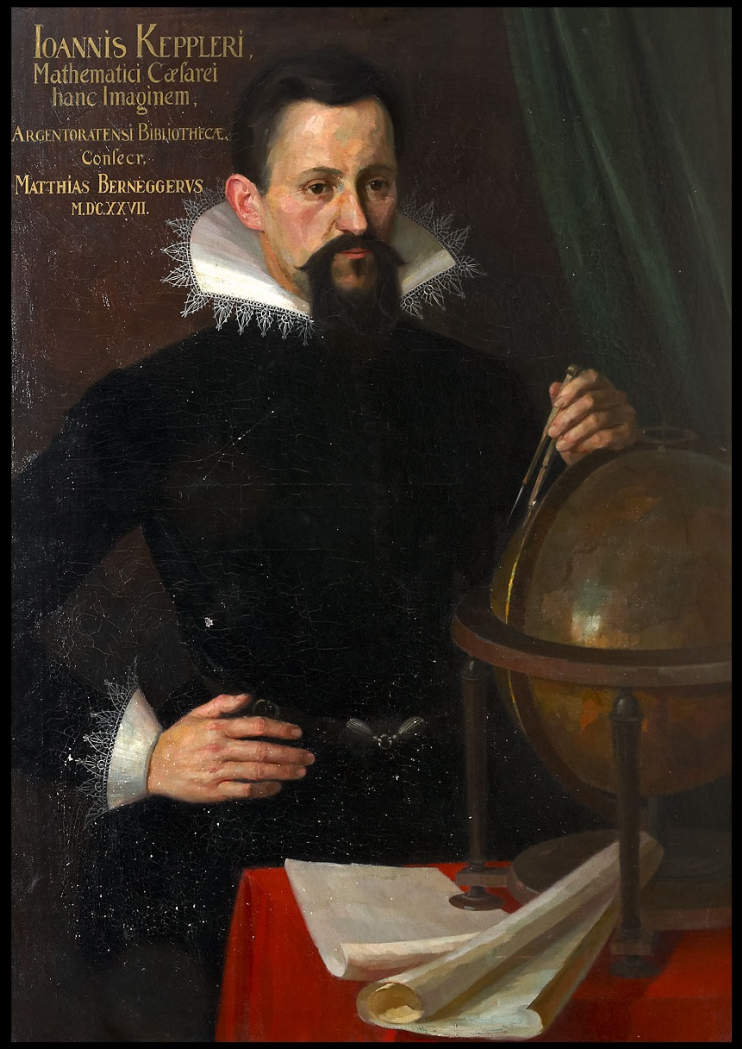
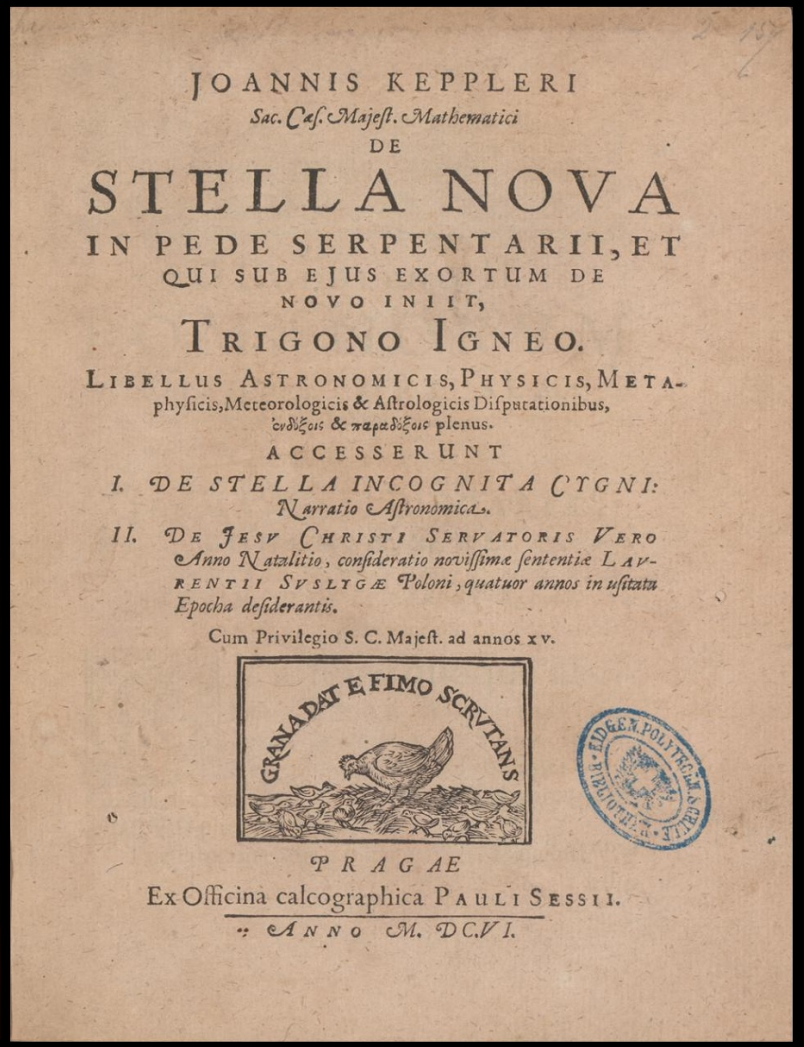




JOANNIS KEPPLERI
Sac. Cæs. Majest. Mathematici
DE
STELLA NOVA
IN PEDE SERPENTARII, ET
QUI SUB EJUS EXORTUM DE
NOVO INIIT,
TRIGONO IGNEO.

LIBELLUS ASTRONOMICIS, PHYSICIS, METAphysicis, Meteorologicis & Astrologicis Disputationibus, ἐνδόξοις & παραδόξοις plenus.

ACCESSERUNT

I. DE STELLA INCOGNITA CYGNI: Narratio Astronomica.

II. DE JESU CHRISTI SERVATORIS VERO Anno Natalitio, consideratio noviſſimæ ſententiæ LAURENTII SUSLIGÆ Poloni, quatuor annos in uſitata Epocha deſiderantis.

Cum Privilegio S. C. Majeſt. ad annos XV.

GRANA DAT EFIMO SCRVTANS

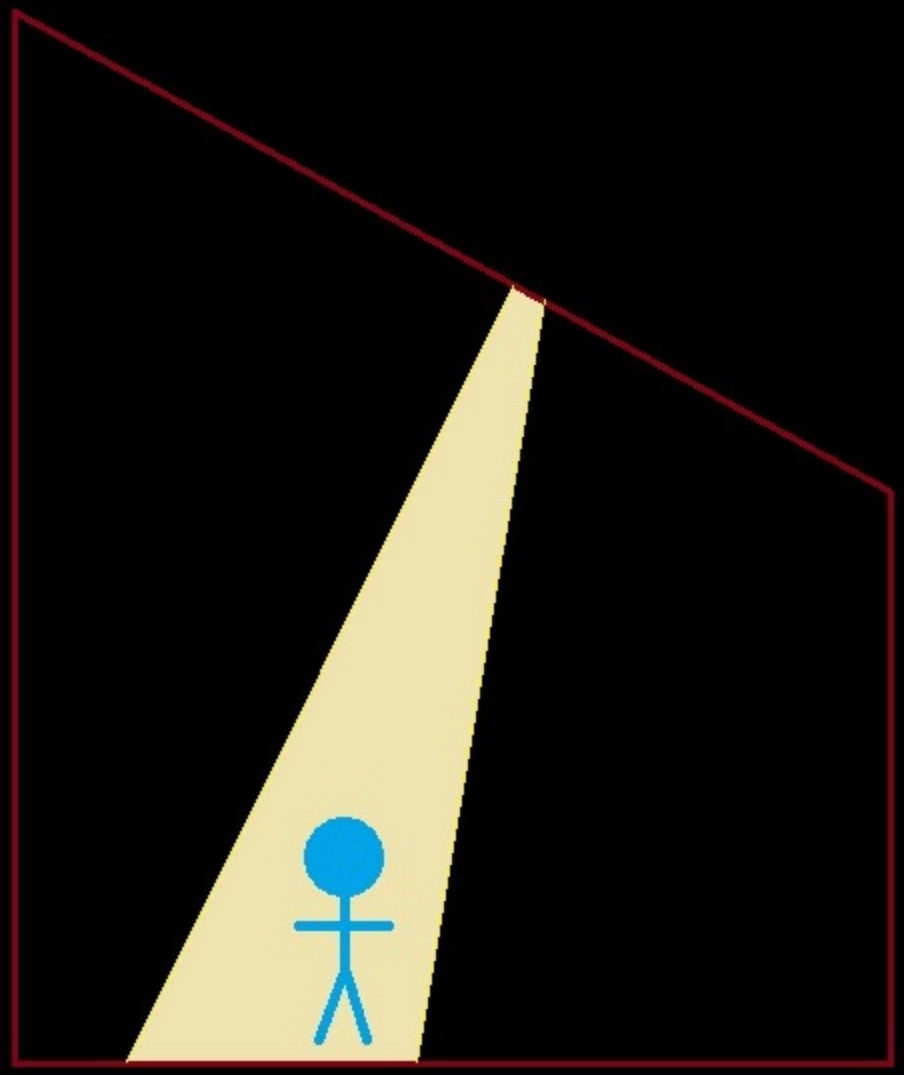
PRAGAE
Ex Officina calcographica PAULI SESSII.
ANNO M. DC.VI.

Hey, Do We LOOK Like Suns to You?

On Johannes Kepler and science shaping our view of the universe

C. M. Graney
Specola Vaticana
(Vatican Observatory)

Public Astronomy Lecture Series
12/1/21



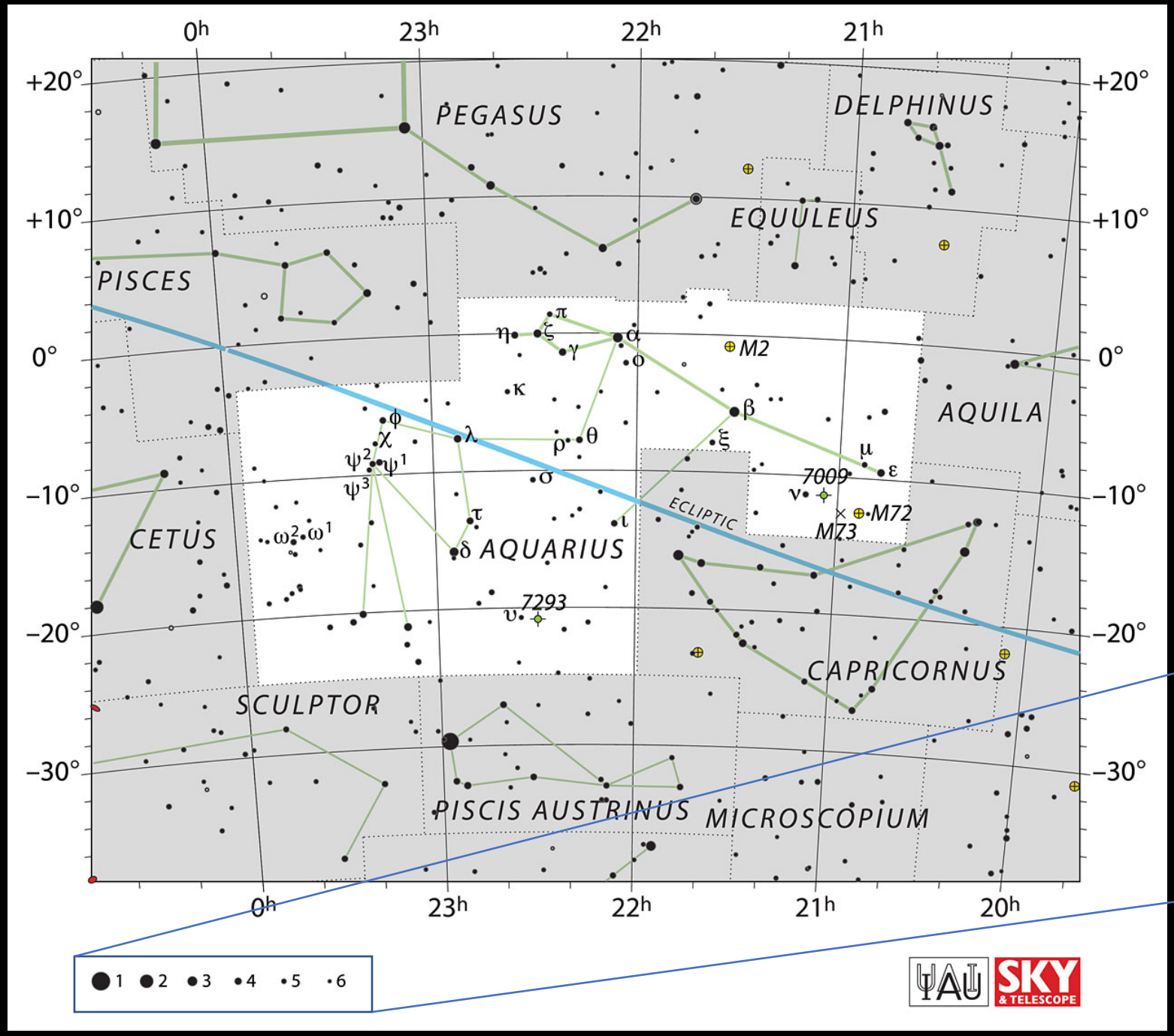
If they [the stars] are suns having the same nature as our sun, why do not these suns collectively outdistance our sun in brilliance? Why do they all together transmit so dim a light…? When sunlight bursts into a sealed room through a hole made with a tiny pin point, it outshines the fixed stars at once. The difference is practically infinite.

— Johannes Kepler, responding in 1610 to Galileo's just-published *Starry Messenger*.

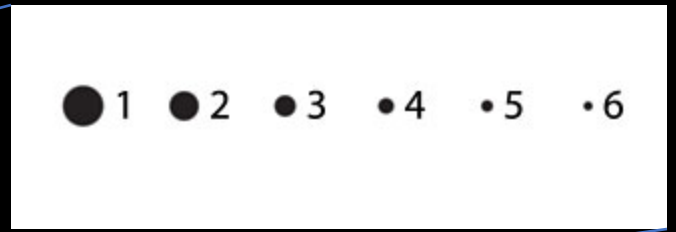
Kepler was arguing against Giordano Bruno's idea that stars were other suns, orbited by other Earths. Kepler felt that Galileo's telescopic observations of stars strengthened the case against Bruno.

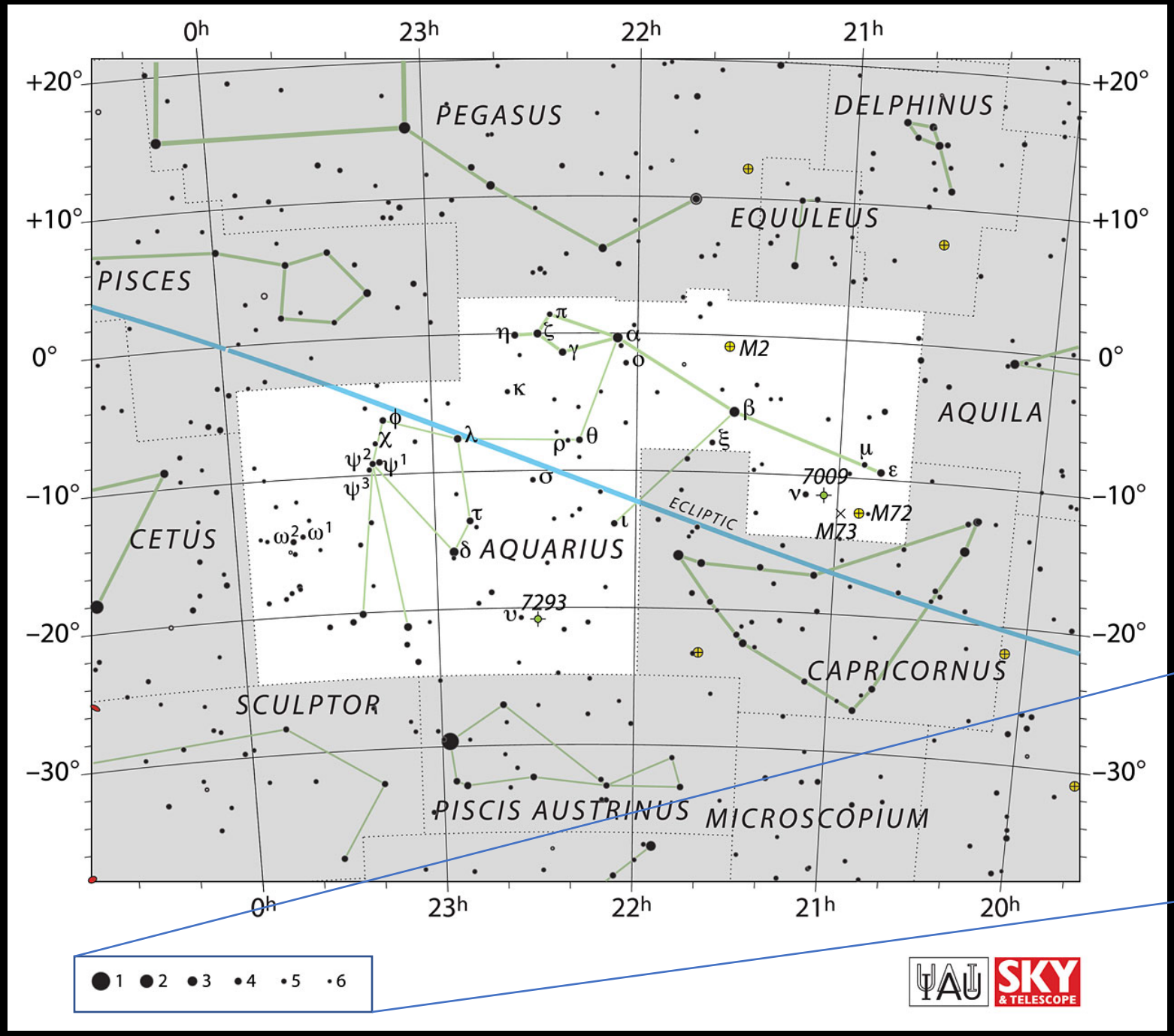
I spread confident wings to space and soared toward the infinite, leaving far behind what others strained to see from a distance. Here, there was no up or down, no edge or center. I saw that the sun was just another star, and the stars were other suns, each escorted by earths, like our own. The revelation of this reality was like falling in love.

Kepler's comments regarding the relative brightnesses of sun and stars are really perceptive. He knew what he was talking about. His comments illustrate something about the sun and stars that we probably do not appreciate.



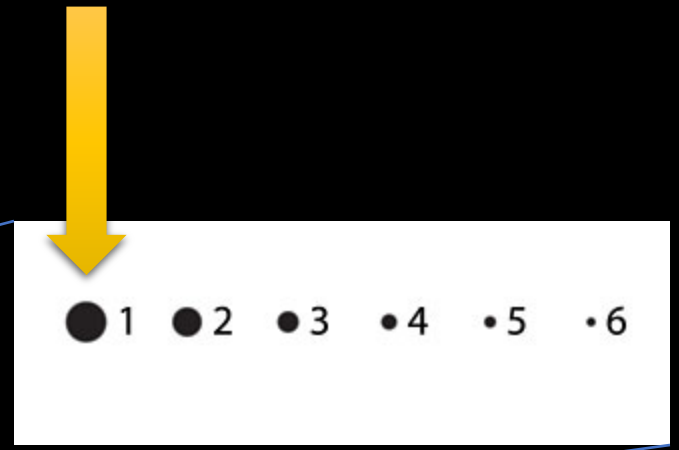
The “magnitude” system — a modern system, tied to an ancient rating scale for stars.

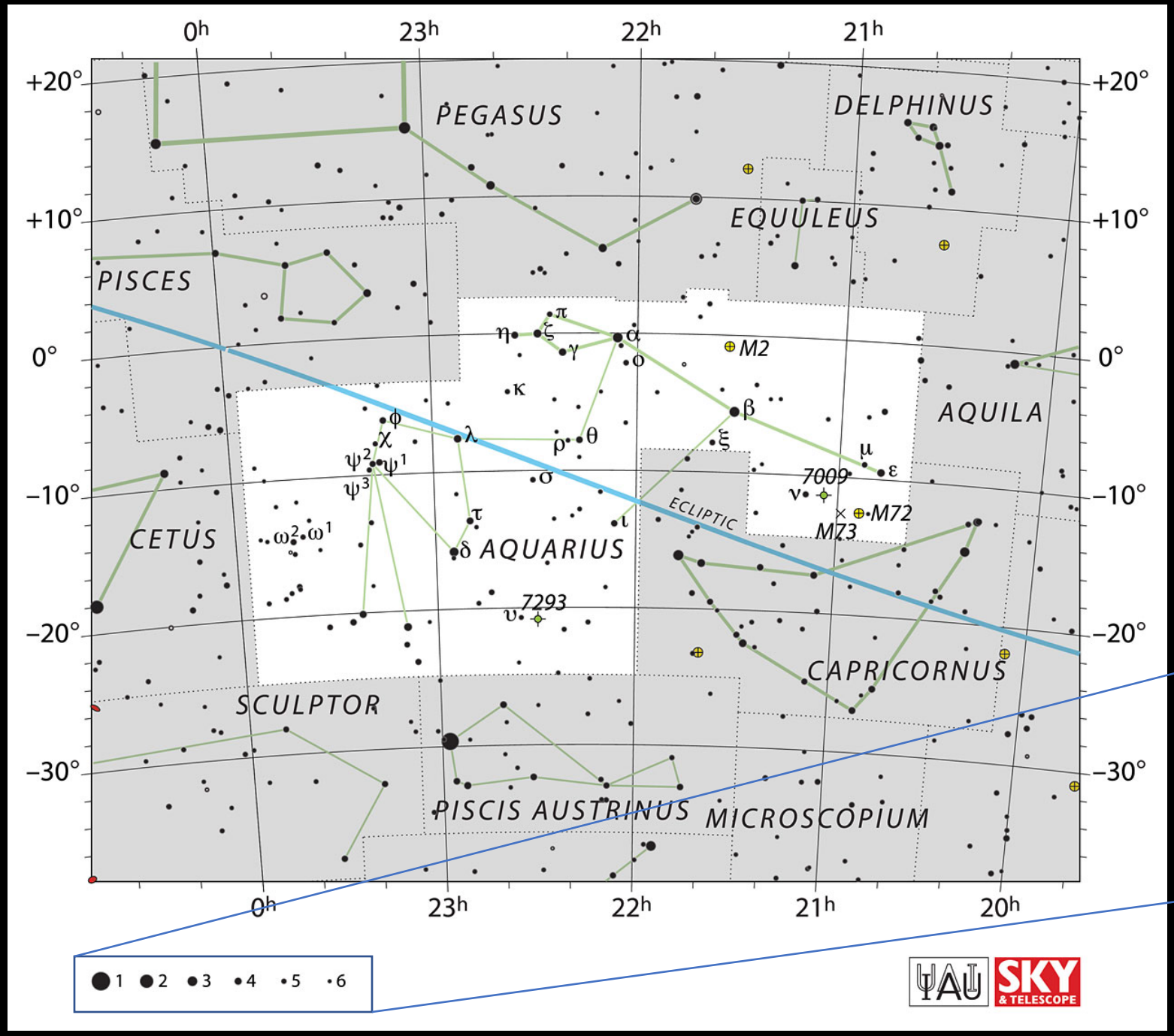




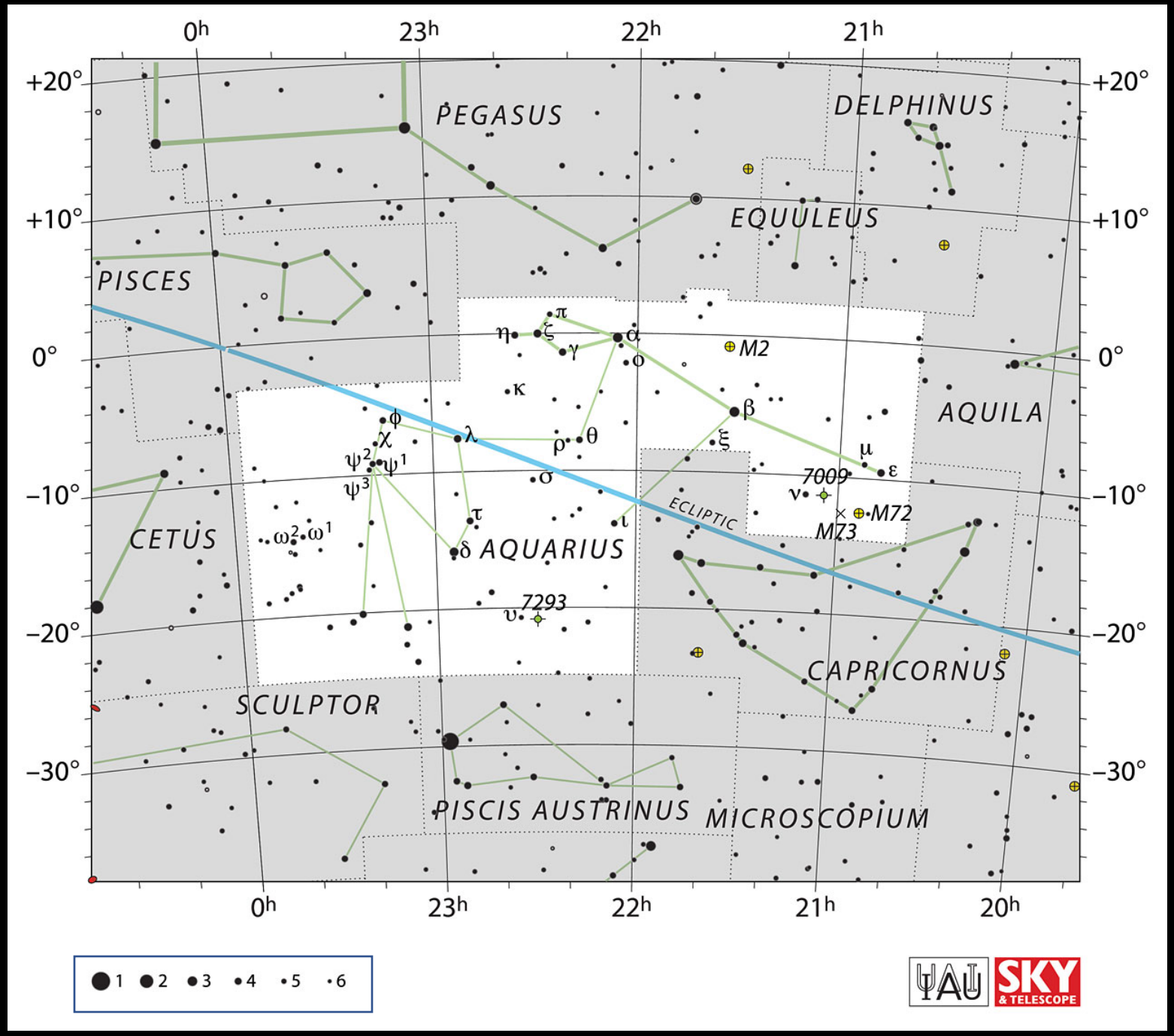
On that ancient scale, the stars in the night sky that appear to be the largest — "magnitude" means "bigness" — were ranked 1.

They were "stars of the 1st magnitude" — "1st-class stars").



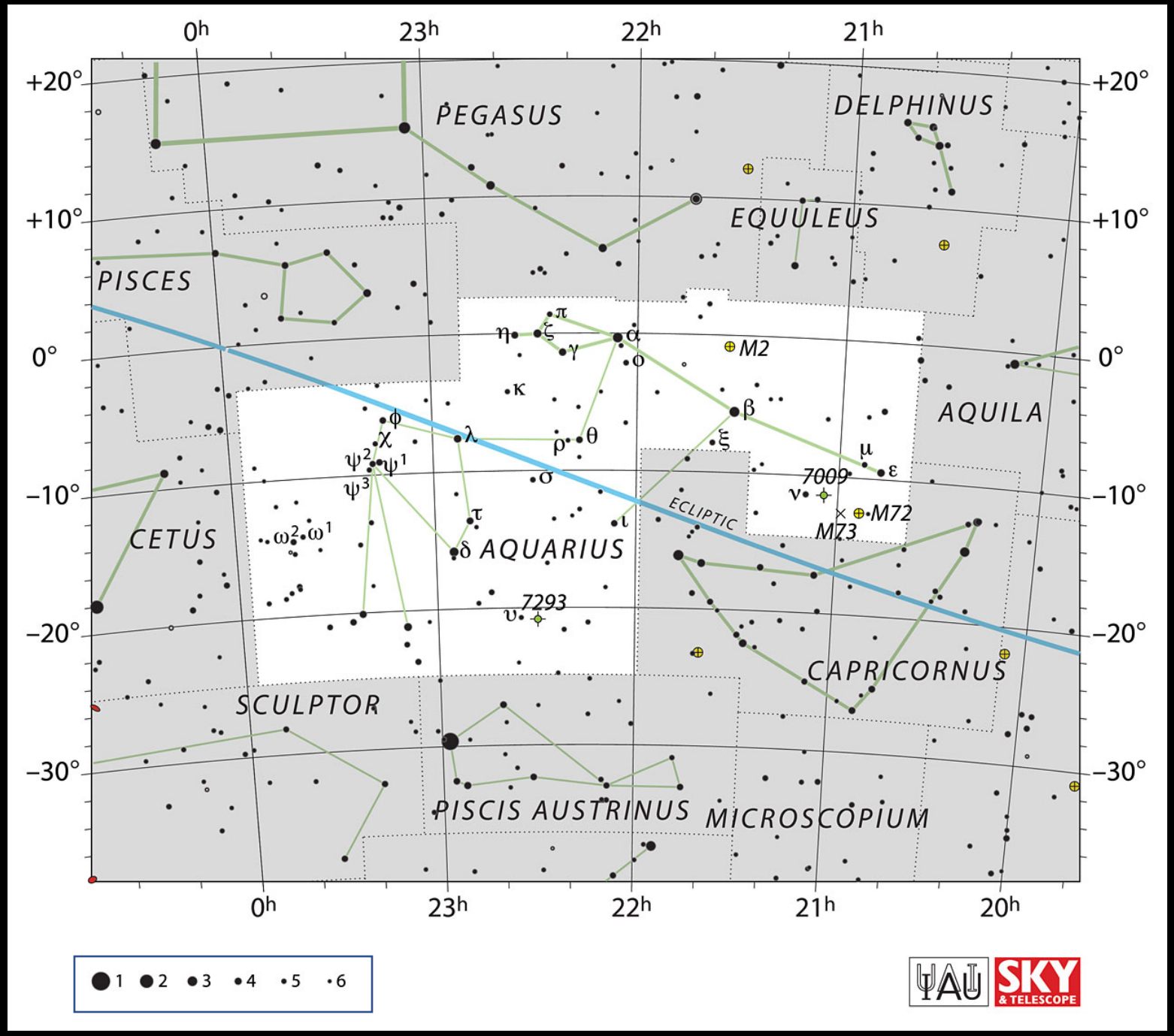


Next came somewhat lesser stars, “stars of the 2nd magnitude” — “2nd-class stars”)



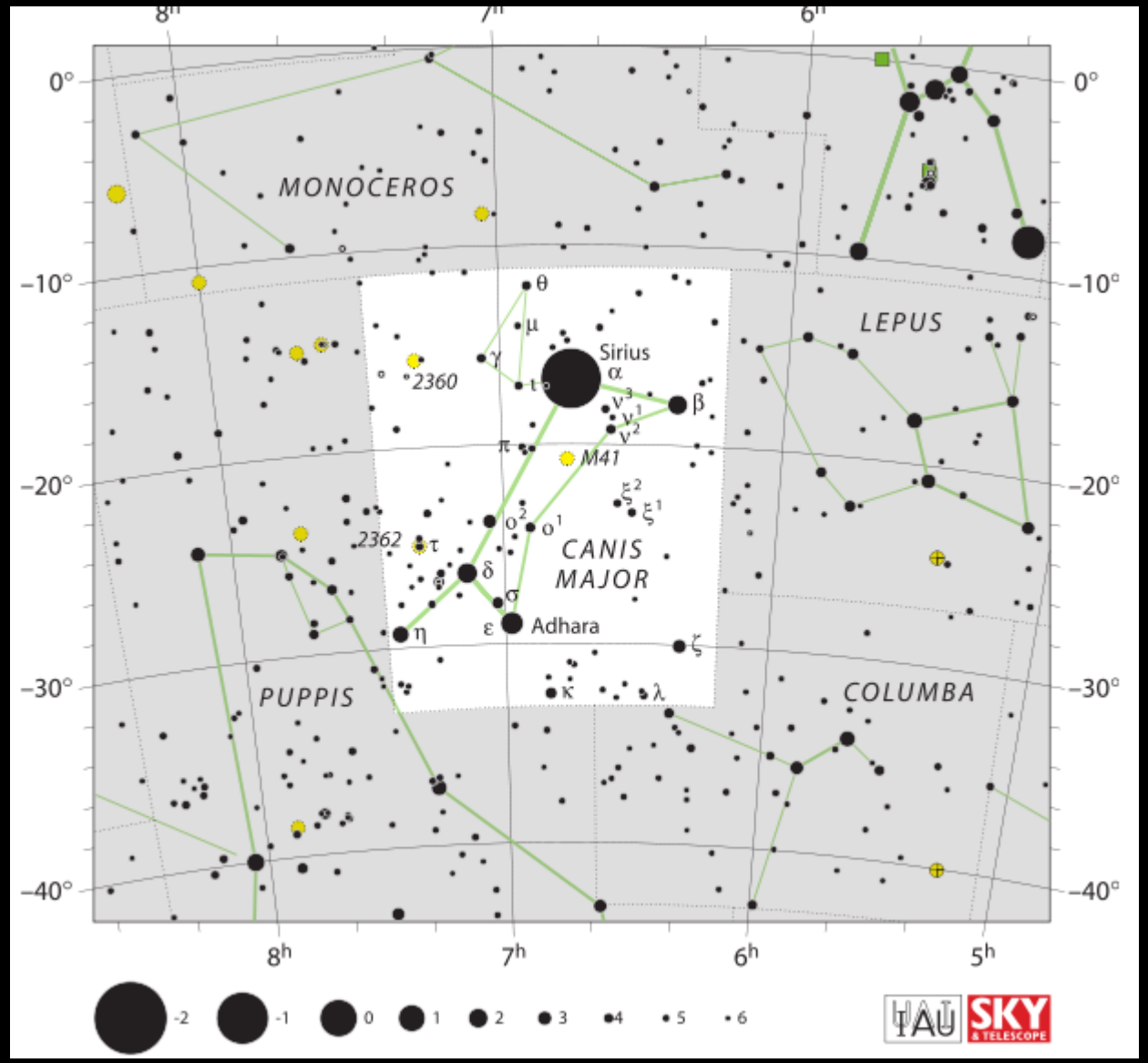
19TH CENTURY:

- Apparent sizes of stars are illusions.
- What matters is stars' light output as seen from Earth — their apparent brightnesses.
- Astronomers develop a mathematical system for precisely stating a star's brightness
- Tied system to the old magnitude scale.



19TH CENTURY:

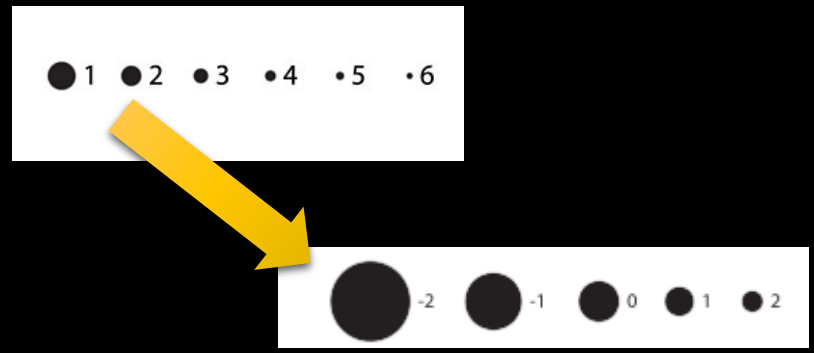
- A star that ranked among the stars of the 1st magnitude in the old scale came up about a 1.0 on the new scale.
- The difference between a magnitude 6.0 star and a magnitude 1.0 star was a factor of 100 in brightness — 5 steps in magnitude equals a factor of 100 in brightness.
- In other words, a single magnitude 1.0 star lights up the night sky as much as 100 magnitude 6.0 stars.



But Sirius is actually brighter than all the other stars.

If a dim star you can barely see is a 6.0, and a pretty bright star is a 2.0, and a bright star is a 1.0, then what is Sirius, which is brighter still?

It turns out that in the modern magnitude system Sirius is a *-1.5*.



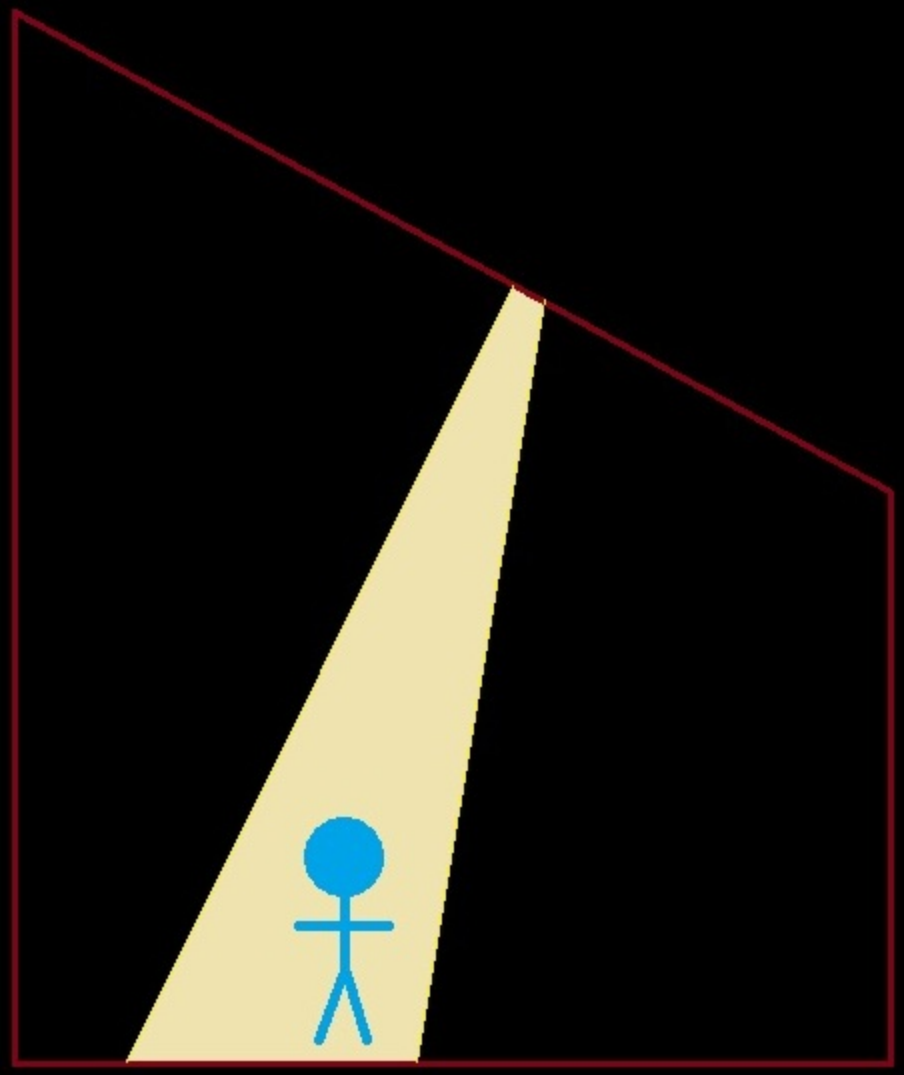
The sun, in this system, comes in at *-26.7*.

The sun is 25 steps of magnitude brighter than Sirius (-1.5).

5 steps corresponds to a factor of 100 in brightness, and since 25 is 5 sets of 5 magnitude steps (*5+5+5+5+5*), then the sun is brighter than Sirius by a factor of *100×100×100×100×100*.

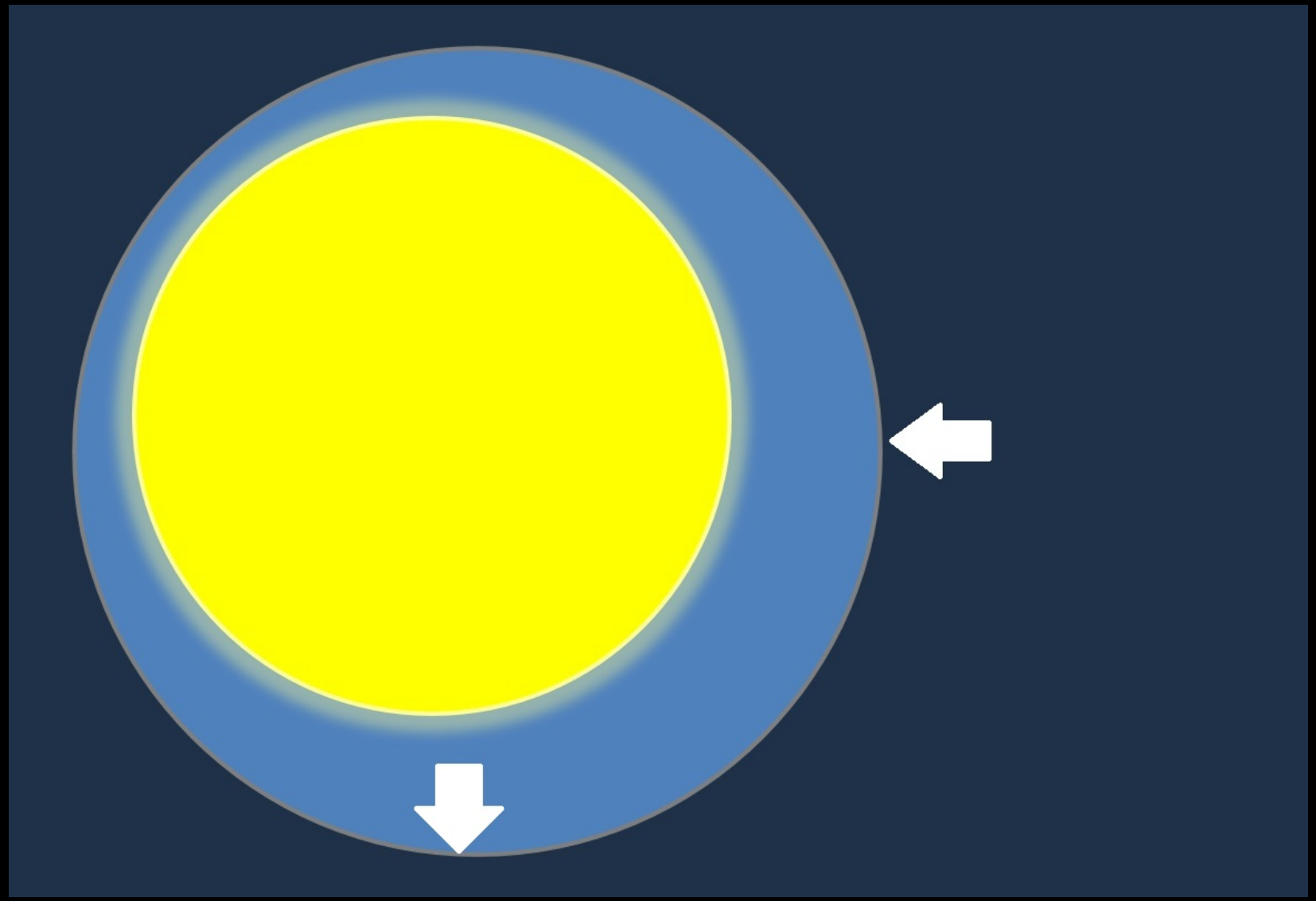
It would require *100×100×100×100×100 = 10,000,000,000* Siriuses in the night sky to be as bright as the sun.

For reference, we can only see a few thousand stars with the naked eye, and all of them are dimmer than Sirius.

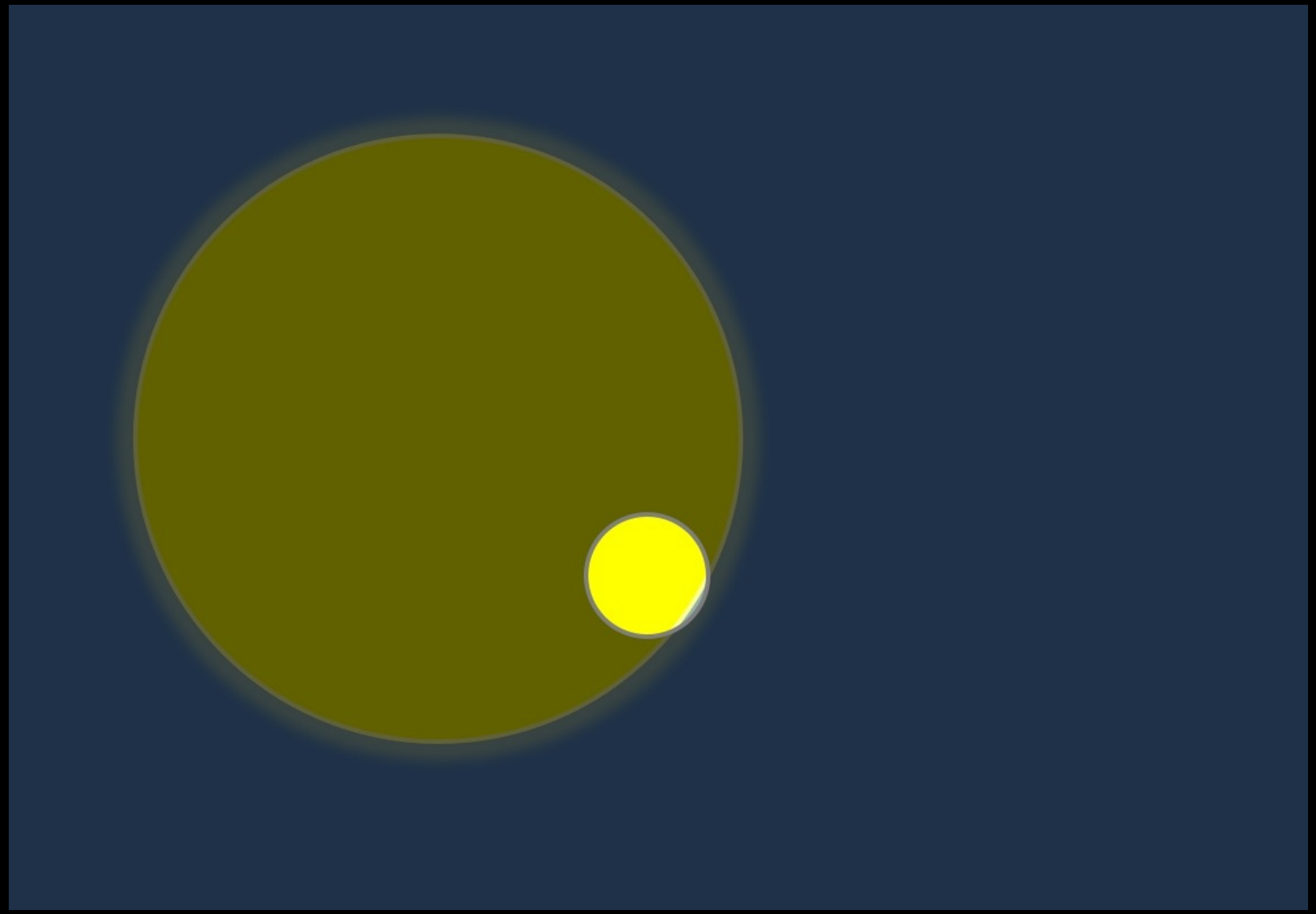


CHECKING KEPLER:

Imagine you are in a dark room, like he says. Imagine the room has a high ceiling, perhaps 3 meters (roughly 10 feet) over your head. No light enters the room except through a hole in the ceiling, through which the sun shines in on you.

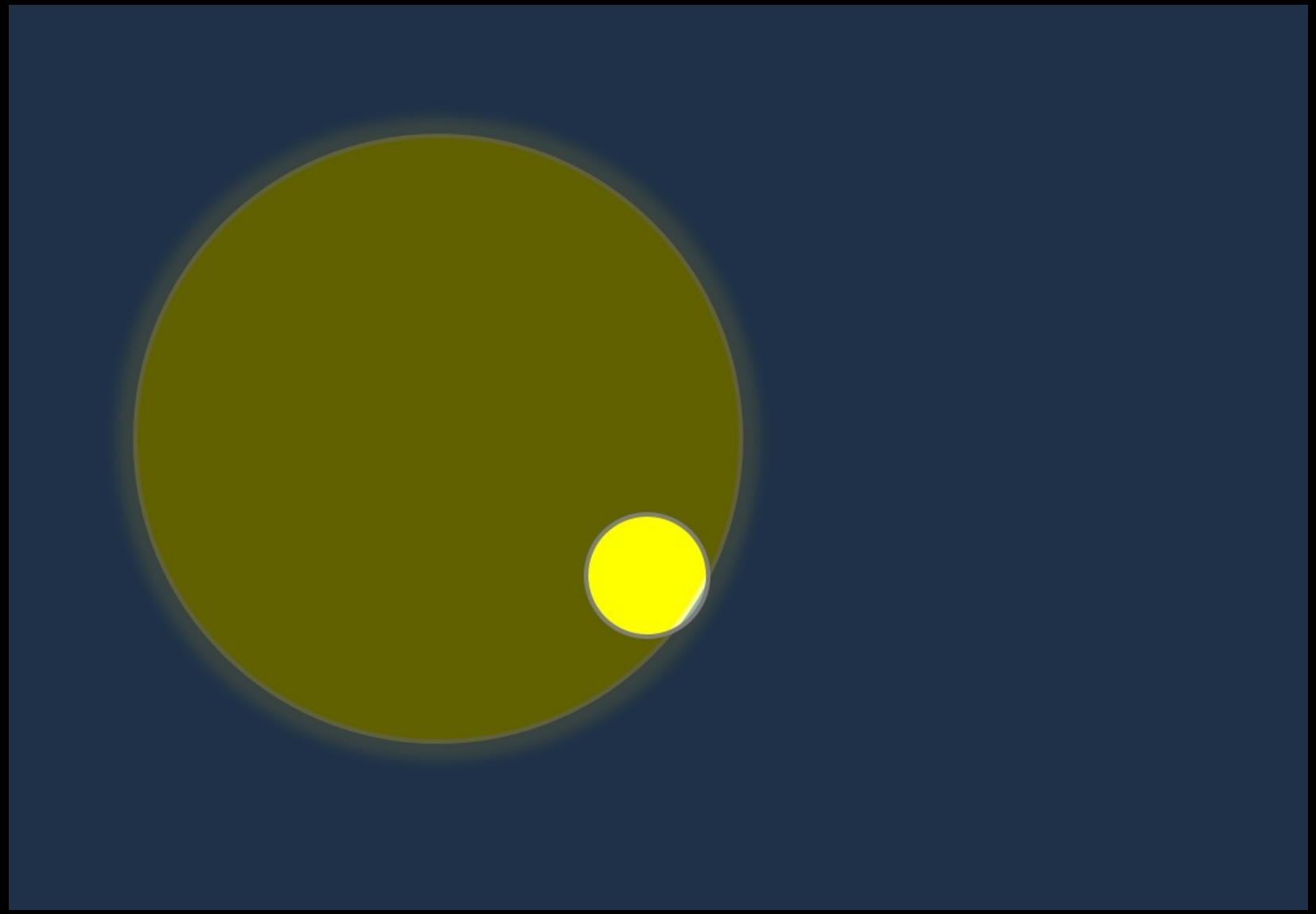


If the hole is large enough, you see the entire sun through the hole. Thus you get the light from the full sun.



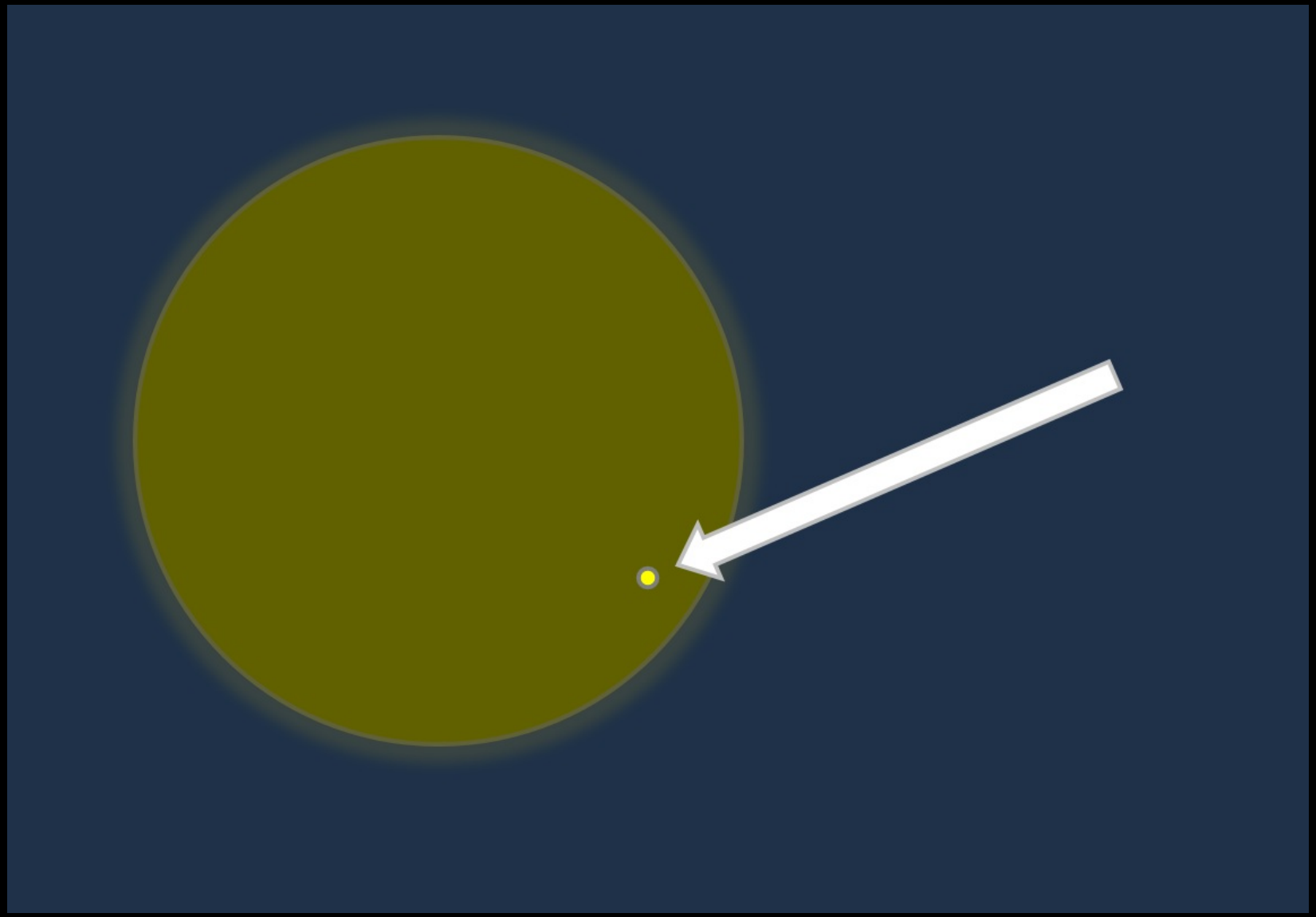
But if the hole is small enough — smaller than 26 mm, or just over an inch — then you will only see a portion of the sun, and only receive a portion of its light.

Here the hole is only about a fifth the apparent diameter of the sun.



Area goes as diameter squared, so only $(1/5)^2$, or 1/25th, of the sun's area is visible through the hole.

The entire disk of the sun is 10 billion Siriuses, so what is seen through the hole is (1/25)×10,000,000,000 = 400 million Siriuses.

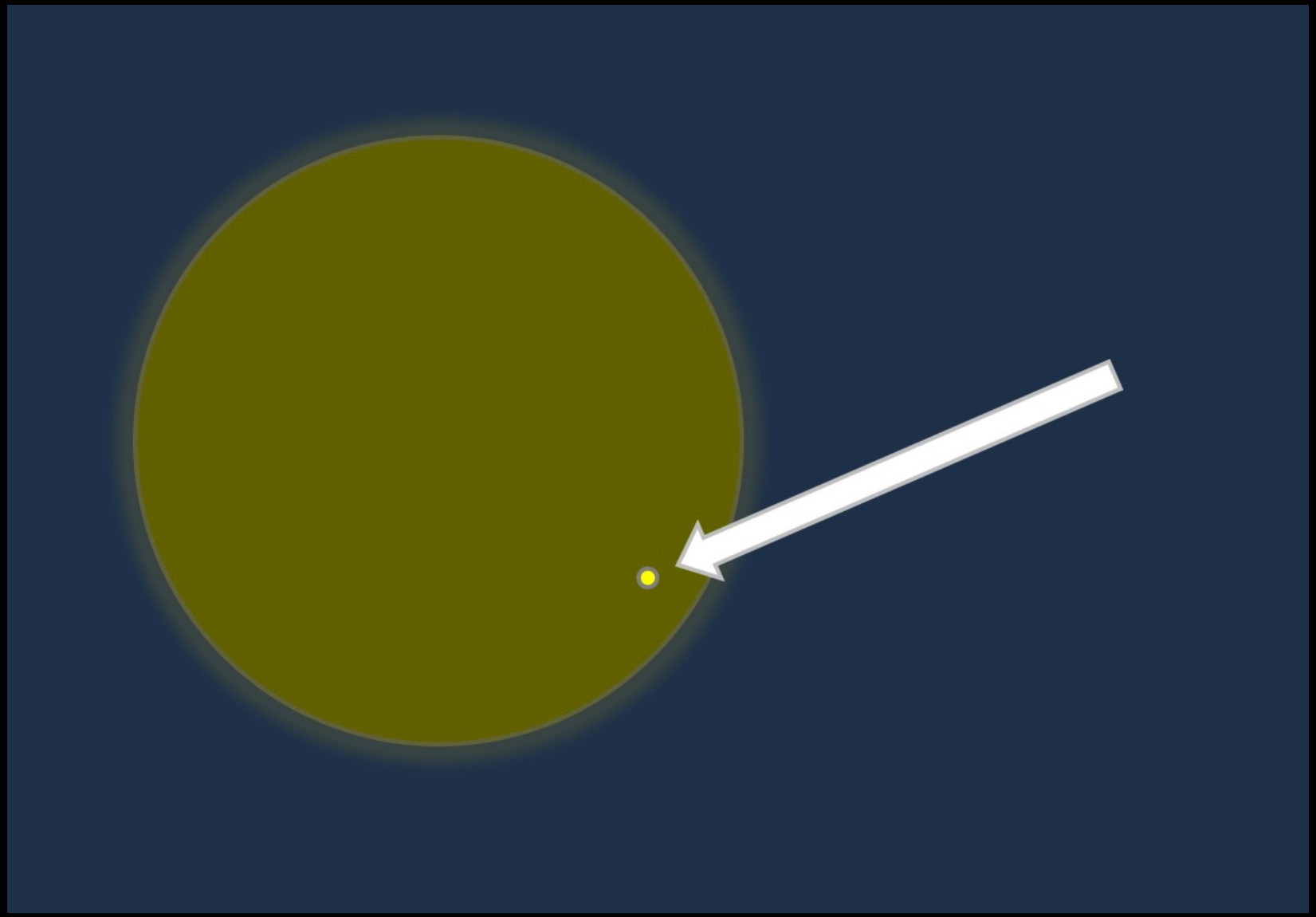


1 mm hole:

1/26th the diameter of the sun.

Area is $(1/26)^2$, or 1/676th that of the sun.

Light coming through is (1/676)×10,000,000,000 = 14.8 million Siriuses.



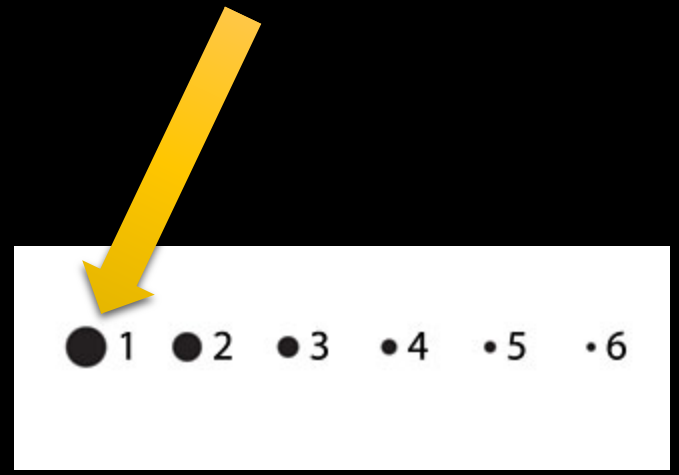
0.1 mm:

148,000 Siriuses

0.01 mm (probably not doable):

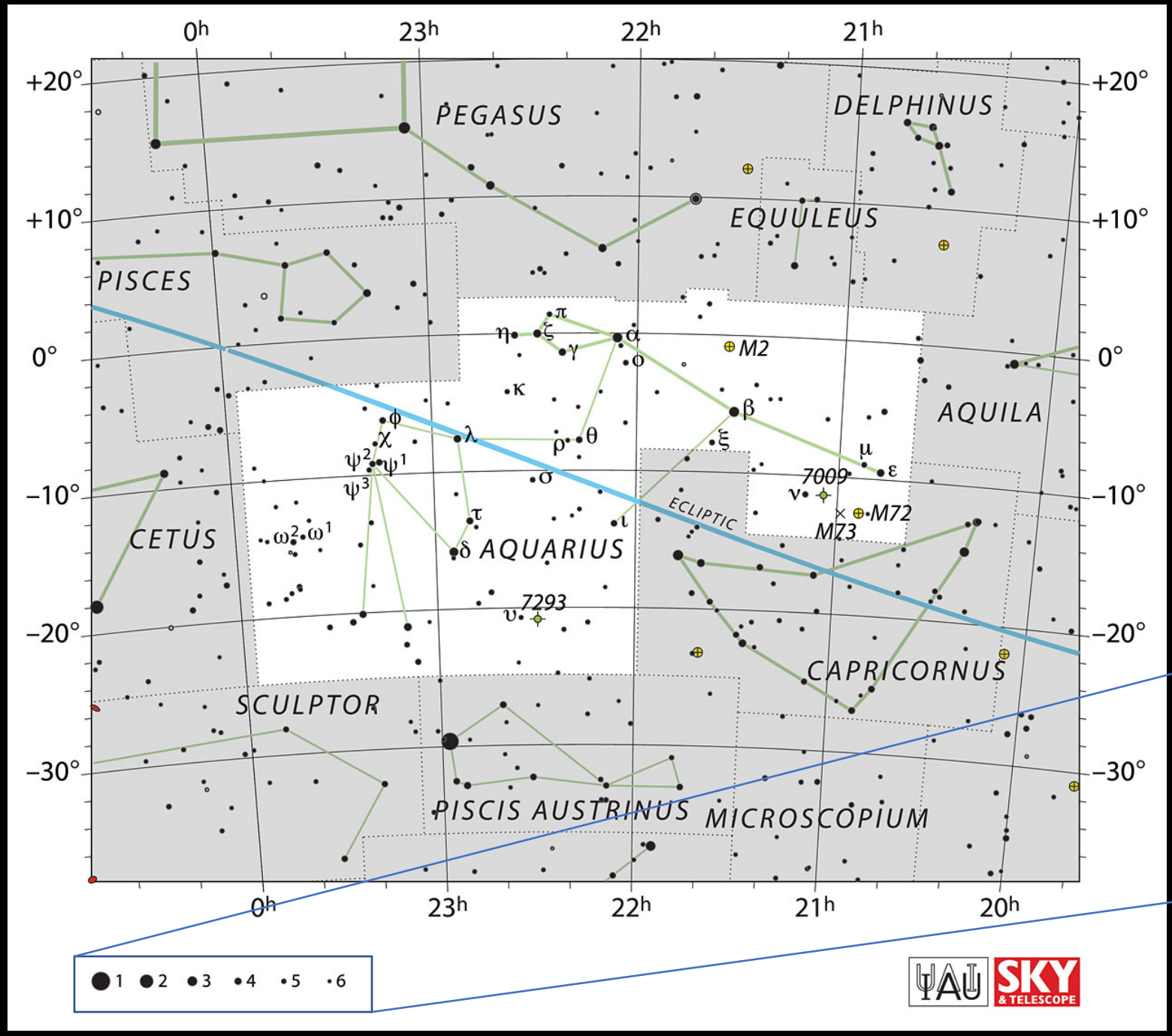
1,480 Siriuses

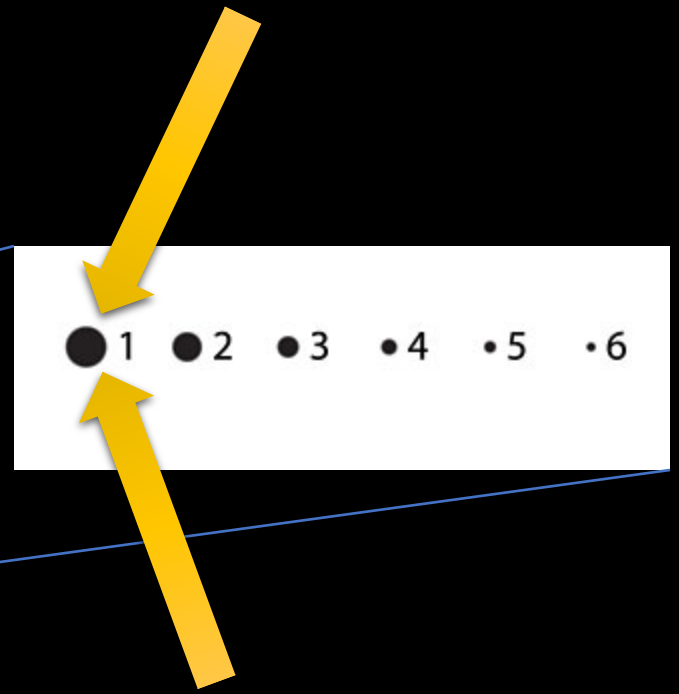
So Kepler was right. There is an immense difference between the sun and the stars. Kepler estimated that the size a larger star appears to the naked eye was about the size the 1 mm hole.

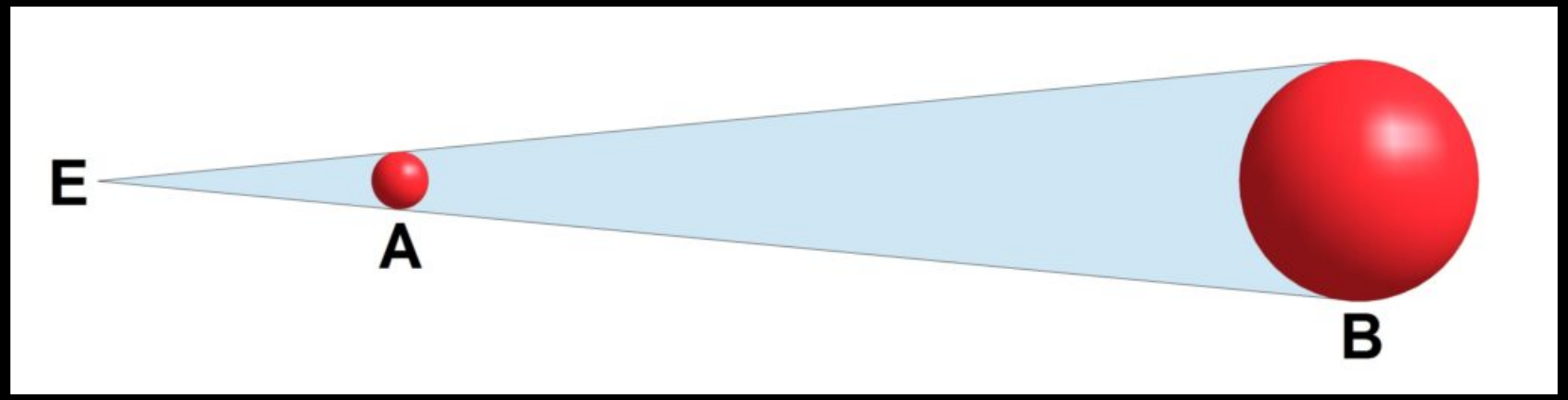


Remember, in Kepler's time the ***apparent*** sizes of stars were thought to be ***real***.

Kepler's size estimate was reproducible – similar to estimates by other astronomers.







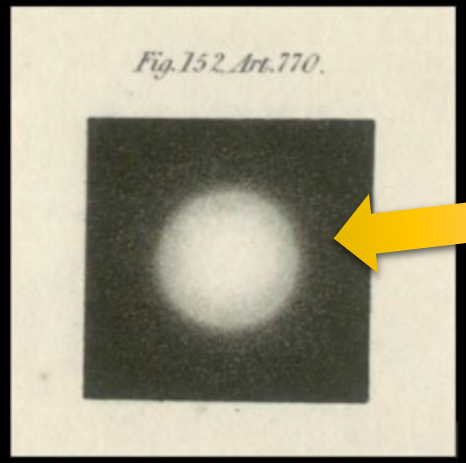
Kepler is a Copernican. Stars must be far away in the Copernican system, which translates to...

They must be large – far larger than the sun (Sirius is larger than orbit of Saturn, all visible stars larger than orbit of Earth).

KEPLER:
OBSERVATIONS SHOW THAT STARS ARE HUGE, AND DIM – ***NOT*** SUNS

HEY! Do we LOOK like suns to you?

No, we don't look like no stinkin' suns!
We're stars, Bruno. We ain't suns.
Ask Kepler. He's a real scientist.



When is this problem solved?

Unclear. Telescopes show stars as having sizes, too. Full explanation awaits the wave theory of light, and George Biddell Airy in the 19th century.

In first half of 18th century Jacques Cassini confirms Kepler's basic ideas (telescopically).

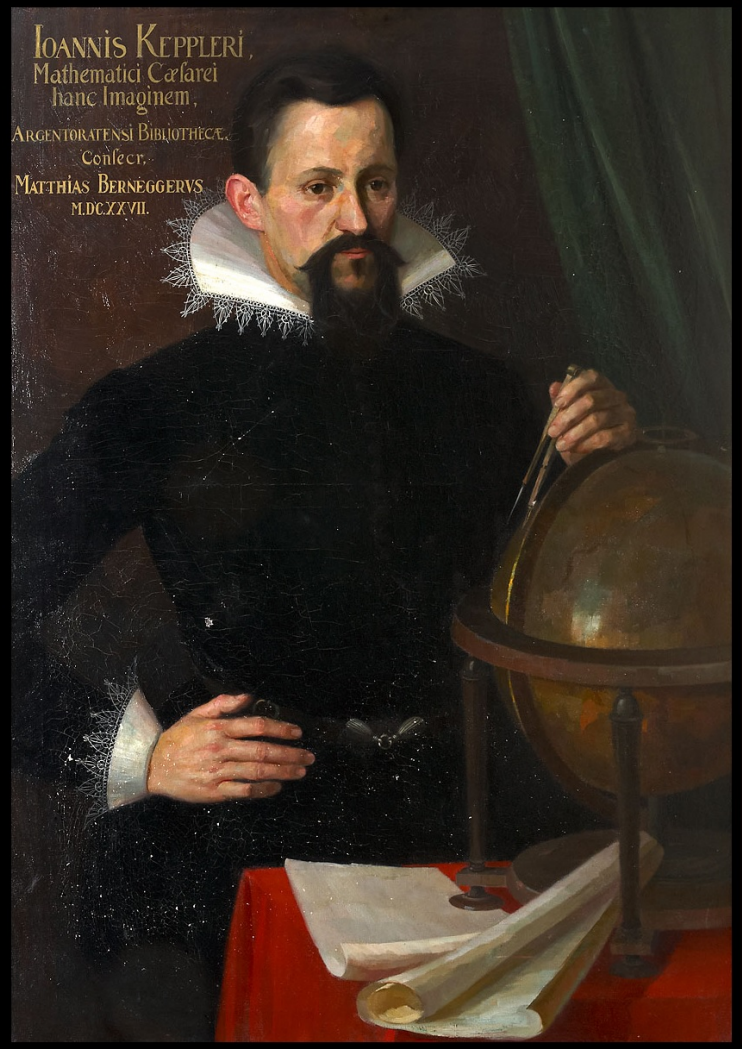
1750's you could find astronomy texts stating that the apparent sizes of stars:

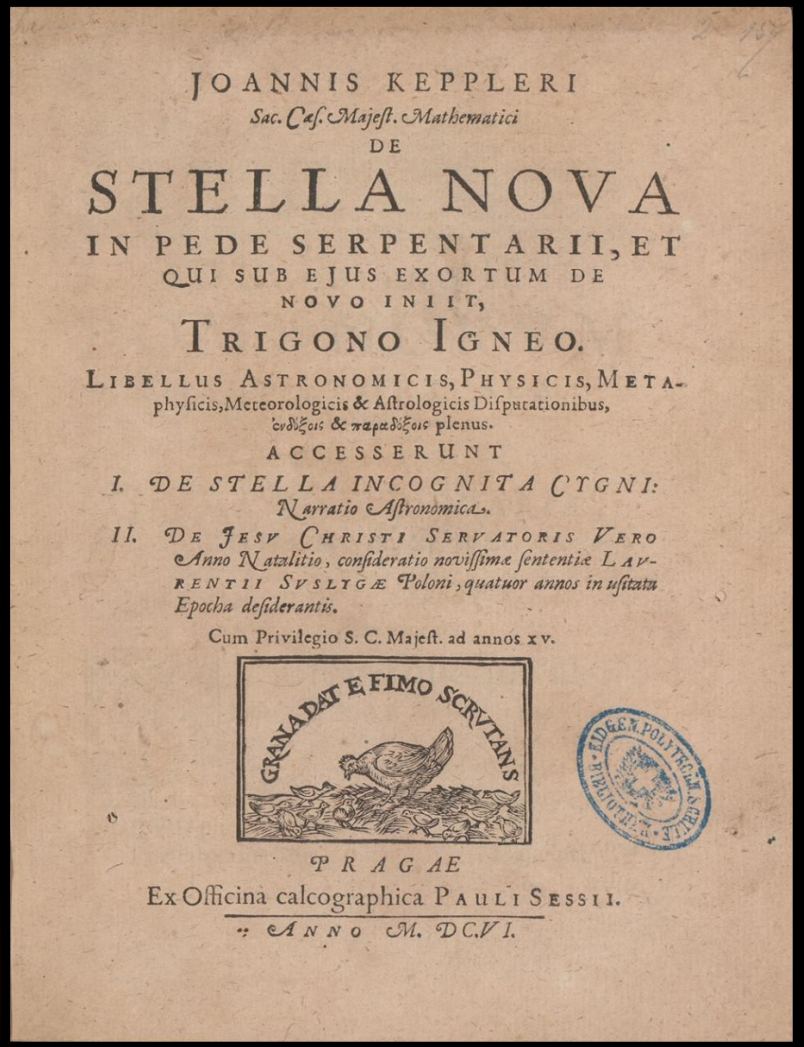
The observation of Sirius's diameter being five seconds, had, for its author, one of the most accurate, and most judicious astronomers the world has ever known, Cassini, and, whenever it is repeated with the same apparatus, it succeeds in the same manner, and verified very punctually; and other stars have also apparent diameters of nearly the same extent. [John Hill, Urania, or a Compleat View of the Heavens (1754)]

0.07 mm ceiling hole

(Star) SIZE MATTERS

Astronomers aligned with Bruno's views long before they had any scientific basis on which to do so. Why? Do philosophical notions about the universe appeal so much that they override science? Could we be doing the same thing today?





JOANNIS KEPPLERI
Sac. Cæs. Majest. Mathematici
DE
STELLA NOVA
IN PEDE SERPENTARII, ET
QUI SUB EJUS EXORTUM DE
NOVO INIIT,
TRIGONO IGNEO.

LIBELLUS ASTRONOMICIS, PHYSICIS, METAphysicis, Meteorologicis & Astrologicis Disputationibus, ἐνδόξοις & παραδόξοις plenus.

ACCESSERUNT

I. DE STELLA INCOGNITA CYGNI: Narratio Astronomica.

II. DE JESU CHRISTI SERVATORIS VERO Anno Natalitio, consideratio novissimæ sententiæ LAURENTII SUSLIGÆ Poloni, quatuor annos in usitata Epocha desiderantis.

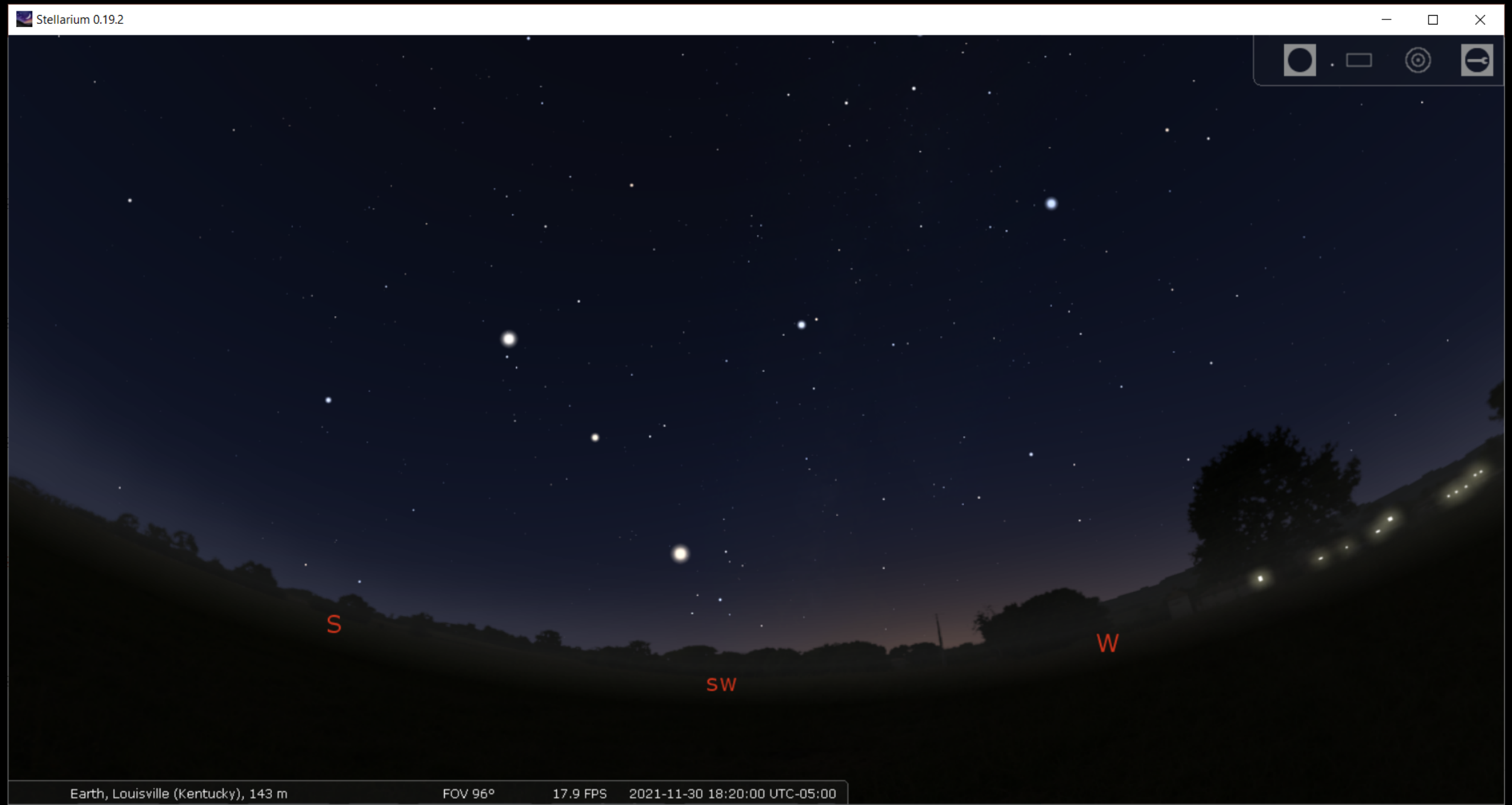
Cum Privilegio S. C. Majest. ad annos XV.

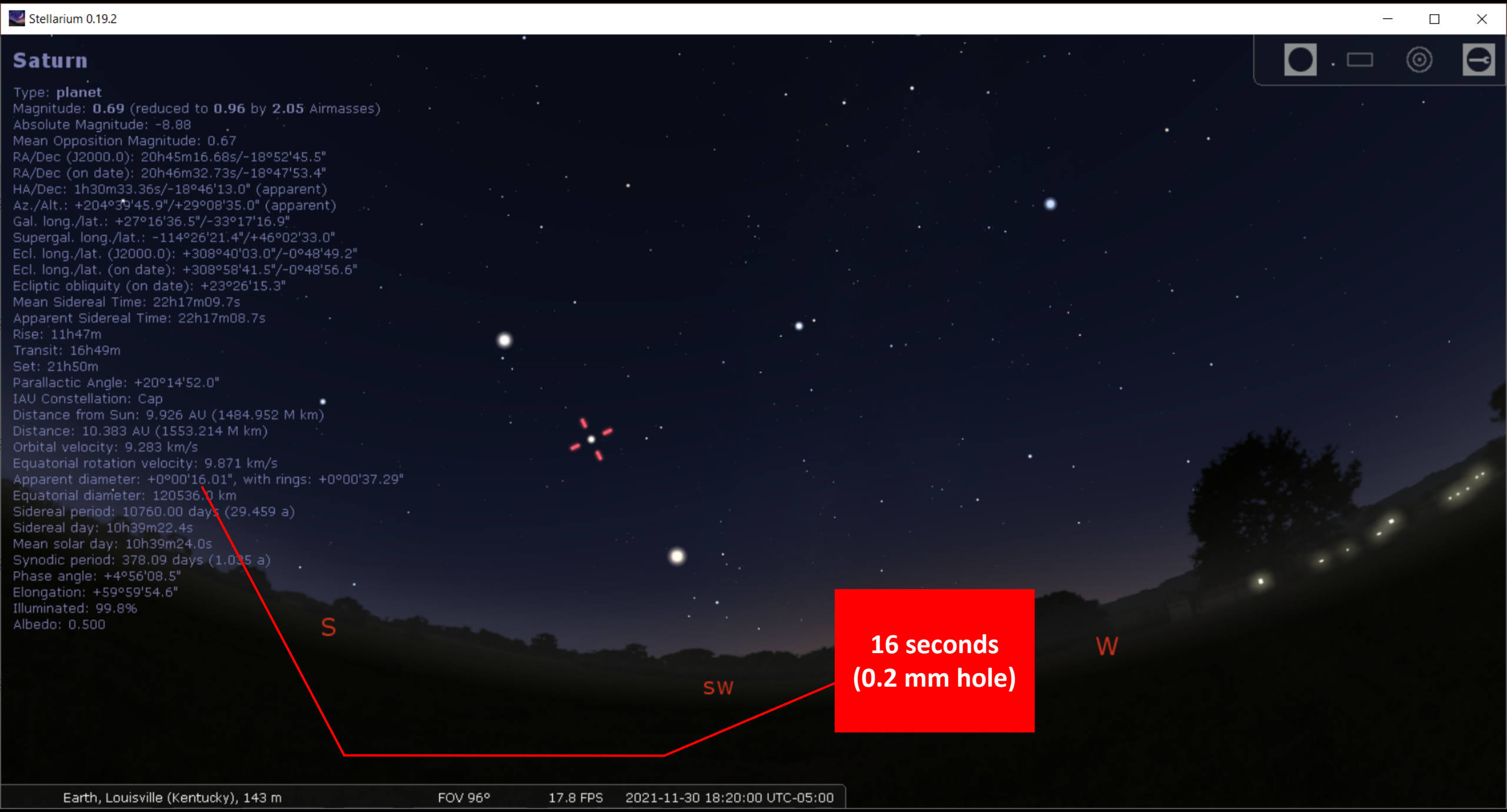
GRANA DAT EFIMO SCRVTANS

PRAGAE
Ex Officina calcographica PAULI SESSII.
ANNO M. DC.VI.

THE END

I knew you would ask that size question...




Stellarium 0.19.2
Saturn
Type: planet
Magnitude: 0.69 (reduced to 0.96 by 2.05 Airmasses)
Absolute Magnitude: -8.88
Mean Opposition Magnitude: 0.67
RA/Dec (J2000.0): 20h45m16.68s/-18°52'45.5"
RA/Dec (on date): 20h46m32.73s/-18°47'53.4"
HA/Dec: 1h30m33.36s/-18°46'13.0" (apparent)
Az./Alt.: +204°39'45.9"/+29°08'35.0" (apparent)
Gal. long./lat.: +27°16'36.5"/-33°17'16.9"
Supergal. long./lat.: -114°26'21.4"/+46°02'33.0"
Ecl. long./lat. (J2000.0): +308°40'03.0"/-0°48'49.2"
Ecl. long./lat. (on date): +308°58'41.5"/-0°48'56.6"
Ecliptic obliquity (on date): +23°26'15.3"
Mean Sidereal Time: 22h17m09.7s
Apparent Sidereal Time: 22h17m08.7s
Rise: 11h47m
Transit: 16h49m
Set: 21h50m
Parallactic Angle: +20°14'52.0"
IAU Constellation: Cap
Distance from Sun: 9.926 AU (1484.952 M km)
Distance: 10.383 AU (1553.214 M km)
Orbital velocity: 9.283 km/s
Equatorial rotation velocity: 9.871 km/s
Apparent diameter: +0°00'16.01", with rings: +0°00'37.29"
Equatorial diameter: 120536.0 km
Sidereal period: 10760.00 days (29.459 a)
Sidereal day: 10h39m22.4s
Mean solar day: 10h39m24.0s
Synodic period: 378.09 days (1.035 a)
Phase angle: +4°56'08.5"
Elongation: +59°59'54.6"
Illuminated: 99.8%
Albedo: 0.500
S
SW
W
16 seconds
(0.2 mm hole)
Earth, Louisville (Kentucky), 143 m
FOV 96°
17.8 FPS
2021-11-30 18:20:00 UTC-05:00