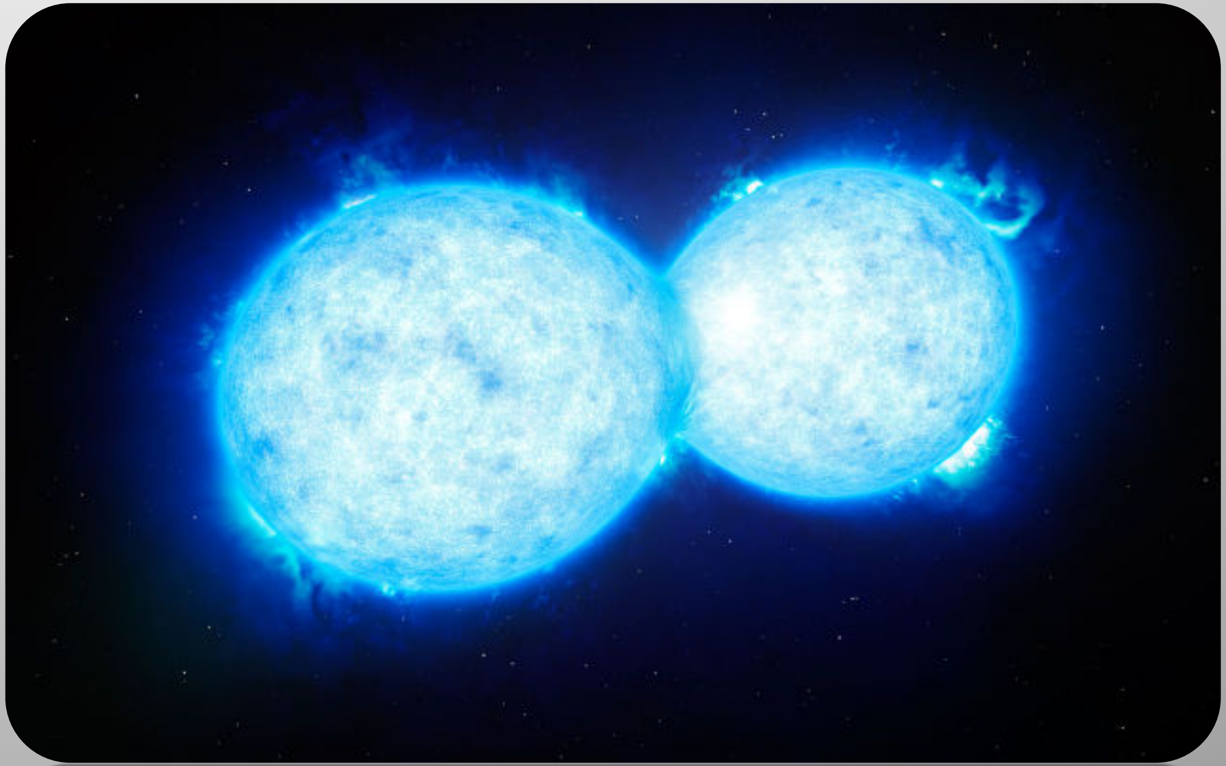
Scheme of the Matrix



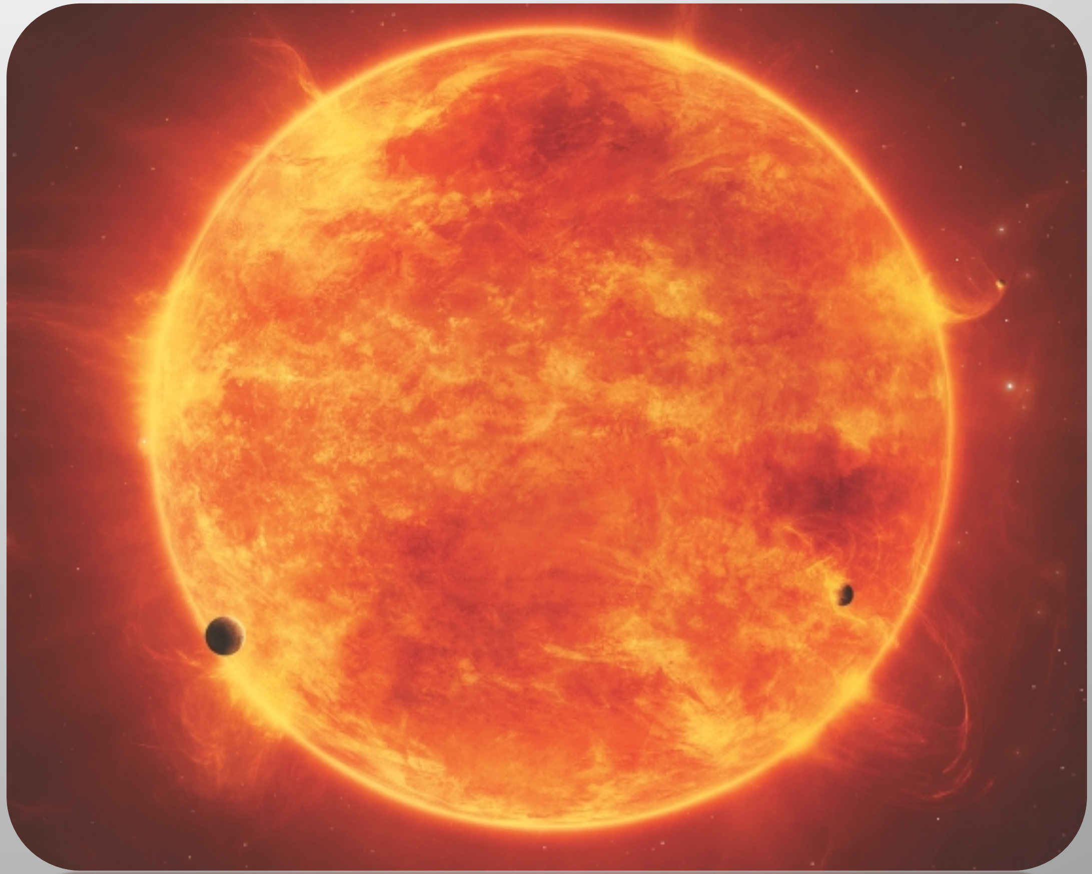
Goals and Objects

Binary Star Systems





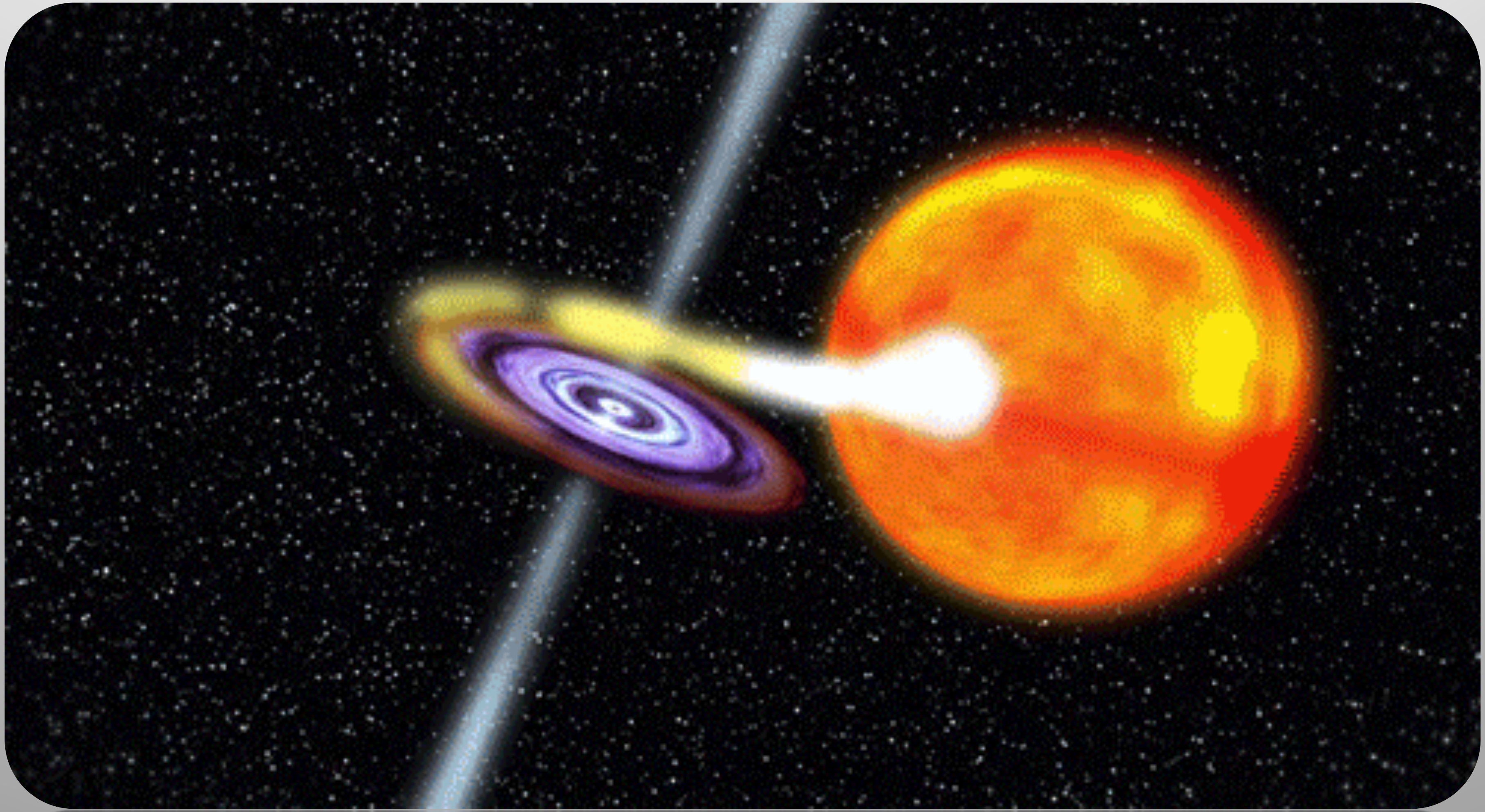
Red Dwarfs



Exoplanet Mapping

Active Galaxy Nuclei

Accretion disks around compact objects



Conclusion

Using the Sun as gravitational lens would provide amazing opportunities to observe extremely interesting astronomical objects and see unprecedented details of the majestic phenomena that happen in the far space.

The implementation of such a project will require solving of extremely difficult technical problems. But we believe that with the technology advancement in the future, they will be overcomed.

Refernces

https://abihollettdrp.files.wordpress.com/2014/12/screen-shot-2015-04-29-at-16-08-58.png (1)

http://pre06.deviantart.net/06ba/th/pre/i/2015/226/b/0/habitable_exoplanet_by_emperorkk-d95mlty.png (2)

http://www.roe.ac.uk/~heymans/website_images/Gravitational-lensing-galaxyApril12_2010-1024x768.jpg (3)

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https://avatanplus.com/files/resources/original/573c87ce7609c154c4727e93.png (4)

https://i.ytimg.com/vi/bI_FH_2Cqr8/maxresdefault.jpg (7)

https://www.google.bg/search?q=albert +einstein&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwiRxIvw2_3S AhWE2xoKHXCeB1wQ_AUIBigB&biw=1366&bih=651#tbm=isch&q=albert+einstein+high +quality&*&imgrc=vPFWYpz6t7nA0M:&spf=397 (8)

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https://en.wikipedia.org/wiki/Aerographene (12)

https://en.wikipedia.org/wiki/Aerogel (13)

https://en.wikipedia.org/wiki/Magnox_(alloy) (14)

http://www.engineeringtoolbox.com/emissivity-coefficients-d_447.html

Thank you for your attention!

Astronomical Observatory "N. Copernicus"

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Teacher: Eva Stefanova Bozhurova

With the special support of Mr. Geoffrey Landis (NASA John Glen Research Center) and

Mr. Zahary Donchev Donchev (Bulgarian Academy of Science)