PHYSICS FOR FUTURE

Sky over Middle-Earth

Astronomy in the work of J. R. R. Tolkien

FZU
Institute of Physics of the Czech Academy of Sciences



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Obloha Stredozeme | Astronómia v diele J. R. R. Tolkiena | Patrik Čechvala

1,6 tis. • pred 3 r.

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https://youtu.be/IcAv6b0hW_Y?si=ri8FPSLlZdHzc8BQ
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Obloha Stredozeme – astronómia v Pánovi prsteňov ako motivácia pre študentov

Časť 2

Patrik Čechvala[1,2]

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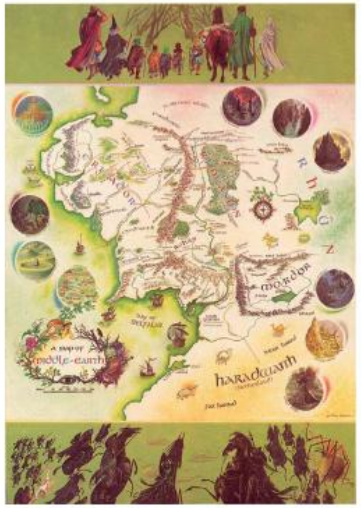
V prvej časti článku sme diskutovali spôsoby akými sú autori fantasy literatúry schopní vtiahnuť čitateľa do svojho sveta a ten mu detailne predstaviť spoločne aj s odkazmi na správanie sa oblohy a jednotlivých objektov na nej. Zamerali sme sa na J. R. R. Tolkiena a to konkrétne na dielo Pán prsteňov, pri ktorom sme postupne predstavovali astronomické odkazy na súhvezdia a asterizmy a hviezdnu scintiláciu. V pokračovaní sa zameriame na ostatné odkazy a to konkrétne na sférický tvar Zeme, na mesačné fázy, na meteority a na elektromagnetické spektrum.

Odkazov týkajúcich sa astronómie a pozorovaní nebeských objektov je v jednotlivých knihách Pán prsteňov od Johna Rolanda Reuela Tolkiena výrazný počet, čo dokazuje aj to, že sme museli rozdeliť predkladaný článok na dve časti. V pokračovaní si predstavíme ostatné tematické bloky opäť podporené citáciami z jednotlivých kníh. Pre odkazy na knihy budeme opäť používať slovenský preklad Pána prsteňov od Otakara Kořínka z rokov 2001 a 2002, ktorý bol vydaný vo vydavateľstve Slovart, spol. s. r. o. [1], [2], [3].



Obr. 1 Mapa Stredozeme. Autor: Pauline Baynes [4]

Sférický tvar Zeme

Zaujímavým odkazom spojeným s astronómiou objavujúcim sa v Pánovi prsteňov je nepriamo spomenutý sférický tvar sveta, na ktorom sa celý príbeh odohráva. Tento sa objavuje v knihe Spoločenstvo prsteňa. Konkrétne je to potom, čo hobiti spoločne s Aragornom po úniku z Morie prichádzajú do sídla elfov Vododol, známe aj ako Imladris. Hobiti prinášajú do Vododolu vládnuci prsteň. Zvolaná je tak Elrondova rada, na ktorej sa stretávajú všetky slobodné národy Stredozeme. Počas nej sa má stanoviť, ako ďalej postupovať. Tu je predstavený Aragorn ako dedič kráľovstva Gondor. Boromir z Gondoru má isté pochybnosti. Na obranu vystupuje hobit Bilbo, ktorý zarecituje báseň. Po prednesenej básni reaguje Aragorn na Boromira.

Aragorn sa naňho usmial a znova sa obrátil k Boromirovi. „Za seba ti tvoje pochybnosti odpúšťam," povedal. „Málo sa podobám postavám Elendila a Isildura, ako sú vytesané v ich majestátoch v sieňach Denethoru. Som len Isildurovým dedičom, nie samým Isildurom. Mal som ťažký život, a dlhý. Míle, ktoré delia toto miesto od Gondoru, sú iba zlomkom

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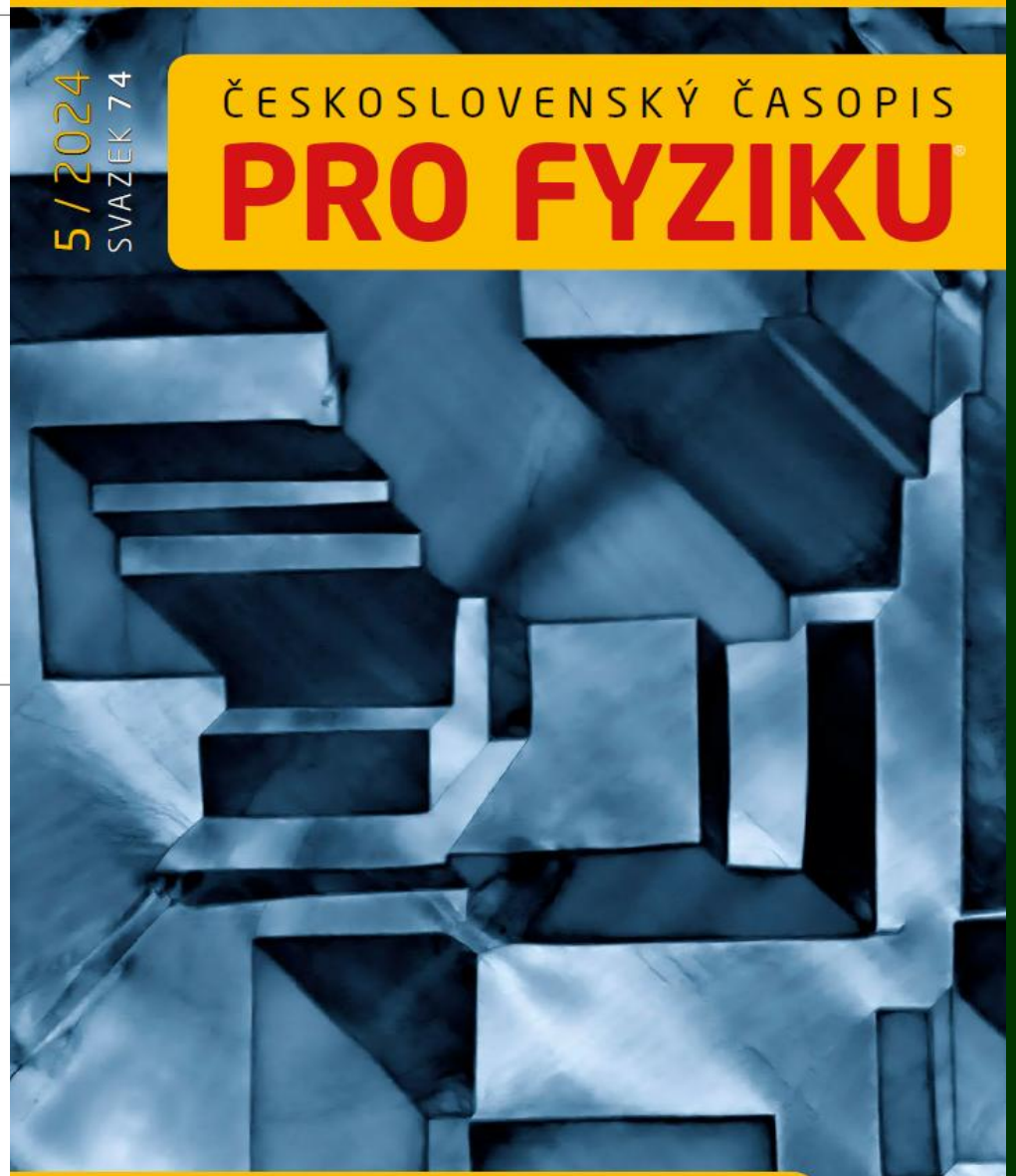

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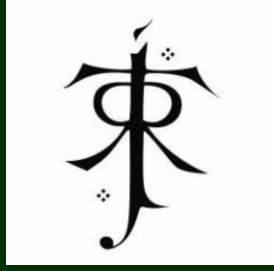
Content

- Presentation of the work of J.R.R. Tolkien
- Link of Tolkien´s work with astronomy
- Examples of astronomy related quotes in The Lord of the Rings
- Explanation of the phenomena



Sky over Middle-Earth

Astronomy in the work of J. R. R. Tolkien

Mgr. Patrík Čechvala, PhD.

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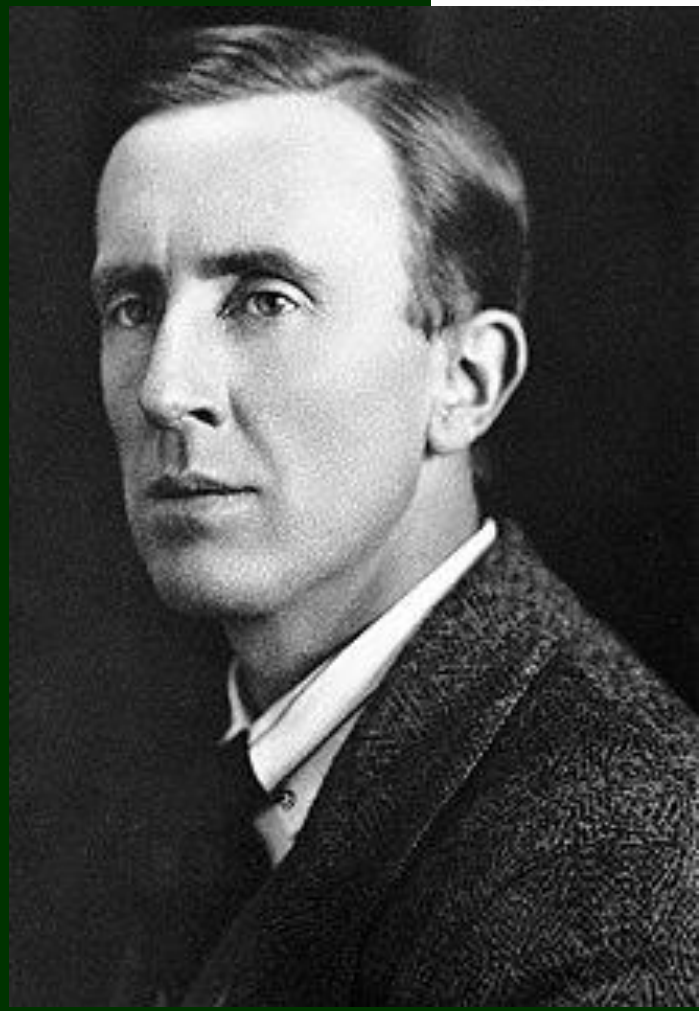
John Ronald Reuel Tolkien

(1892, Bloemfontein, South Africa- 1973, Bournemouth, England)



- English writer, poet, philologist and professor
- Author of Hobbit (1937), The Lord of the Rings (1954-1955), The Silmarillion (1977), Unfinished Tales (1980)
    - The Lord of the Rings (LOTR) – The Fellowship of the Ring, The Two Towers, The Return of the King

John Ronald Reuel Tolkien

(1892, Bloemfontein, South Africa- 1973, Bournemouth, England)

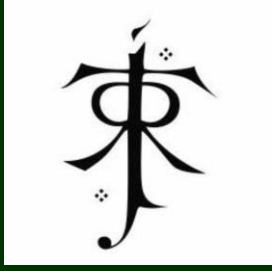


Credit: Álida Carvalho

Middle-Earth



- Middle-earth is the main continent of Earth (Arda) in an imaginary period of the Earth's past, ending with Tolkien's Third Age, about 6,000 years ago – wiki
- Complexity of this world together with its own geography, history, mythology and astronomy makes this story much more attractive



Astronomy and work of J.R.R. Tolkien? Spoiler Alert!

Why we are talking about that?

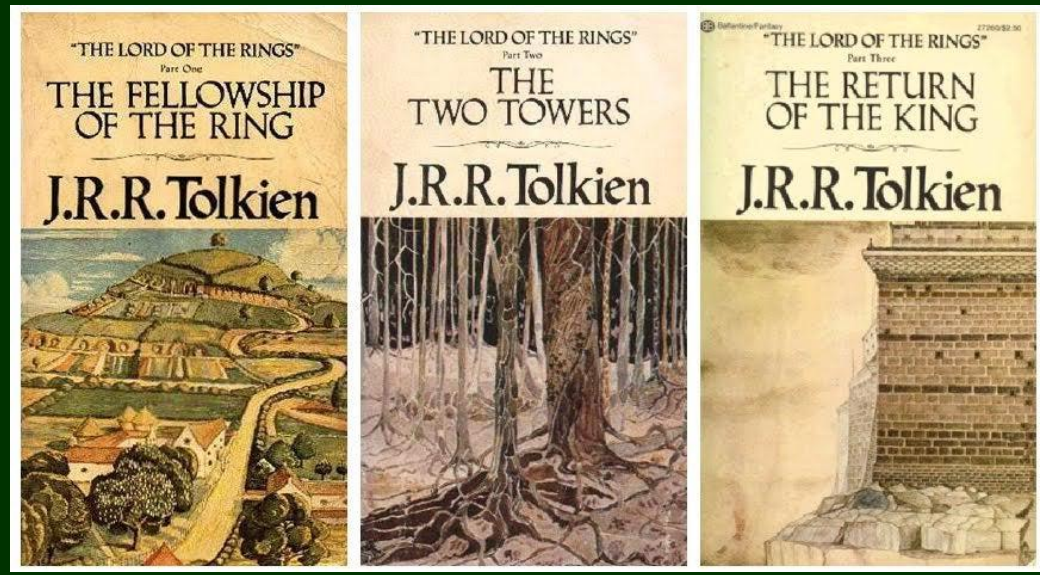
Mgr. Patrík Čechvala, PhD.

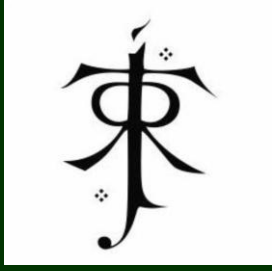
The Movies



The Books

- The books contain much more developed story of the main characters – practically impossible to contain everything in the movies
- Reading the books one can notice many astronomy related scenes and descriptions
- Deeper look shows that prof. Tolkien paid attention to the timeline which is based on the lunar phases, positions of the Sun and the Moon together with different constellations
- From these descriptions we can derive that the heroes of LOTR are looking on the same skies as we are
- It shows us that prof. Tolkien had knowledge about astronomy and also modern physics which he incorporated into his story
- He was also an amateur astronomer





Educating astronomy and public outreach using LOTR?

It would be interesting to use the story of LOTR and scenes where the objects in the skies are involved to use them as a tool to show general audience the basics of astronomy

Mgr. Patrík Čechvala, PhD.

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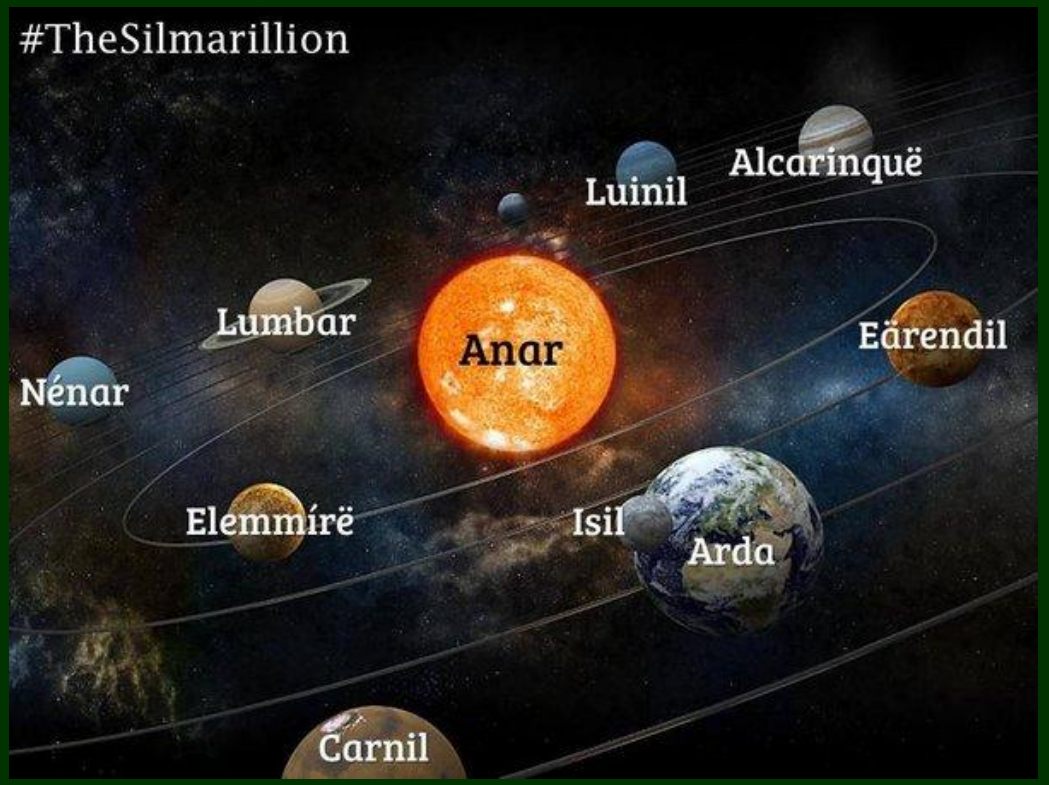
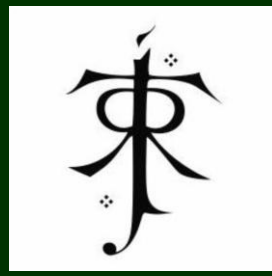
Education of astronomy and public outreach using LOTR

- Several astronomers worldwide have already noticed this possibility
  - Prof. Kristine Larsen – professor of astronomy and physics, Central Connecticut State University, https://physics.ccsu.edu/larsen/
    - Many papers about this topic

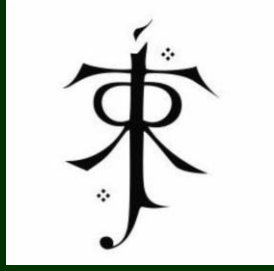


What is incorporated in the books (LOTR)

- Prof. Tolkien created his own world together with its own mythology – described in The Silmarillion (1977) – cosmology and cosmogony – creation of the world
- In LOTR – mainly in The Fellowship of the Ring we can see many scenes
  - Lunar phases
  - Movement of the Sun
  - Stellar catalogs, constellations and asterism – same as we can see in the skies, different names
  - Spherical shape of the world
  - Scintillation of the stars
  - Calendars
  - Spectroscopy
  - Planets – mainly Venus
  - Meteorite



1. Stellar catalogs, constellations and asterism



'Bring news,' said the Wild Man. 'We look out from hills. We climb big mountain and look down. Stone-city is shut. Fire burns there outside; now inside too. You wish to come there? Then you must be quick. But gorguˆn and men out of far-away,' he waved a short gnarled arm eastward, 'sit on horse-road. Very many, more than Horse-men.' 'How do you know that?' said Eomer. ´ The old man's flat face and dark eyes showed nothing, but his voice was sullen with displeasure. 'Wild Men are wild, free, but not children,' he answered. 'I am great headman, Ghaˆn-buri-Ghaˆn. I count many things: stars in sky, leaves on trees, men in the dark. You have a score of scores counted ten times and five. They have more. Big fight, and who will win? And many more walk round walls of Stone-houses.'

(The Return of the King, Book 5, Chapter V, The Ride of the Rohirrim)

1. Stellar catalogs, constellations and asterism

I count many things: stars in sky, leaves on trees, men in the dark. You have a score of scores counted ten times and five.

- Score = 20
- 20 x 20 x (10 + 5) = 6000
- 6000 spears

1. Stellar catalogs, constellations and asterism

- How many stars are in the night sky?



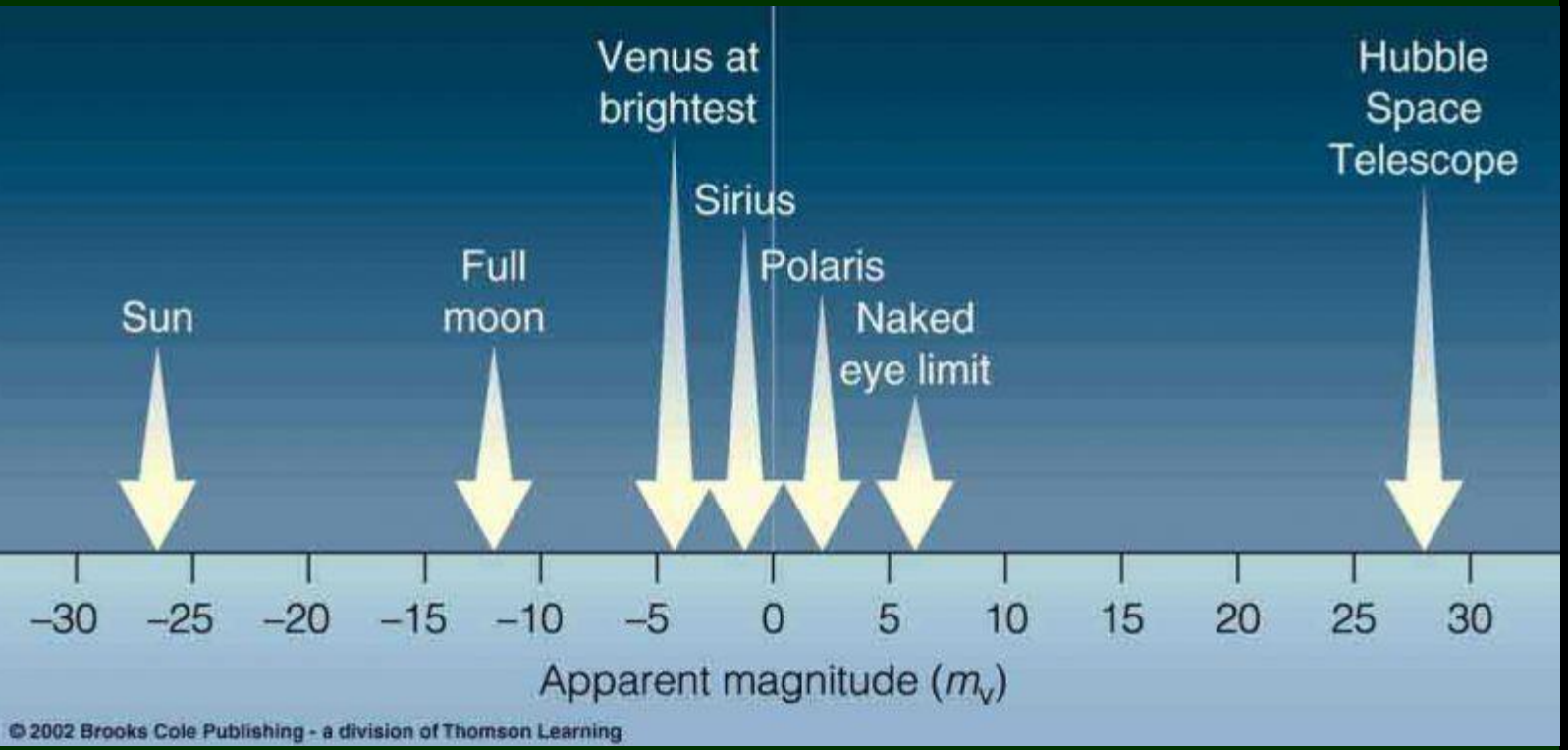
Credit: Tomáš Slovinský, Roque de los Muchachos, La Palma, https://slovinsky.art/sk/home/

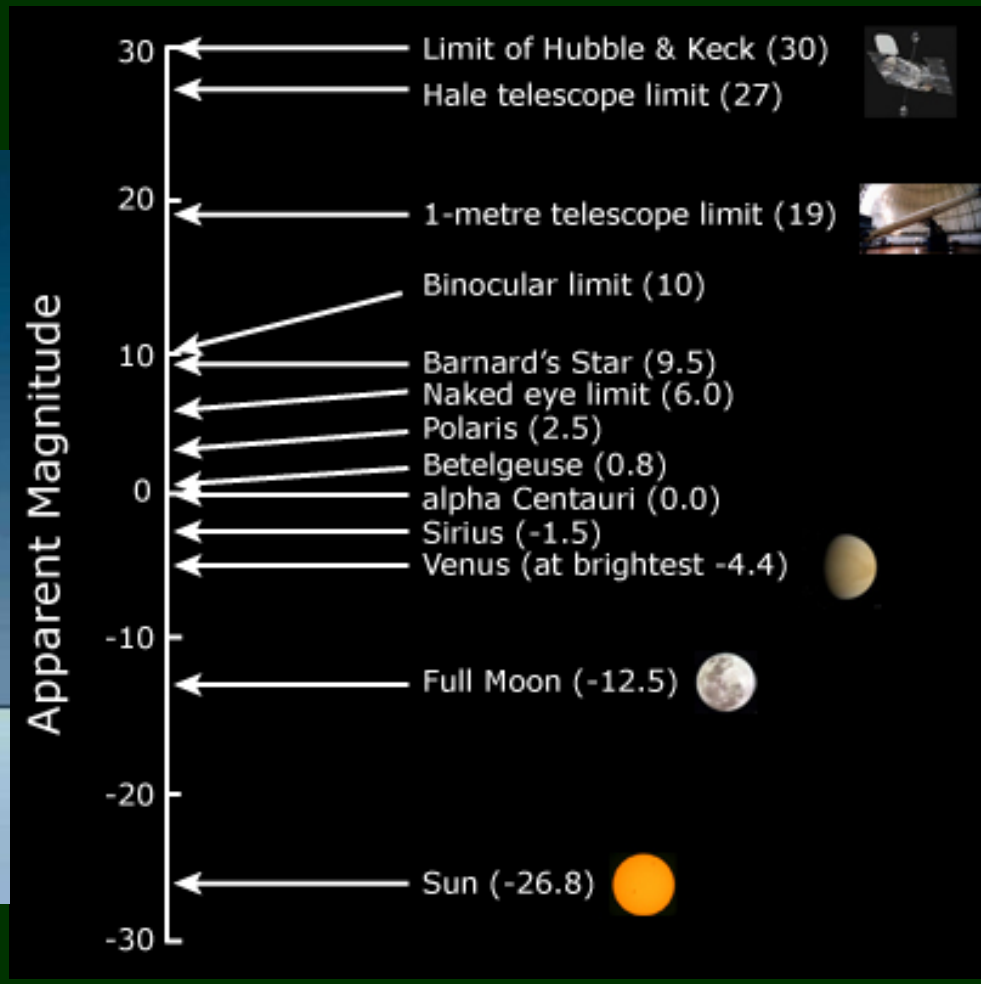
1. Stellar catalogs, constellations and asterism

- How many stars are in the night sky? (Visible to the naked eye)

- Apparent magnitude – unitless measure used in astronomy to express the brightness of a celestial object
- Lower the magnitude brighter the object
- Invented already by Ancient Greeks – 1st stars are 1^m , … , 6th stars are 6^m
- Nowadays we know it is in logarithmic scale – **Pogson´s equation**
- 1 magnitude change + means 2.5 times lower flux from the object
- Difference of 5 magnitudes + means 100 times lower the flux
- Used not only for stars but also for Sun, Moon, planets, asteroids, comets and also for satellites

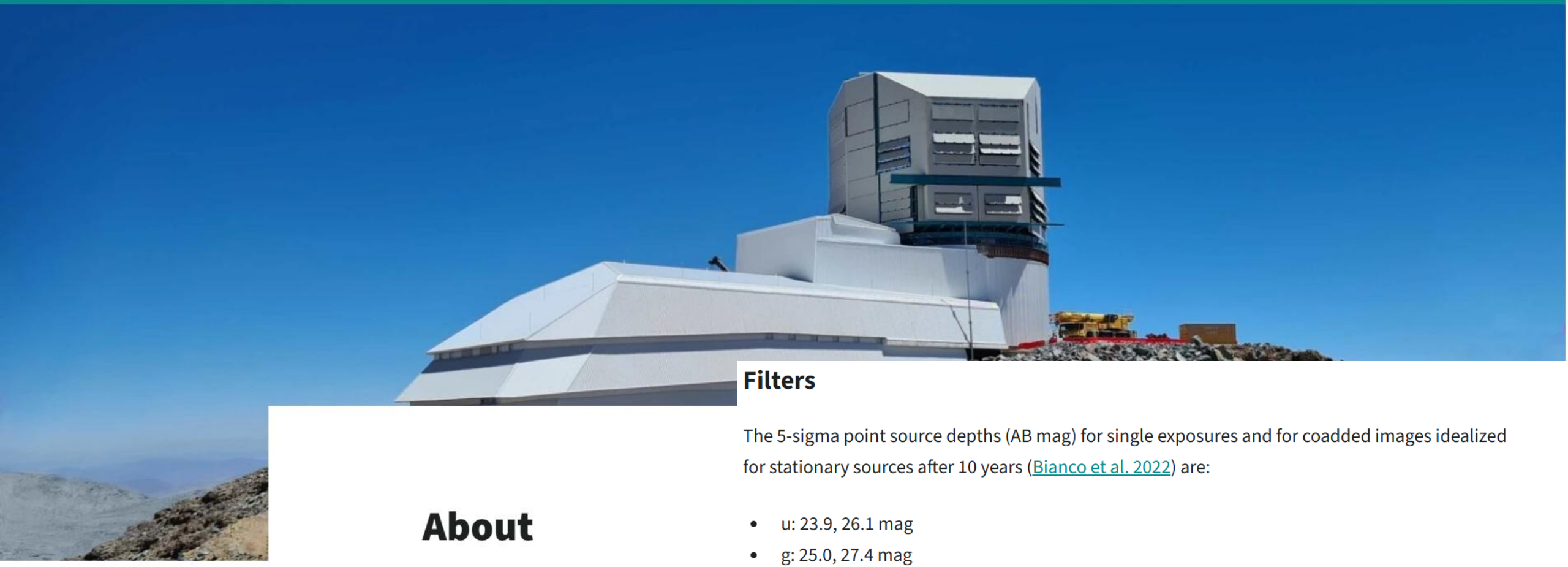
1. Stellar catalogs, constellations and asterism





https://earthsky.org/astronomy-essentials/what-is-stellar-magnitude/

https://planetary-science.org/astronomy/magnitudes-brightness/



About

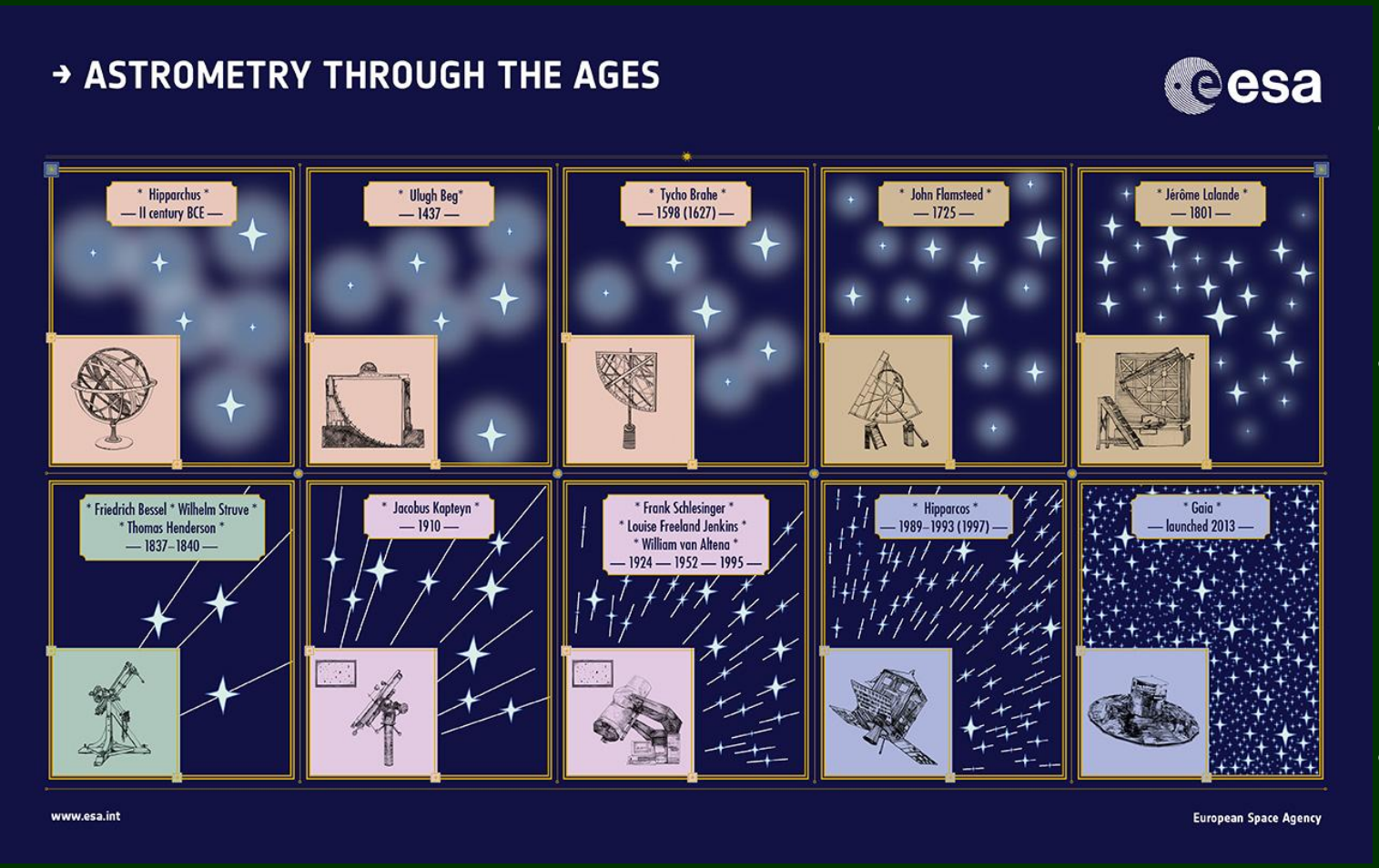
Filters

The 5-sigma point source depths (AB mag) for single exposures and for coadded images idealized for stationary sources after 10 years (Bianco et al. 2022) are:

- u: 23.9, 26.1 mag
- g: 25.0, 27.4 mag
- r: 24.7, 27.5 mag
- i: 24.0 , 26.8 mag
- z: 23.3, 26.1 mag
- y: 22.1, 24.9 mag

Mgr. Patrík Čechvala, PhD.

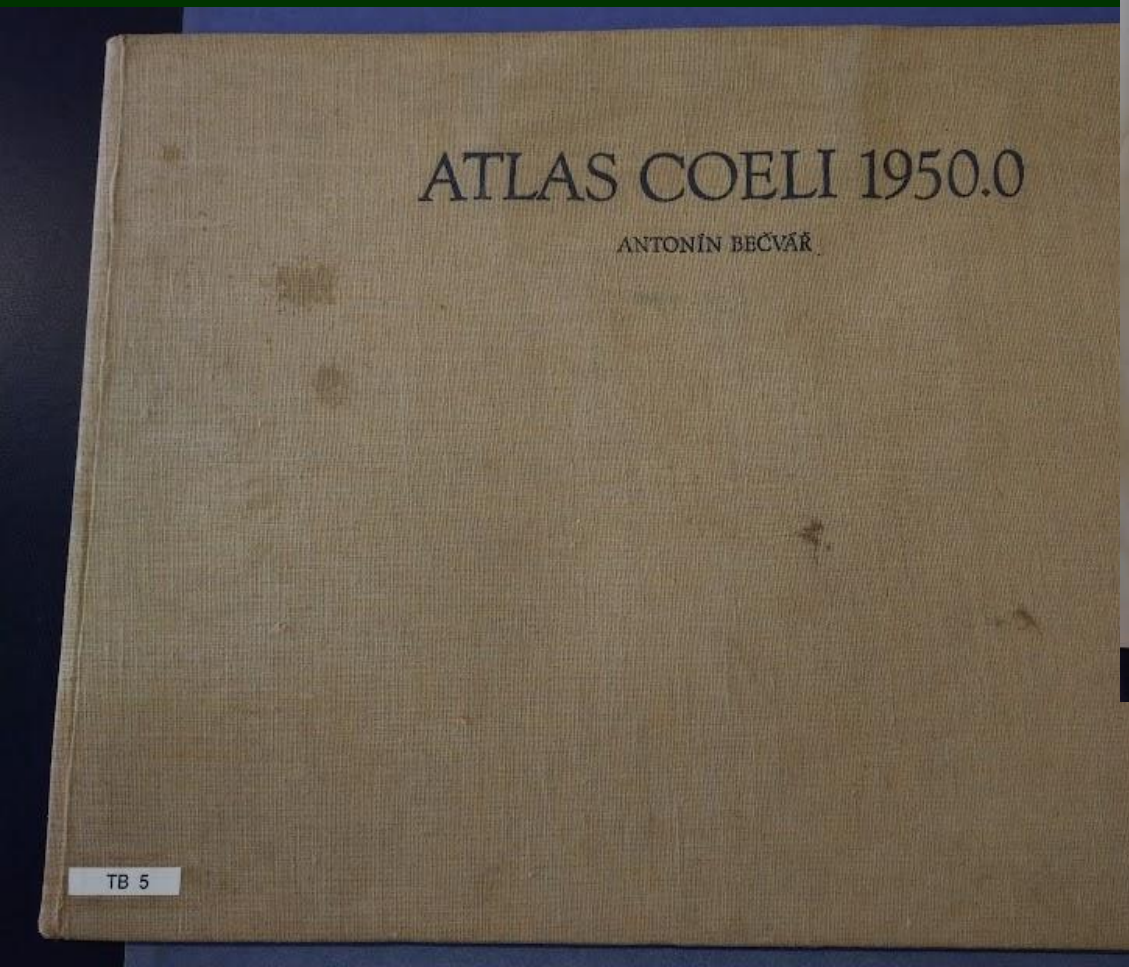
1. Stellar catalogs, constellations and asterism

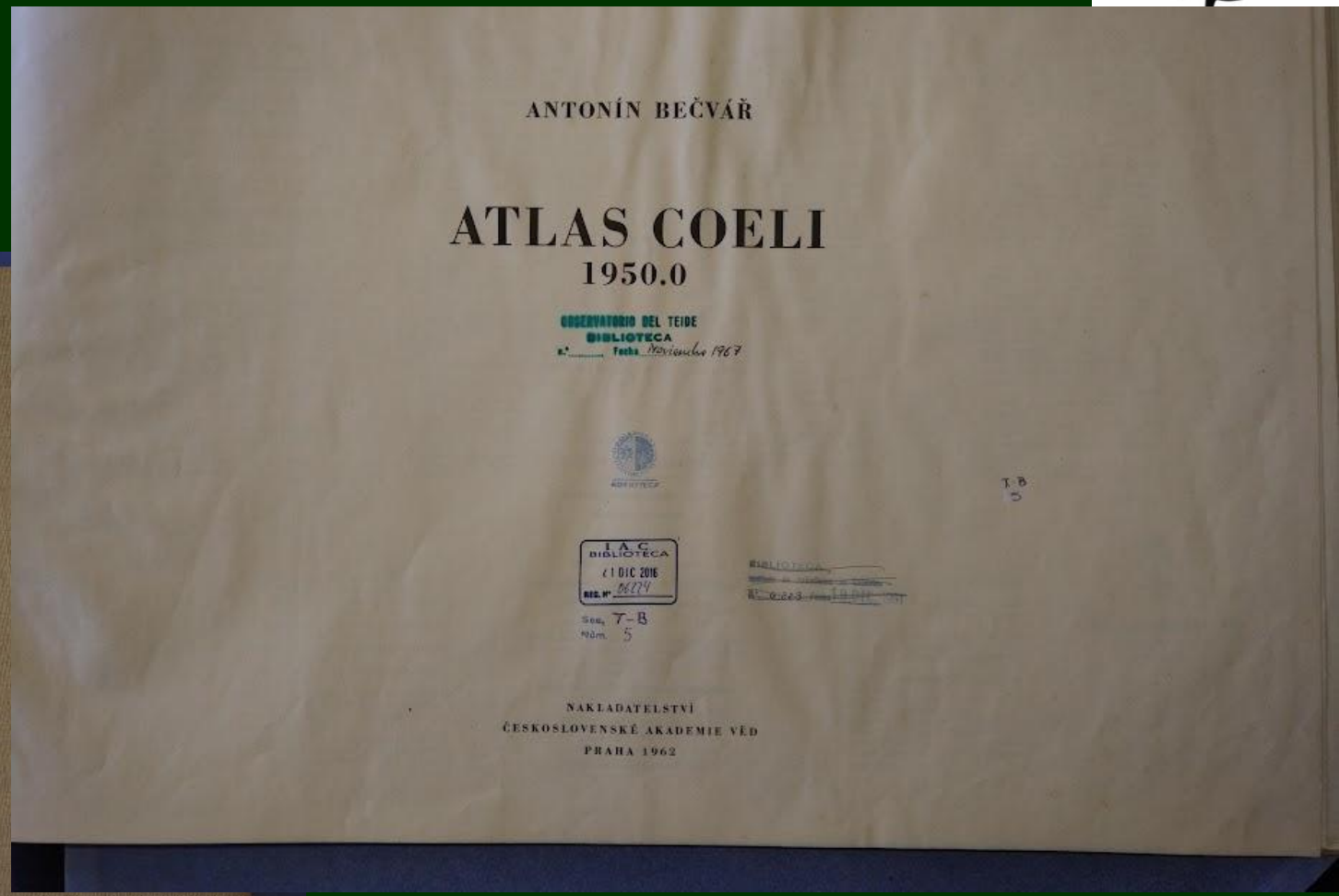


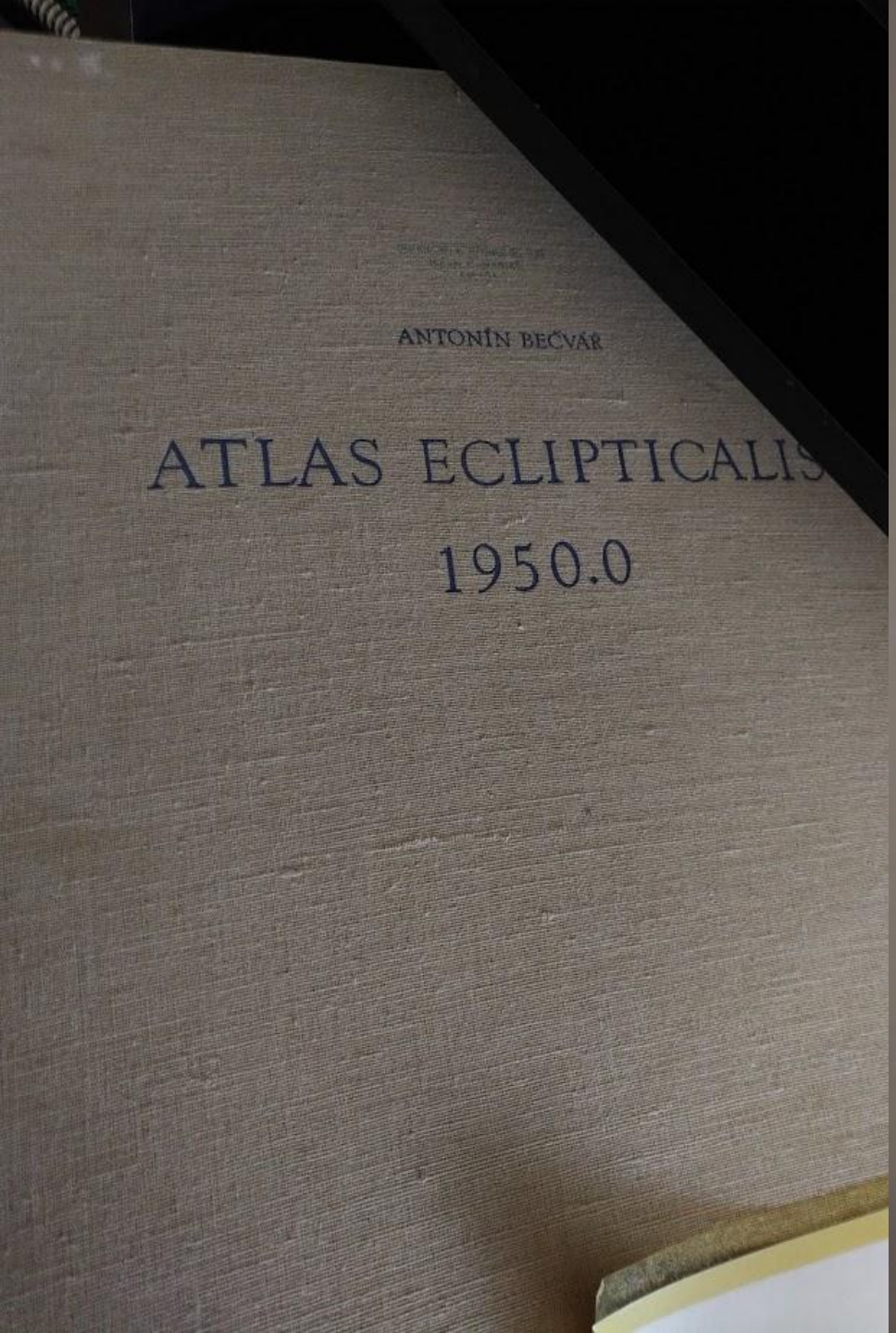
Source: European Space Agency ESA

- Stellar catalogs – astrometry of the stars
- Measuremnt of the positions, movement and the brightness of the stars
- Today we know that there are approx. 6000 stars visible to the naked eye – all sky – perfectly match with Ghaˆn-buri-Ghaˆn´s computing
- For an observer visible only one half of the sky – approx. 3000 stars

1. Stellar catalogs, constellations and asterism







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1. Stellar catalogs, constellations and asterism

„Twilight was about them as they crept back to the lane. The West wind was sighing in the branches. Leaves were whispering. Soon the road began to fall gently but steadily into the dusk. A star came out above the trees in the darkening East before them. They went abreast and in step, to keep up their spirits. After a time, as the stars grew thicker and brighter, the feeling of disquiet left them, and they no longer listened for the sound of hoofs.“

(The Fellowship of the Ring, Book 1, Chapter III, Three is Company)

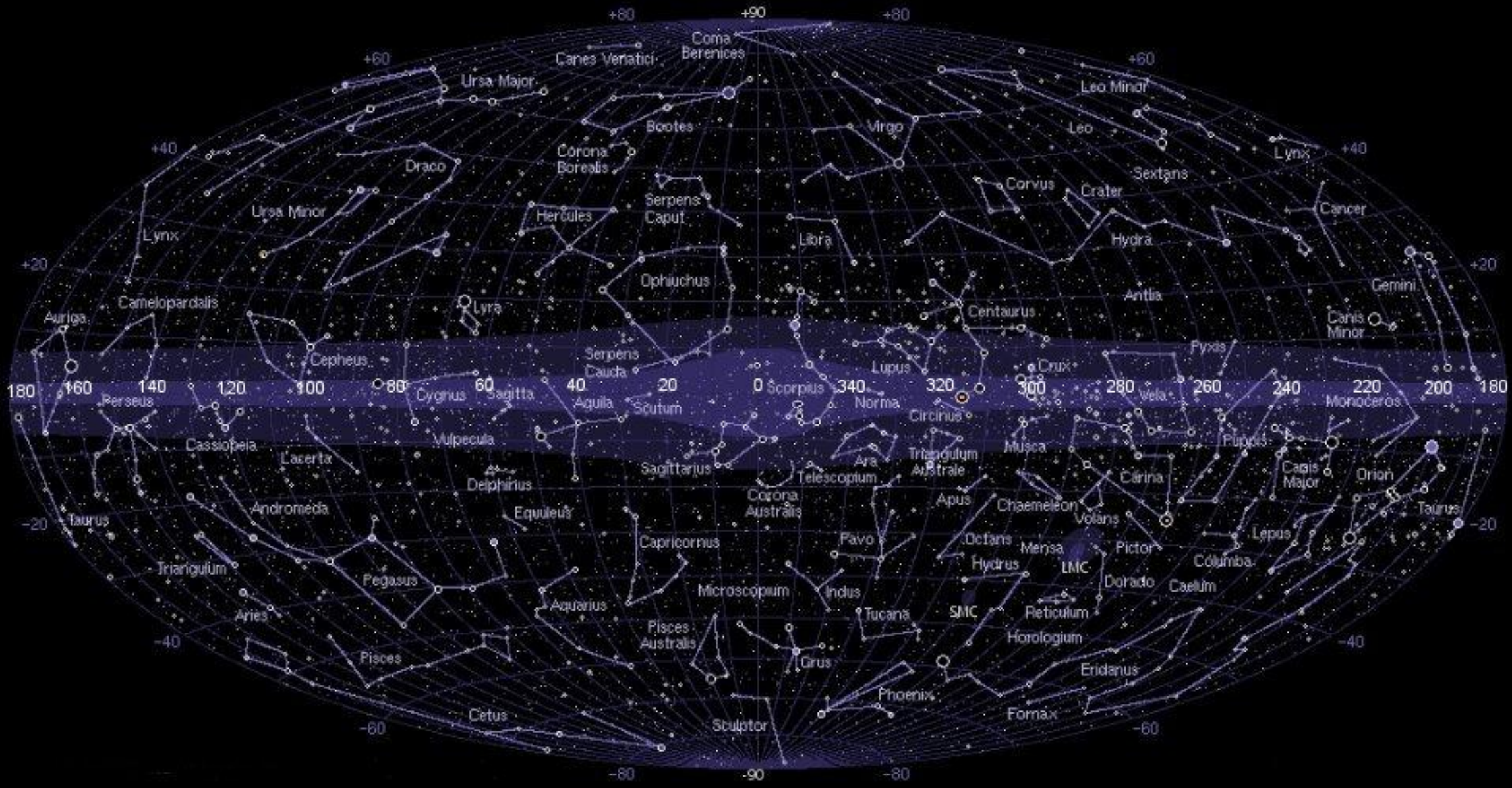
1. Stellar catalogs, constellations and asterism

„The Elves sat on the grass and spoke together in soft voices; they seemed to take no further notice of the hobbits. Frodo and his companions wrapped themselves in cloaks and blankets, and drowsiness stole over them. The night grew on, and the lights in the valley went out. Pippin fell asleep, pillowed on a green hillock. Away high in the East swung Remmirath, the Netted Stars, and slowly above the mists red Borgil rose, glowing like a jewel of fire. Then by some shift of airs all the mist was drawn away like a veil, and there leaned up, as he climbed over the rim of the world, the Swordsman of the Sky, Menelvagor with his shining belt. The Elves all burst into song. Suddenly under the trees a fire sprang up with a red light.“

(The Fellowship of the Ring, Book 1, Chapter III, Three is Company)

1. Stellar catalogs, constellations and asterism

How many constellations are there on the sky?



https://www.go-astronomy.com/constellations.htm

1. Stellar catalogs, constellations and asterism

- According to the International Astronomical Union (IAU) – we currently know 88 constellations
- In 1922 – use of 3 letter abbreviation – IAU General Assembly – Taurus (Tau), Orion (Ori), Ursa Major (UMa)
- 1930 – Délimination scientifique des constellations – Eugène Delporte – on behalf of the Comission 3 of IAU
- Names of the stars are derived from the intensity of the stars and from the latin name of the constellation in genitive – Alpha Tauri - Aldebaran
- Constellation is not only the visible asterism – it is a part of the sky delimited by the coordinates
- Sky is divided into 88 parts
- We know the so called seasonal constellations, circumpolar or also southern and northern

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INTERNATIONAL ASTRONOMICAL UNION

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DÉLIMITATION SCIENTIFIQUE DES CONSTELLATIONS

(TABLES ET CARTES)

Par

E. DELPORTE

Astronome à l'Observatoire royal de Belgique

CAMBRIDGE

AT THE UNIVERSITY PRESS

1930

DÉLIMITATION SCIENTIFIQUE DES CONSTELLATIONS

par E. DELPORTE,

Astronome à l'Observatoire royal de Belgique

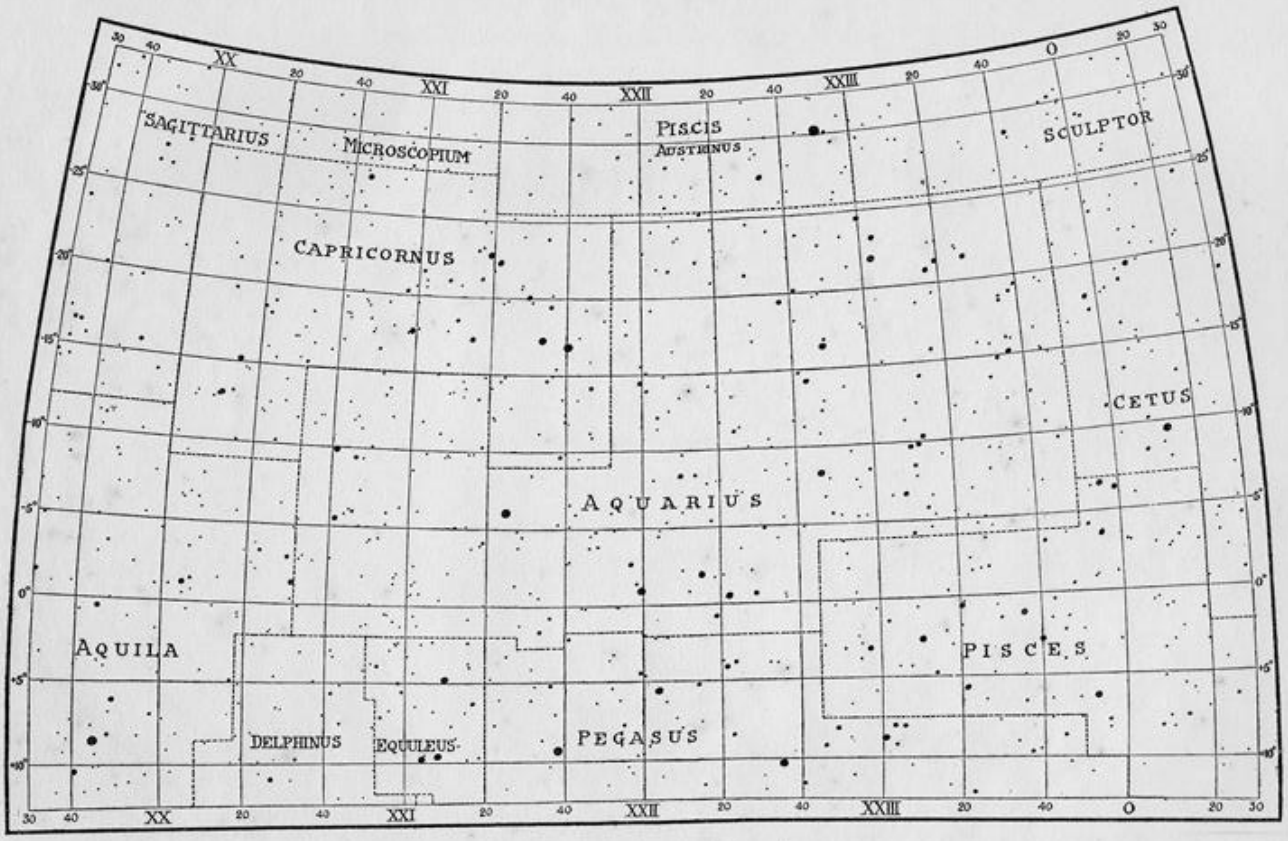
Historique

Les anciens nous ont légué, dans leurs descriptions, le ciel étoilé partagé en astérismes, mais sans limites arrêtées. Bode fut le premier astronome qui, aux figures symboliques, adjoignit dans son atlas céleste des lignes de démarcation pour les constellations; C. L. Harding, dans son *Atlas novus coelestis* (Gottingue, 1822), maintint les limites en supprimant les figures. Ses continuateurs prirent de réelles libertés quant aux tracés de ces limites, celles-ci différant alors d'un atlas à l'autre. Une tentative de John Herschel, pour délimiter les constellations sous forme de quadrilatères sphériques, apparut comme trop radicale; son projet faisait passer en effet trop d'étoiles principales d'un astérisme à un autre; F. Baily, dans la préface du *Catalogue of Stars of the British Association* (1845), énonça un ensemble de règles susceptibles, pensait-il, dans leur application, de donner des limites stables aux constellations, tout en leur conservant un accord suffisant avec les descriptions du ciel de Ptolémée. Aucune réalisation pratique ne fut tentée. À la même époque, Fr. Argelander faisait paraître (1843) son *Uranometria Nova*. Les limites qu'il donna aux constellations de l'hémisphère nord auraient dû être considérées, suivant le vœu émis par l'Astronomische Gesellschaft en 1867, comme admises *ne varietur*. Cependant, les auteurs suivants d'atlas célestes ne tinrent pas note de ce vœu et l'on peut dire que les atlas usuels diffèrent essentiellement l'un de l'autre, par les limites des constellations et même par le nombre de celles-ci.

Les tracés d'Argelander ne sont d'ailleurs pas susceptibles de définition mathématique.

Or, la délimitation précise des constellations est d'une importance capitale pour beaucoup de travaux astronomiques, tels que l'observation systématique des étoiles filantes et des bolides, l'étude et la dénomination des variables, l'observation des novae, etc.

Le travail de B. A. Gould (*Uranometria Argentina, mapas*, 1877) réalisa la réforme pour l'hémisphère sud, les limites des constellations étant formées par des méridiens d'ascension droite et des parallèles de déclinaison pour l'équinoxe de 1875,0 et, dans quelques cas particuliers, par des courbes se rapprochant le plus possible de grands cercles de la sphère et dont la position est donnée par les intersections avec des méridiens et des parallèles.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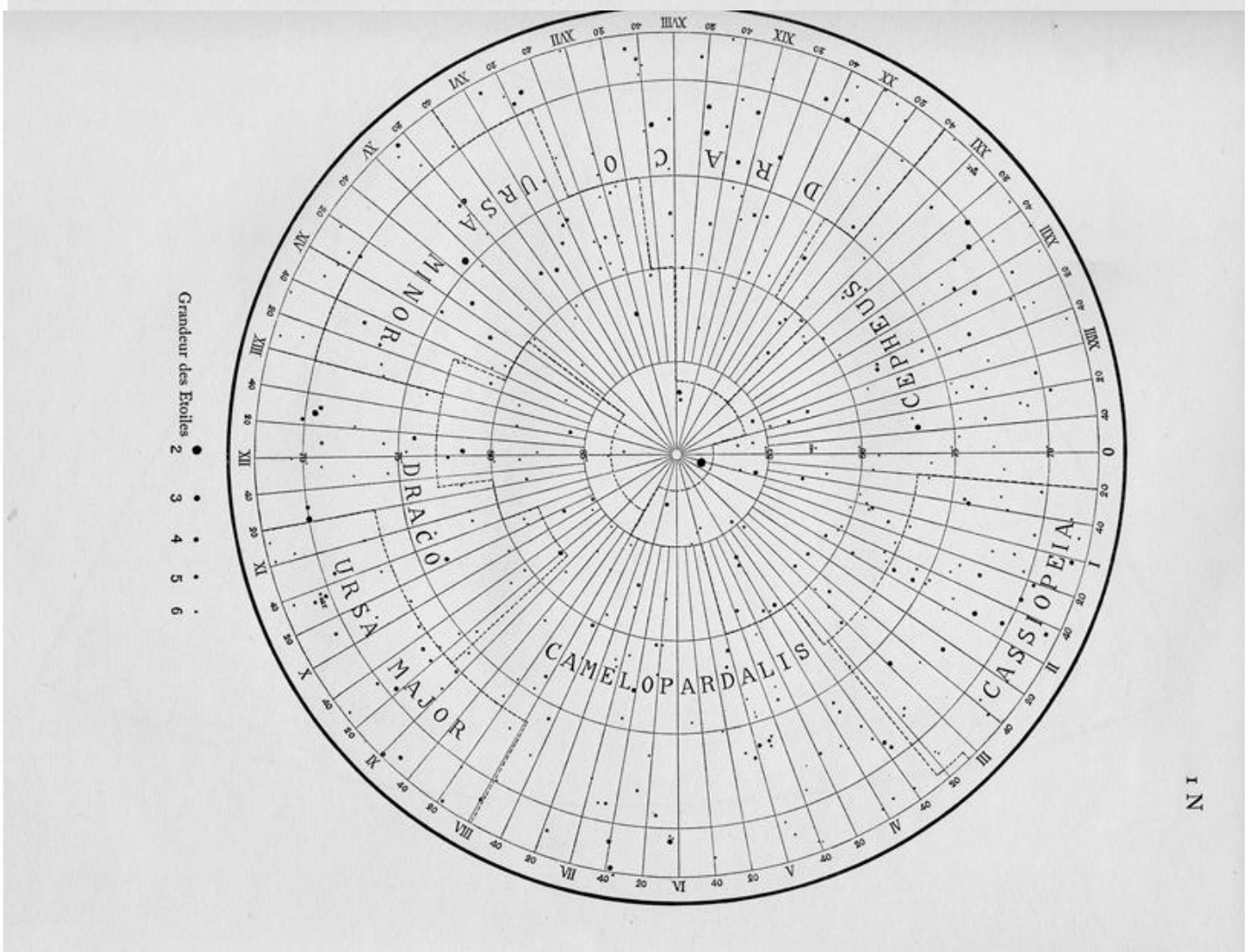
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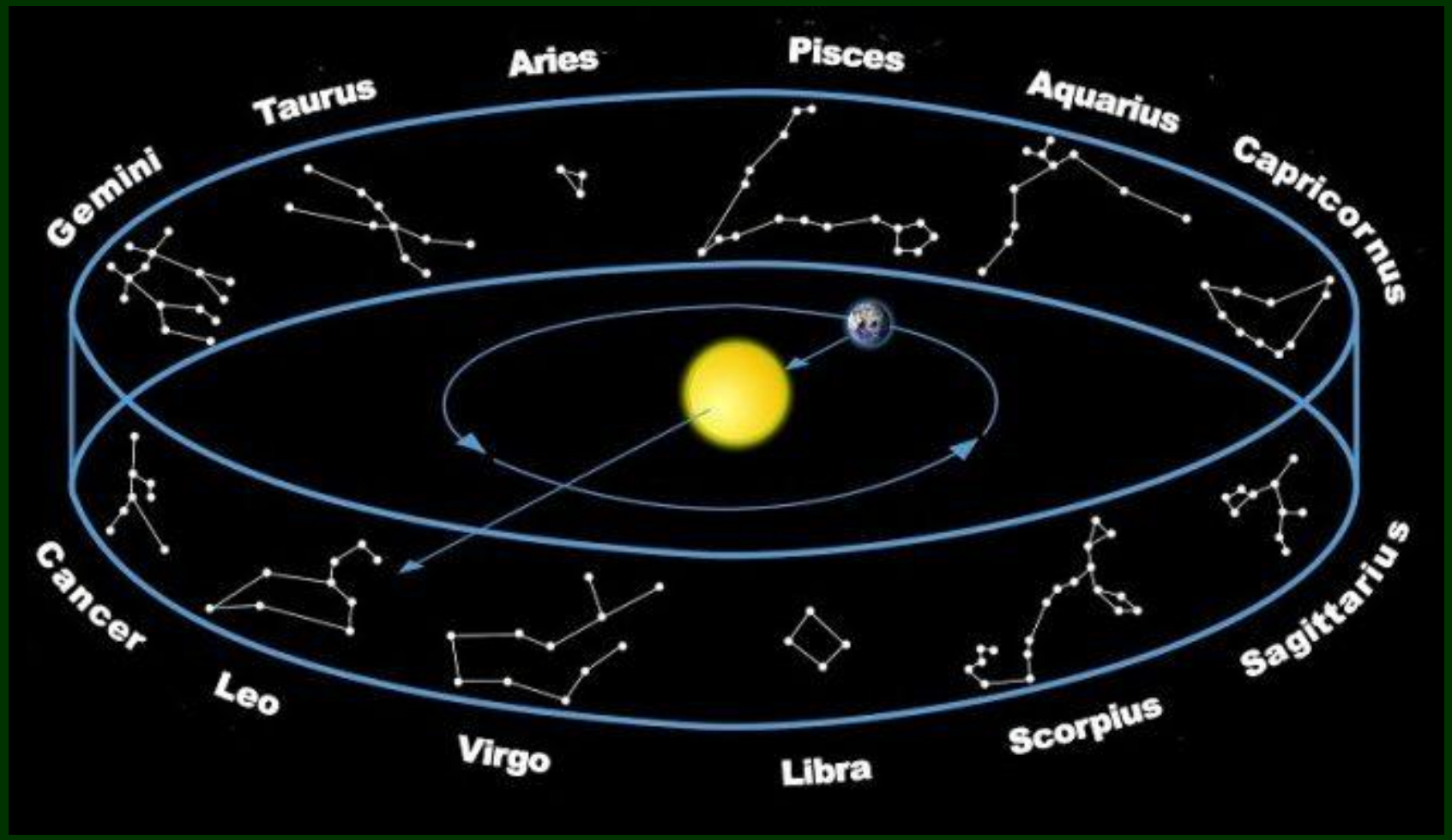
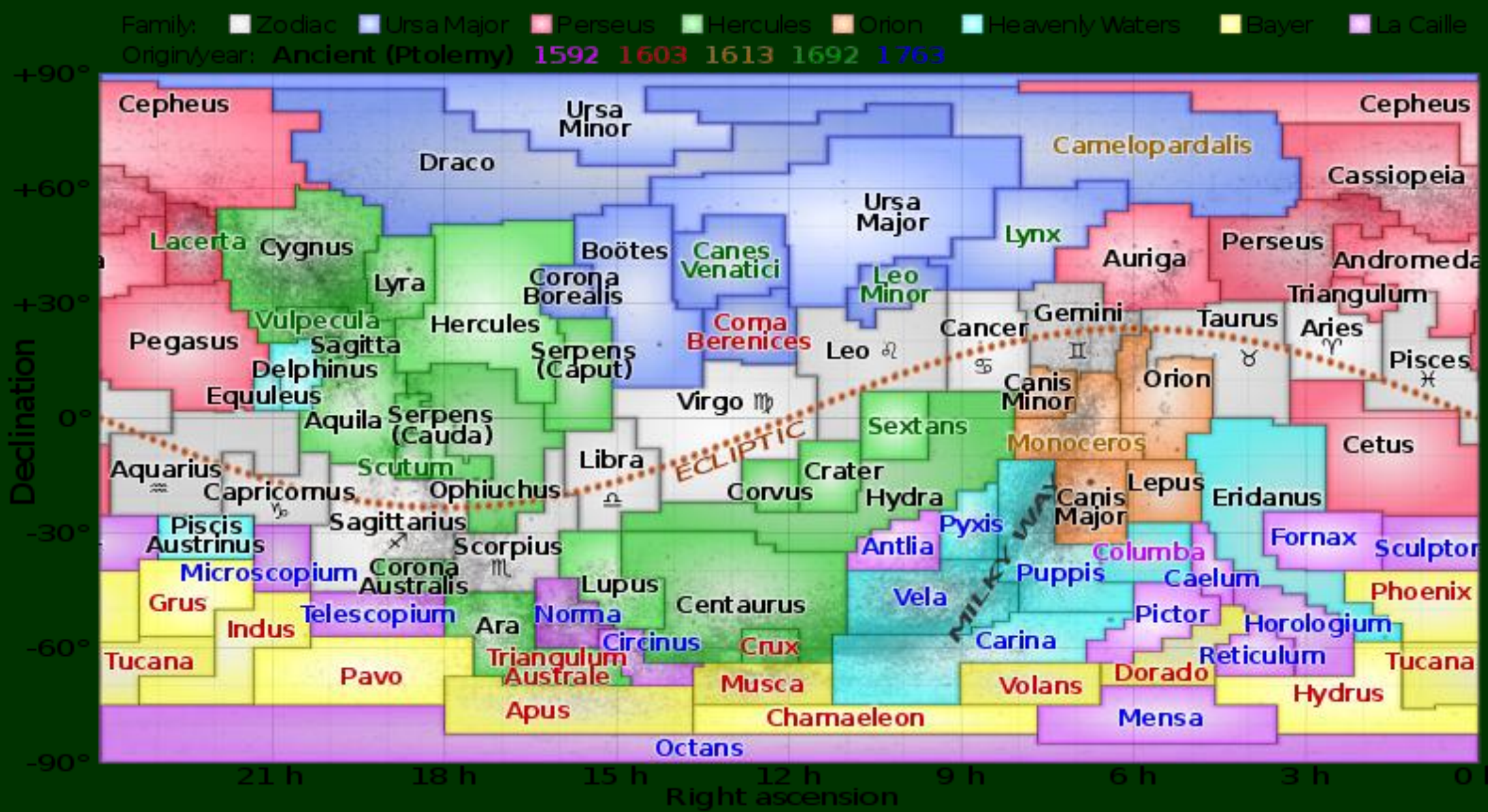
1. Stellar catalogs, constellations and asterism

Zodiac



https://www.astronomytrek.com/star-constellations-the-zodiac/



Credit: NASA

Mgr. Patrík Čechvala, PhD.

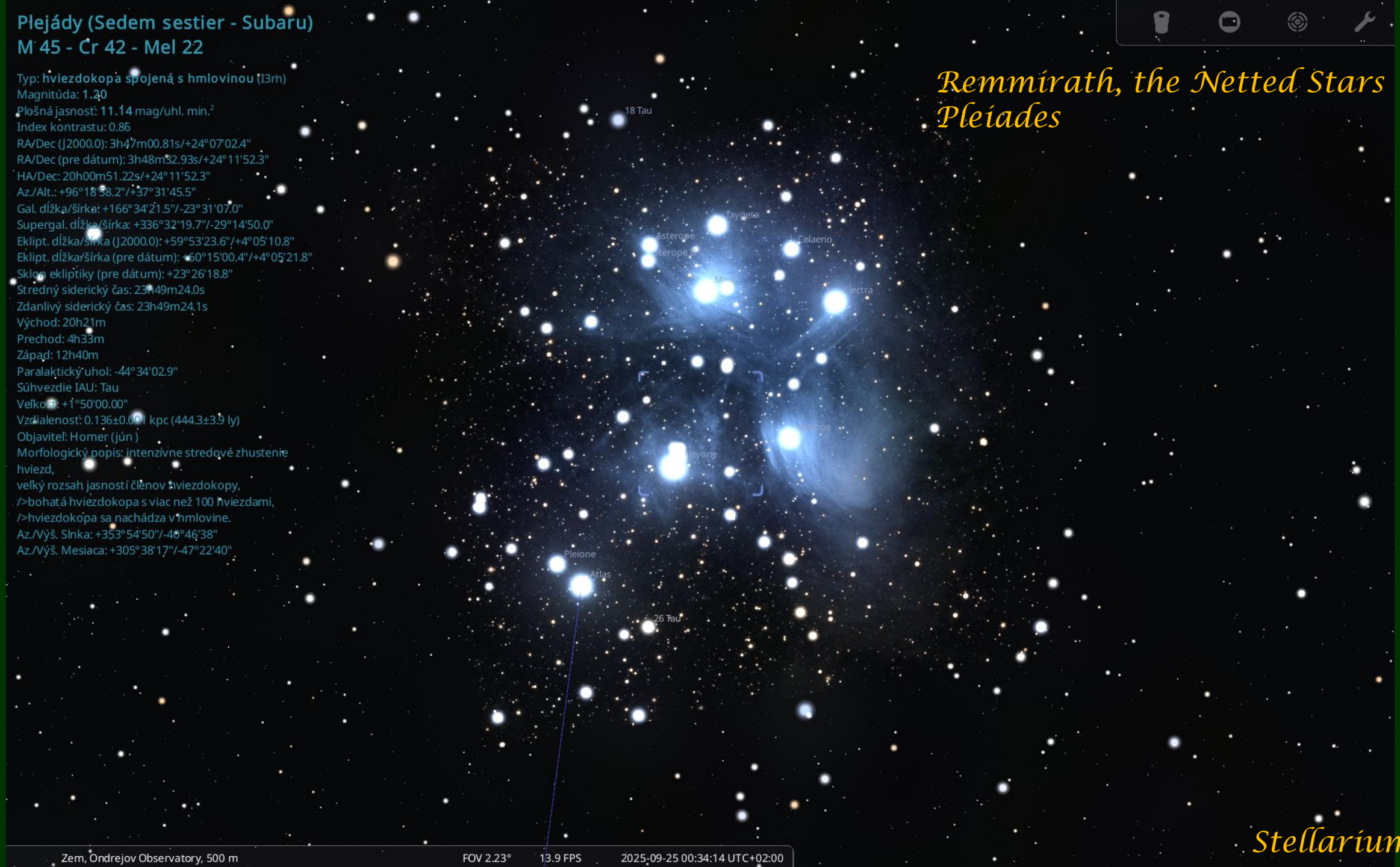
TAS2026

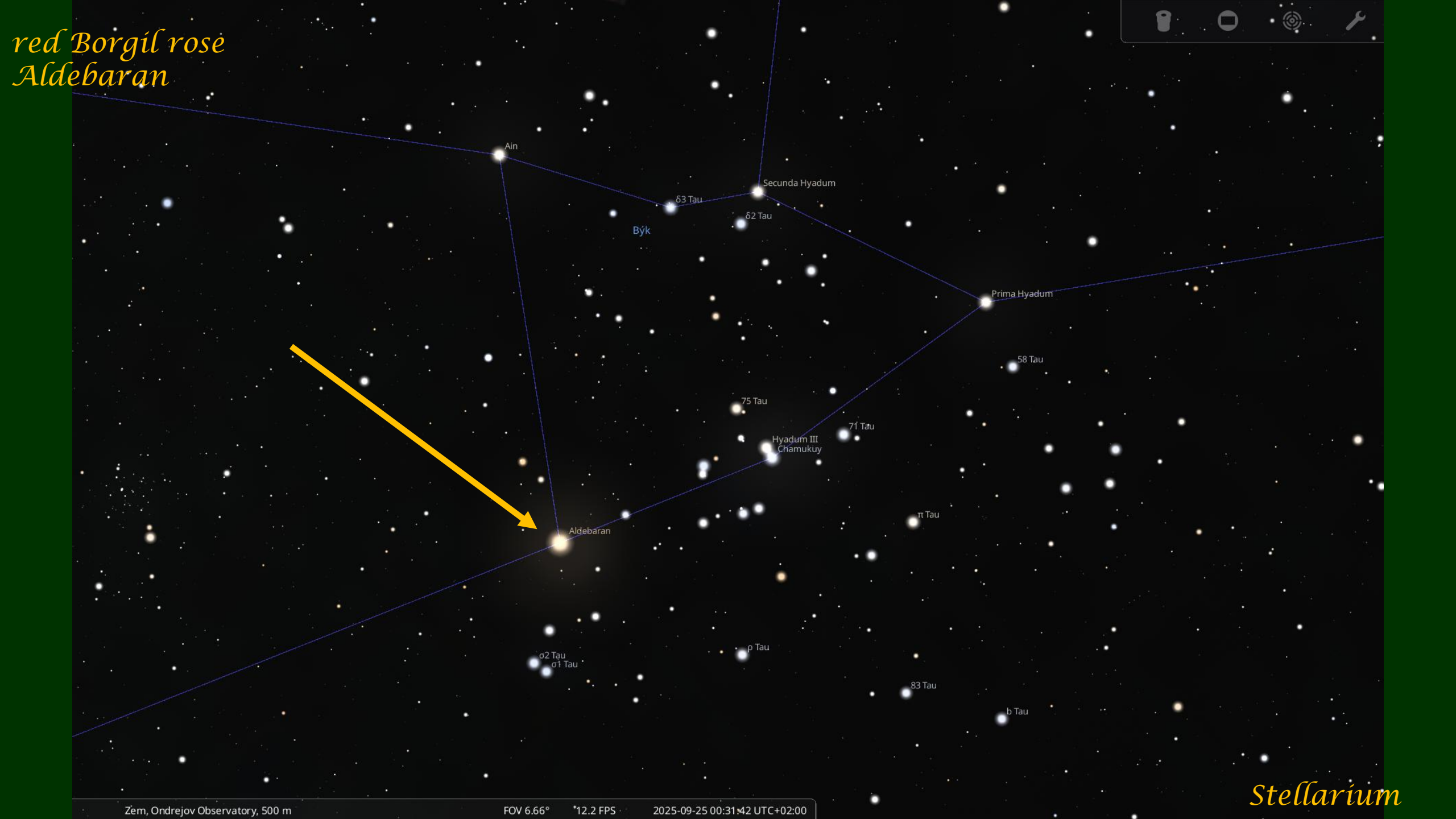
Away high in the East swung Remmirath, the Netted Stars, and slowly above the mists red Borgil rose, glowing like a jewel of fire. Then by some shift of airs all the mist was drawn away like a veil, and there leaned up, as he climbed over the rim of the world, the Swordsman of the Sky, Menelvagor with his shining belt.

- *Late September (24th) and the beginning of October*
- *Possible to see autumn constellations together, winter constellations are beginning to rise over the horizon*


Capella
Menkalinan
Povozník
Urán
Veľryba
Elnath
Býk
Aldebaran
Blíženci
Bellatrix
Orión
Alhena
Betelgeuse
Jupiter
Alnilam
V
JV
Zem, Ondrejov Observatory, 500 m
FOV 55.8°
10.9 FPS
2025-09-25 00:33:20 UTC+02:00
Stellarium




Plejády (Sedem sestier - Subaru)
M 45 - Cr 42 - Mel 22
Typ: hviezdokopa spojená s hmlovinou (I3rn)
Magnitúda: 1.20
Plošná jasnosť: 11.14 mag/uhl. min.²
Index kontrastu: 0.86
RA/Dec (J2000.0): 3h47m00.81s/+24°07'02.4"
RA/Dec (pre dátum): 3h48m32.93s/+24°11'52.3"
HA/Dec: 20h00m51.22s/+24°11'52.3"
Az./Alt.: +96°18'58.2"/+37°31'45.5"
Gal. dĺžka/šírka: +166°34'21.5"/-23°31'07.0"
Supergal. dĺžka/šírka: +336°32'19.7"/-29°14'50.0"
Eklipt. dĺžka/šírka (J2000.0): +59°53'23.6"/+4°05'10.8"
Eklipt. dĺžka/šírka (pre dátum): +60°15'00.4"/+4°05'21.8"
Sklon ekliptiky (pre dátum): +23°26'18.8"
Stredný siderický čas: 23h49m24.0s
Zdanlivý siderický čas: 23h49m24.1s
Východ: 20h21m
Prechod: 4h33m
Západ: 12h40m
Paralaktický uhol: -44°34'02.9"
Súhvezdie IAU: Tau
Veľkosť: +1°50'00.00"
Vzdialenosť: 0.136±0.001 kpc (444.3±3.9 ly)
Objaviteľ: Homer (jún)
Morfologický popis: intenzívne stredové zhustenie hviezd,
veľký rozsah jasností členov hviezdokopy,
/>bohatá hviezdokopa s viac než 100 hviezdami,
/>hviezdokopa sa nachádza v hmlovine.
Az./Výš. Slnka: +353°54'50"/-40°46'38"
Az./Výš. Mesiaca: +305°38'17"/-47°22'40"
Remmirath, the Netted Stars
Pleiades
18 Tau
Taygeta
Asterope
Celaeno
Merope
Electra
Pleione
Atlas
26 Tau
Zem, Ondrejov Observatory, 500 m
FOV 2.23°
13.9 FPS
2025-09-25 00:34:14 UTC+02:00
Stellarium


red Borgil rosé
Aldebaran
Ain
Secunda Hyadum
δ3 Tau
δ2 Tau
Býk
Prima Hyadum
58 Tau
75 Tau
71 Tau
Hyadum III
Chamukuy
π Tau
Aldebaran
ρ Tau
σ2 Tau
σ1 Tau
83 Tau
b Tau
Zem, Ondrejov Observatory, 500 m
FOV 6.66°
12.2 FPS
2025-09-25 00:31:42 UTC+02:00
Stellarium

the Swordsman of the Sky, Menelvagor with his shining belt
Orion and Orion´s belt – Alnilam, Alnitak, Mintaka



Stellarium

1. Stellar catalogs, constellations and asterism

'Stay here, and do not go to your rooms! They are sure to have found out which those are. The hobbit-rooms have windows looking north and close to the ground. We will all remain together and bar this window and the door. But first Nob and I will fetch your luggage.'

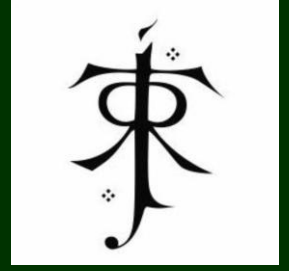
Their bags and gear they piled on the parlour-floor. They pushed a low chair against the door and shut the window. Peering out, Frodo saw that the night was still clear. The Sickle was swinging bright above the shoulders of Bree-hill. He then closed and barred the heavy inside shutters and drew the curtains together. Strider built up the fire and blew out all the candles.*

** The Hobbits' name for the Plough or Great Bear.*

(The Fellowship of the Ring, Book 1, Chapter X, Strider)


Drak
Malý medveď
Capella
Povozník
Elnath
Rys
Veľká medvedica
Alioth
Blíženci
Pollux
Jupiter
Malý pes
Malý Lev
Rak
S
SV
V
Zem, Ondrejov Observatory, 500 m
FOV 73.3°
10.5 FPS
2025-09-25 01:56:04 UTC+02:00
Stellarium

2. Stellar scintillation



„The thin crescent of the Moon had fallen early into the pale sunset, but the sky was clear above, and though far away in the South there were great ranges of cloud that still shone faintly, in the West stars glinted bright."

(The Fellowship of the Ring, Book 2, Chapter IX, The Great River)

Then he was filled with a red wrath and shouted aloud, and displaying his standard, black serpent upon scarlet, he came against the white horse and the green with great press of men; and the drawing of the scimitars of the Southrons was like a glitter of stars. Then The´oden was aware of him, and would not wait for his onset, but crying to Snowmane he charged headlong to greet him.

(The Return of the King, Book 5, Chapter VI, The Battle of the Pelennor Fields)

2. Stellar scintillation





Bob King, Sky & Telescope

3. Spherical shape of the Earth

„Aragorn smiled at him; then he turned to Boromir again. 'For my part I forgive your doubt,' he said. 'Little do I resemble the figures of Elendil and Isildur as they stand carven in their majesty in the halls of Denethor. I am but the heir of Isildur, not Isildur himself. I have had a hard life and a long; and the leagues that lie between here and Gondor are a small part in the count of my journeys. I have crossed many mountains and many rivers, and trodden many plains, even into the far countries of Rhuˆn and Harad where the stars are strange.“

(The Fellowship of the Ring, Book 2, Chapter II, The Council of ELrond)

3. Spherical shape of the Earth



Credit: Apollo 17, NASA

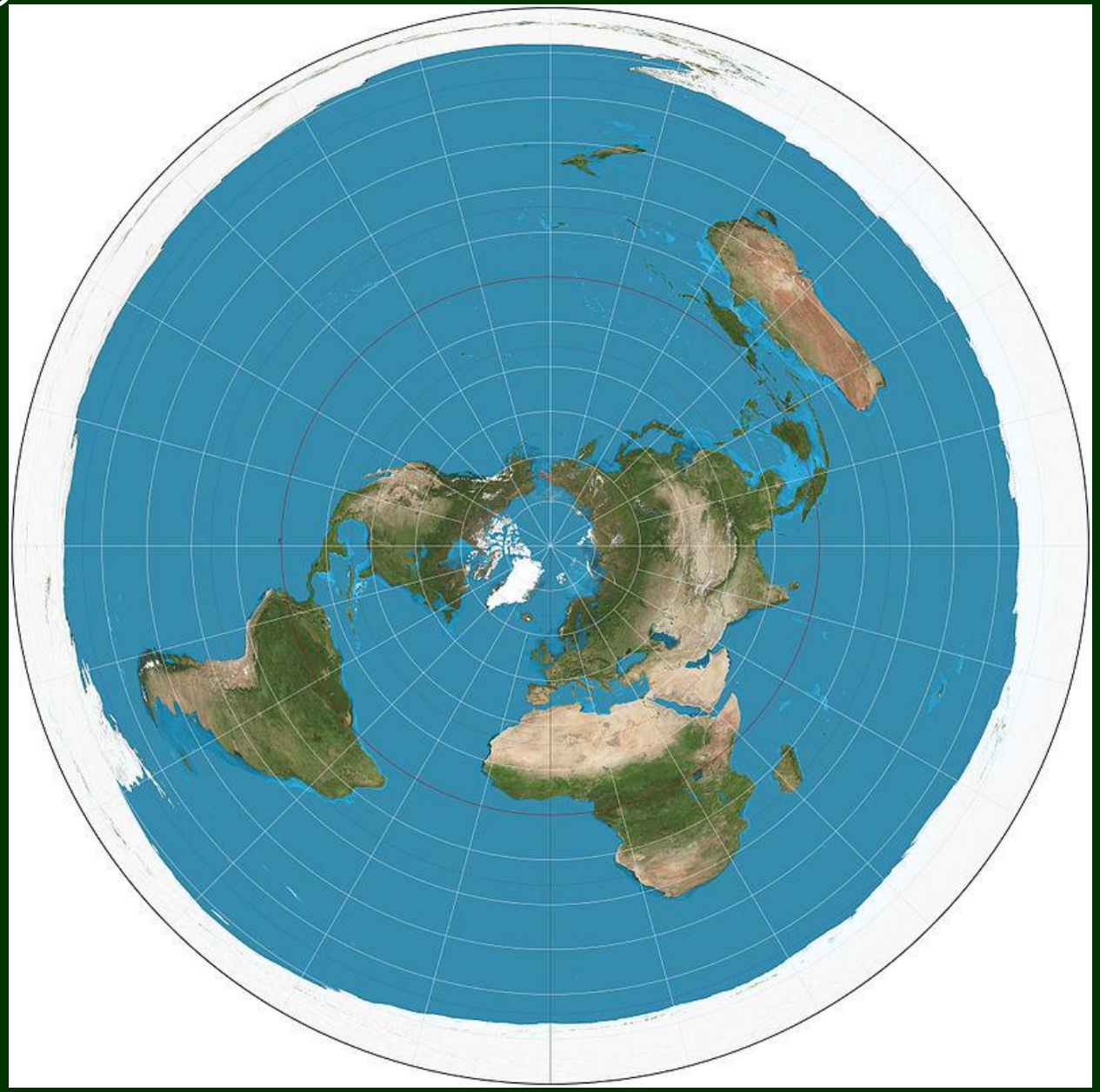
Mgr. Patrík Čechvala, PhD.

3. Spherical shape of the Earth



Source: https://reactormag.com/tolkiens-map-and-the-perplexing-river-systems-of-middle-earth/

3. Spherical shape of the Earth



https://en.wikipedia.org/wiki/Azimuthal_equidistant_projection


Jastrica
Trojuholník
Labuť
Deneb
Kasiopeja
Lýra
Vega
Cefeus
Perzeus
Ekliptika pre 12000,0
Býk
Aldebaran
Žirafa
Herkules
Drak
Malý medveď
ô-Aurigidy
Capella
Povozník
Severná koruna
Veľká medvedica
Rys
Blíženci
Sever
Zem, Bratislava, 157m
FOV 97.2°
25 FPS
2018-09-23 23:53:14 UTC+02:00
Stellarium


Labuť
Deneb
Trojuholník
Ekliptika pre J2000,0
Lýra
Vega
Kasiopeja
Cefeus
Perzeus
18h
4h
Žirafa
Býk
Aldebaran
Herkules
Drak
17h
Malý medveď
δ-Aurigidy
Capella
5h
Povozník
+10°
Severná koruna
Veľká medvedica
Rys
Blížen
Severné
Sever
Zem, Prague, 202m
FOV 97.2°
13 FPS
2018-09-23 23:54:12 UTC+02:00
Stellarium


Kasiopeja
Cefeus
Lýra
Vega
Perzeus
Ekliptika pre J2000.0
18h
4h
Žirafa
Býk
Aldeb
δ-Aurigidy
Capella
Drak
Malý medveď
Herkules
Povozník
5h
17h
Severná koruna
Veľká medvedica
Rys
Blíženci
Pollux
Poľovné psy
Malý lev
+10°
6h
Sever
Zem, Stockholm, 28m
FOV 97.2°
23.4 FPS
2018-09-23
23:55:49 UTC+02:00
Stellarium


Žirafa
Ekliptika pre J2000.0
Dráč
Malý medveď
δ-Aurigidy
Capella
Herkules
Povozník
Severná koruna
Veľká medvedica
Rys
Blíženci
Pollux
Pastier
Poľovné psy
Malý lev
Arcturus
Vlasy Bereniky
Rak
Lev
Sever
Zem, Longyearbyen, 1m
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22.6 FPS
2018-09-23
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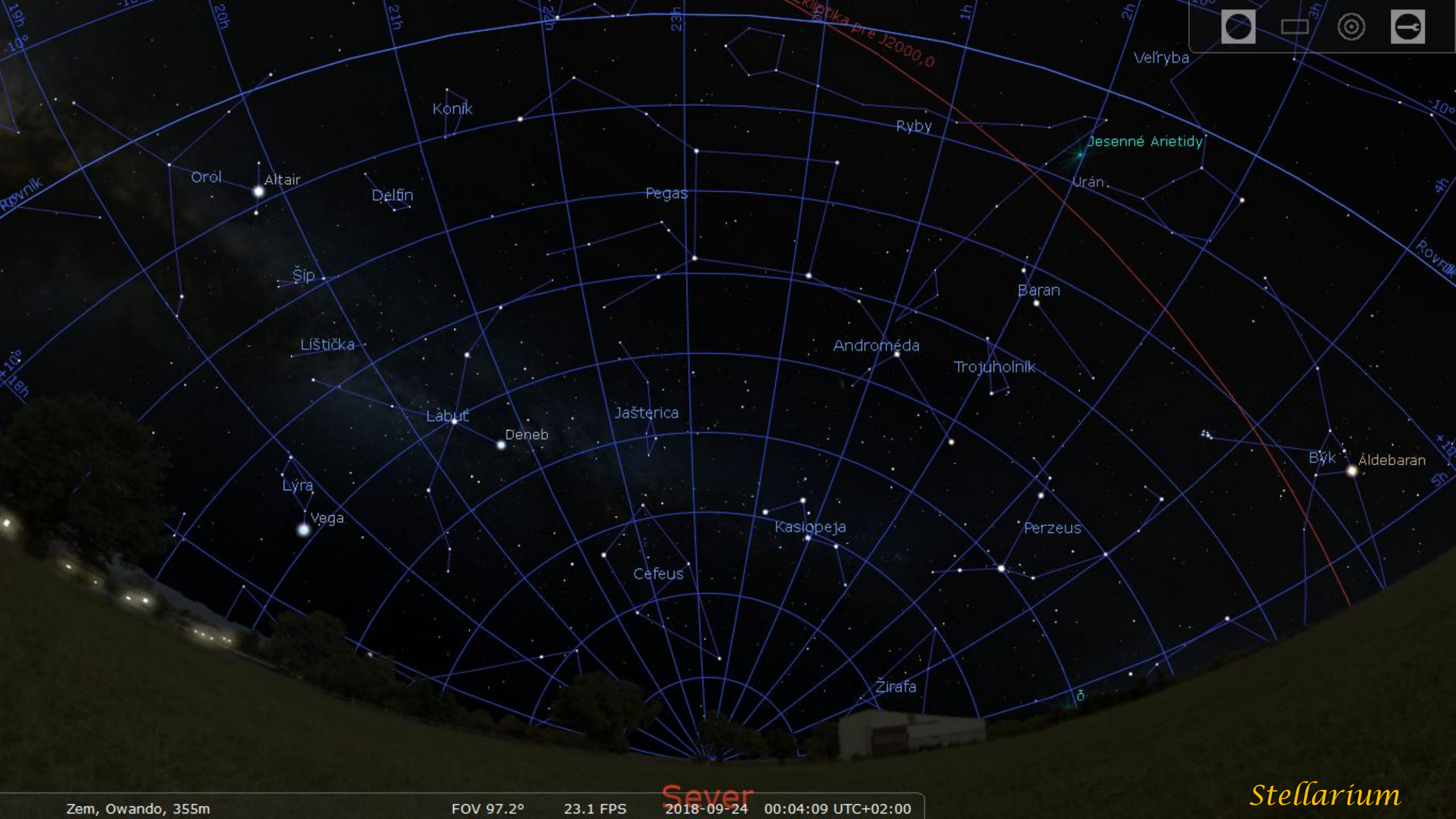
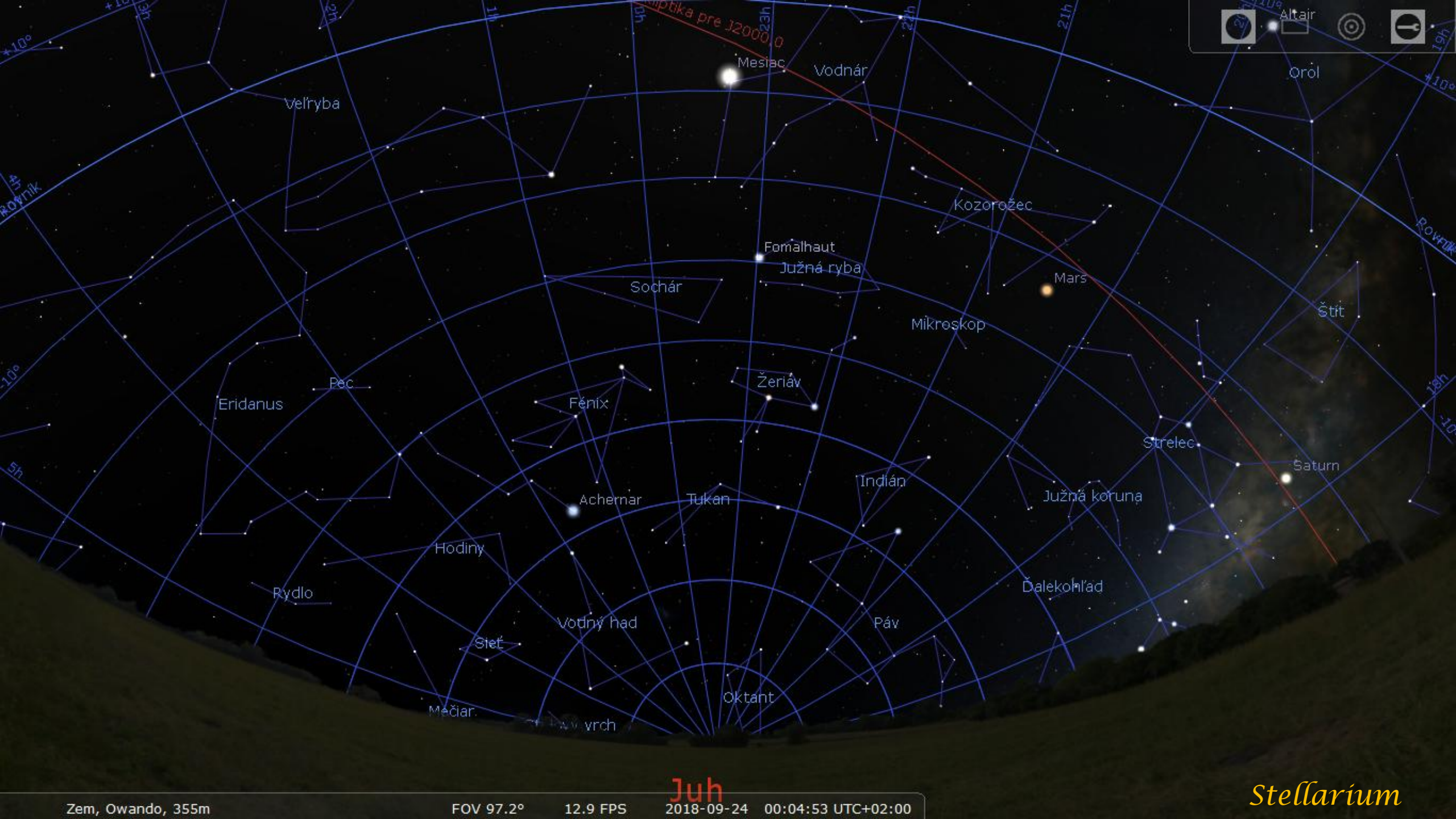
Stellarium


Jastrica
Trojuholník
Labuť
Deneb
Kasiopeja
Lýra
Vega
Cefeus
Perzeus
Byk
Aldebaran
Žirafa
Herkules
Drak
Malý medveď
δ-Aurigidy
Capella
Povozník
Severná koruna
Veľká medvedica
Rys
Ekliptika pre 12000,0
19h
20h
21h
22h
23h
0h
1h
4h
5h
17h
18h
+20°
+30°
+40°
+10°
Sever
Zem, Bratislava, 157m
FOV 97.2°
25 FPS
2018-09-23 23:53:14 UTC+02:00
Stellarium

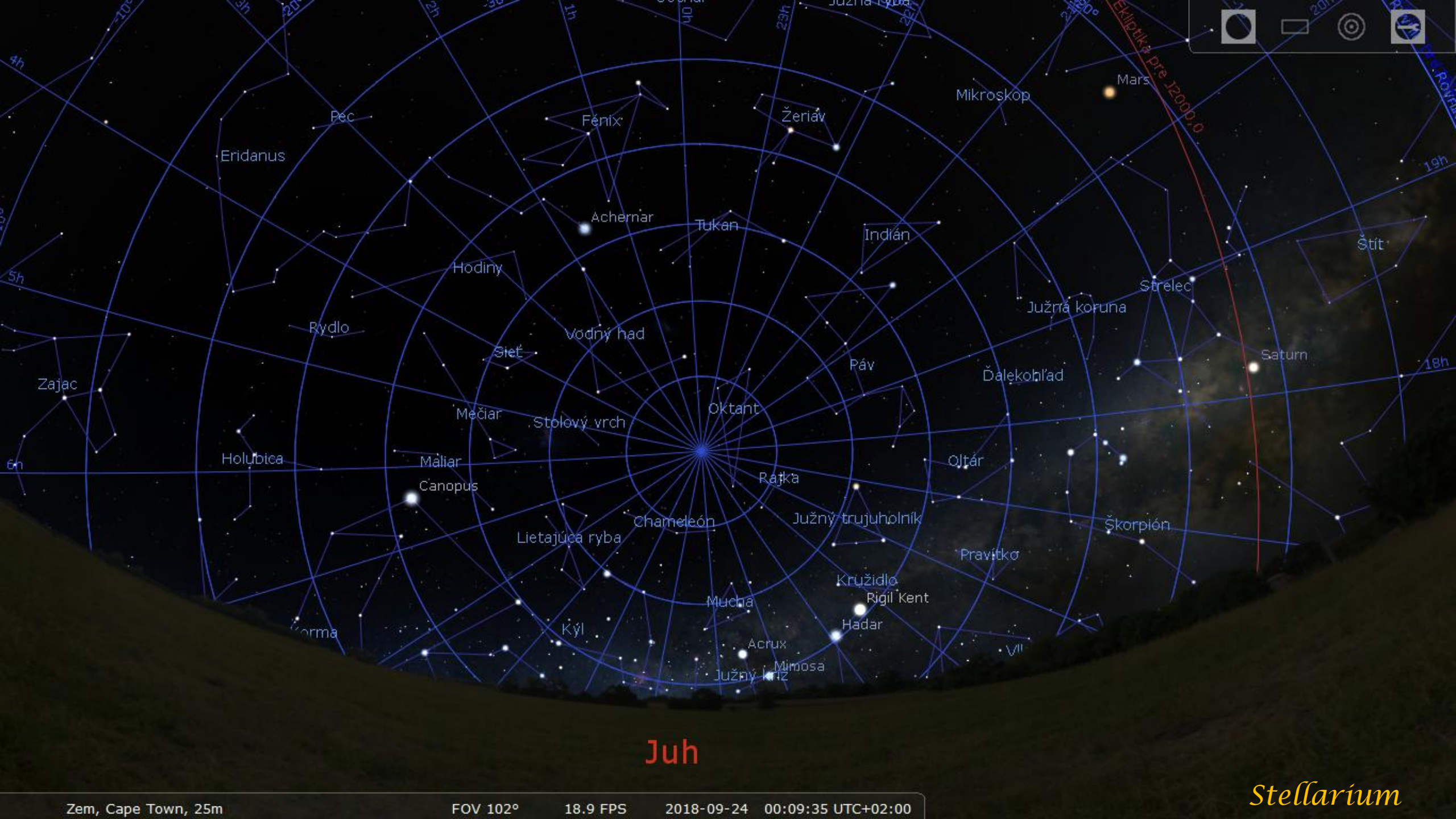

Líštička
Jašterica
Trojuholník
Labuť
Deneb
Kasiopeja
Lýra
Vega
Cefeus
Perzeus
Býk
Aldebaran
Žirafa
δ-Aurigidy
Capella
Povozník
Herkules
Drak
Malý medveď
Veľká medvedica
Rys
Ekliptika pre J2000,0
Sever
Zem, Dubrovnik, 52m
FOV 97.2°
23.8 FPS
2018-09-24
00:00:06 UTC+02:00
Stellarium


Orol
Altair
Delfín
Pegas
Ryby
Jesenné Ariesidy
Urán
Šíp
Baran
Líštička
Androméda
Trojuholník
Labuť
Deneb
Jašterica
Lýra
Vega
Kasiopeja
Perzeus
Býk
Aldebaran
Cefeus
Herkules
Žirafa
ô-Aurigidy
Capella
Povozník
Drak
Malý medveď
Sever
Zem, Mao, 339m
FOV 97.2°
24.1 FPS
2018-09-24
00:01:23 UTC+02:00
Stellarium


Ekliptika pre J2000,0
Veľryba
Koník
Ryby
Jesenné Arietidy
Orol
Altair
Delfín
Pegas
Urán
Rovník
Šíp
Baran
Lištička
Andromeda
Trojuholník
Jašterica
Labuť
Deneb
Býk
Aldebaran
Lýra
Vega
Kasiopeja
Perzeus
Cefeus
Žirafa
Sever
Zem, Owando, 355m
FOV 97.2°
23.1 FPS
2018-09-24
00:04:09 UTC+02:00
Stellarium



Zem, Owando, 355m FOV 97.2° 12.9 FPS 2018-09-24 00:04:53 UTC+02:00


Mars
Mikroskop
Pec
Fénix
Žeriav
Eridanus
Achernar
Tukan
Indián
Štít
Hodiny
Strelec
Južná koruna
Rydlo
Vodný had
Sieť
Saturn
Páv
Ďalekohľad
Zajac
Oktant
Mečiar
Stolový vrch
Holúbica
Maliar
Oltár
Canopus
Rajka
Chameleón
Južný trujuholník
Škorpión
Lietajúca ryba
Pravítko
Kružidlo
Rigil Kent
Mucha
Hadar
Kýl
Acrux
Mimosa
Južný kríž
Juh
Zem, Cape Town, 25m
FOV 102°
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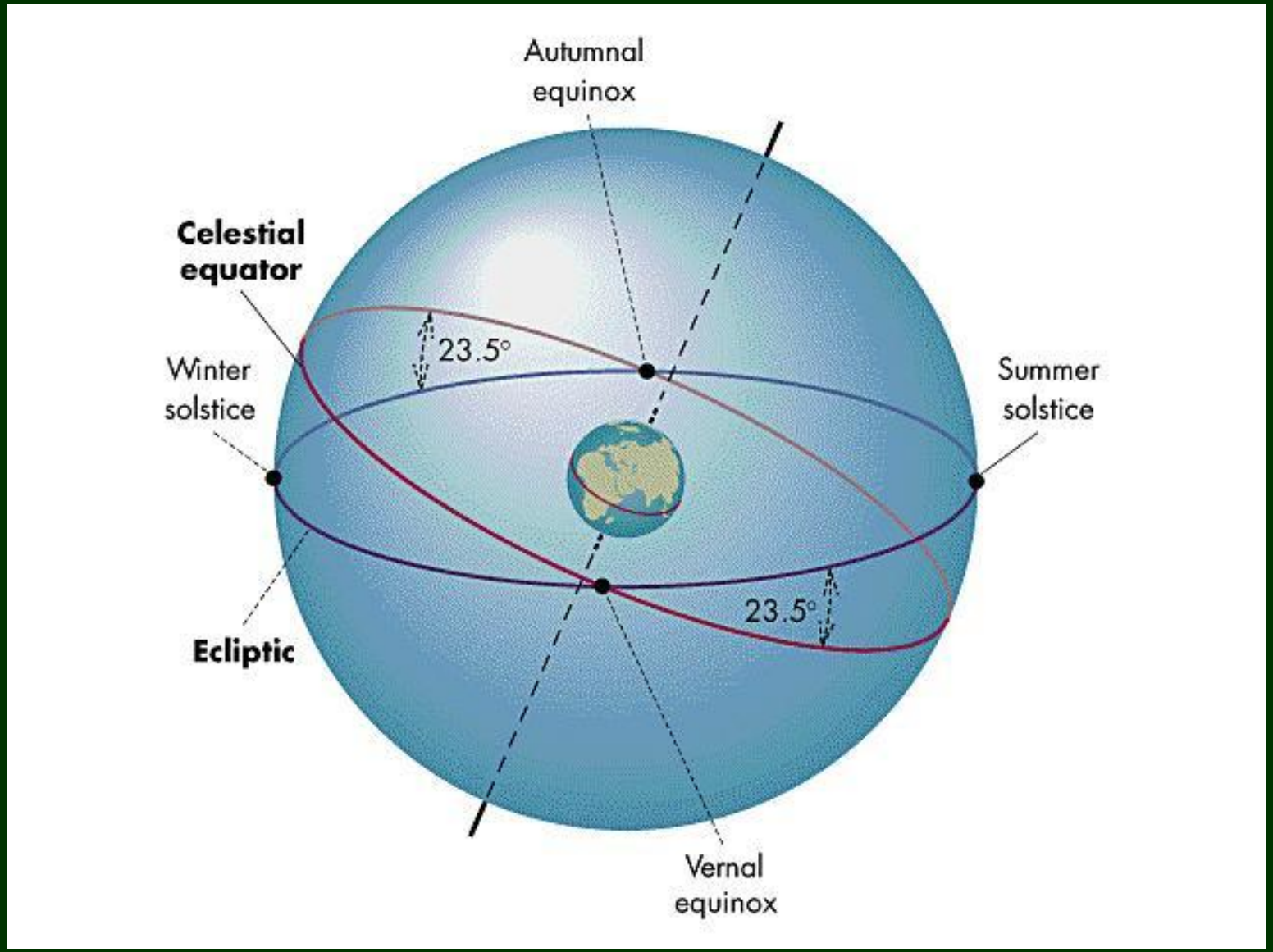
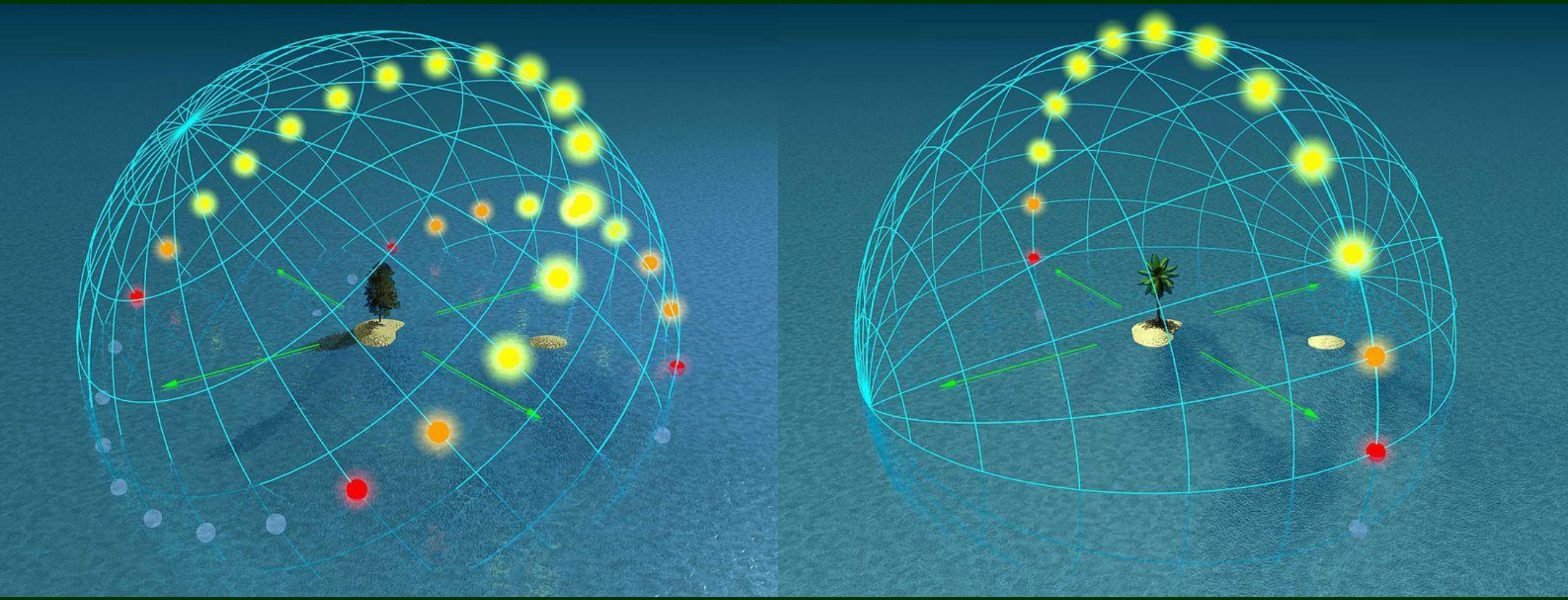
2018-09-24 00:09:35 UTC+02:00
Stellarium


Autumnal
equinox
Celestial
equator
23.5°
Winter
solstice
Summer
solstice
23.5°
Ecliptic
Vernal
equinox









21.6.2019
La Laguna, Tenerife

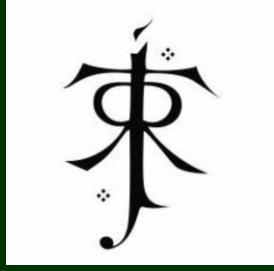
4. Lunar phases

„Sam sat tapping the hilt of his sword as if he were counting on his fingers, and looking up at the sky. 'It's very strange,' he murmured. 'The Moon's the same in the Shire and in Wilderland, or it ought to be. But either it's out of its running, or I'm all wrong in my reckoning. You'll remember, Mr. Frodo, the Moon was waning as we lay on the flet up in that tree: a week from the full, I reckon. And we'd been a week on the way last night, when up pops a New Moon as thin as a nail-paring, as if we had never stayed no time in the Elvish country. 'Well, I can remember three nights there for certain, and I seem to remember several more, but I would take my oath it was never a whole month. Anyone would think that time did not count in there!' 'And perhaps that was the way of it,' said Frodo. 'In that land, maybe, we were in a time that has elsewhere long gone by. It was not, I think, until Silverlode bore us back to Anduin that we returned to the time that flows through mortal lands to the Great Sea. And I don't remember any moon, either new or old, in Caras Galadhon: only stars by night and sun by day.'"

(The Fellowship of the Ring, Book 2, Chapter IX, The Great River)

22nd of February

4. Lunar phases



„Guided by Aragorn they struck a good path. It looked to Frodo like the remains of an ancient road, that had once been broad and well planned, from Hollin to the mountain-pass. The Moon, now at the full, rose over the mountains, and cast a pale light in which the shadows of stones were black. Many of them looked to have been worked by hands, though now they lay tumbled and ruinous in a bleak, barren land.“

(The Fellowship of the Ring, Book 2, Chapter III, The Ring Goes South)

‘This journey is over, maybe,’ said The´oden, ‘but I have far yet to go. Two nights ago the moon was full, and in the morning I shall ride to Edoras to the gathering of the Mark.’ ´ ‘Harrowdale at last!’ said Eomer. ‘Our journey is almost at an ‘But if you would take my counsel,’ said Eomer in a low voice, ‘you would then return hither, until the war is over, lost or won.’ The´oden smiled. ‘Nay, my son, for so I will call you, speak not the soft words of Wormtongue in my old ears!’

(The Return of the King, Book 5, Chapter III, The Muster of Rohan)

The night was old, and westward the waning moon was setting, gleaming fitfully through the breaking clouds. Suddenly Frodo started from sleep. Without warning a storm of howls broke out fierce and wild all about the camp. A great host of Wargs had gathered silently and was now attacking them from every side at once.

(The Fellowship of the Ring, Book 2, Chapter IV, A Journey in the Dark)

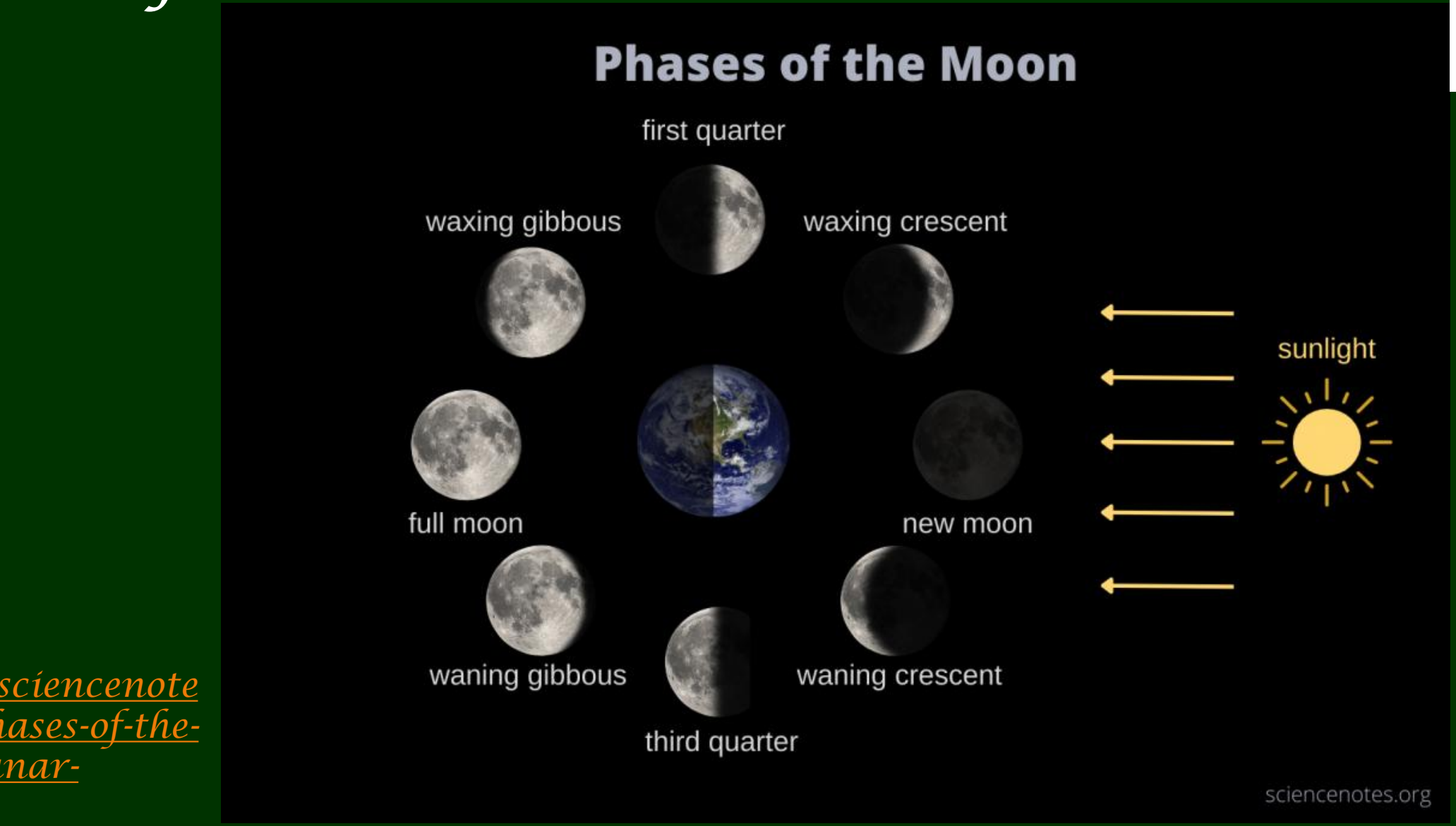
'I have no memory of this place at all!' said Gandalf, standing uncertainly under the arch. He held up his staff in the hope of finding some marks or inscription that might help his choice; but nothing of the kind was to be seen. 'I am too weary to decide,' he said, shaking his head. 'And I expect that you are all as weary as I am, or wearier. We had better halt here for what is left of the night. You know what I mean! In here it is ever dark; but outside the late Moon is riding westward and the middle-night has passed.'

(The Fellowship of the Ring, Book 2, Chapter IV, A Journey in the Dark)

‘Be swift then!’ said Aragorn, looking back towards the Gates. ‘The Sun sinks early. The Orcs will not, maybe, come out till after dusk, but we must be far away before nightfall. The Moon is almost spent, and it will be dark tonight.’

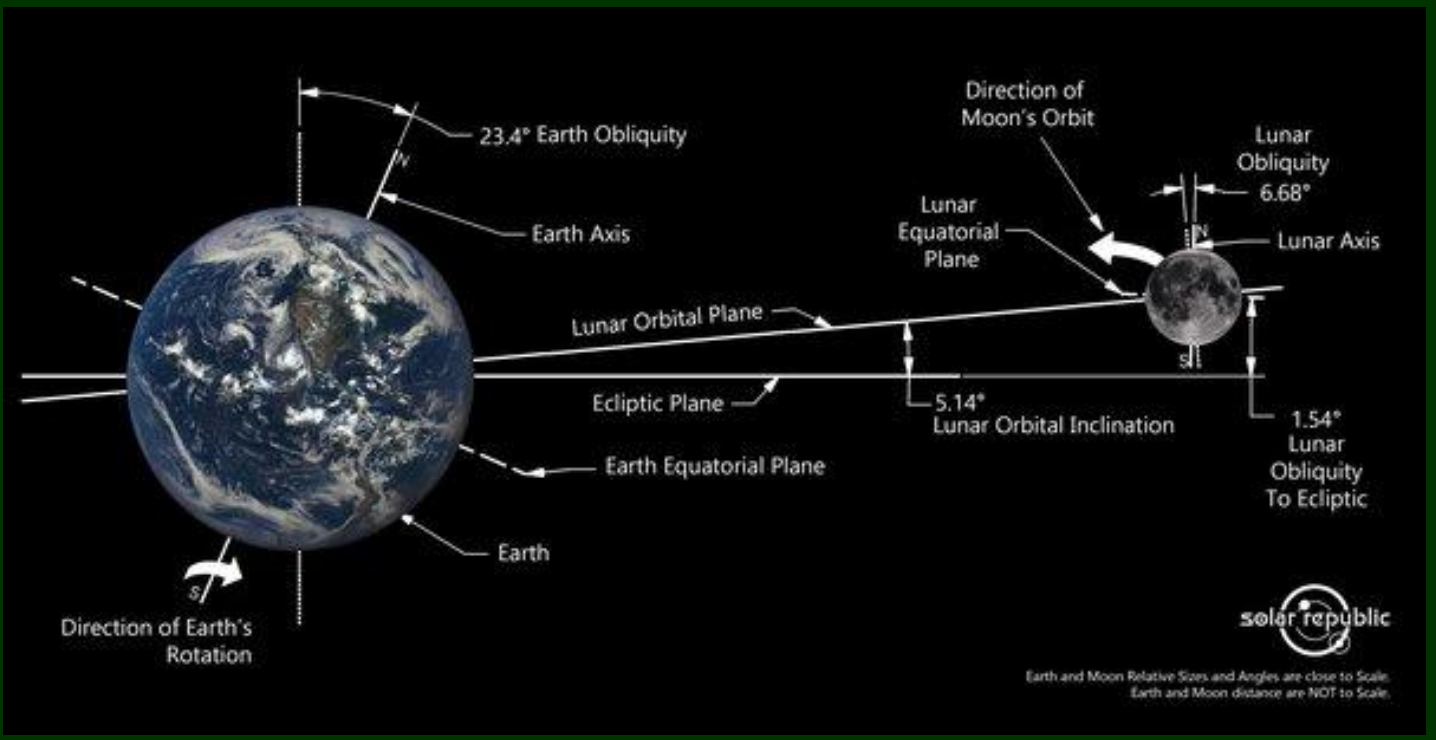
(The Fellowship of the Ring, Book 2, Chapter VI, Lothlórien)

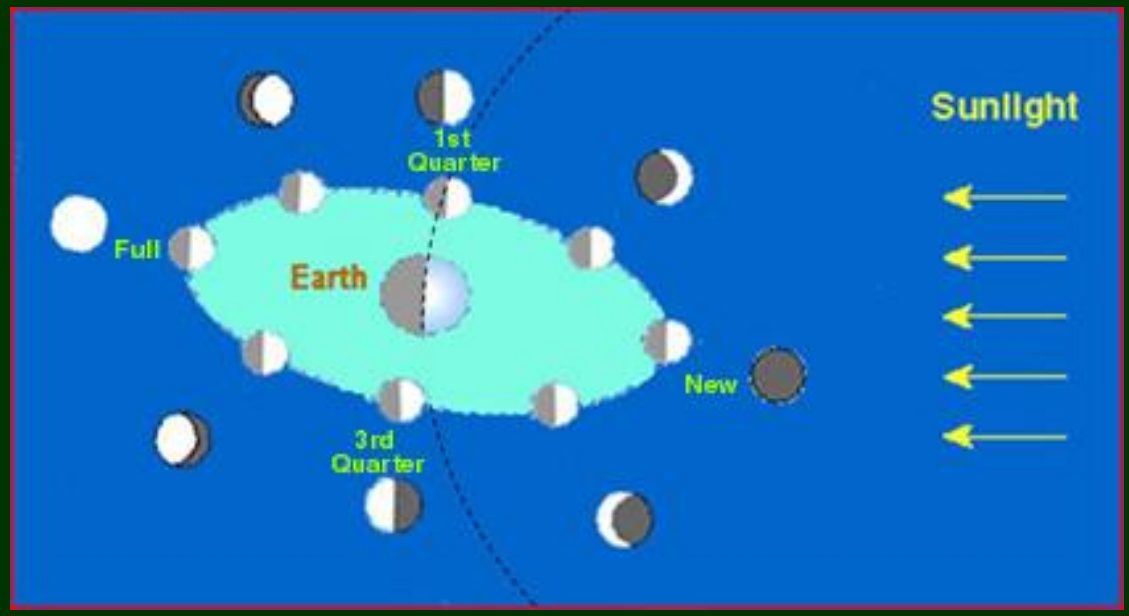
4. Lunar phases



https://sciencenotes.org/phases-of-the-moon-lunar-phases/

4. Lunar phases





https://www.quora.com/Does-our-moon-orbit-the-earth-in-the-same-plane-as-our-other-planets

https://ematusov.soe.udel.edu/science/moon-phases/index.htm

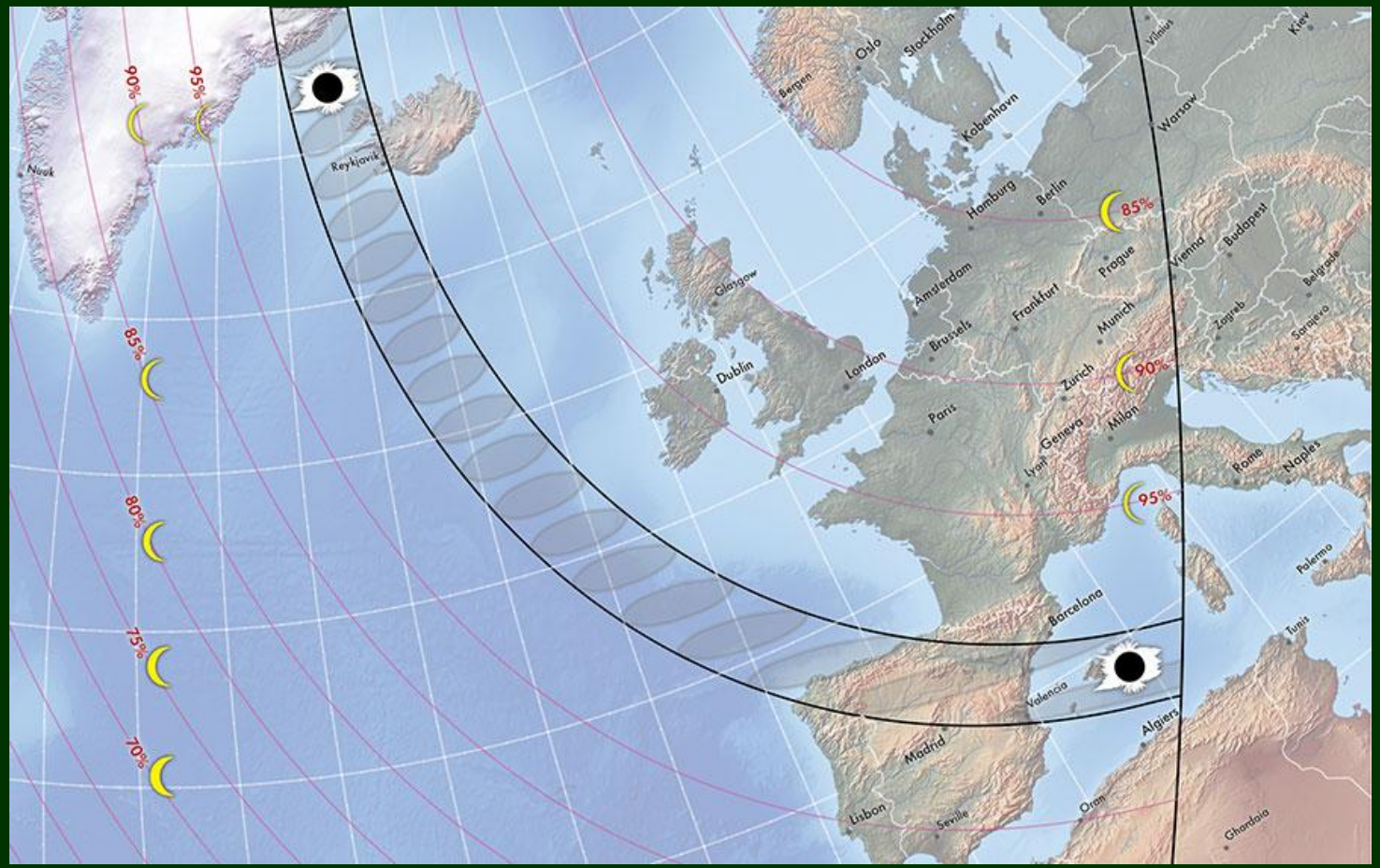
4. Lunar phases

Orbital parameters

Perigee	362600 km (356400–370400 km)
Apogee	405400 km (404000–406700 km)
Semi-major axis	384399 km (1.28 ls, 0.00257 AU)[1]
Eccentricity	0.0549[1]
Orbital period (sidereal)	27.321661 d (27 d 7 h 43 min 11.5 s[1])
Orbital period (synodic)	29.530589 d (29 d 12 h 44 min 2.9 s)

Source: Wikipedia

Total Solar Eclipse 12.08.2026!



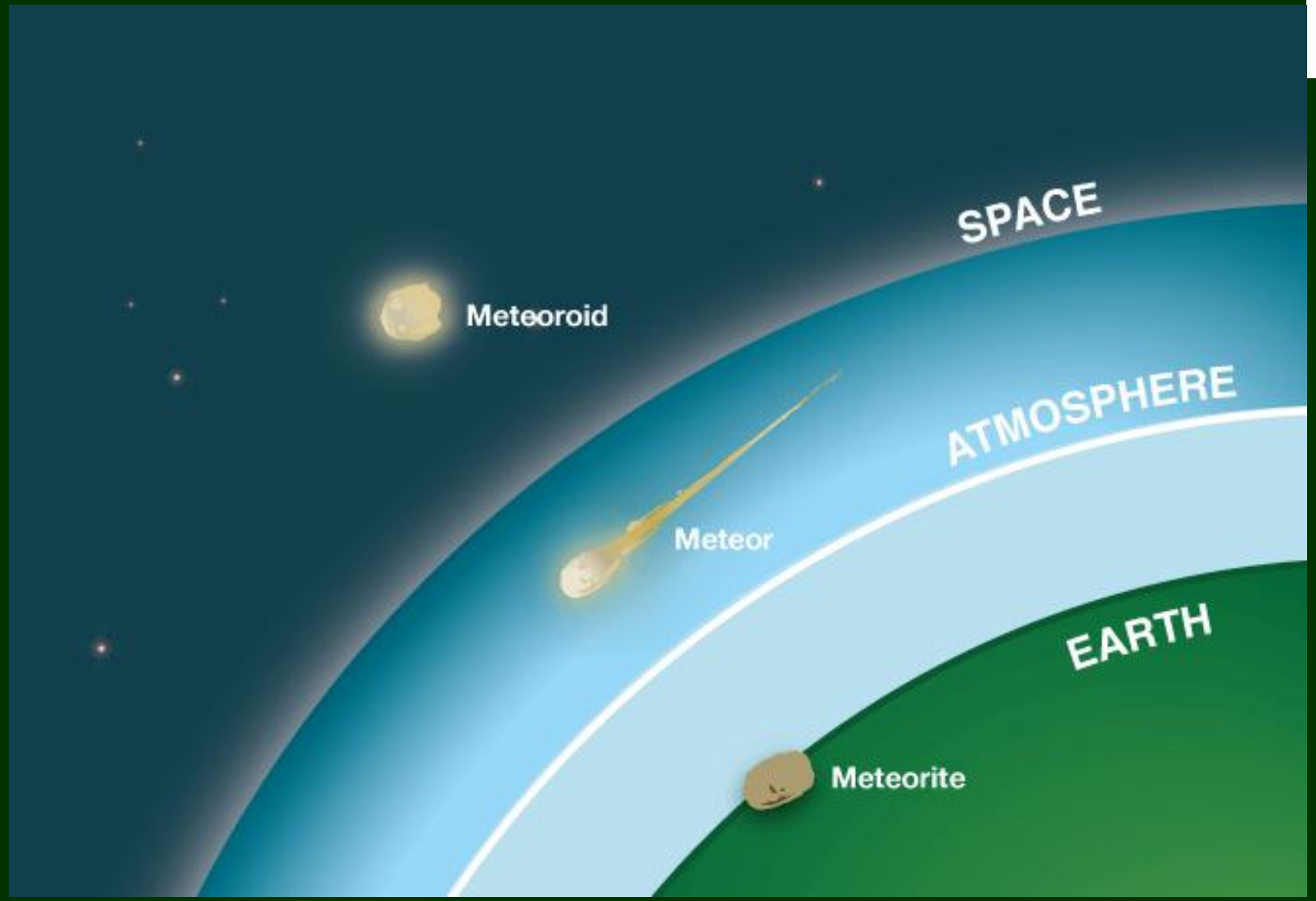
https://skyandtelescope.org/astronomy-news/plan-now-for-the-2026-total-solar-eclipse-in-europe/

5. Meteorite

„Long had the terror of the Dead lain upon that hill and upon the empty fields about it. For upon the top stood a black stone, round as a great globe, the height of a man, though its half was buried in the ground. Unearthly it looked, as though it had fallen from the sky, as some believed; but those who remembered still the lore of Westernesse told that it had been brought out of the ruin of Nu´menor and there set by Isildur at his landing.“

(The Return of the King, Book 5, Chapter II, The Passing of the Grey Company)

5. Meteorite



https://socratic.org/questions/how-are-meteoroids-meteors-and-meteorite-related

5. Meteorite

Košice meteorite (2010)



https://fmph.uniba.sk/microsites/daa/daa/veda-a-vyskum/amos/meteorit-kosice/



(Borovička et al., 2013)

5. Meteorite





Source: AMOS, Geminids, Chile Juraj Tóth

5. Meteorite

Zdroj: https://space.asu.cas.cz/~meteor/bolid/2022_06_25/index.html

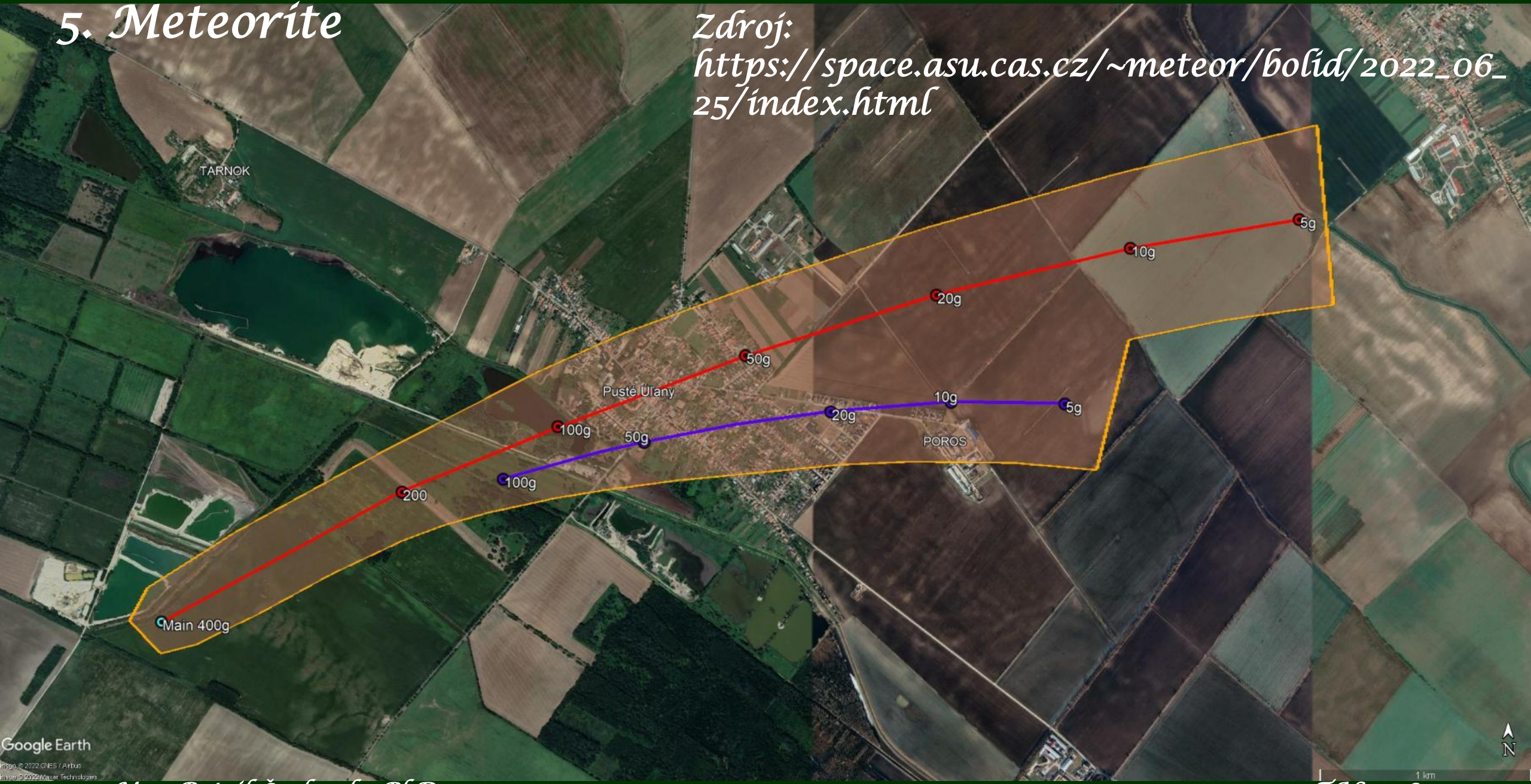




Photo: Stanislav Griguš, 2022



Photo: Stanislav Griguš, 2022



Photo: Stanislav Griguš, 2022

5. Meteorite



Photo: Pavol Matlovič, 2022

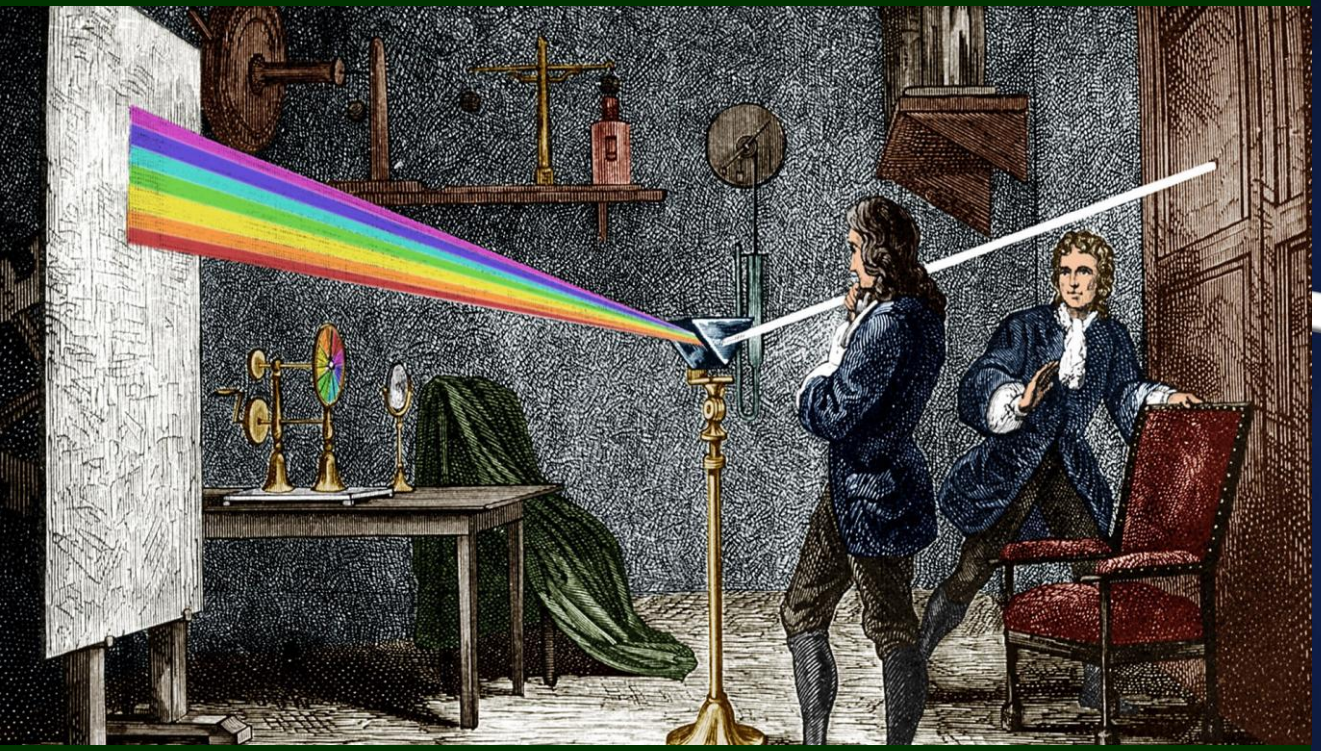
6. Spectroscopy

‘ “Radagast the Brown!” laughed Saruman, and he no longer concealed his scorn. “Radagast the Bird-tamer! Radagast the Simple! Radagast the Fool! Yet he had just the wit to play the part that I set him. For you have come, and that was all the purpose of my message. And here you will stay, Gandalf the Grey, and rest from journeys. For I am Saruman the Wise, Saruman Ring-maker, Saruman of Many Colours!” ‘I looked then and saw that his robes, which had seemed white, were not so, but were woven of all colours, and if he moved they shimmered and changed hue so that the eye was bewildered. ‘ “I liked white better,” I said. ‘ “White!” he sneered. “It serves as a beginning. White cloth may be dyed. The white page can be overwritten; and the white light can be broken.”

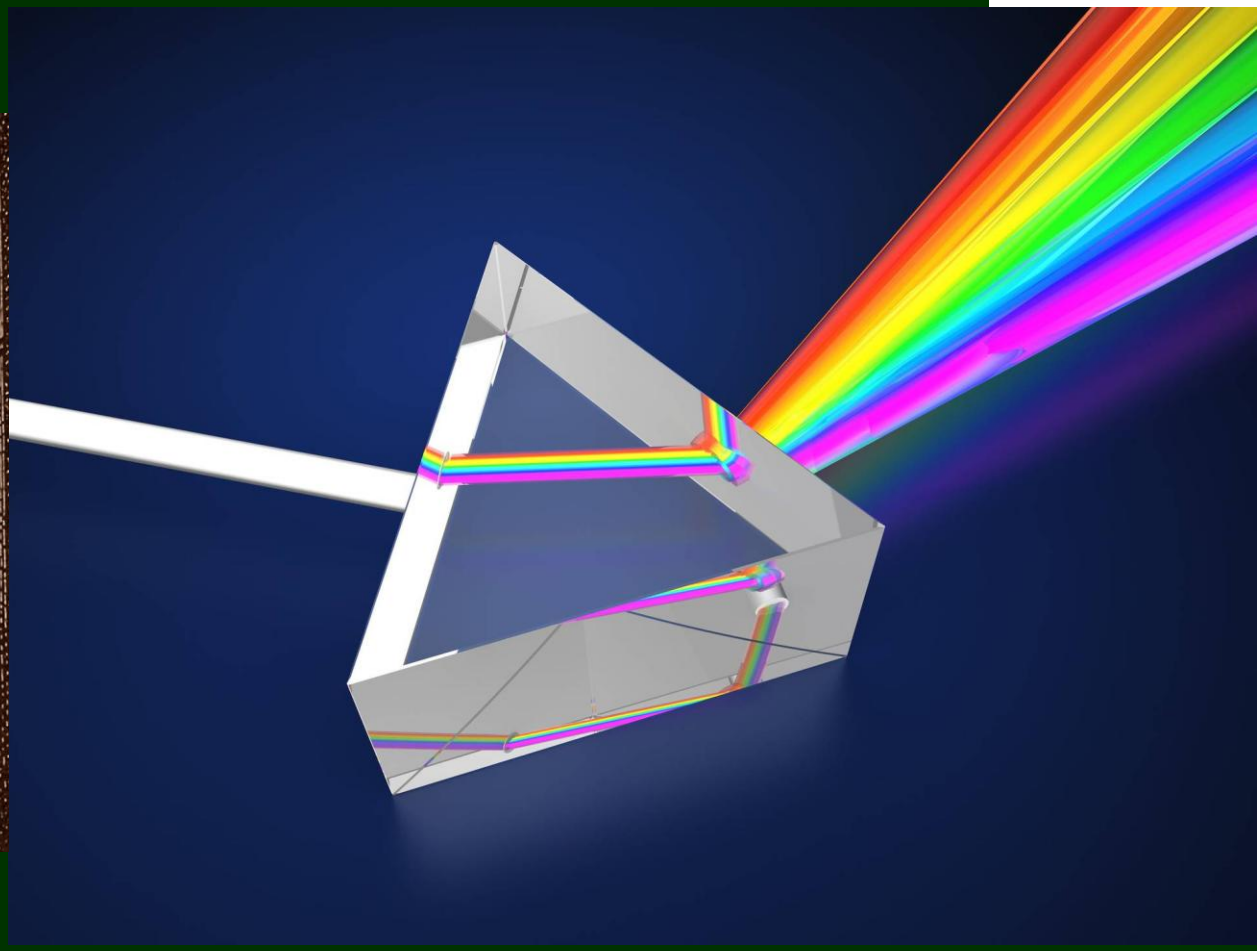
(The Fellowship of the Ring, Book 2, Chapter II, The Council of ELrond)

6. Spectroscopy

https://www.atascientific.com.au/spectrometry/



Credit: Getty Images



6. Spectroscopy

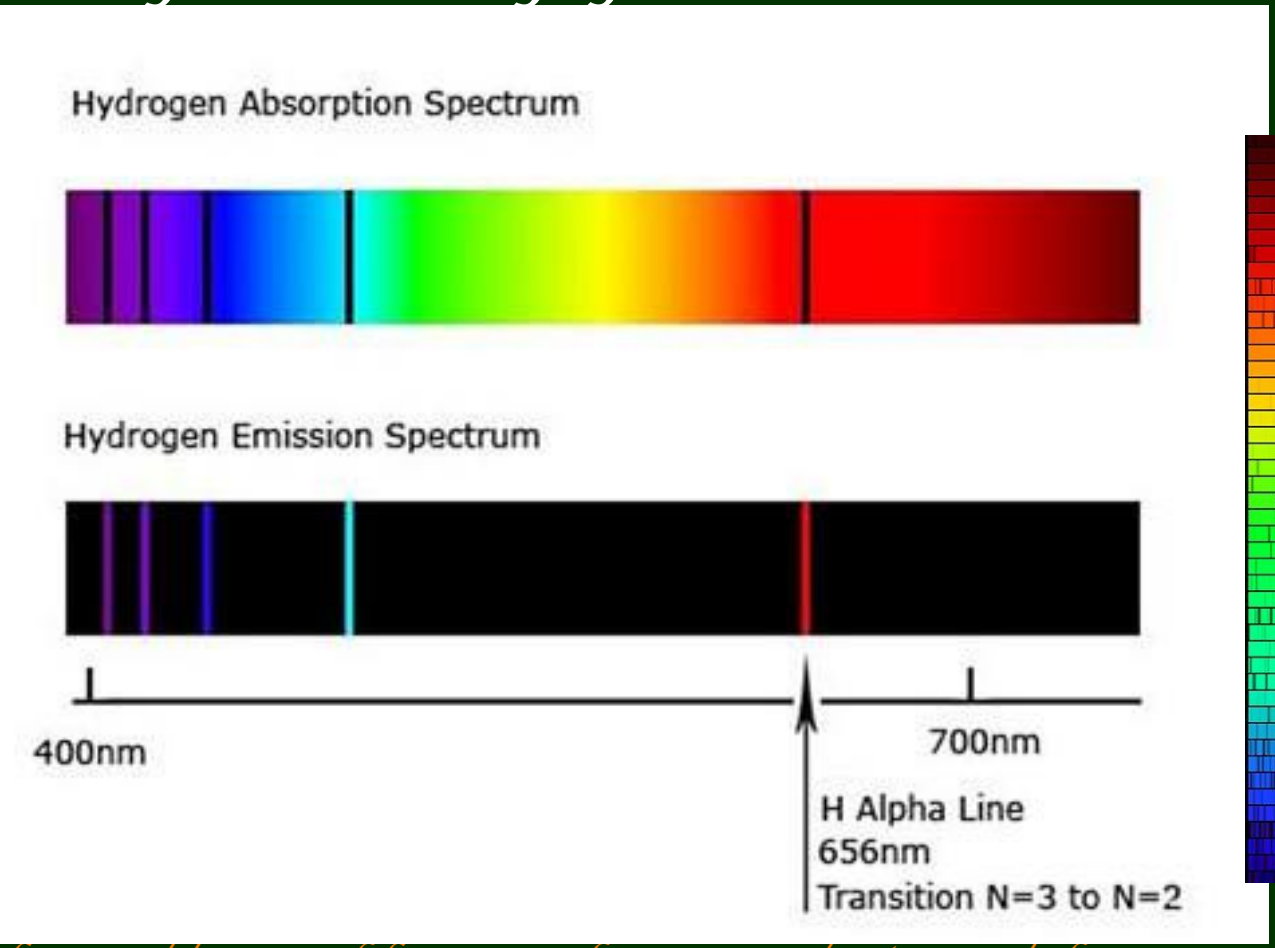
Joseph von Fraunhofer

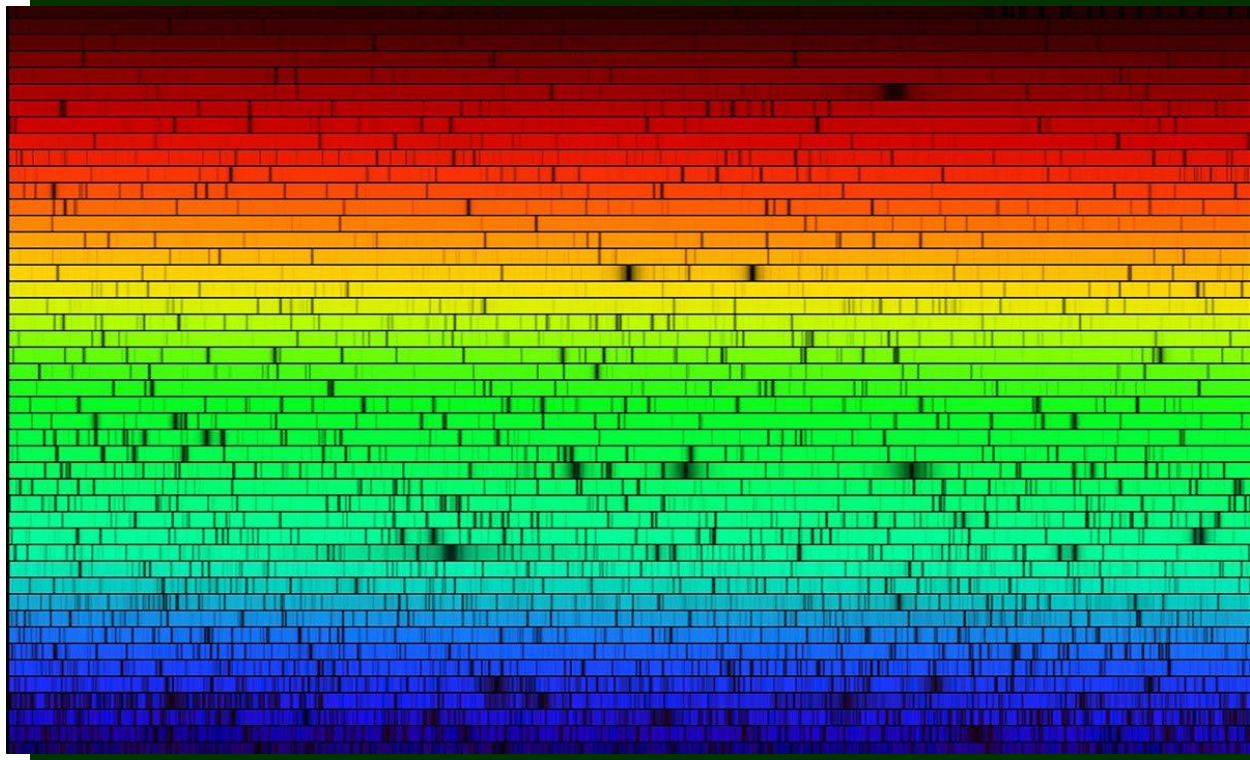
6 March 1787 – 7 June 1826



https://www.vus.sk/apvv-ewf/aktivity/02_Fraunhofer_Short_Presentation_English.pdf

6. Spectroscopy





Credit: N.A.Sharp, NOAO/NSO/Kitt Peak FTS/AURA/NSF

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This work was supported by Slovak Research and Development Agency grant number APVV 18-0103

Thank you very much for your attention
To be continued

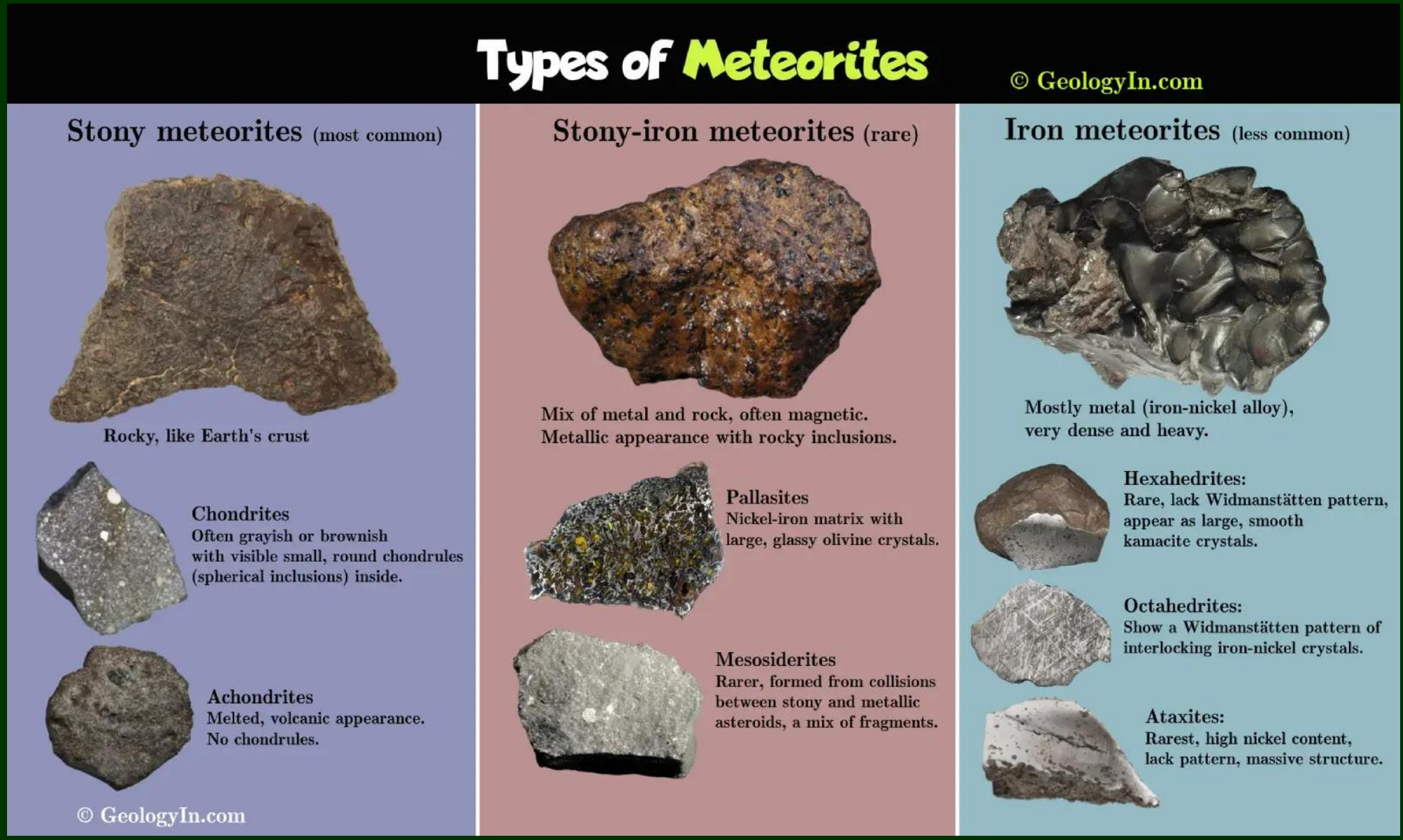
"So do all who live to see such times. But that is not for them to decide. All we have to decide is what to do with the time that is given us."
— J.R.R Tolkien, The Fellowship of the Ring

This work was supported by Slovak Research and Development Agency grant number APVV 18-0103

Turning aside, she led them towards the southern slopes of the hill of Caras Galadhon, and passing through a high green hedge they came into an enclosed garden. No trees grew there, and it lay open to the sky. The evening star had risen and was shining with white fire above the western woods. Down a long flight of steps the Lady went into the deep green hollow, through which ran murmuring the silver stream that issued from the fountain on the hill. At the bottom, upon a low pedestal carved like a branching tree, stood a basin of silver, wide and shallow, and beside it stood a silver ewer.

(The Fellowship of the Ring, Book 2, Chapter VII, The Mirror of Galadriel)

5. Meteorite


Types of Meteorites
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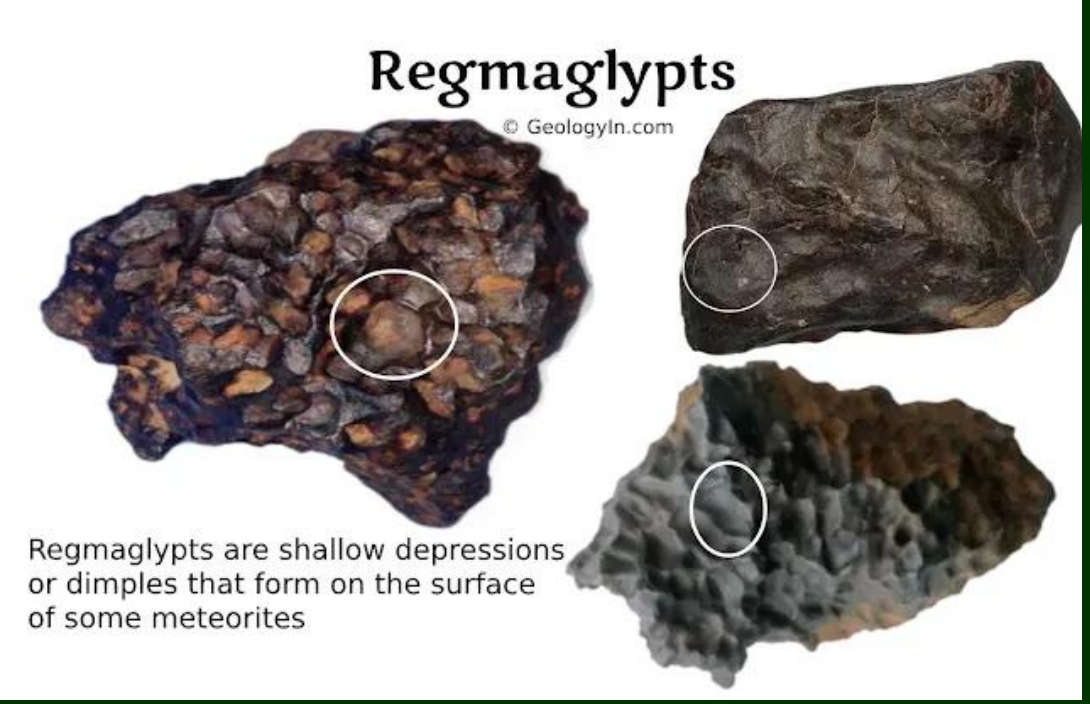
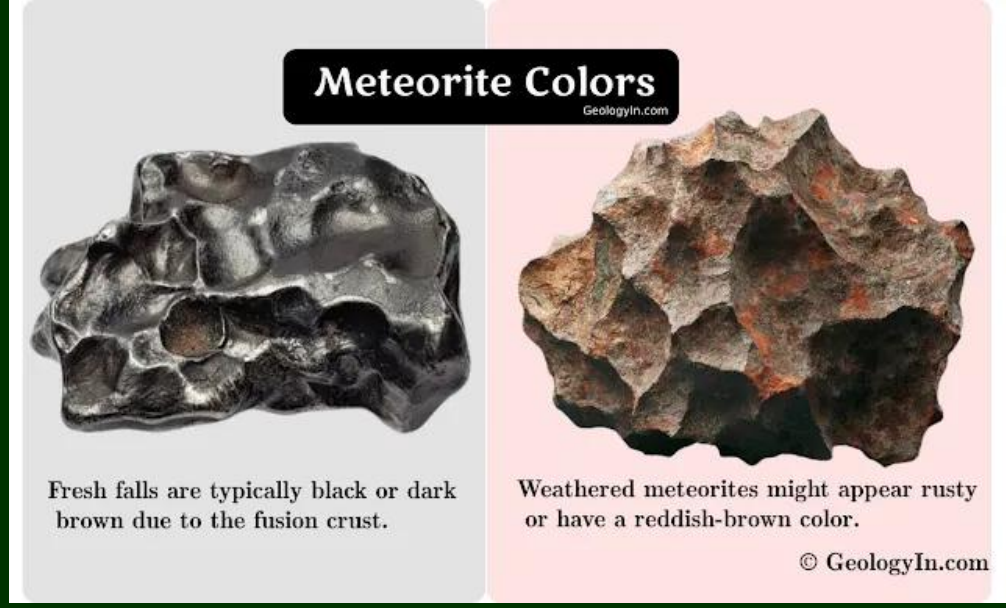
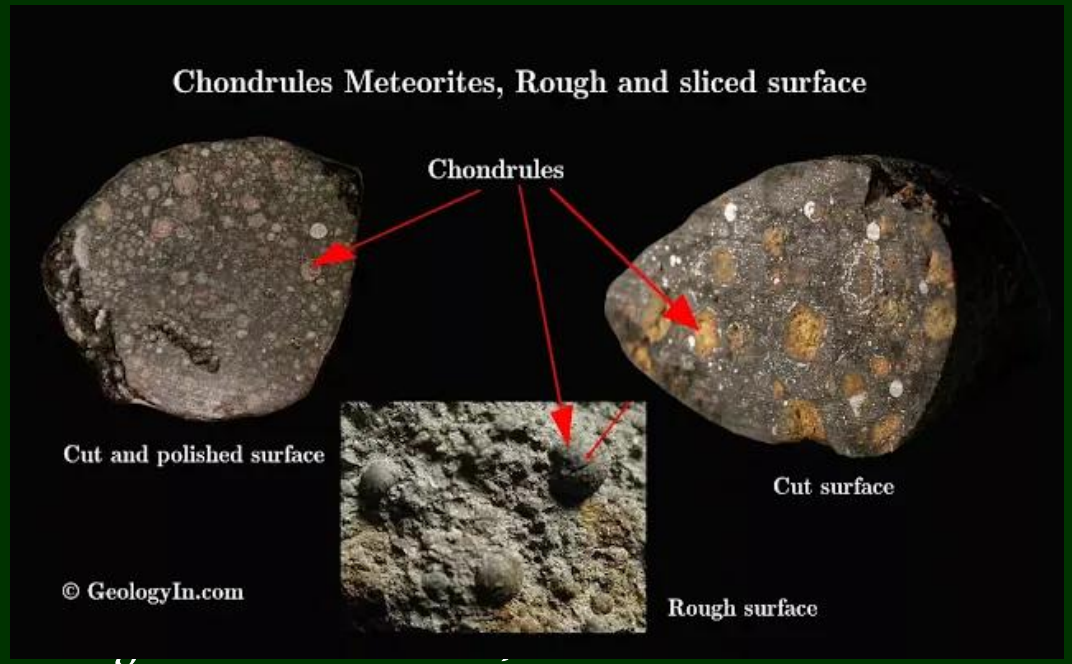
Stony meteorites (most common)
Rocky, like Earth's crust
Chondrites
Often grayish or brownish with visible small, round chondrules (spherical inclusions) inside.
Achondrites
Melted, volcanic appearance. No chondrules.
© GeologyIn.com
Stony-iron meteorites (rare)
Mix of metal and rock, often magnetic. Metallic appearance with rocky inclusions.
Pallasites
Nickel-iron matrix with large, glassy olivine crystals.
Mesosiderites
Rarer, formed from collisions between stony and metallic asteroids, a mix of fragments.
Iron meteorites (less common)
Mostly metal (iron-nickel alloy), very dense and heavy.
Hexahedrites:
Rare, lack Widmanstätten pattern, appear as large, smooth kamacite crystals.
Octahedrites:
Show a Widmanstätten pattern of interlocking iron-nickel crystals.
Ataxites:
Rarest, high nickel content, lack pattern, massive structure.


Regmaglypts
© GeologyIn.com
Regmaglypts are shallow depressions or dimples that form on the surface of some meteorites


Meteorite Colors
GeologyIn.com
Fresh falls are typically black or dark brown due to the fusion crust.
Weathered meteorites might appear rusty or have a reddish-brown color.
© GeologyIn.com


Chondrules Meteorites, Rough and sliced surface
Chondrules
Cut and polished surface
Cut surface
Rough surface
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Widmanstätten Patterns
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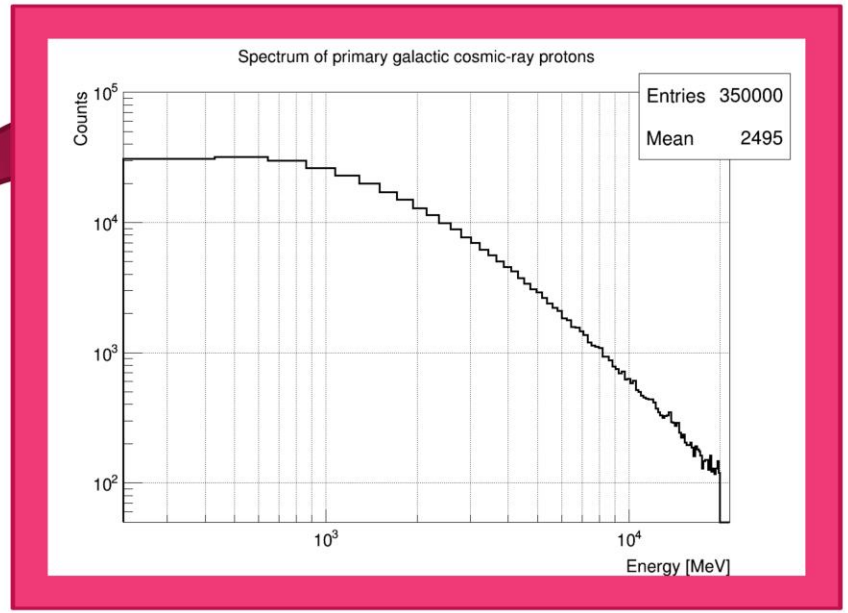
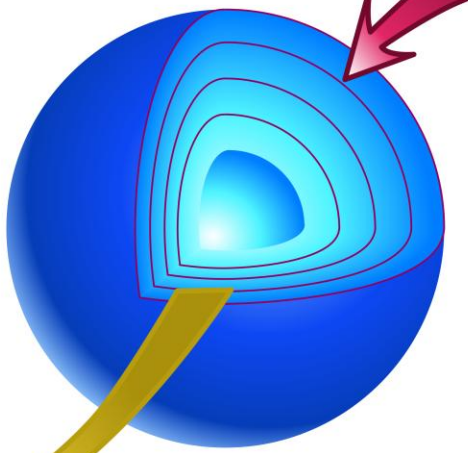
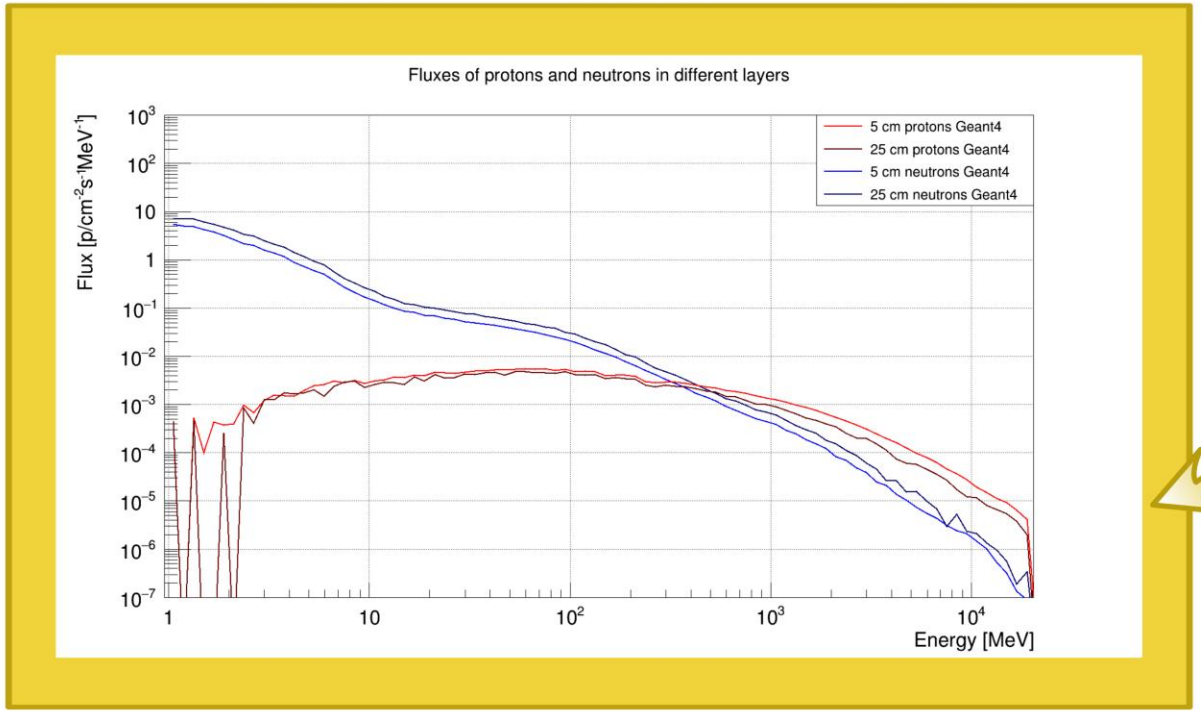
5. Meteorite







Author: Justína Balážová

5. Meteorite

Isotope	Half-life (years)
^{10}Be	$1.388*10^6$
^{26}Al	717000
^{36}Cl	302000
^{41}Ca	100200
^{53}Mn	$3.7*10^6$

Isotope	
^{3}He	
^{21}Ne	
^{22}Ne	
^{38}Ar	
^{39}Ar	

