

International Young Naturalists' Tournament



Problem №12: “Moon”

Team: “Moonlight”, Russia, Voronezh

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Problem condition

The **apparent size** of the Moon perceived by an observer depends on **multiple factors**. Investigate these factors and their role.





The Moon seems much smaller
then it is...



... due to the great distance between
the Moon and the Earth



Factors affecting the apparent size of the Moon



- Distance.
- Astronomical refraction.
- Human factor.

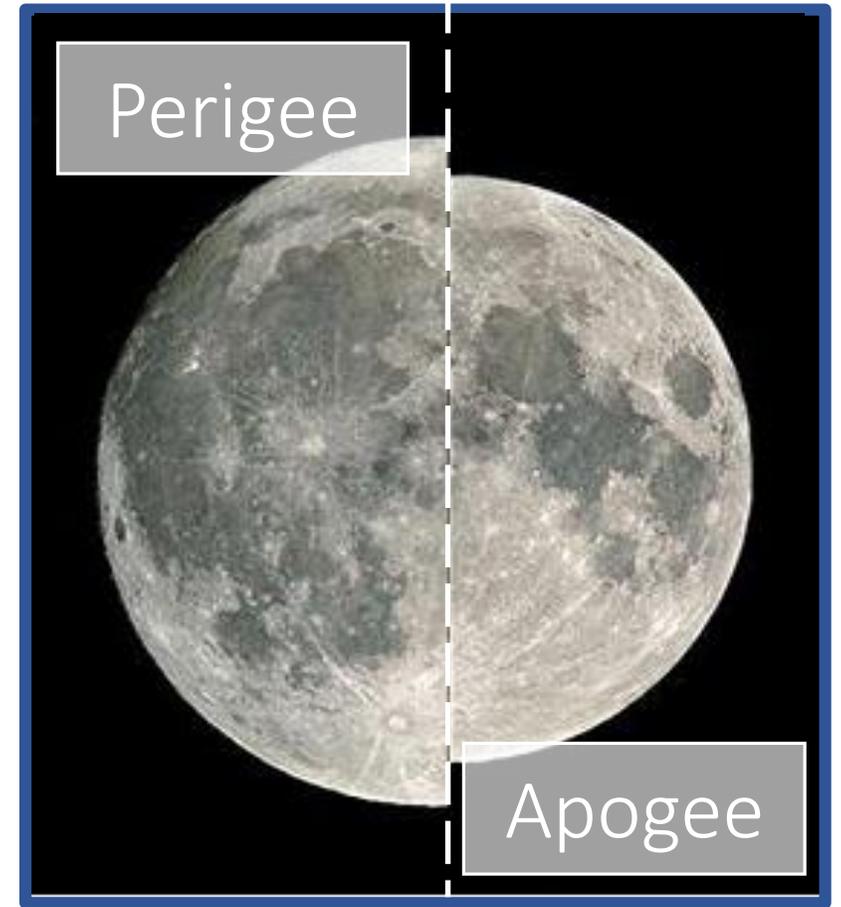
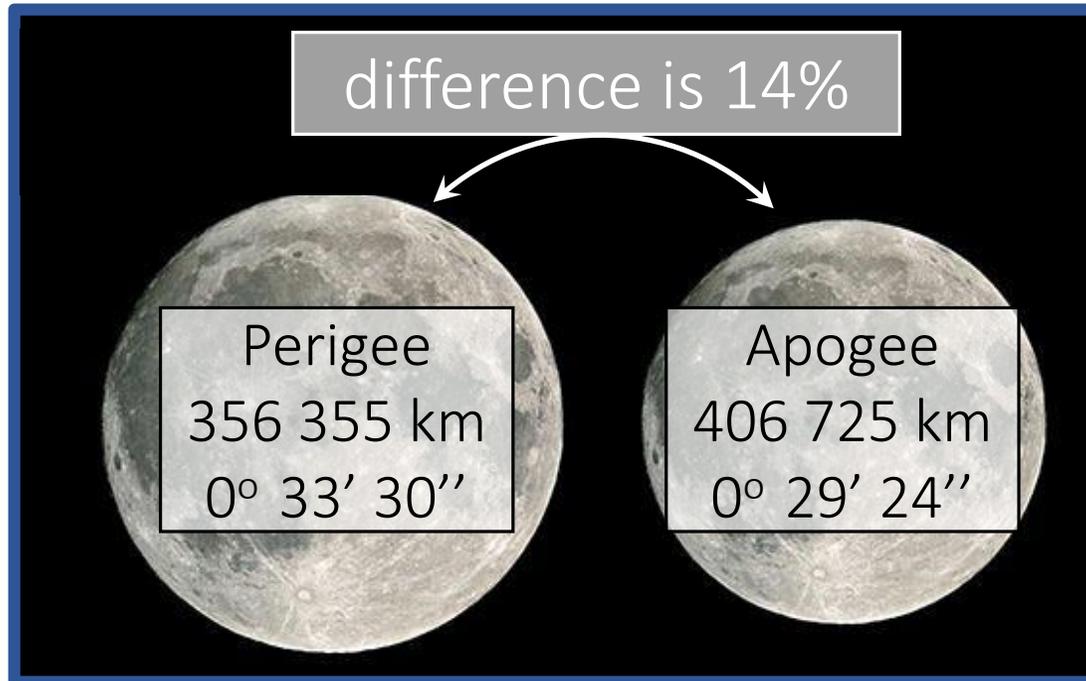


Apogee and perigee



Perigee is the closest to the Earth point of the near-earth orbit of the celestial body

Apogee is the most distant point from the Earth near-earth orbit of the celestial body



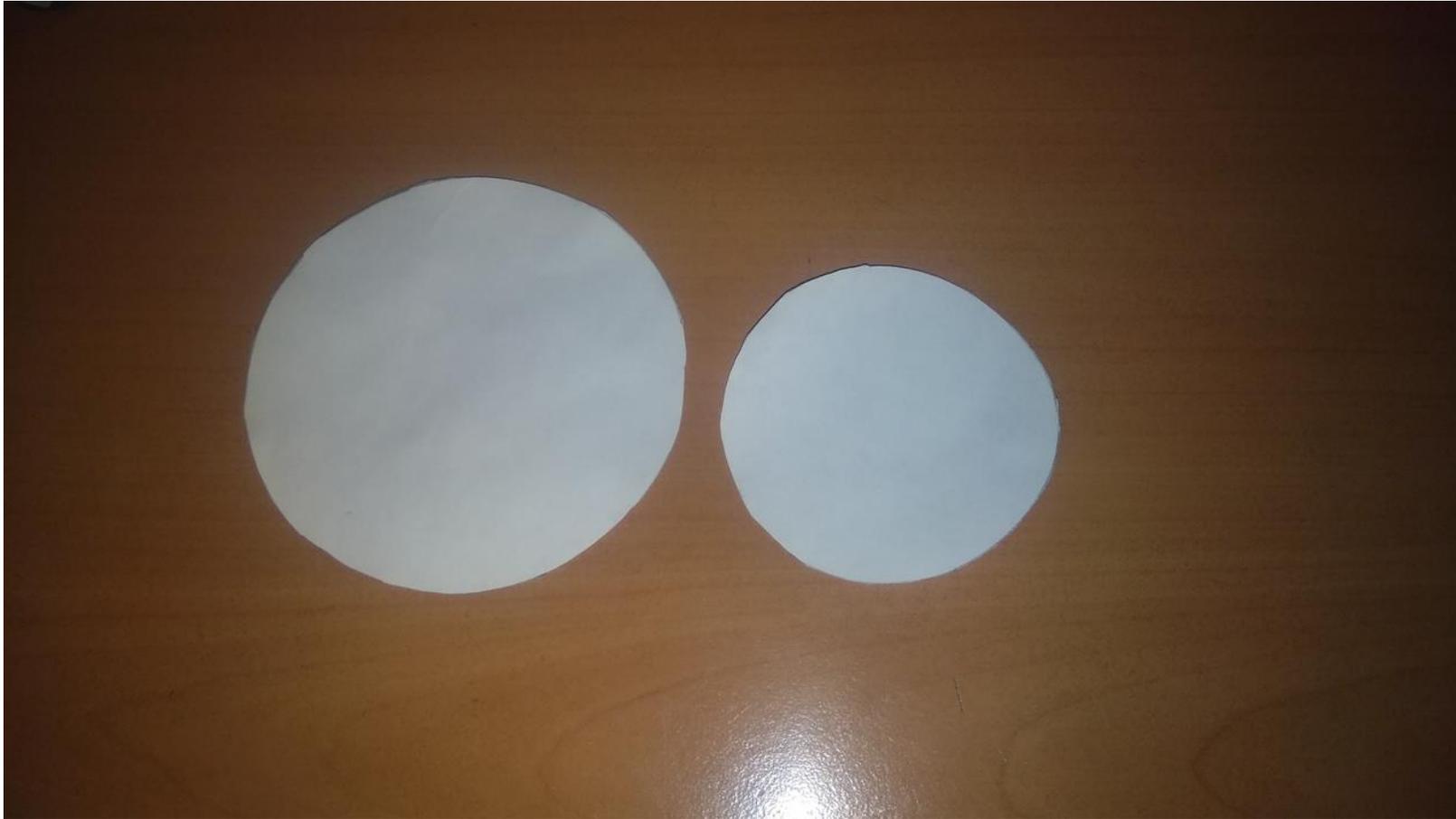


Experiment





In fact

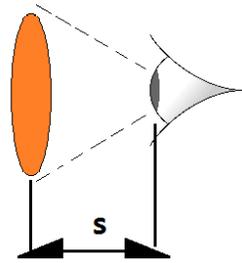




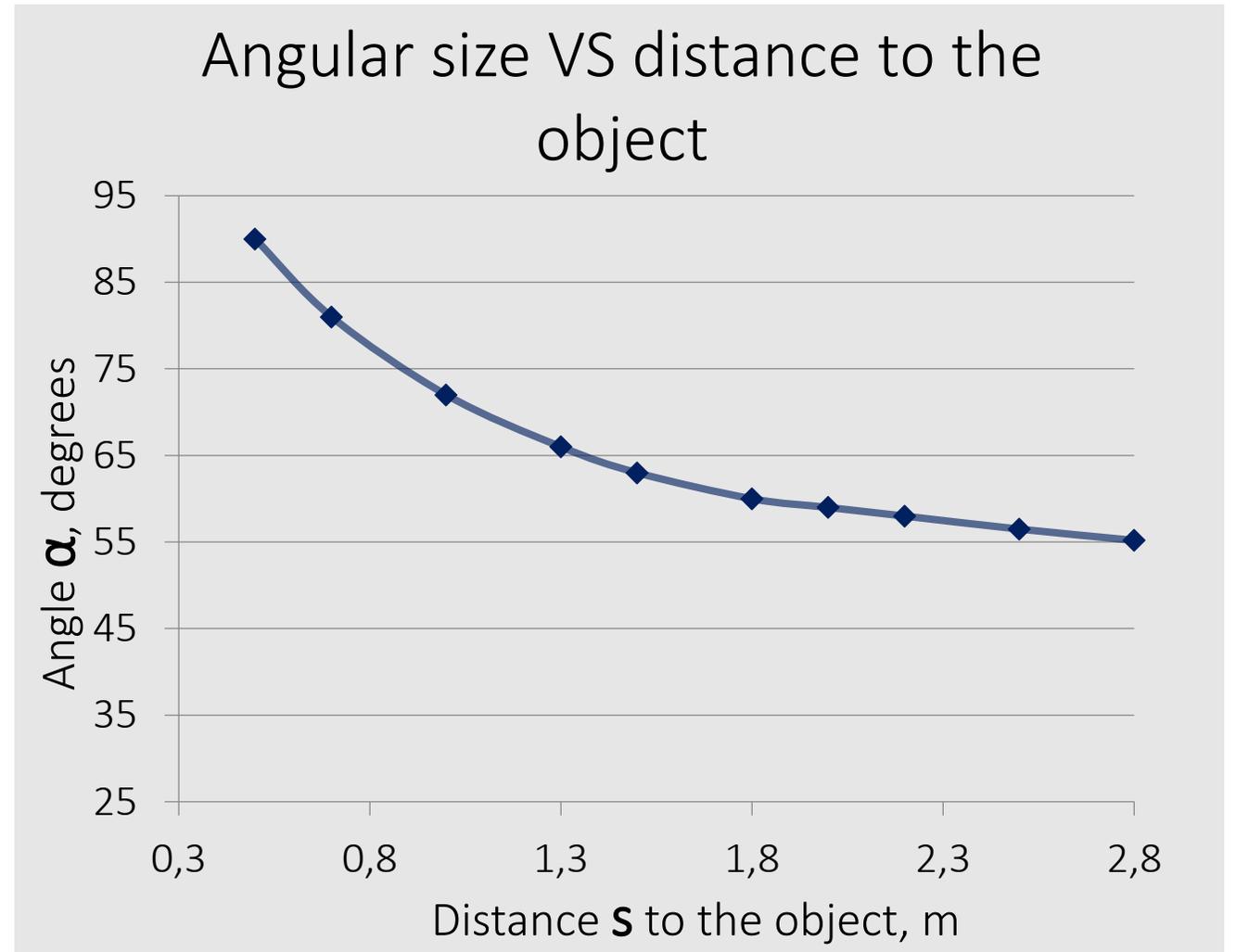
Apparent size VS distance



Eye percepts an **angular size** of the object



Angular size reduces with increasing of the distance between the object and observer



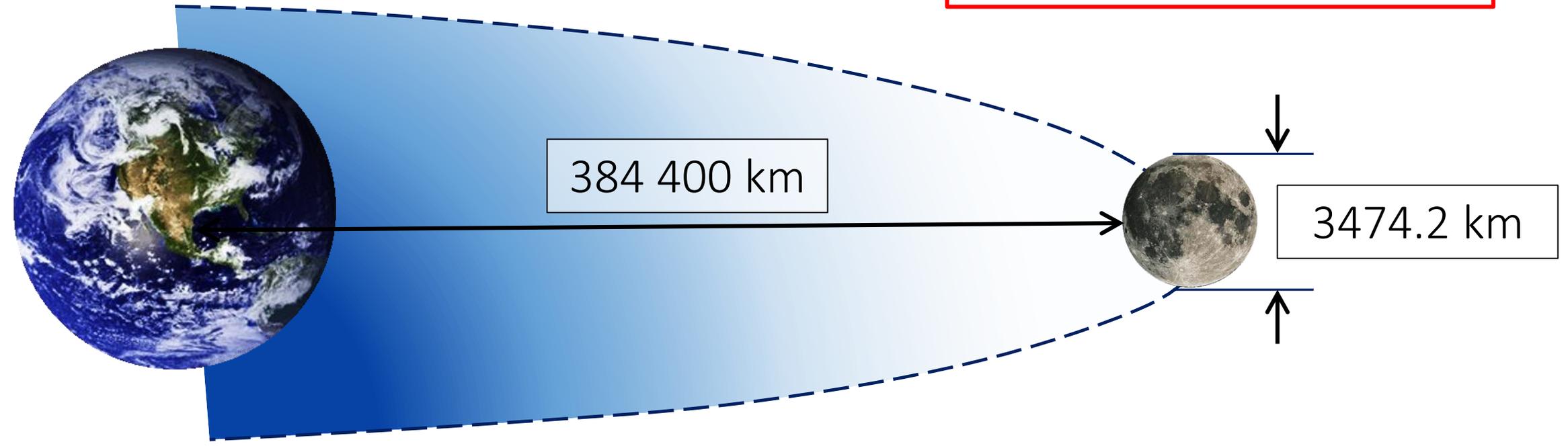


Changing of the average radius of orbit over long periods of time



In our days:

Angular size of the Moon:
 $a \approx 31.07^\circ$



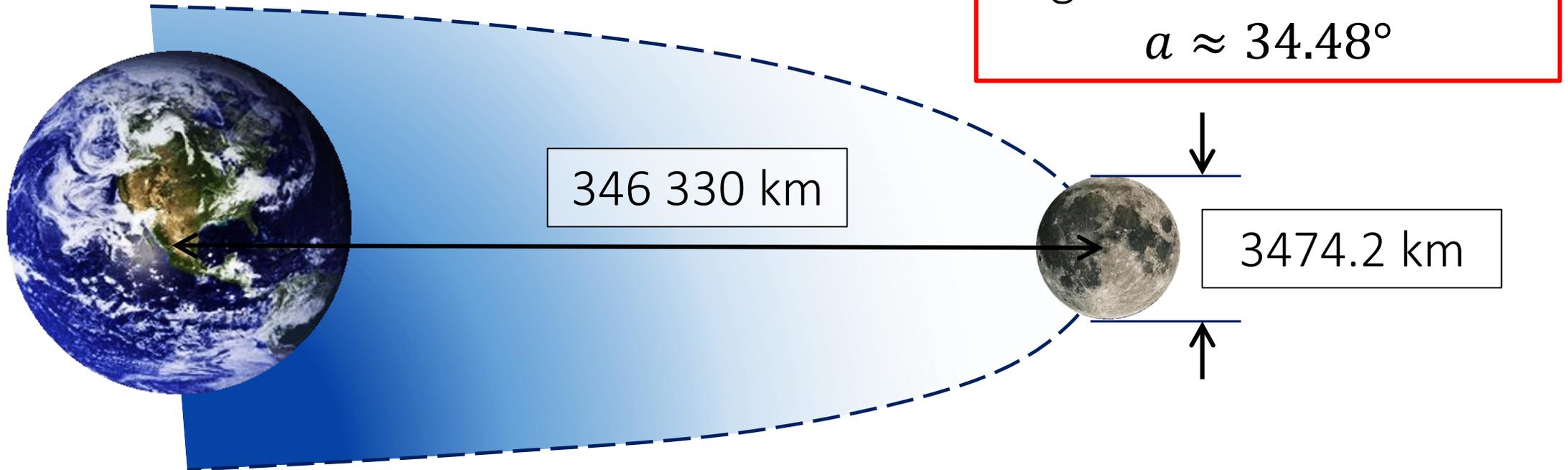


Changing of the average radius of orbit over long periods of time



Speed of the distancing: $\approx 3.8 \cdot 10^{-5} \text{ km/year}$

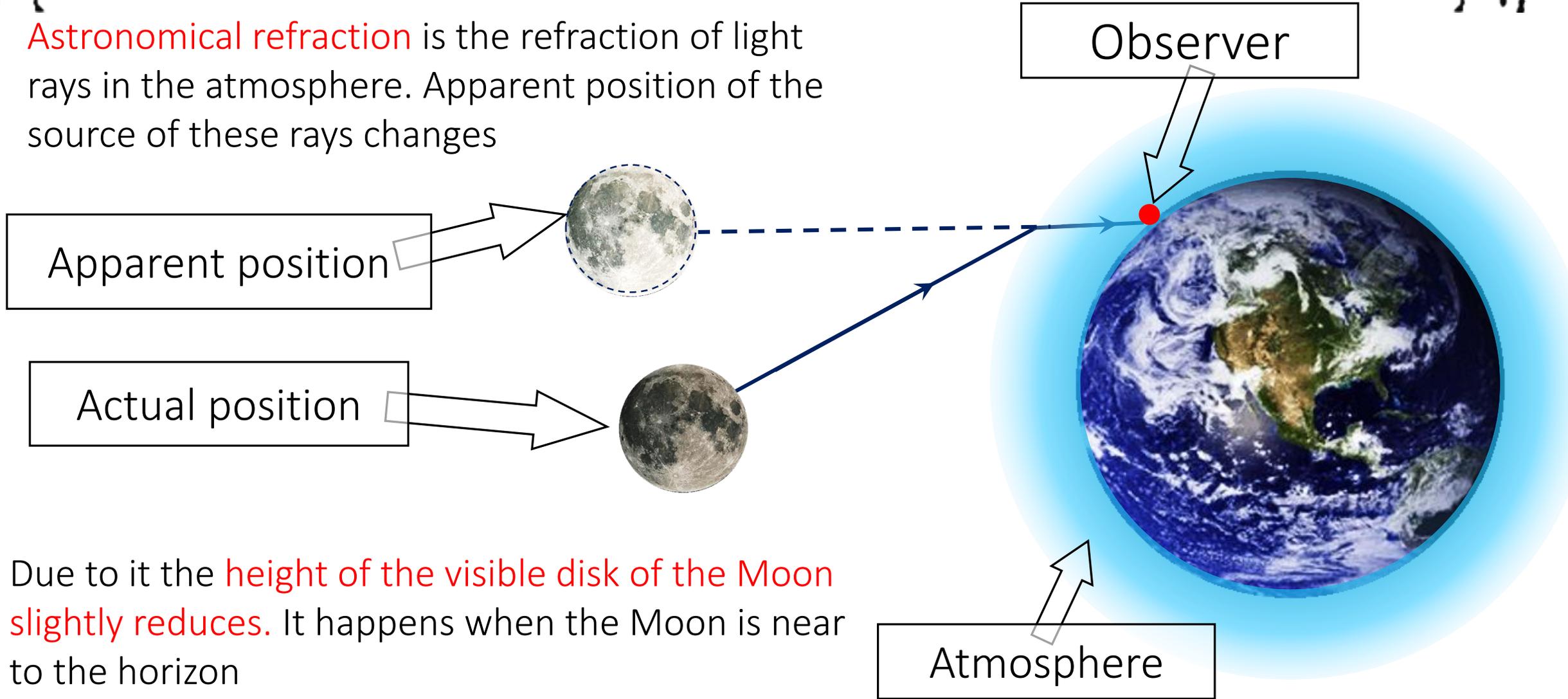
One milliard years ago:





Refraction

Astronomical refraction is the refraction of light rays in the atmosphere. Apparent position of the source of these rays changes

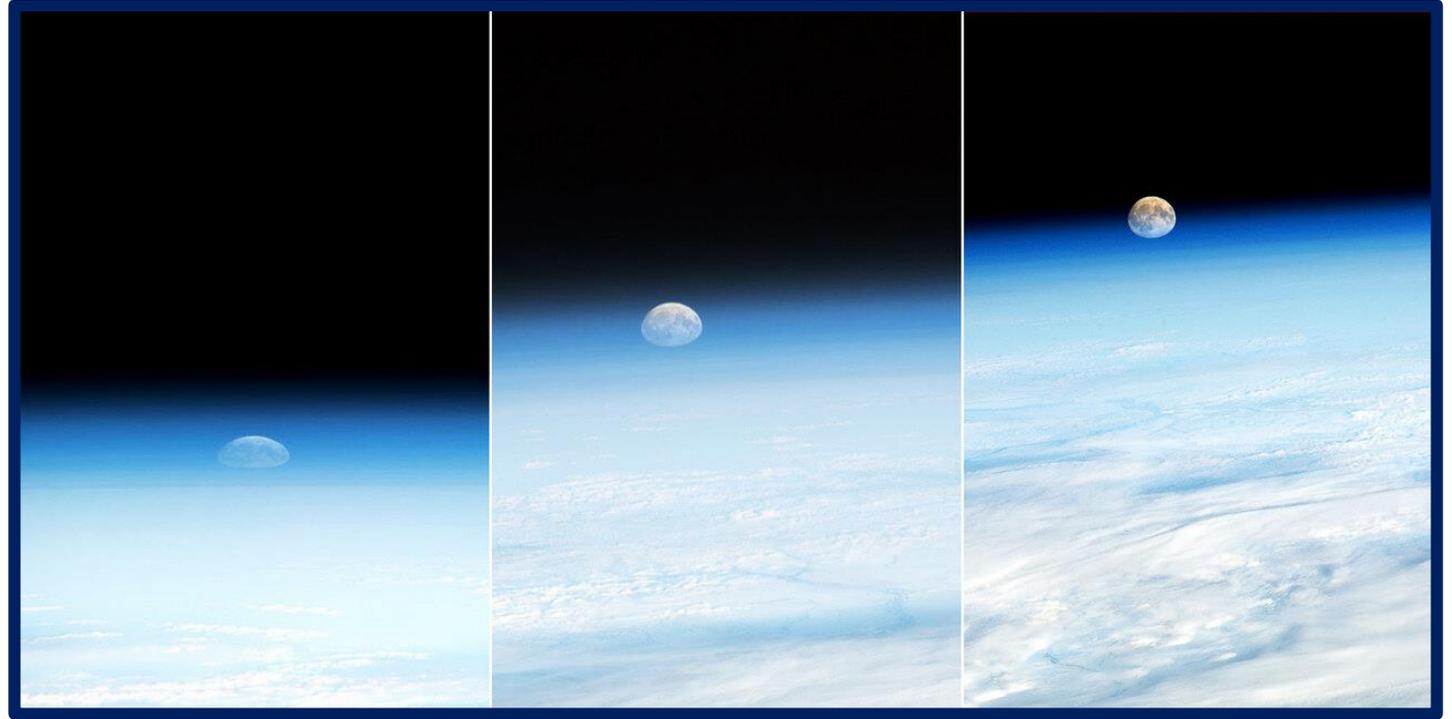


Due to it the **height of the visible disk of the Moon slightly reduces**. It happens when the Moon is near to the horizon



Moon near the horizon

Source: <https://igor-salnikov.livejournal.com/44761.html>



“Flattened” Moon. Photos from ISS

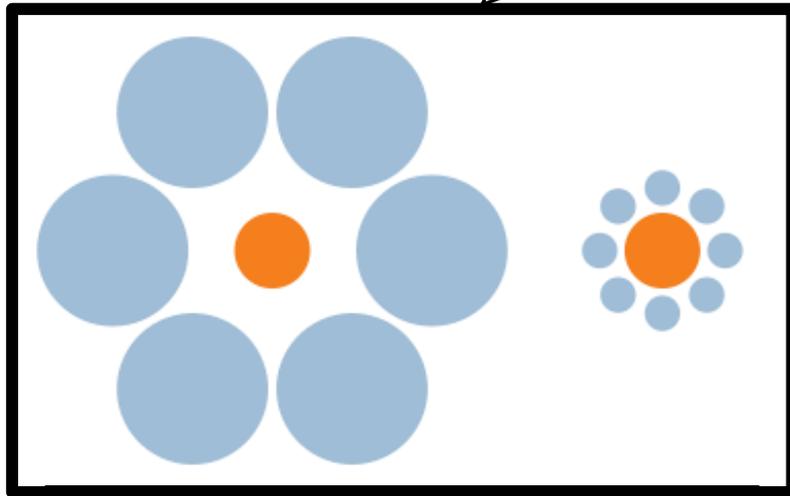
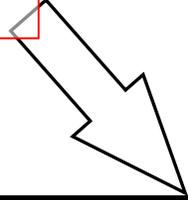
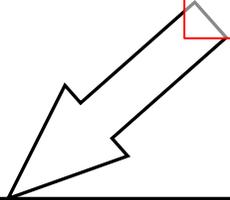
Source: <https://kiri2ll.livejournal.com/359246.html>



Factors based on the humans' perception



Factors based on the humans' perception



Theory of relative size



Theory of apparent distance (Emmert's Law)



Theory of apparent distance: Emmert's Law

$$D = a \cdot r$$

D is the
apparent size
of the object

a is the angular
diameter of the
object

r is the apparent distance
to the object
(it depends on the
surroundings of the object)



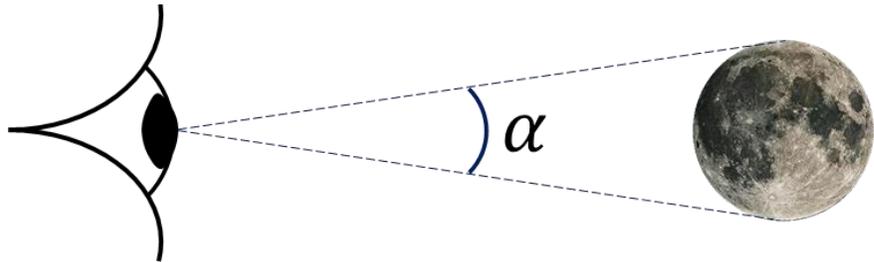
Angular size and apparent distance



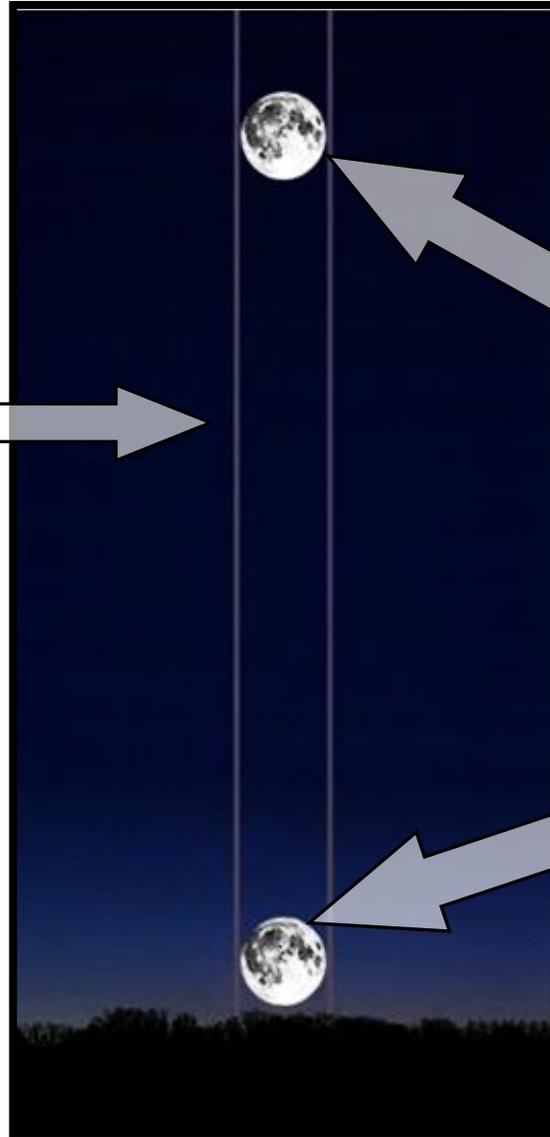
The angular sizes
are the same

Seems smaller in relation
to the large space

Seems bigger in
relation to the
surrounding trees

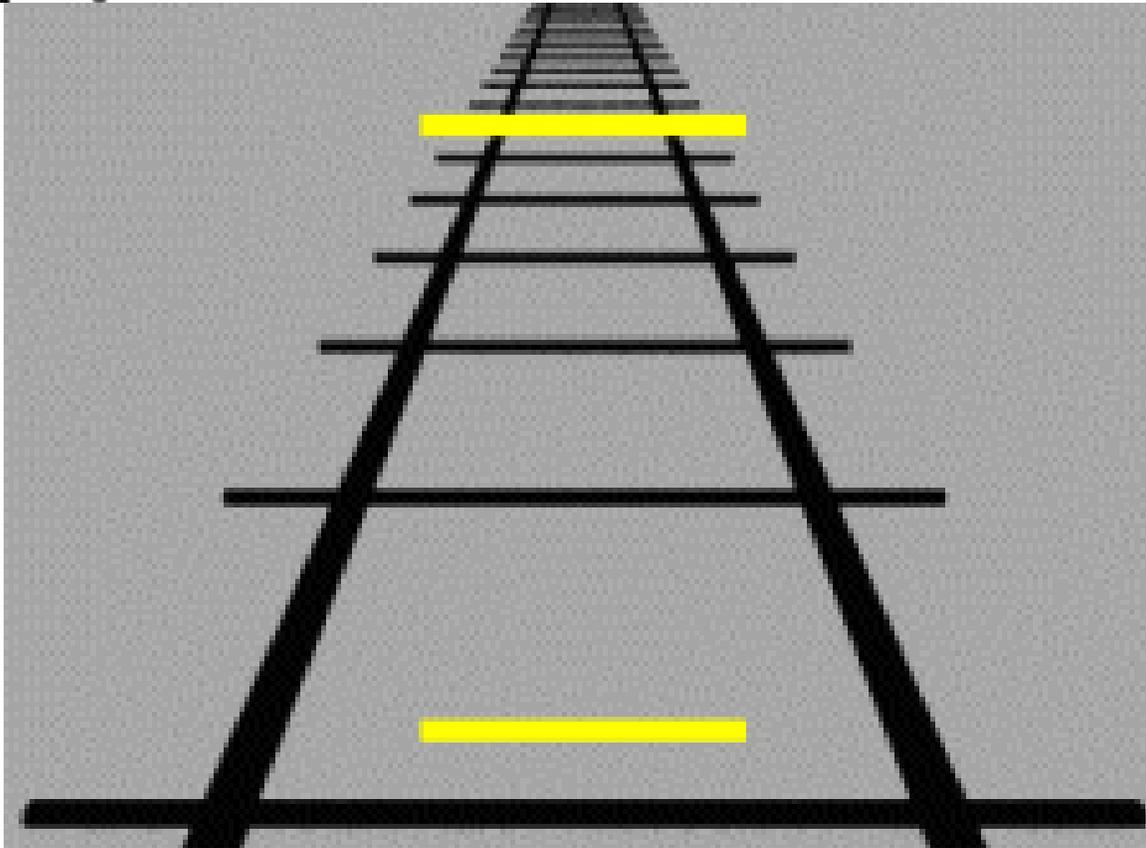


α is an angular size





Ponzo illusion



Source:

https://en.wikipedia.org/wiki/Ponzo_illusion#/media/File:Ponzo_illusion.gif

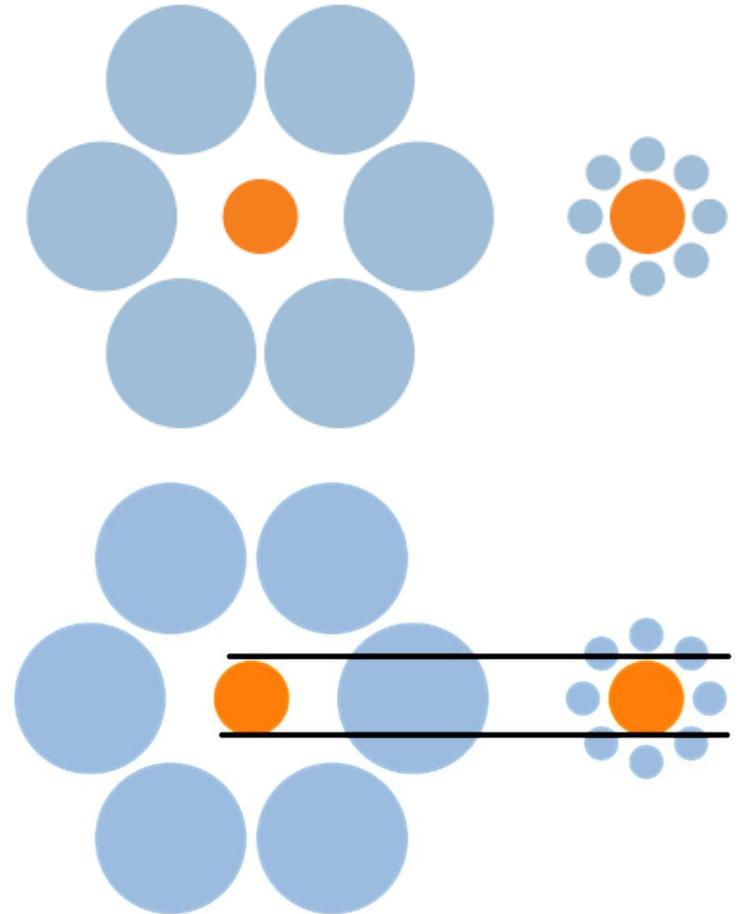
Ponzo illusion is based on the Emmert's Law



Theory of the relative size



Ebbinghaus illusion:



The Moon seems bigger if it is surrounded by the smaller objects

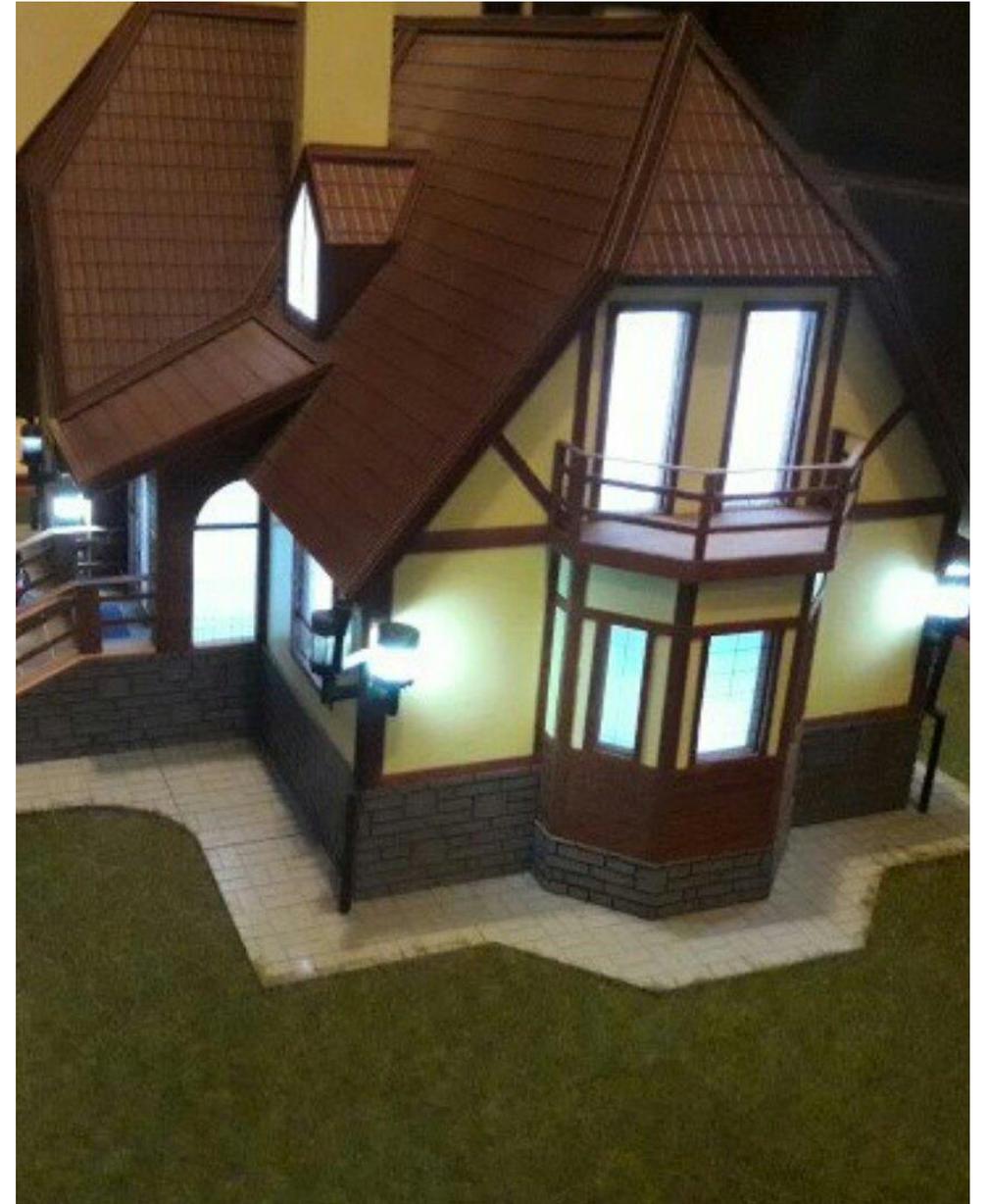


My car





My house





But in fact it`s scale model





Conclusion



- 1) The visible size of the Moon depends on many factors like:
 - Changing distance between the Earth and the Moon (apogee and perigee, distancing of the Moon from the Earth over a long periods of time)
 - Refraction of the rays from the Moon
 - Optical illusions that can be described by the theories of relative size and apparent distance
- 2) Following factors have the most significant influence:
 - Existence of apogee and perigee
 - Optical illusions
- 3) Considering the optical illusions the apparent size of the Moon depends on the objects around its image, namely:
 - The dimensions of these objects
 - How far away these objects are

Thank you for your attention!



Eccentricity



Eccentricity is the measure of elongation of the orbit

