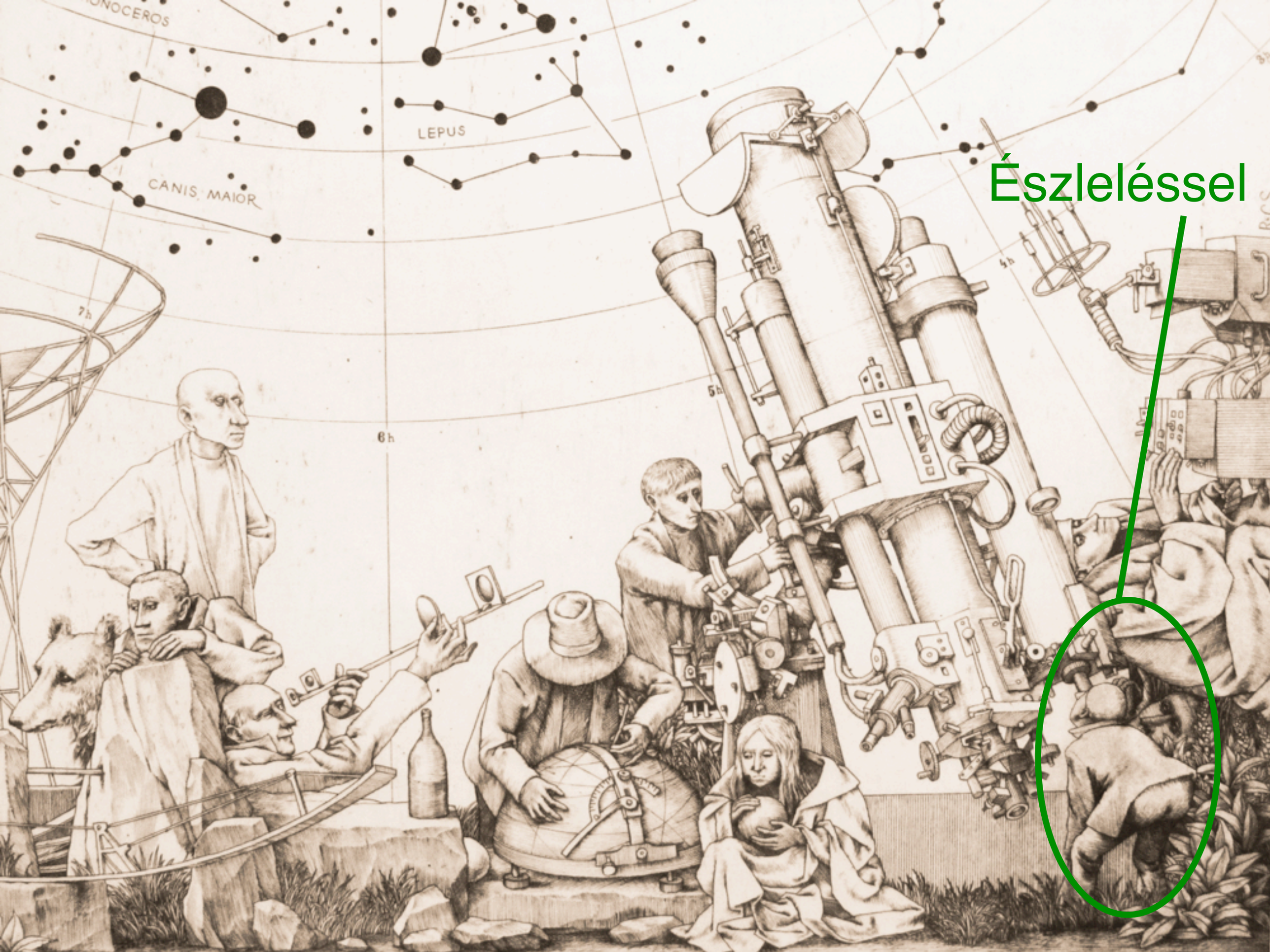
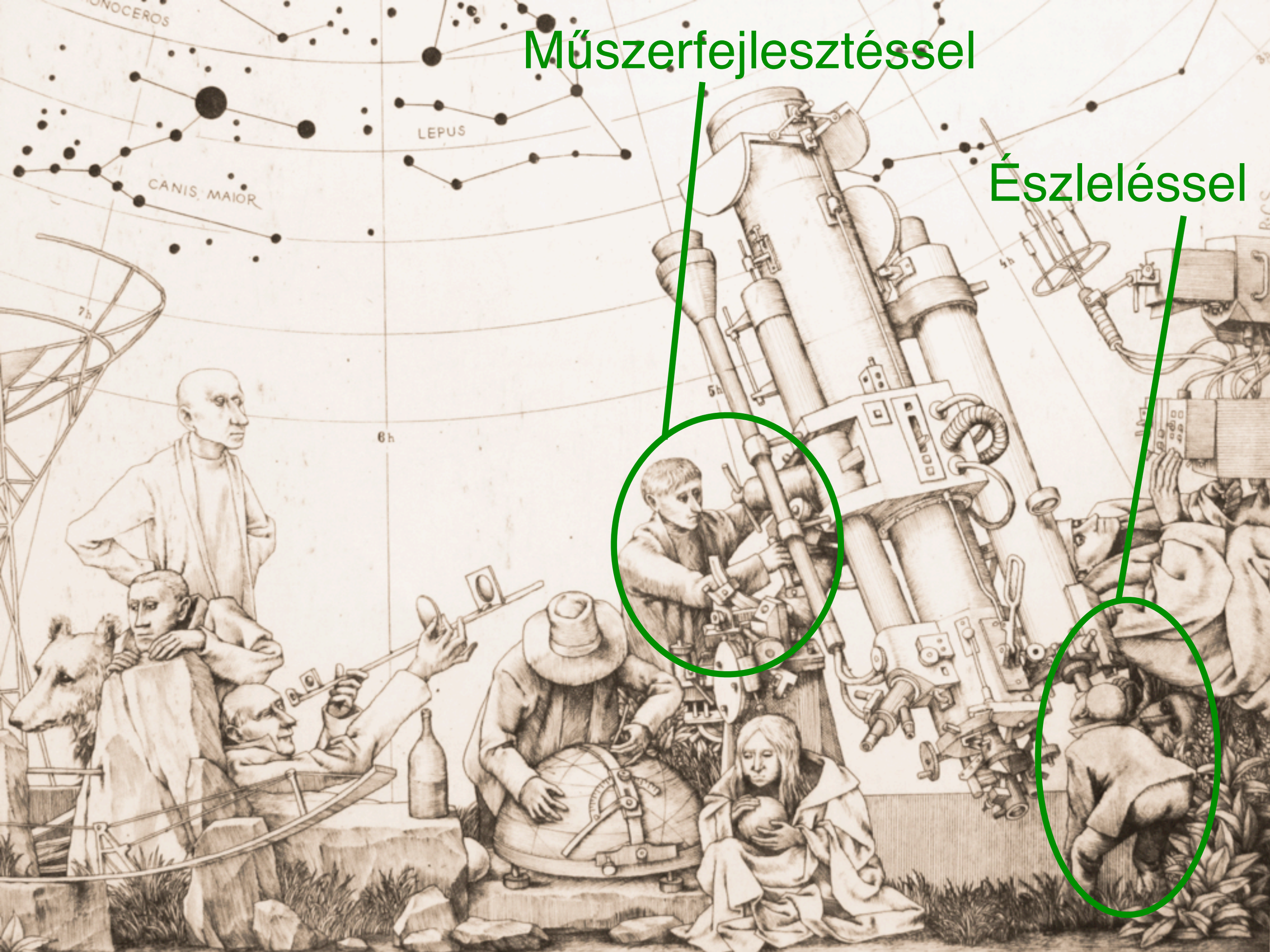
# Mivel foglalkozik egy XXI. századi csillagász?

Kóspál Ágnes

MTA Konkoly Thege Miklós Csillagászati Intézet

2014. október 2.

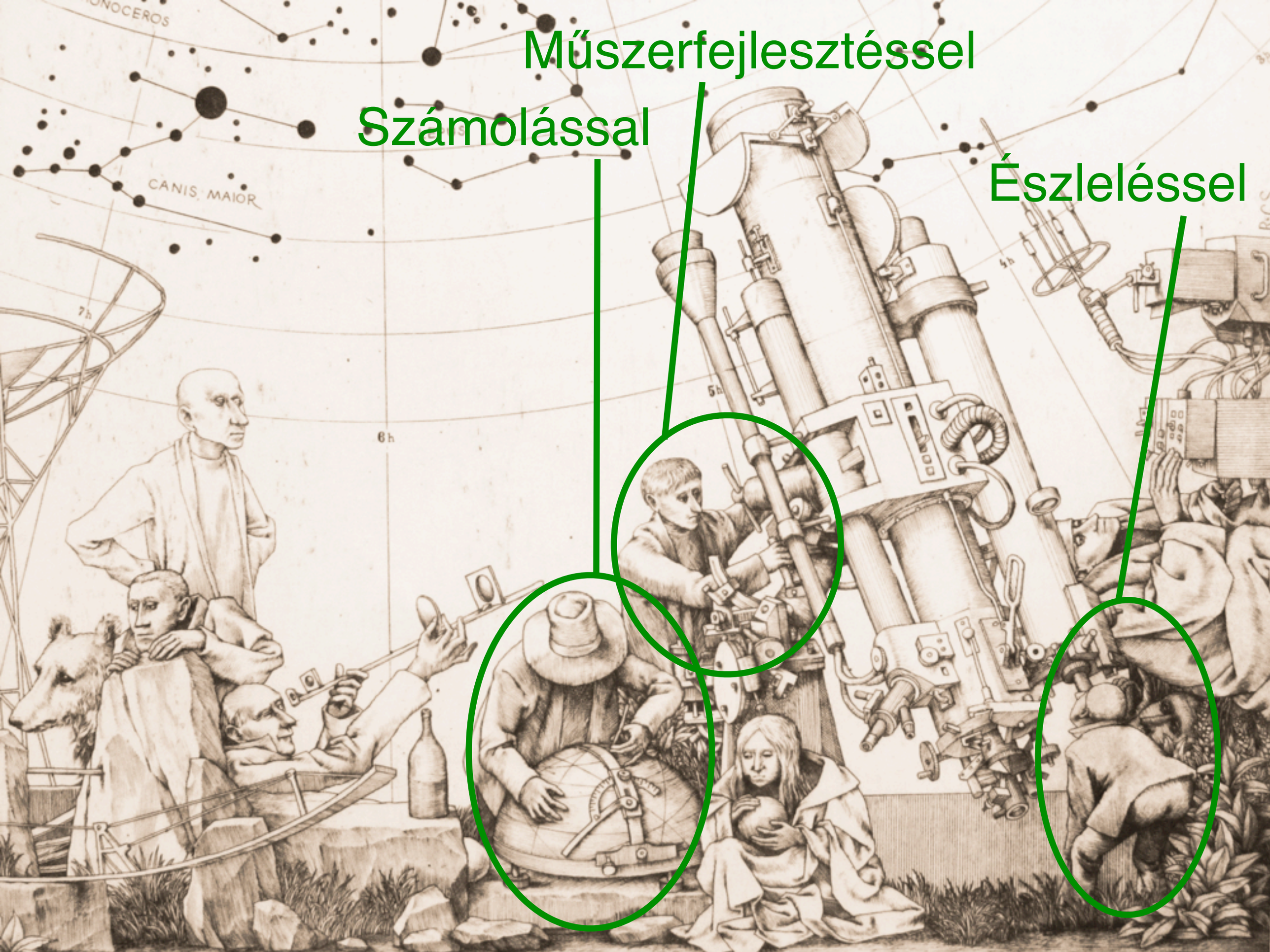

MONOCEROS
LEPUS
CANIS MAIOR
7h
6h
5h
4h
Észleléssel


Műszerfejlesztéssel
Észleléssel
MONOCEROS
LEPUS
CANIS MAIOR
7h
6h
5h
4h

Számolással

Műszerfejlesztéssel

Észleléssel

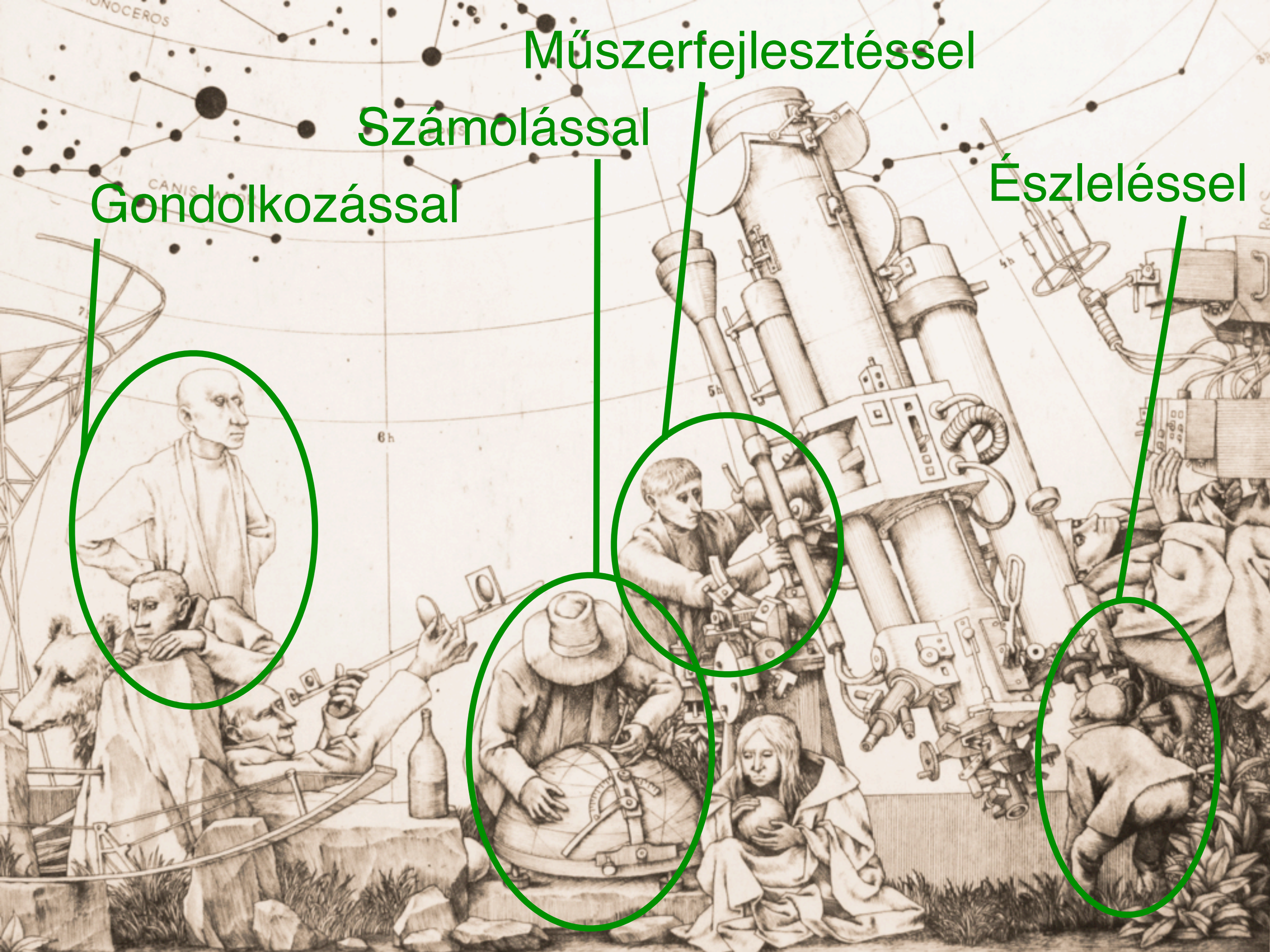


Gondolkozással

Számolással

Műszerfejlesztéssel

Észleléssel



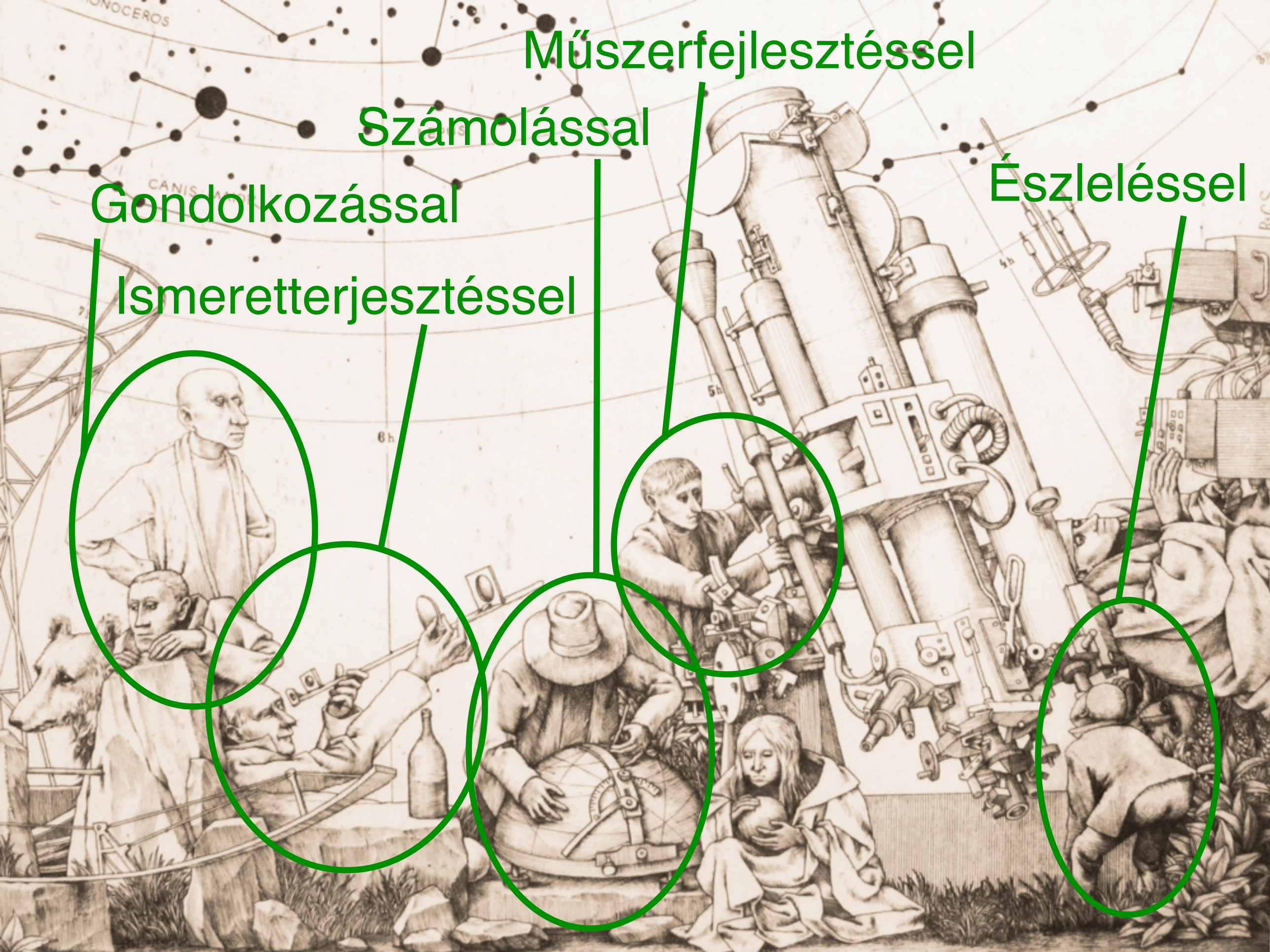
Gondolkozással

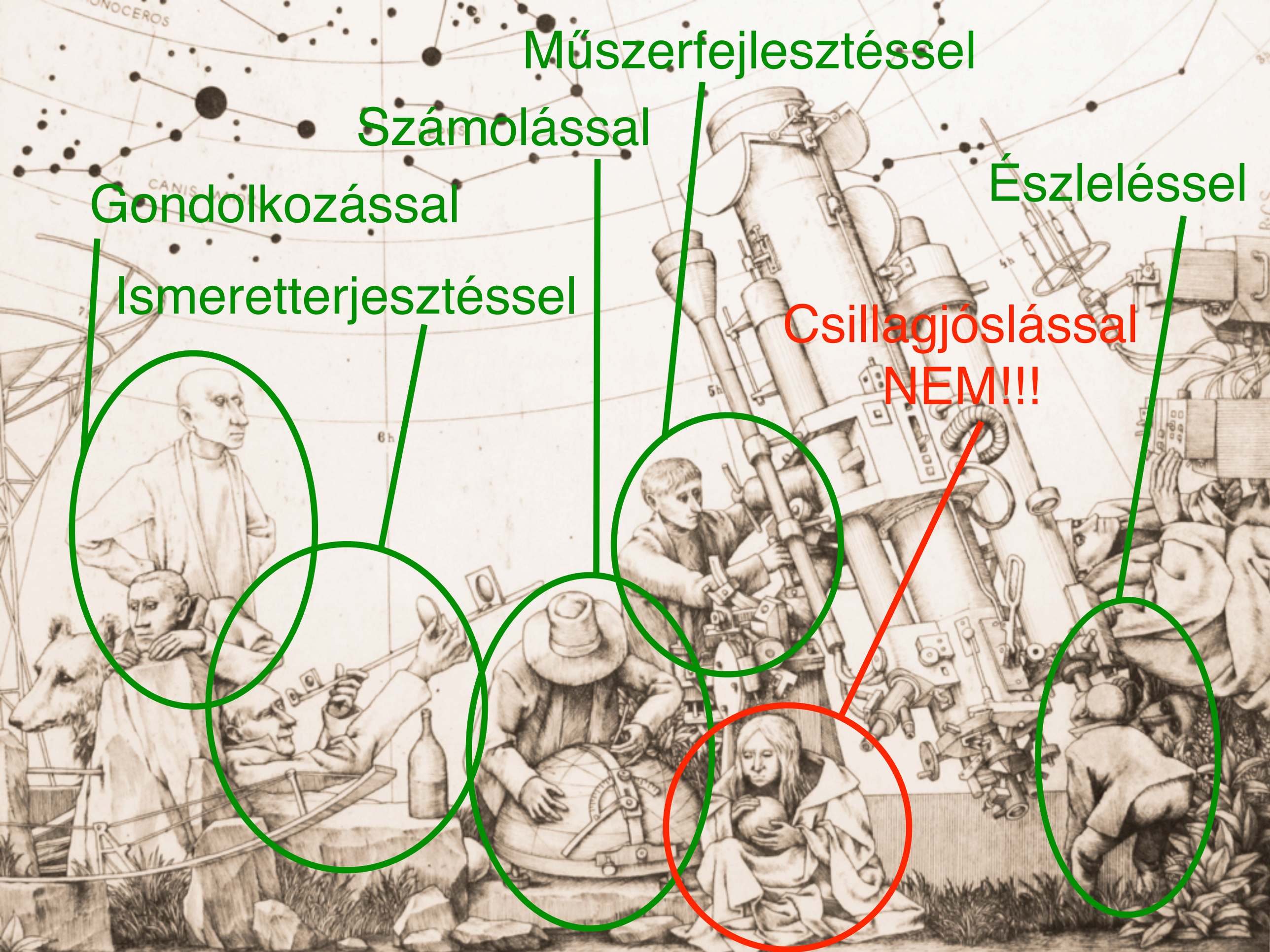
Ismeretterjesztéssel

Számolással

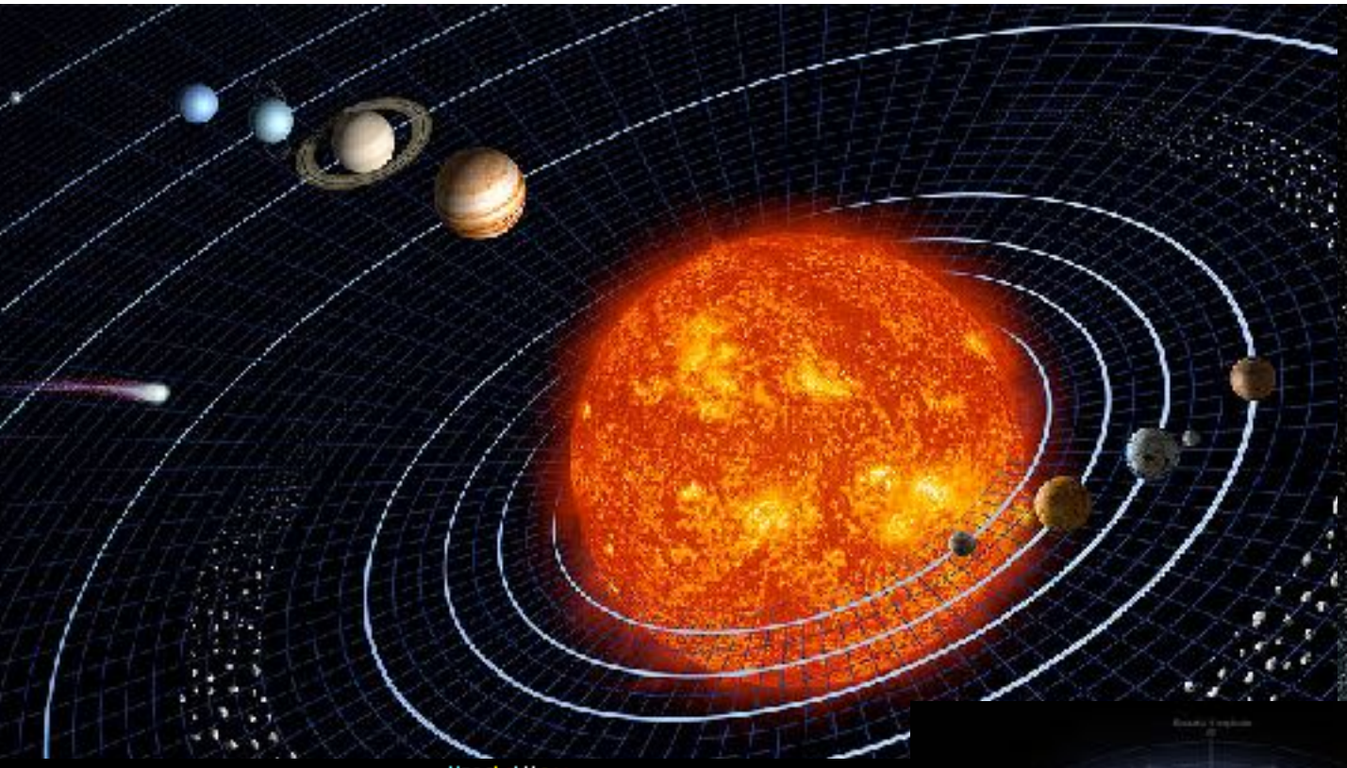
Műszerfejlesztéssel

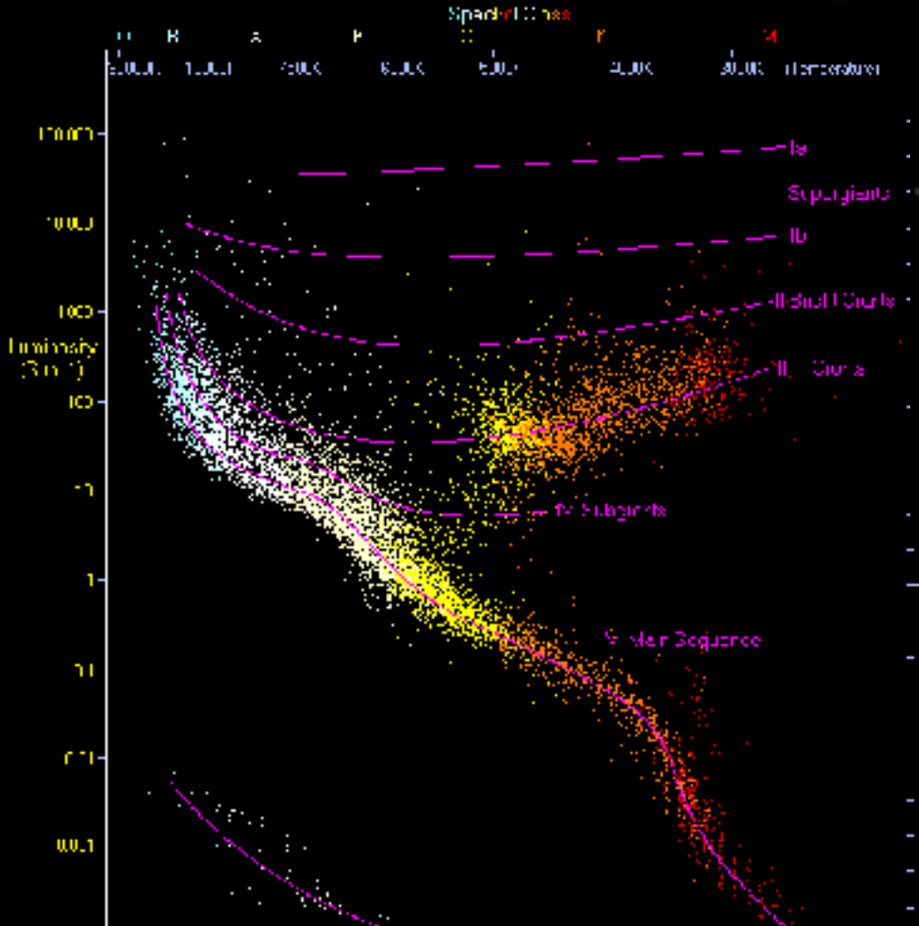
Észleléssel

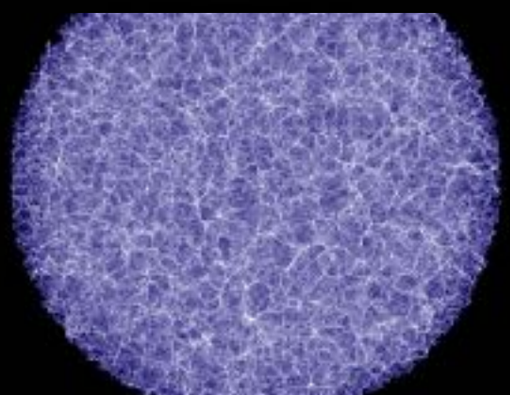


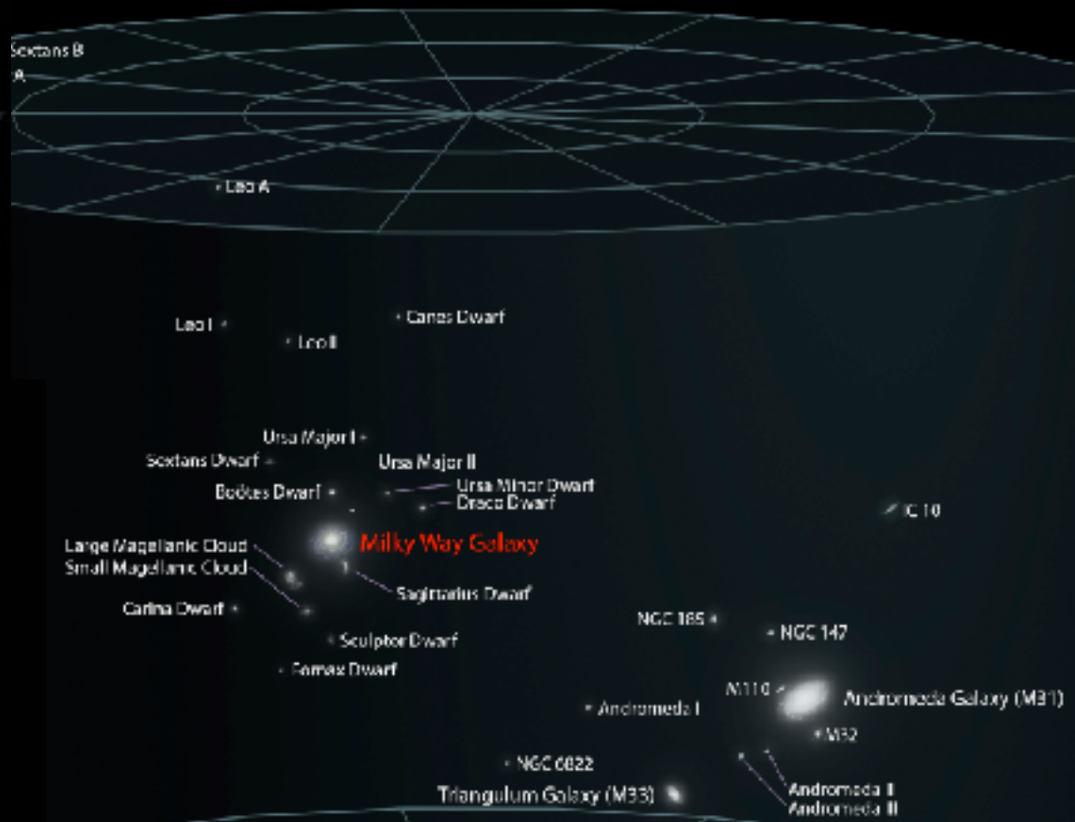

Műszerfejlesztéssel
Számolással
Gondolkozással
Észleléssel
Ismeretterjesztéssel
Csillagjóslással
NEM!!!

# Hogyan működik az Univerzum?

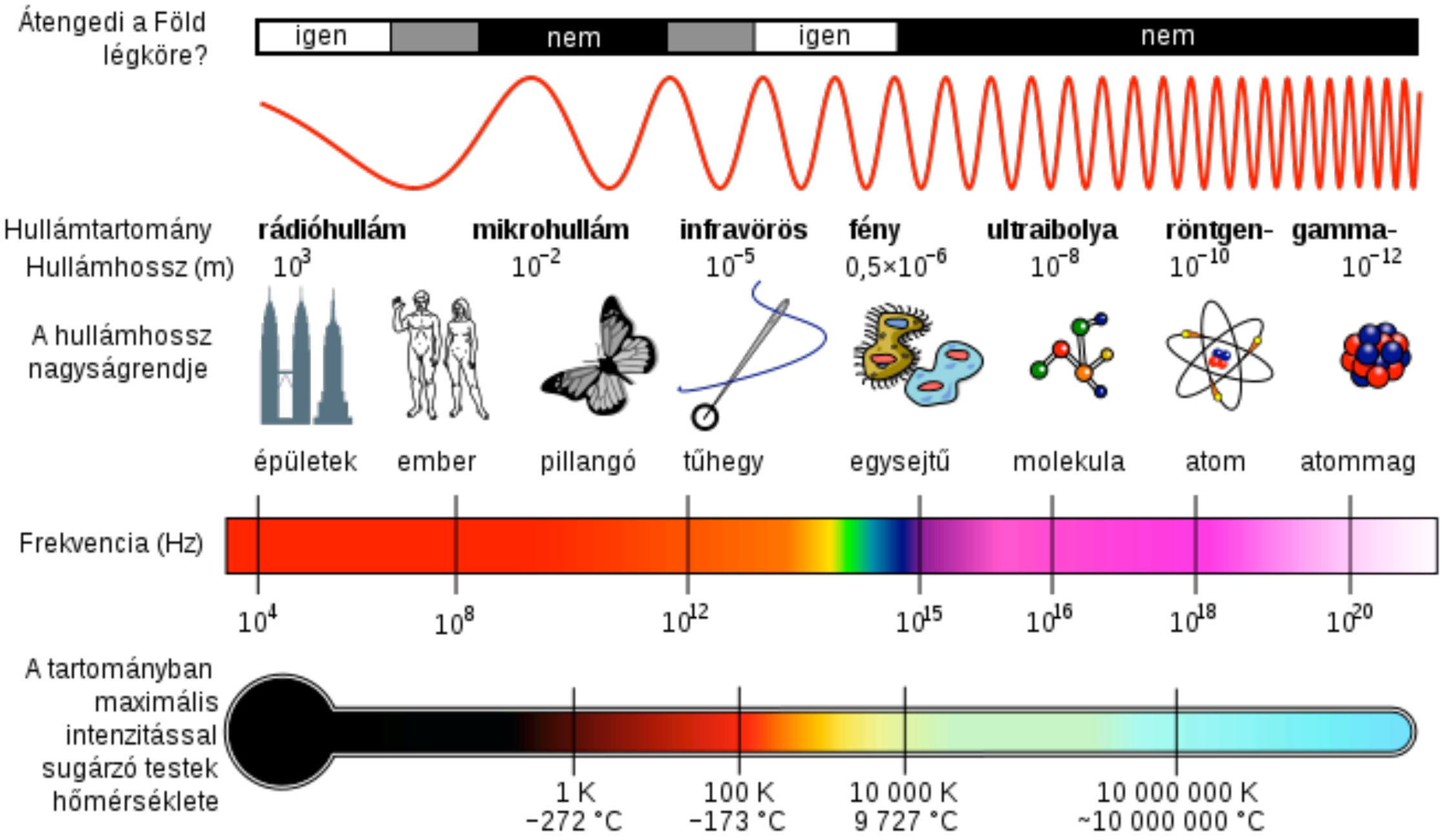




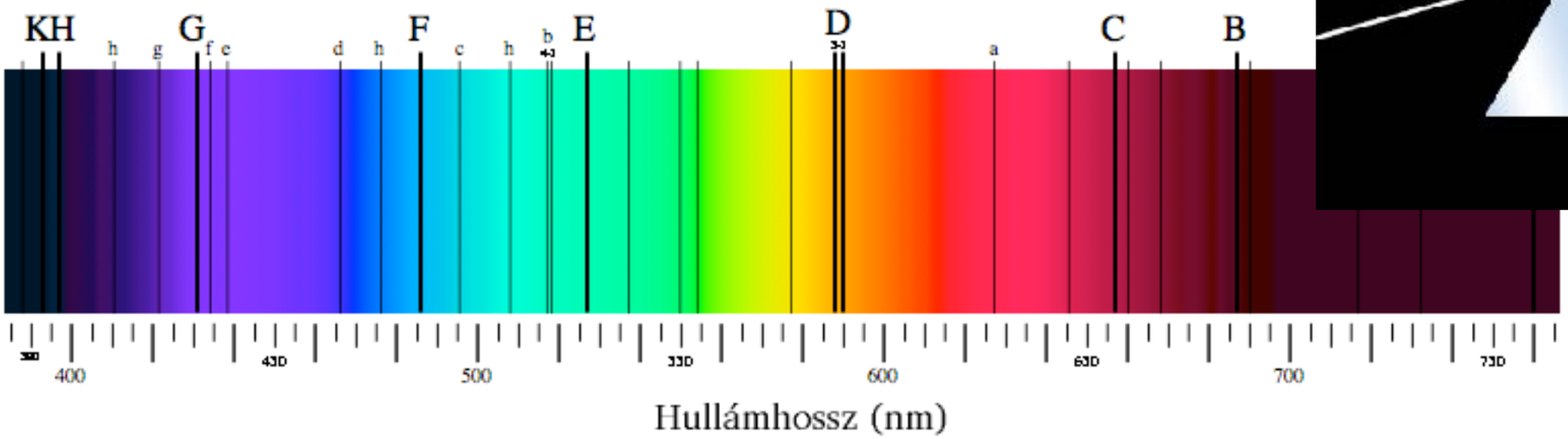


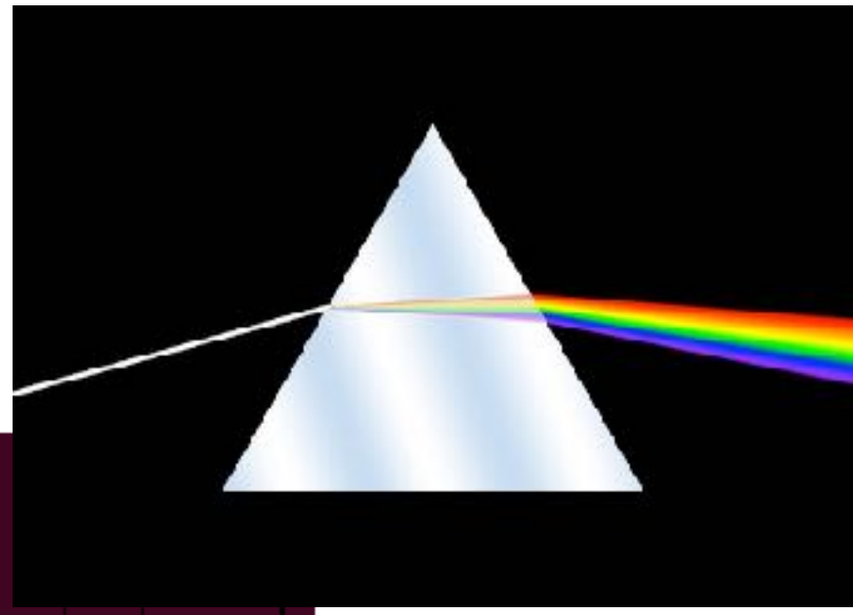
# Hogyan szerzünk erről információt?



# Hogyan szerzünk erről információt?

1814: Fraunhofer színképvonalakat fedez fel a Nap spektrumában

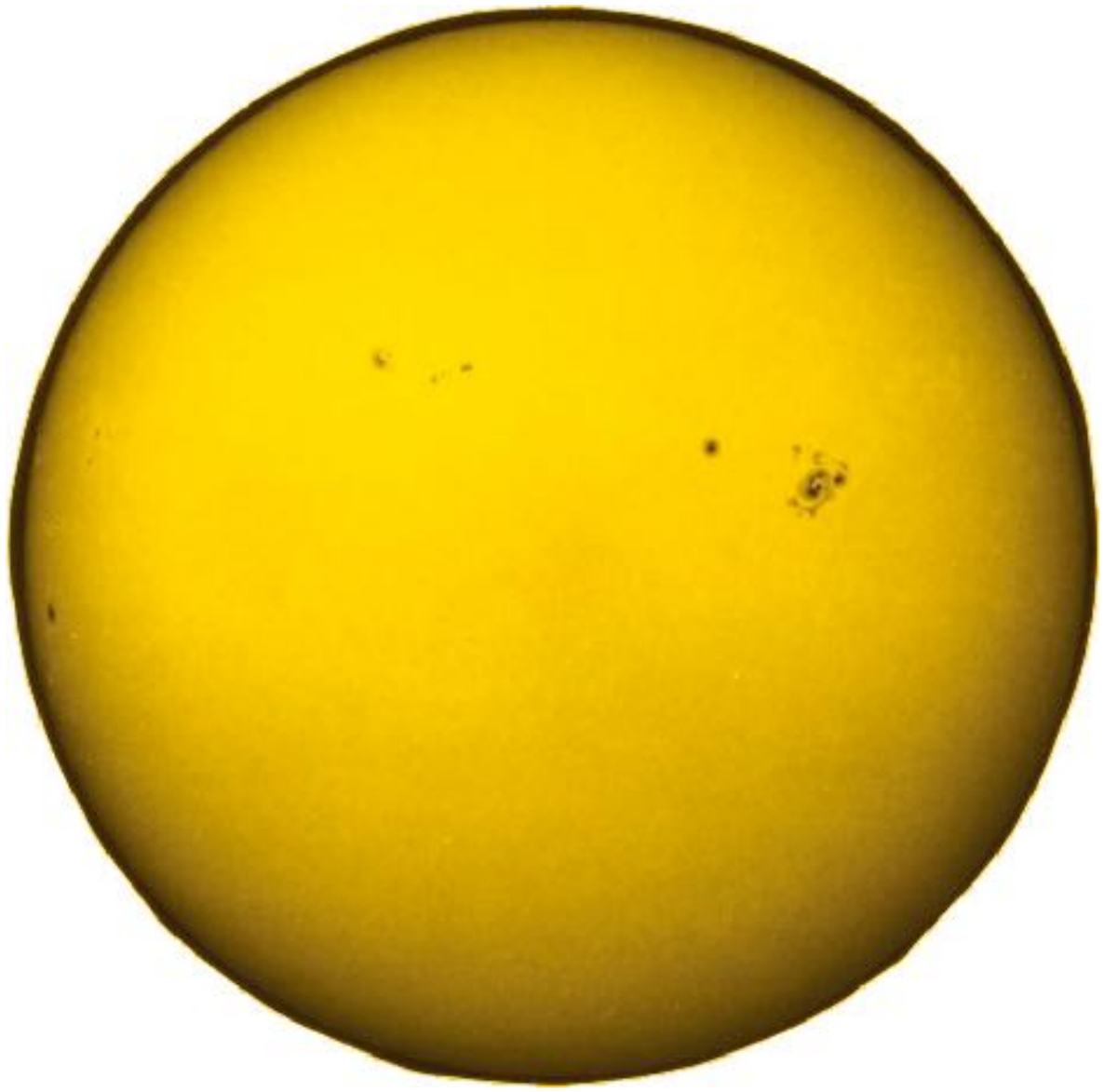


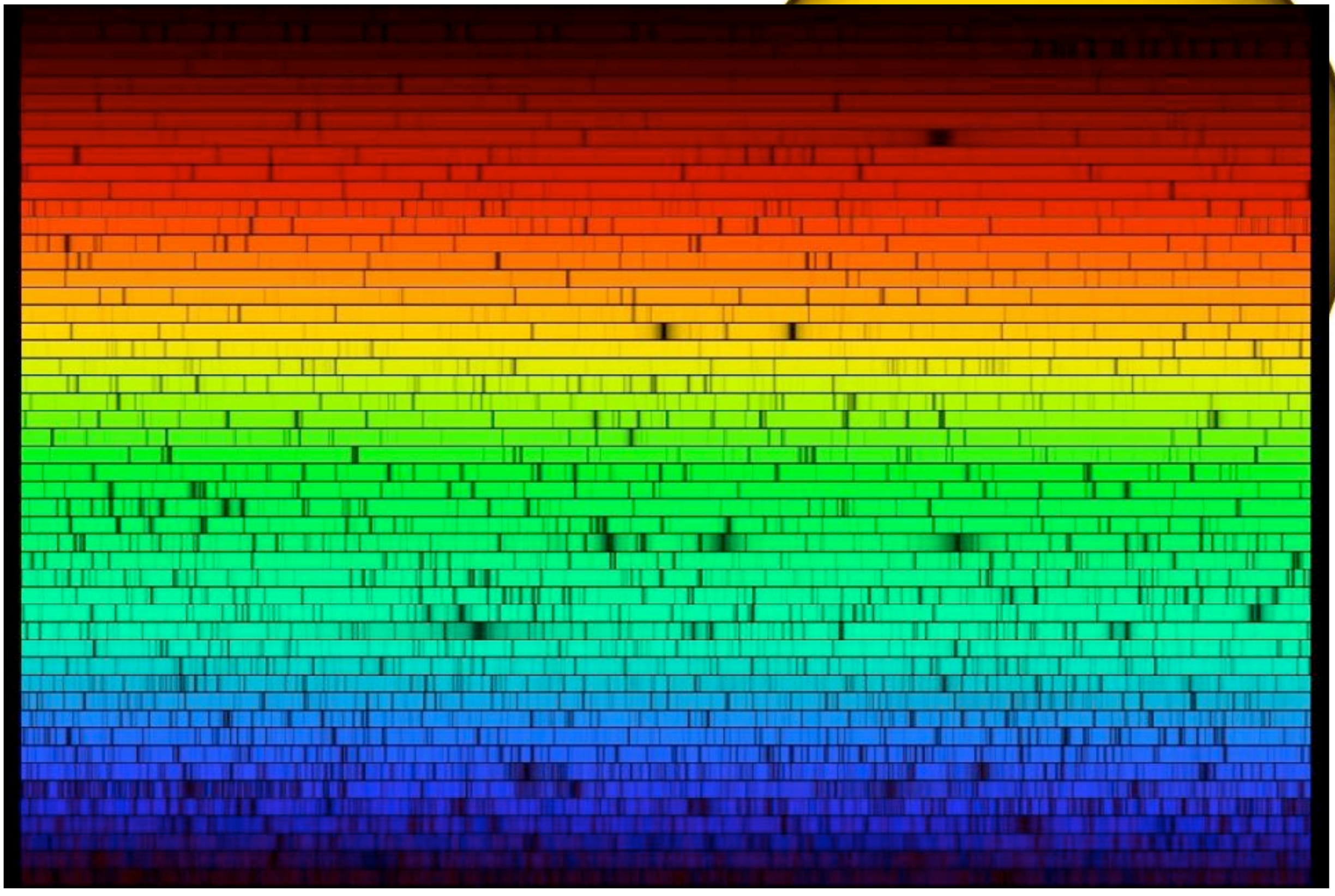
1959: Kirchhoff és Bunsen rájött, hogy a vonalakat a Napban lévő atomok elnyelése okozza

Kapcsolat van az égitestek fizikai jellemzői és a spektrumuk között: megszületett az **asztrofizika**

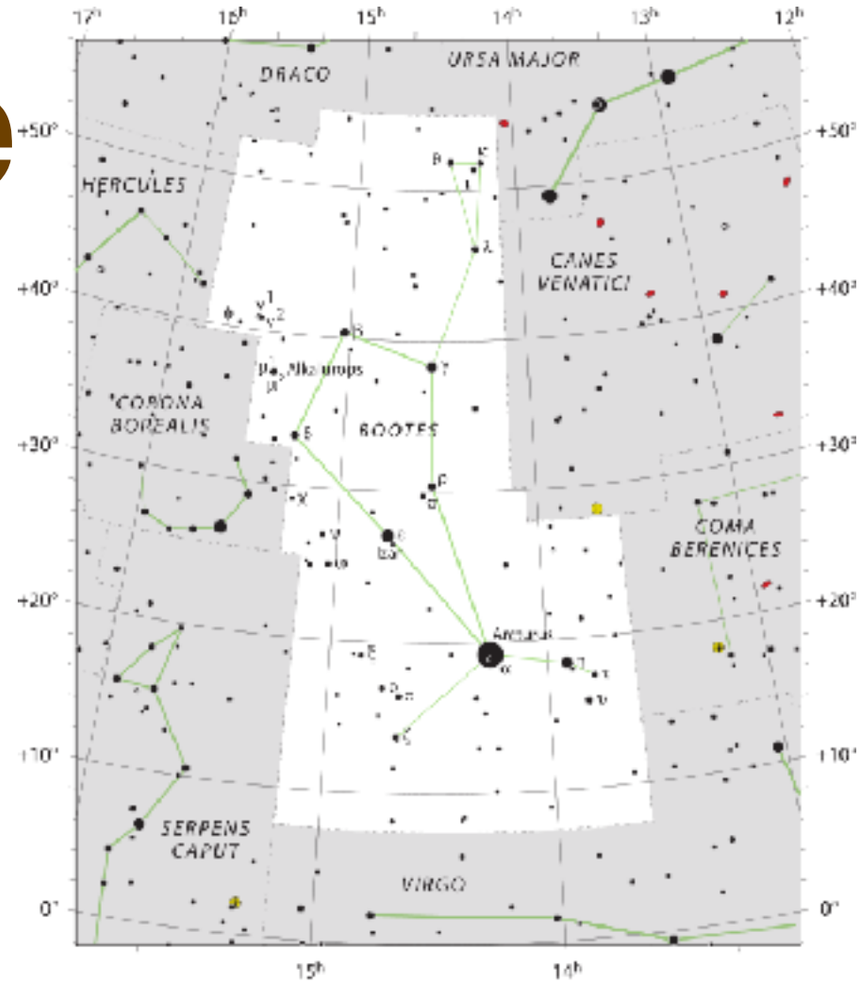
# A Nap színképe



# A Nap színképe



# Az Arcturus színképe



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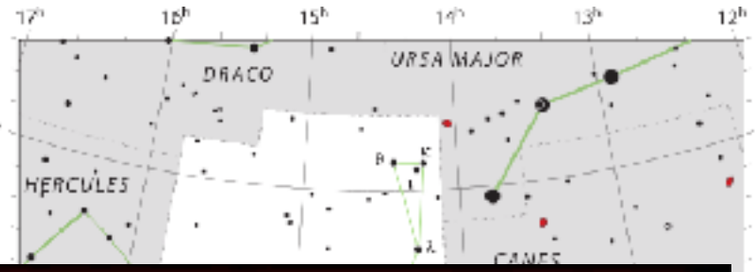
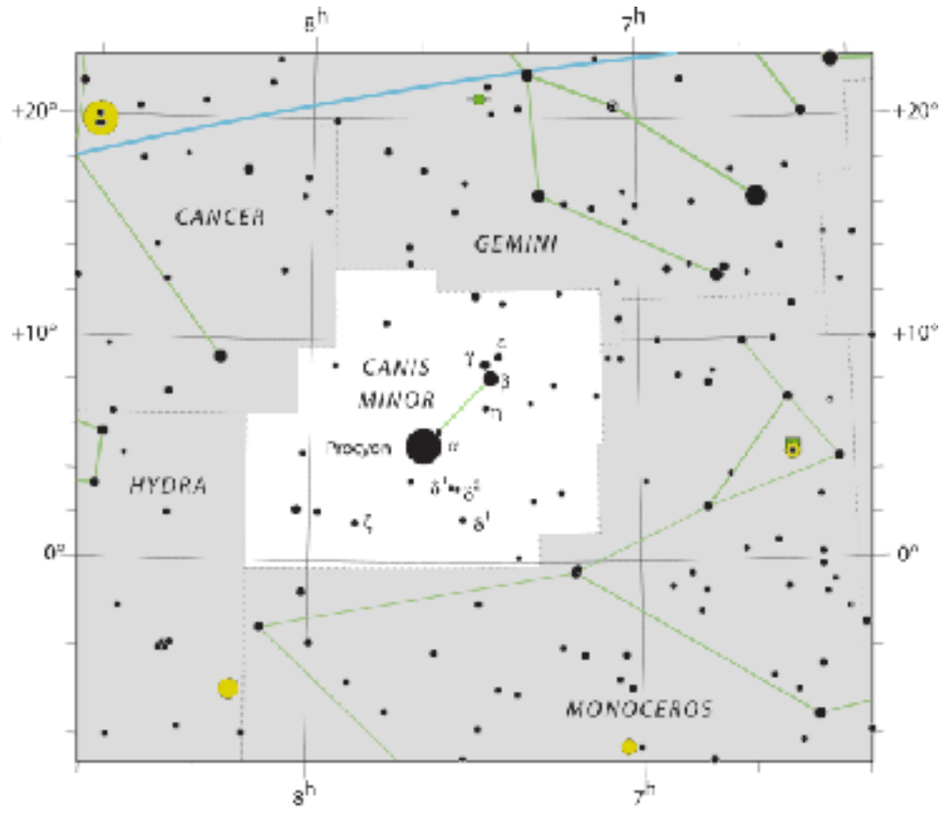


# A Procyon színképe



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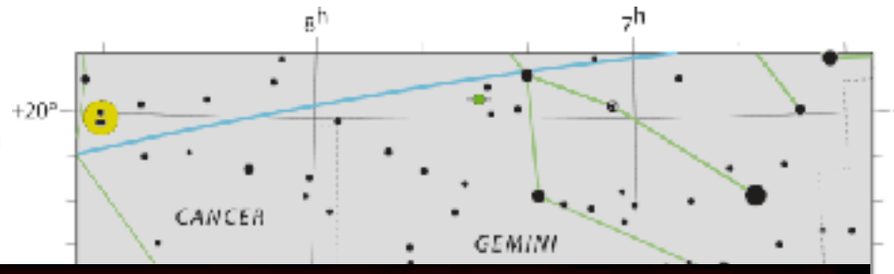
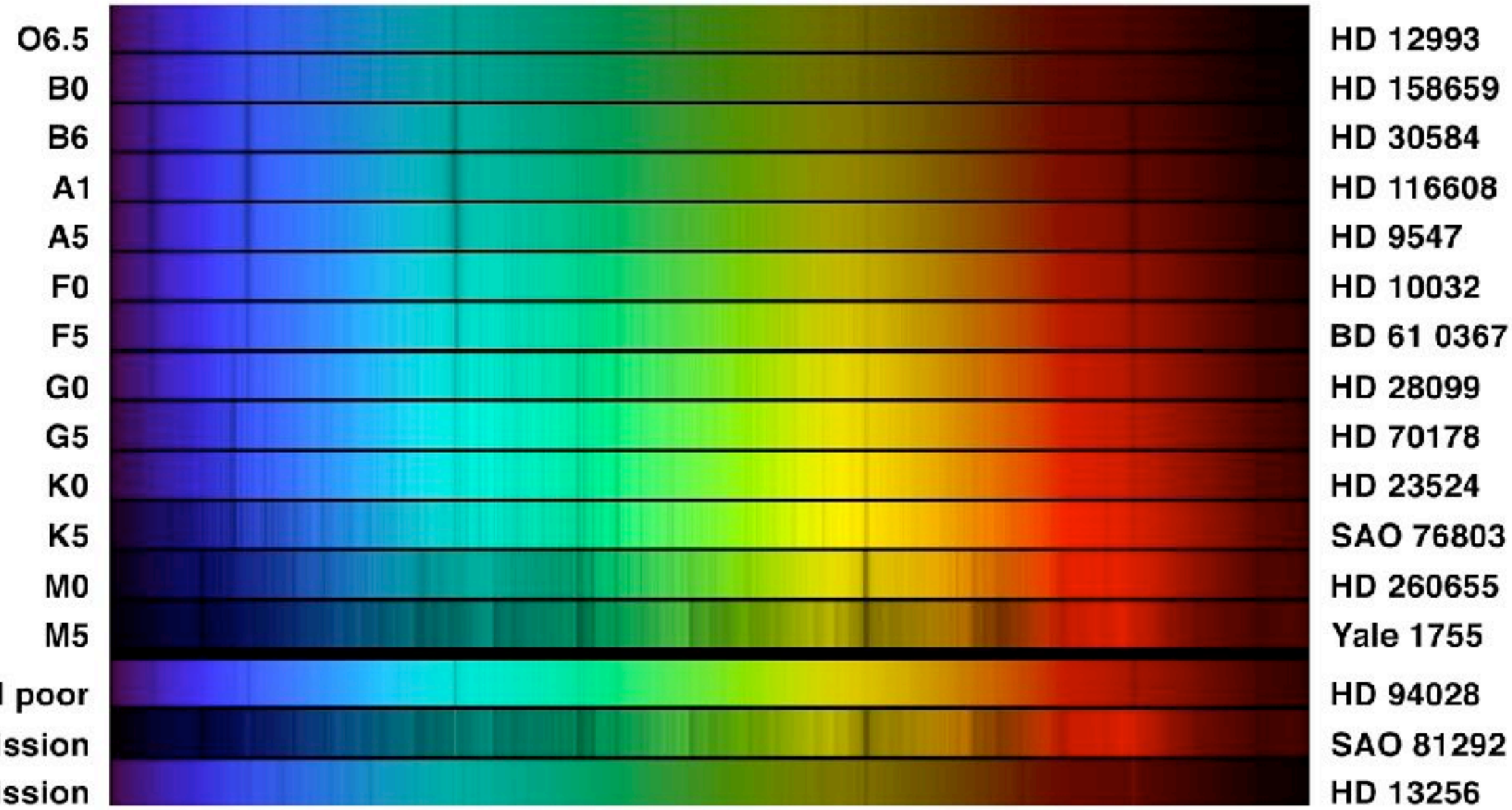
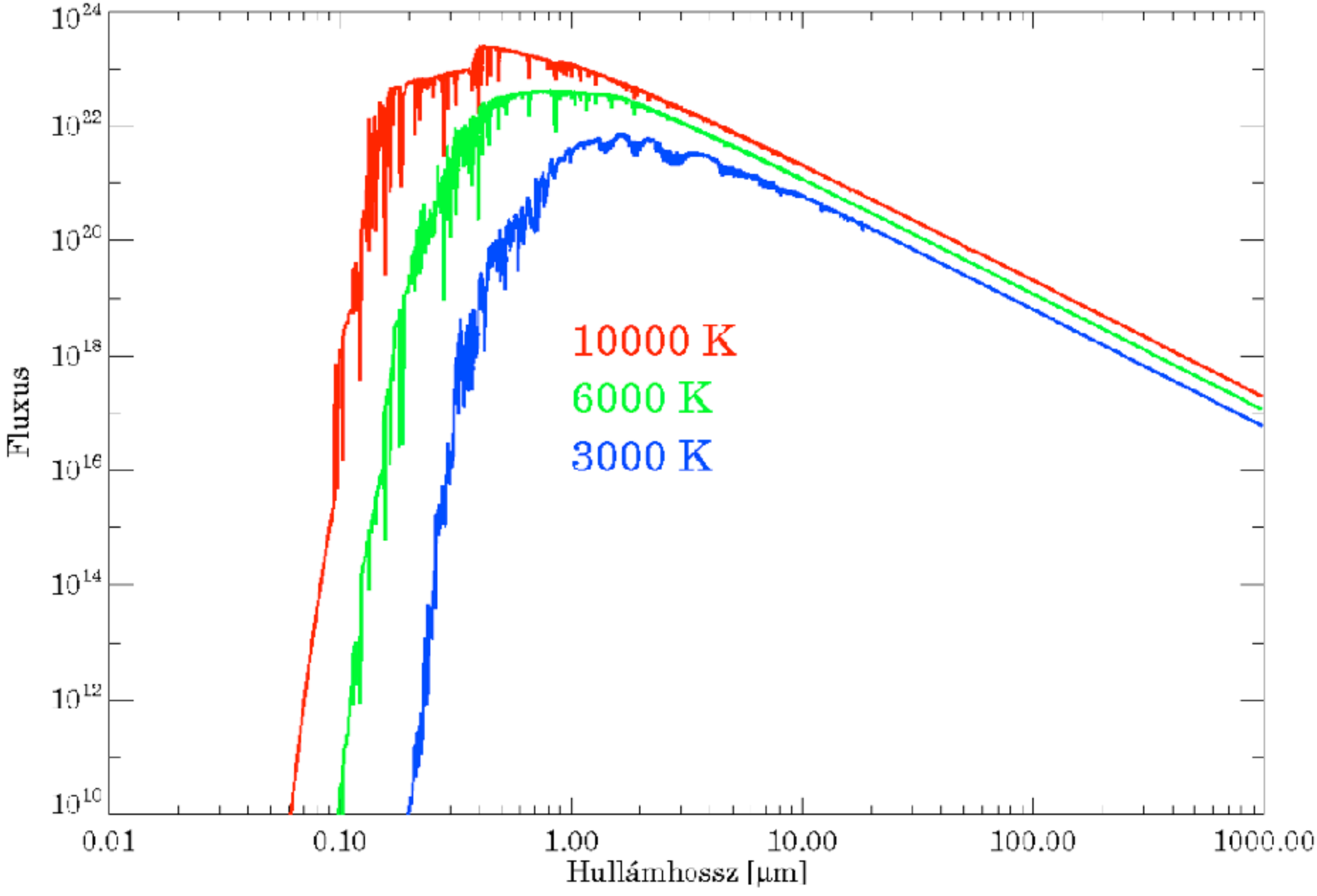


# Színképosztályozás



# Csillagszínképek



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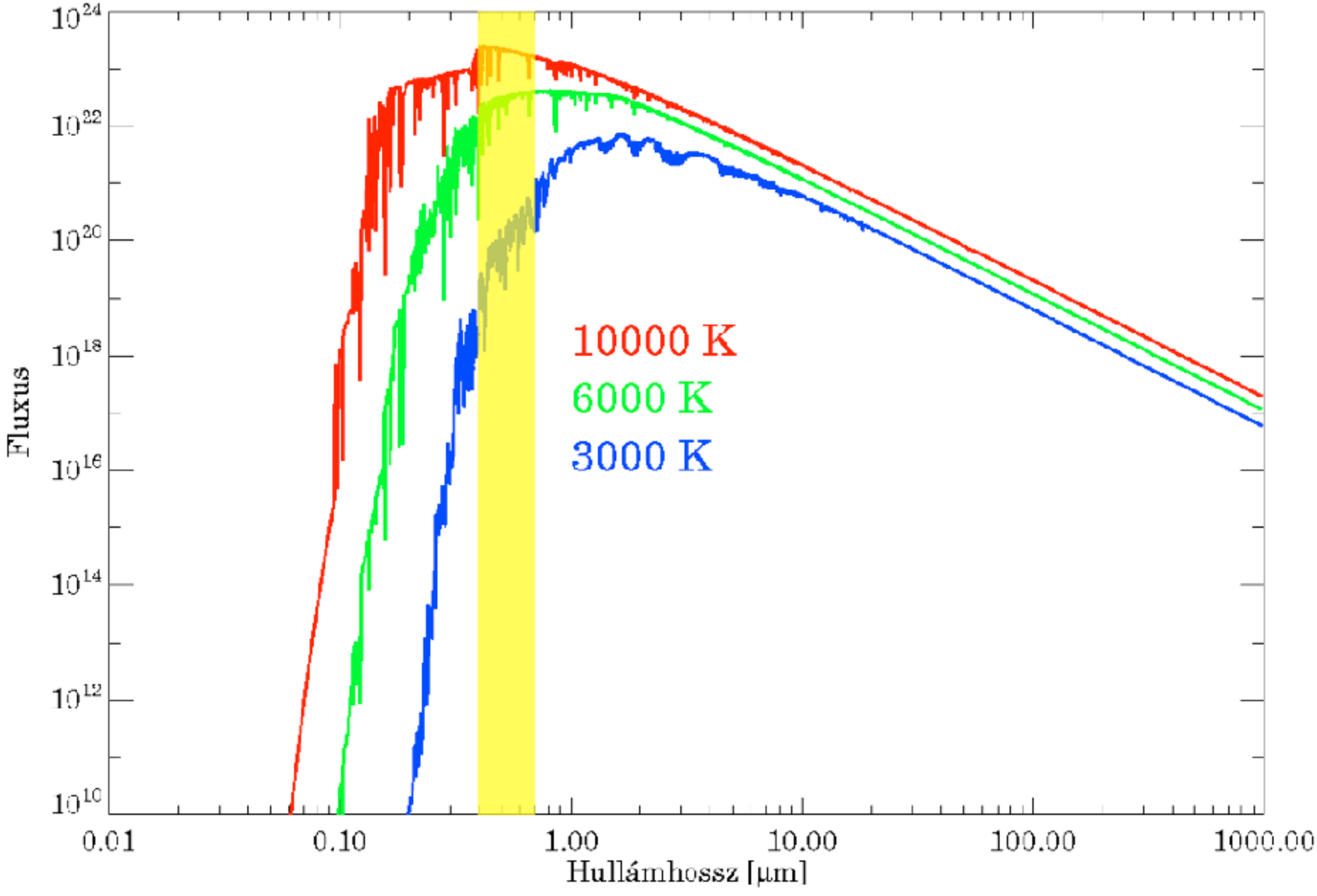

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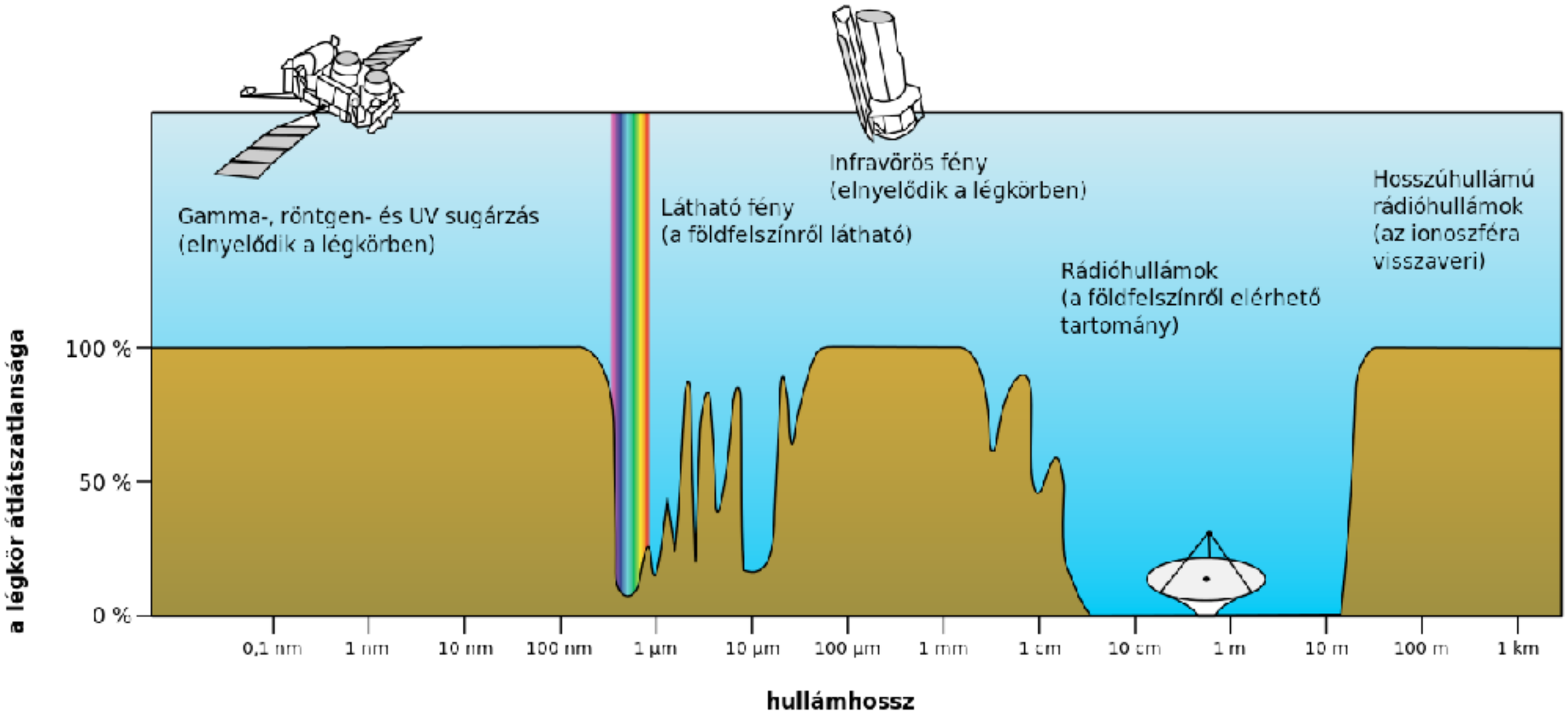

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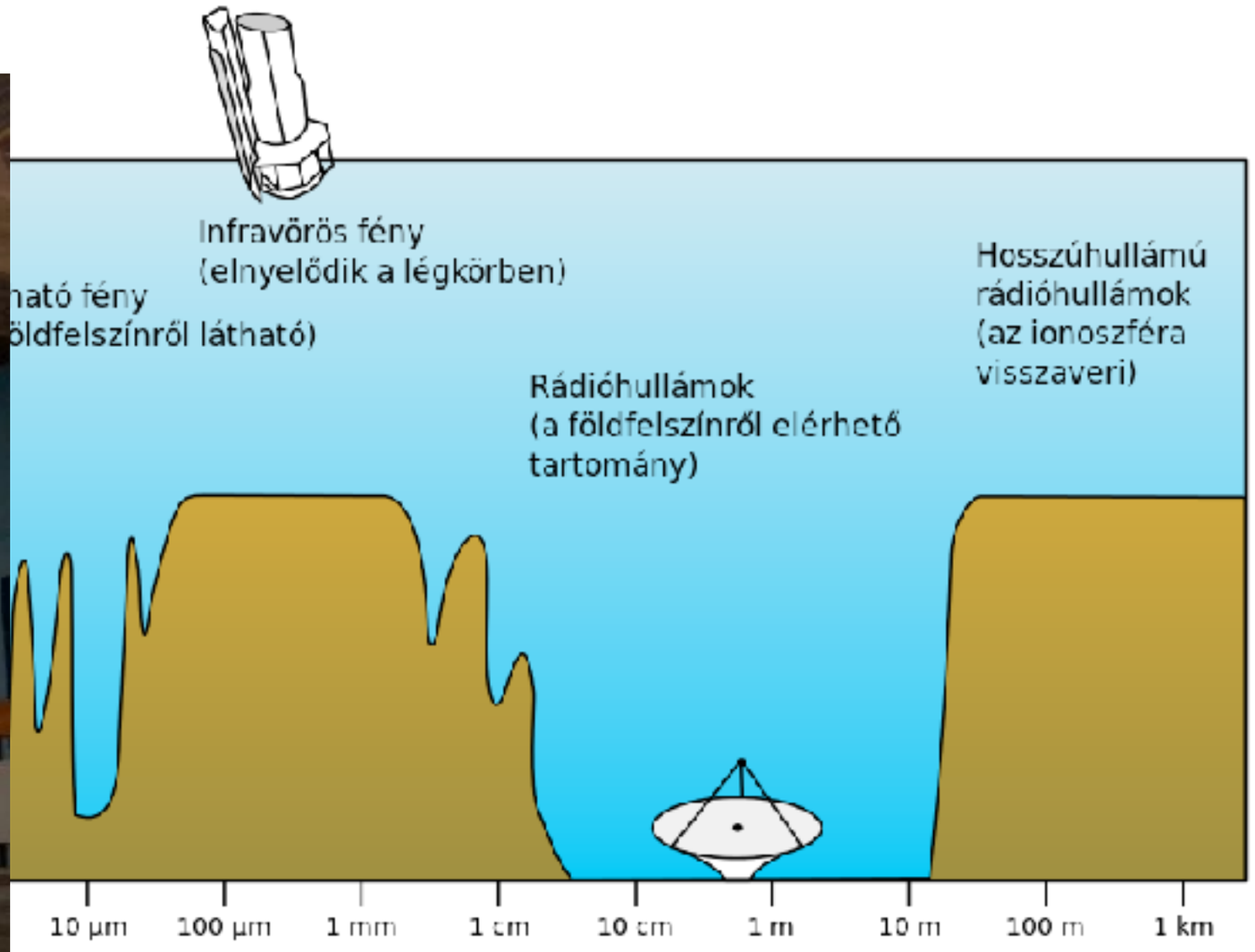

# A földi légkör áteresztése

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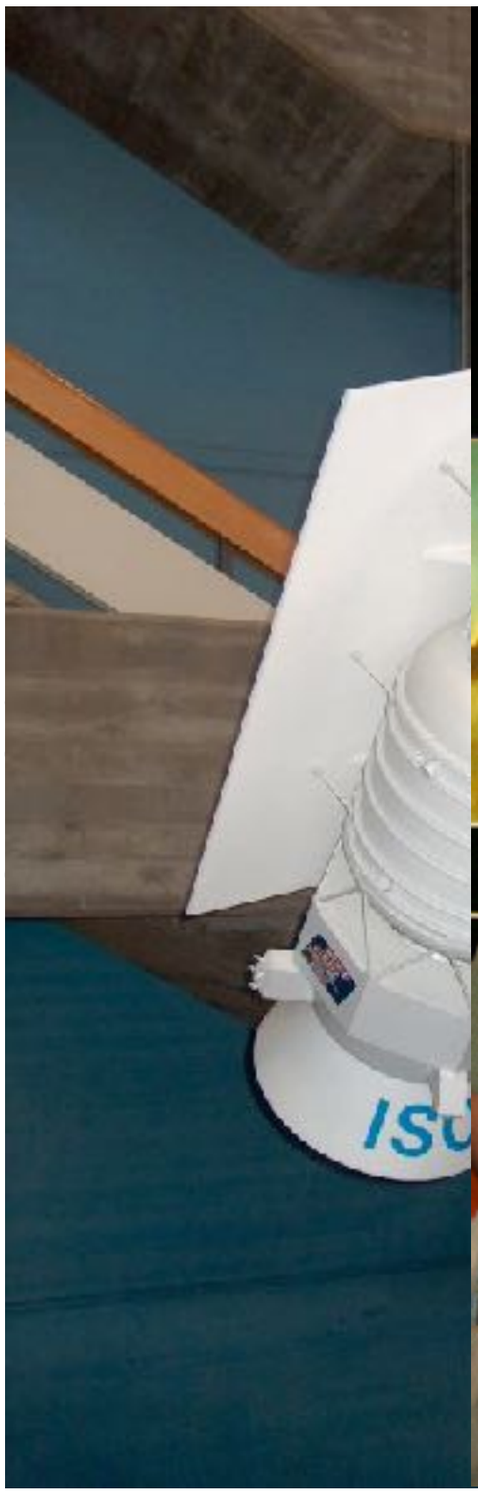
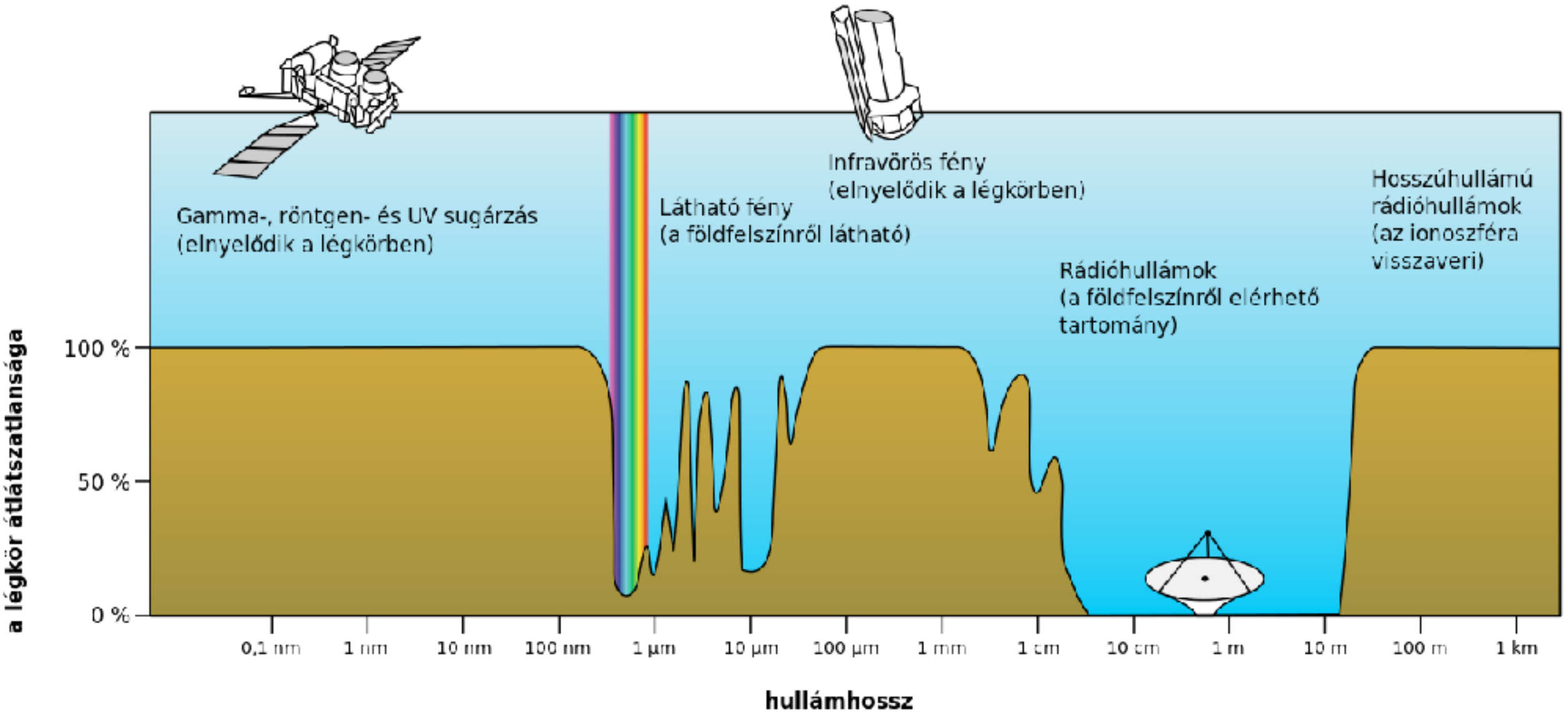
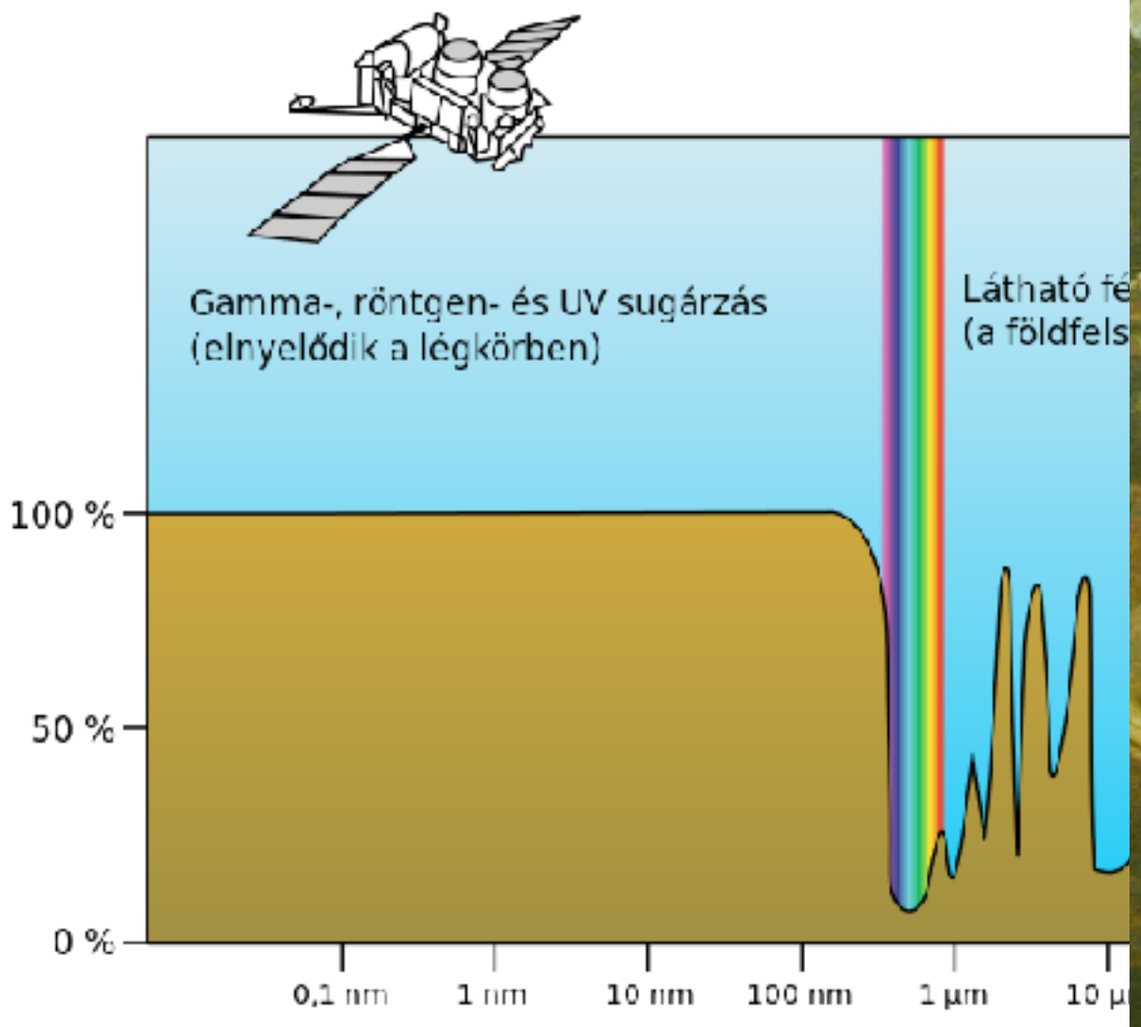


# Infravörös sugárzás



# Infravörös sugárzás

## Sir William Herschel (1738-1822)



# A világ infravörösben

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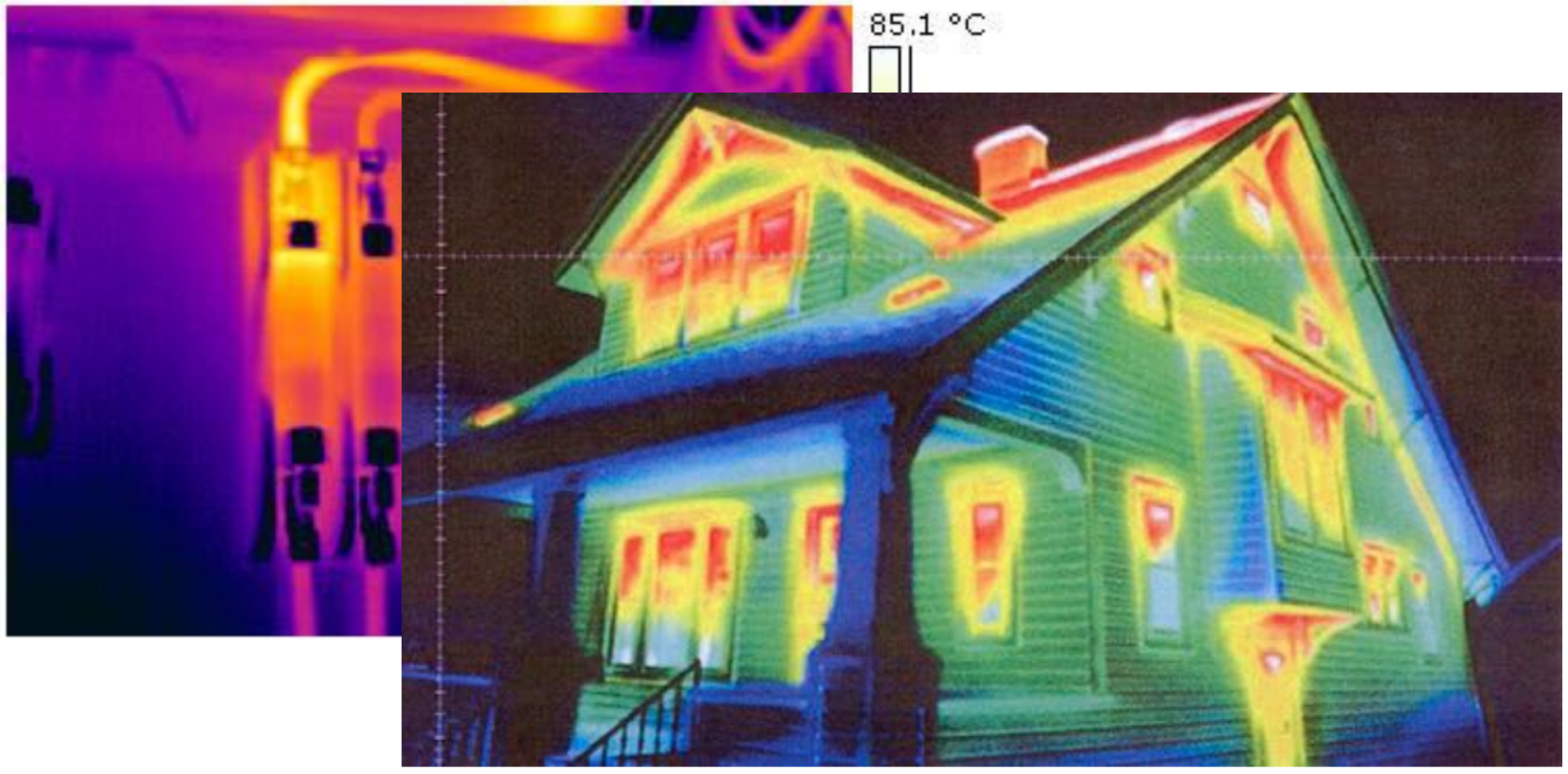

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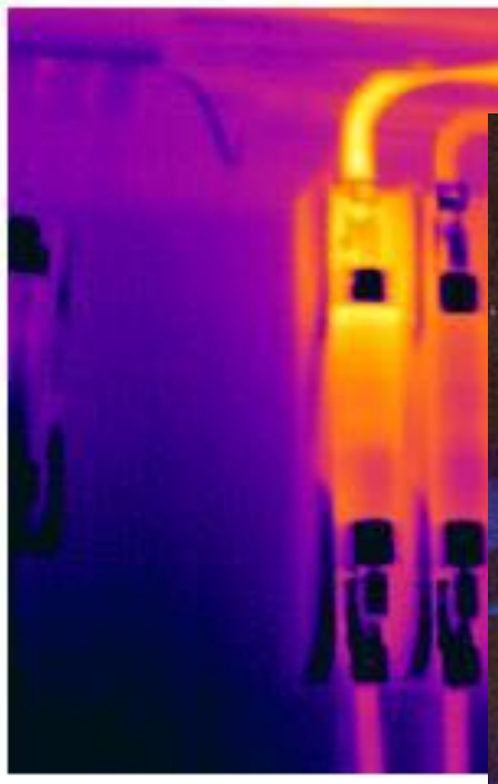

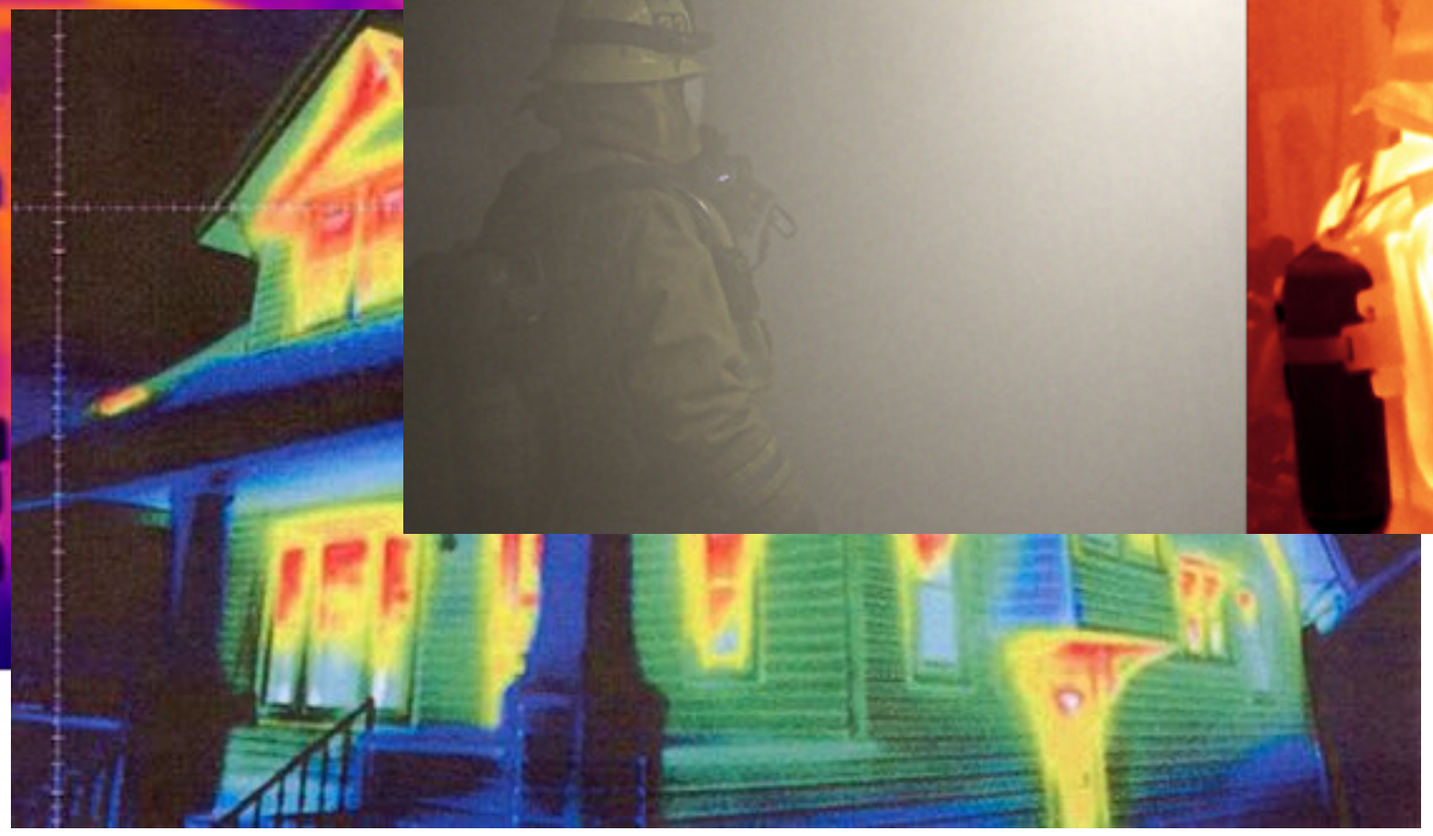



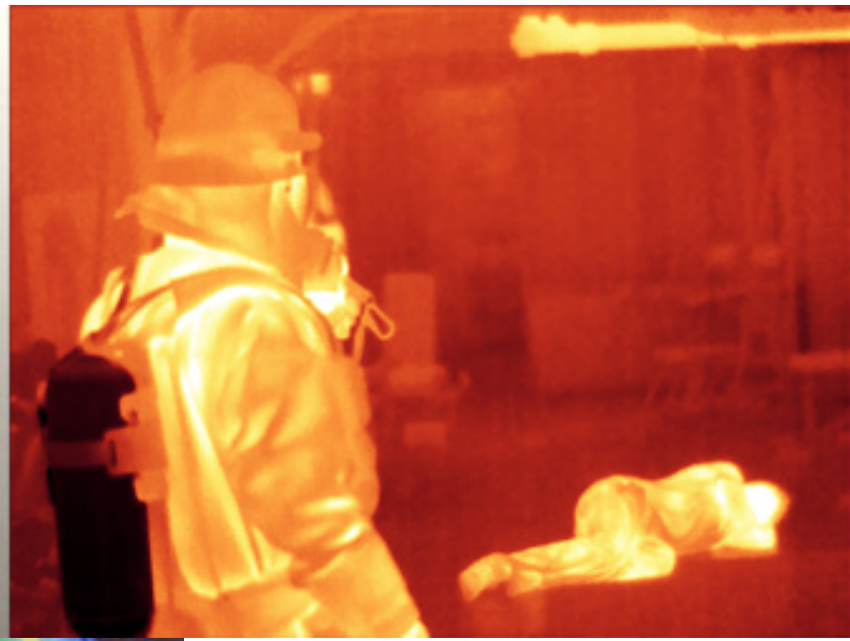

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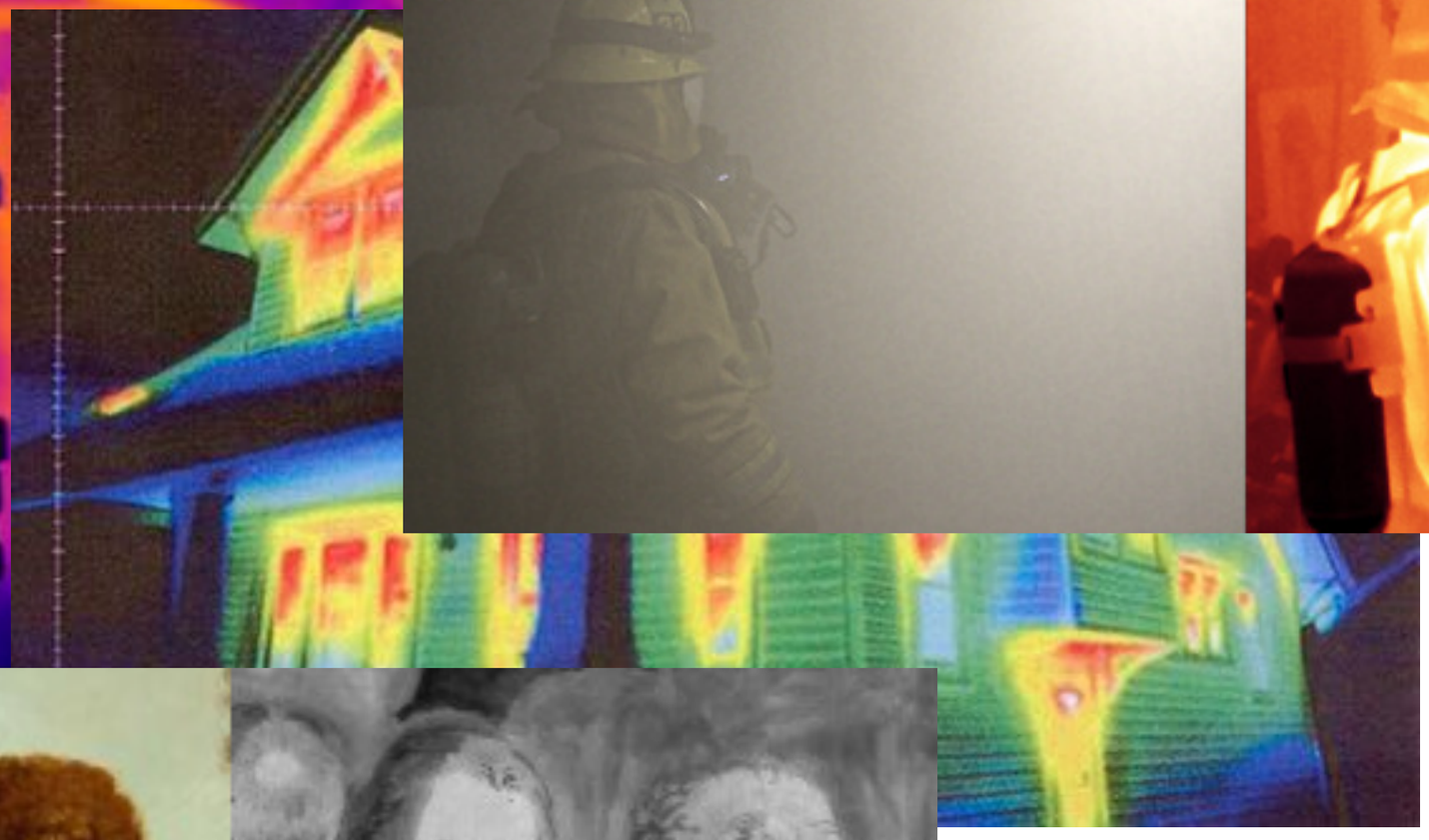
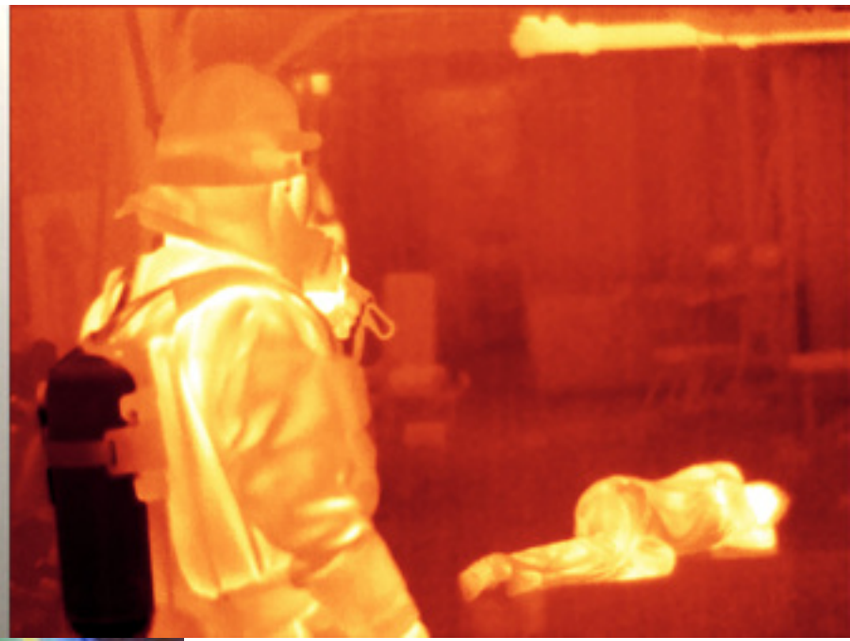
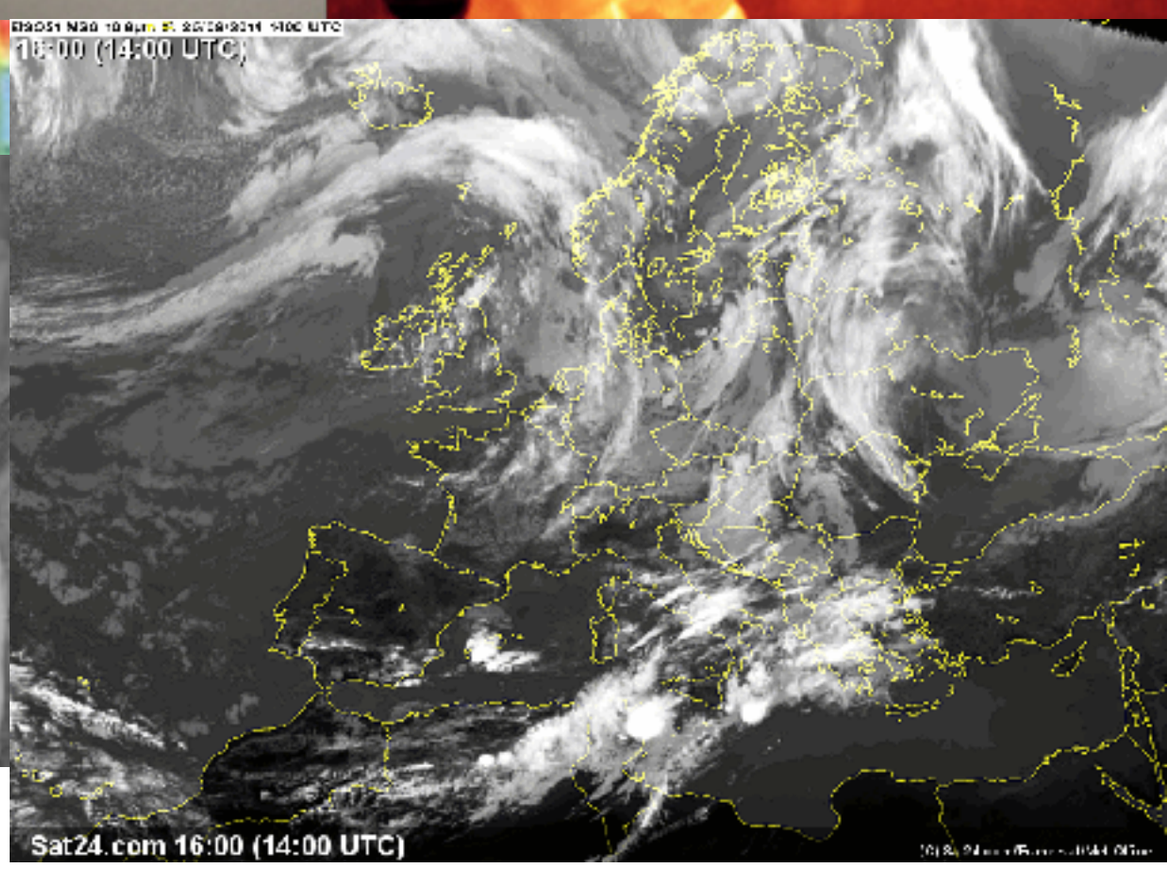




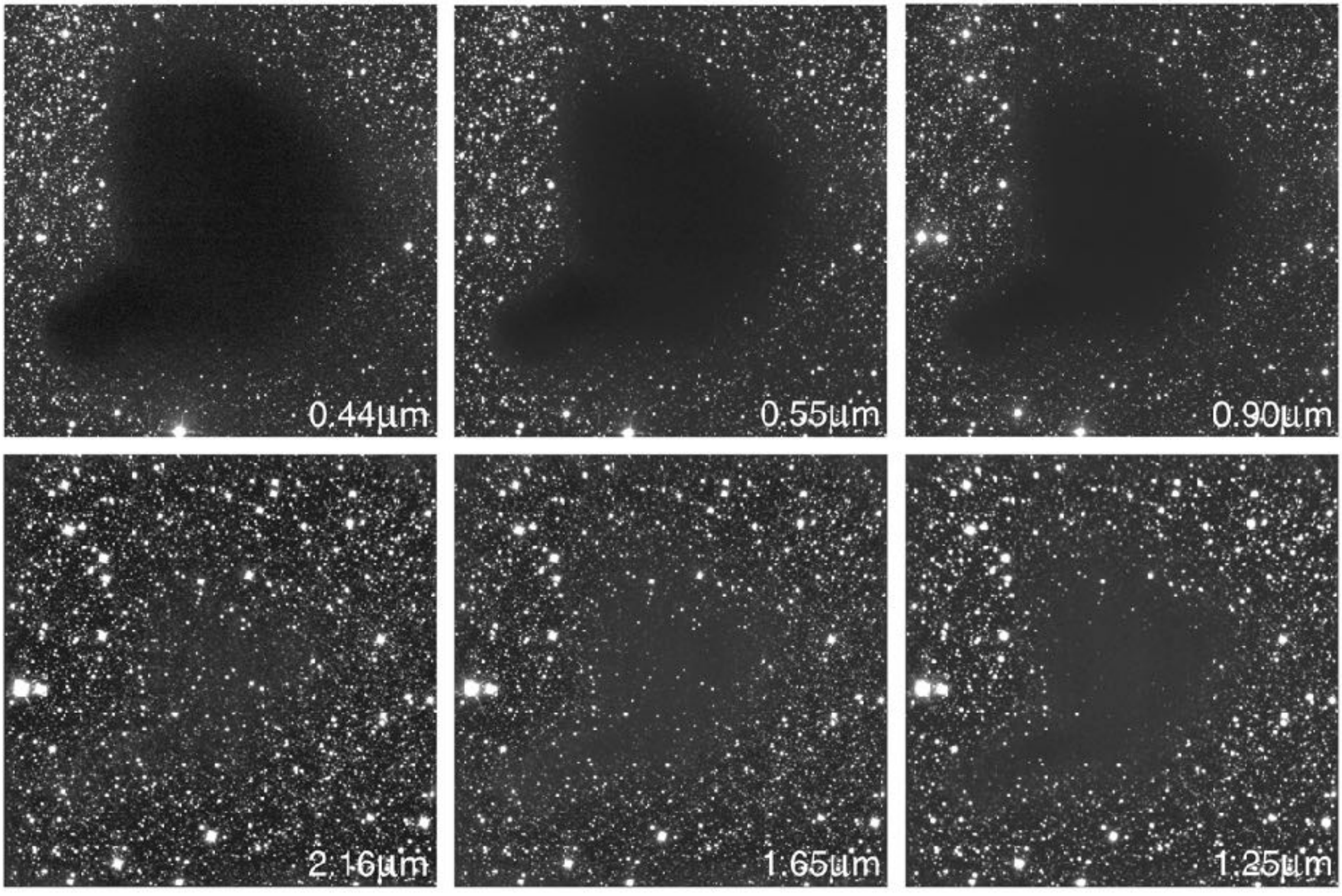


# A világ infravörösben





# Az univerzum infravörösben



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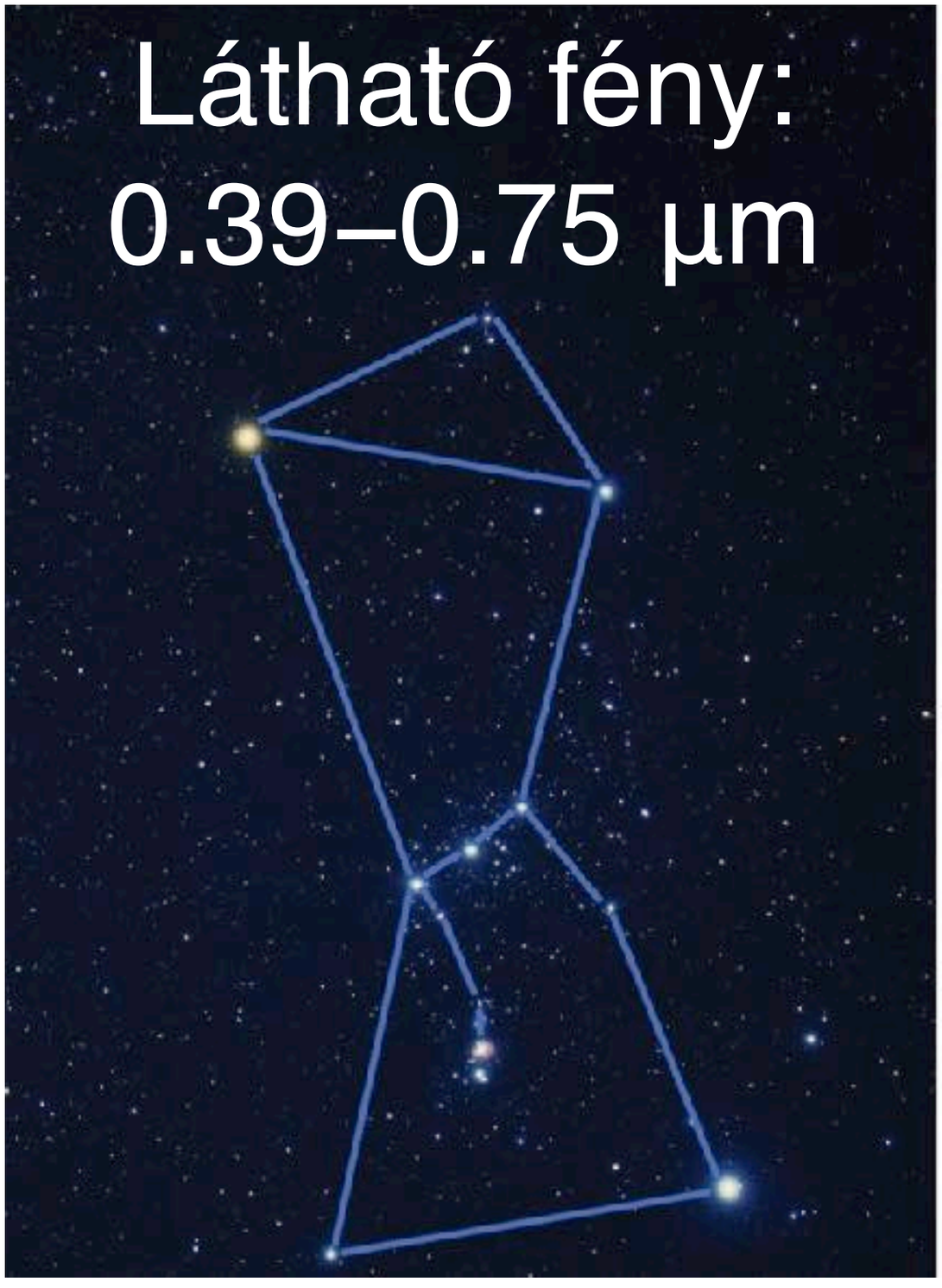

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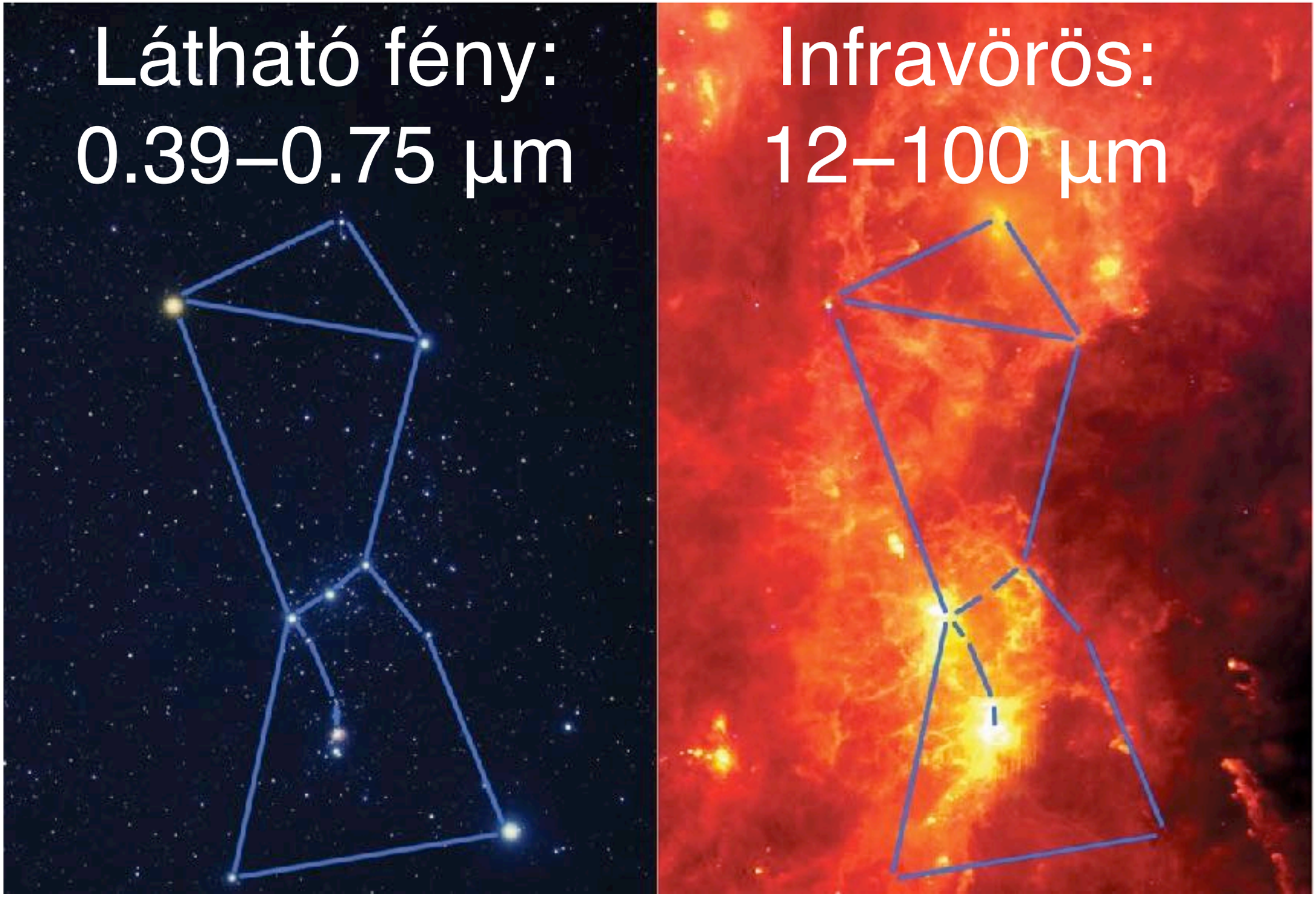


# Észak-Amerika köd

# Ophiuchus


SPITZER
SPACE TELESCOPE
NASA/JPL-Caltech www.spitzer.caltech.edu

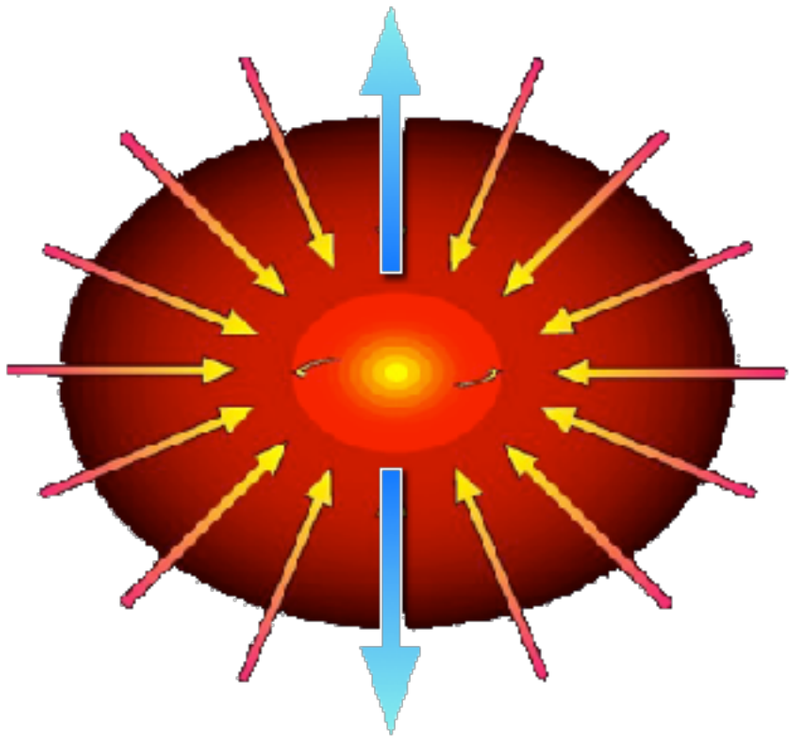
# Cygnus X

herschel

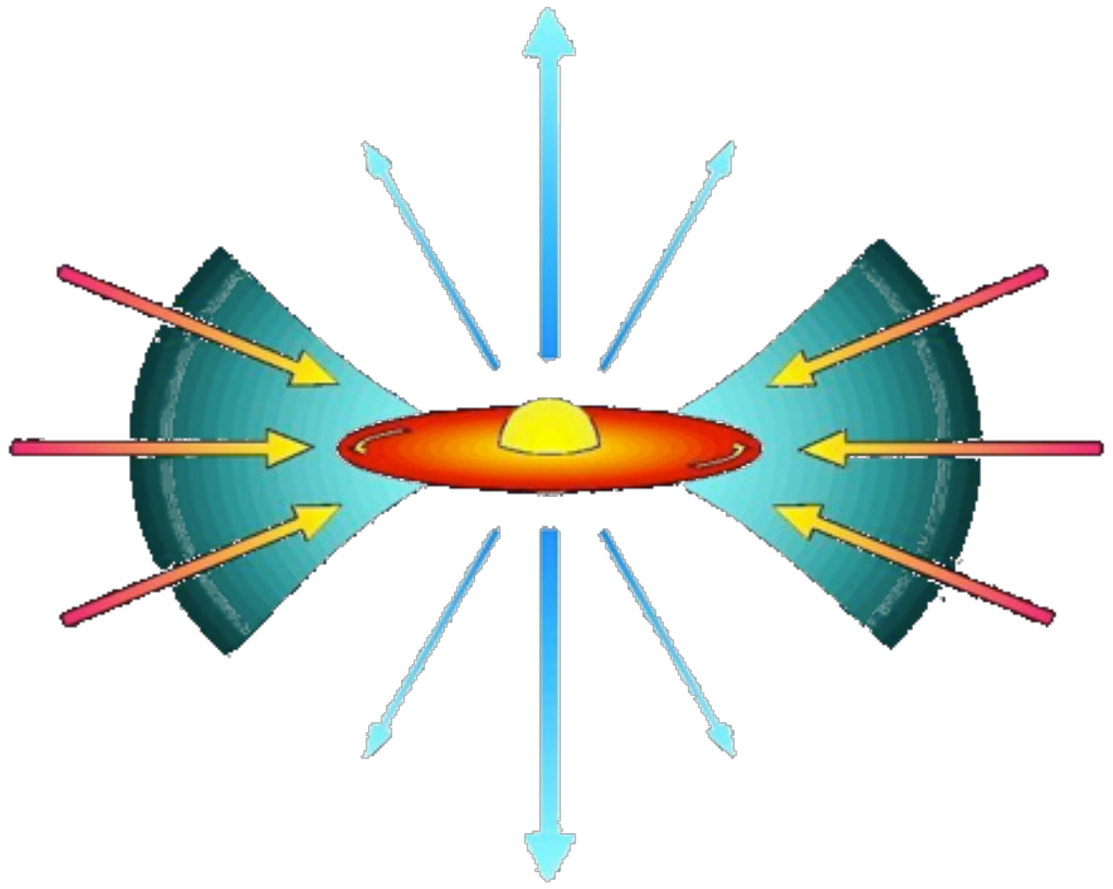
# Carina köd

herschel

# Csillagkeletkezés

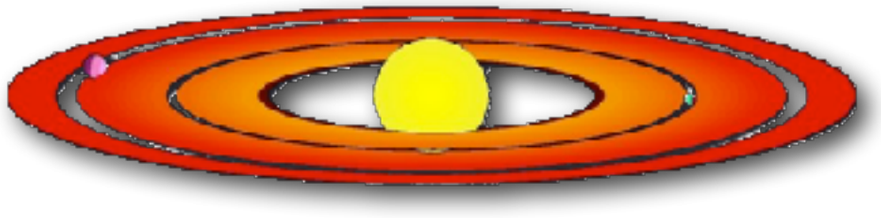


0. osztály
10 000 év
10 000 CsE
10–300 K

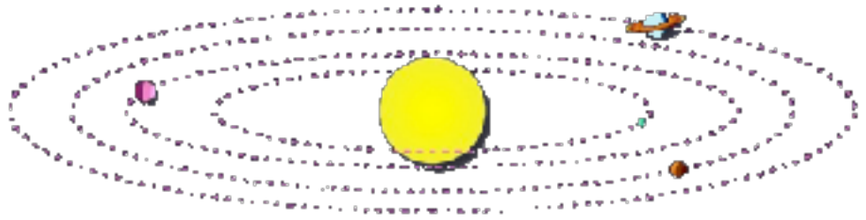


1. osztály
100 000 – 1 millió év
1000 CsE
100–3000 K

# Csillagkeletkezés



2. osztály
1–10 millió év
100 CsE
100–5000 K

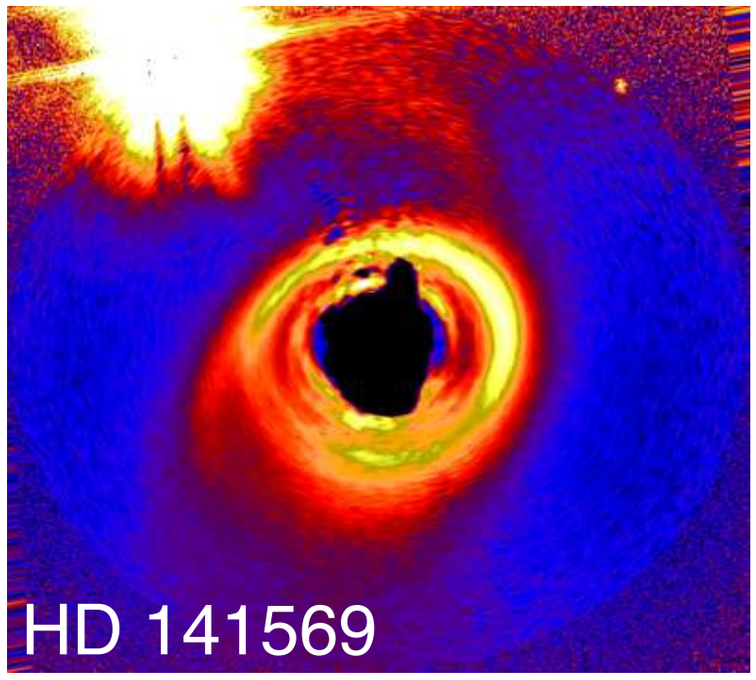


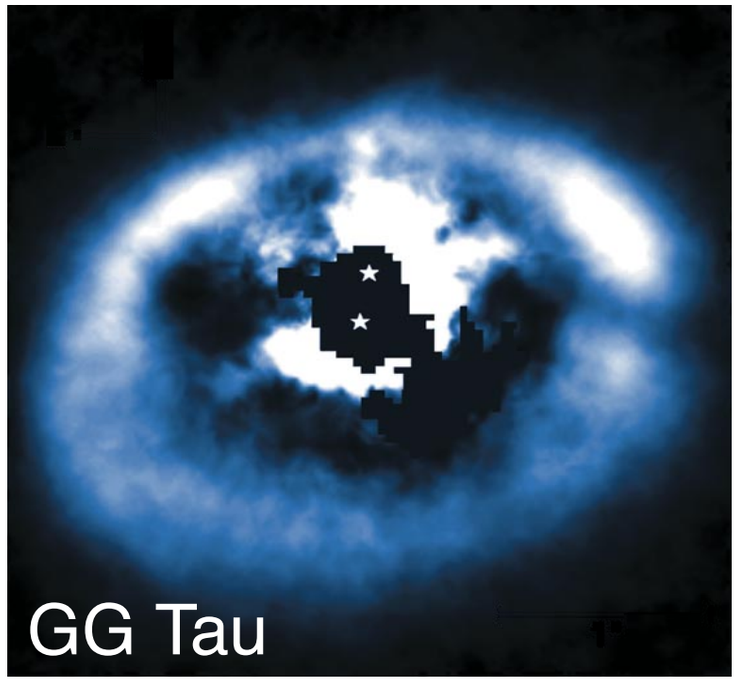
3. osztály
1 millió – 1 milliárd év
100 CsE
100–5000 K

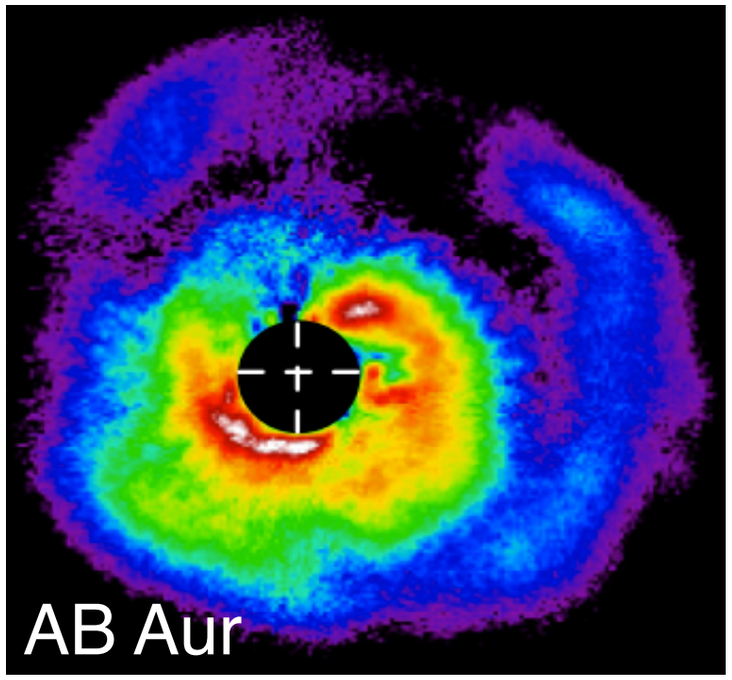
# Csillagkörüli korongok

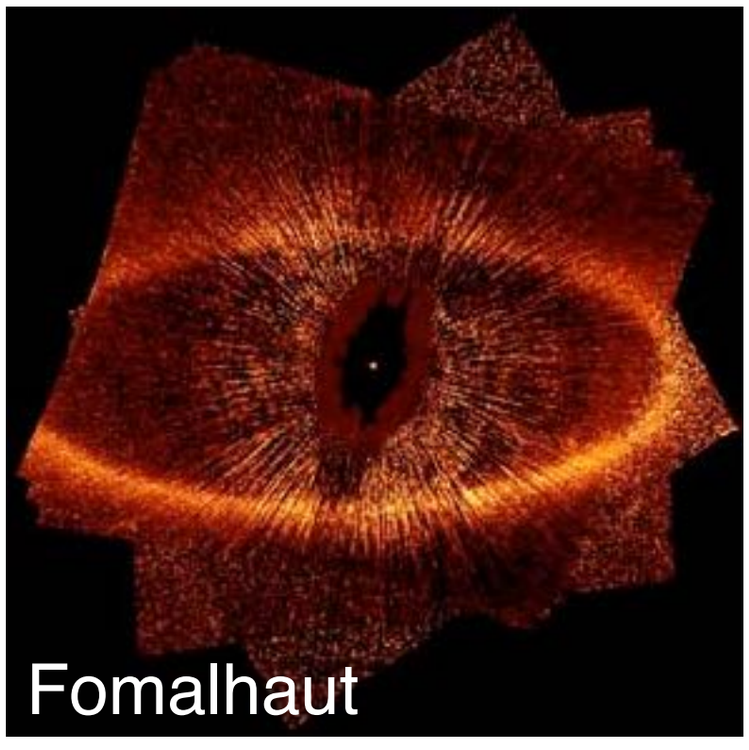
# Csillagkörüli korongok

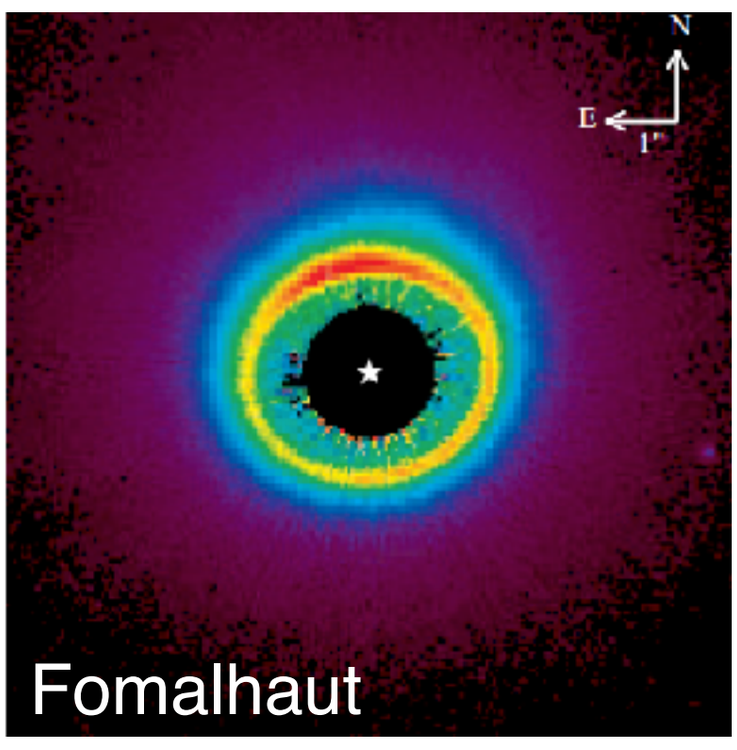
## Ahogyan a csillagászok látják:

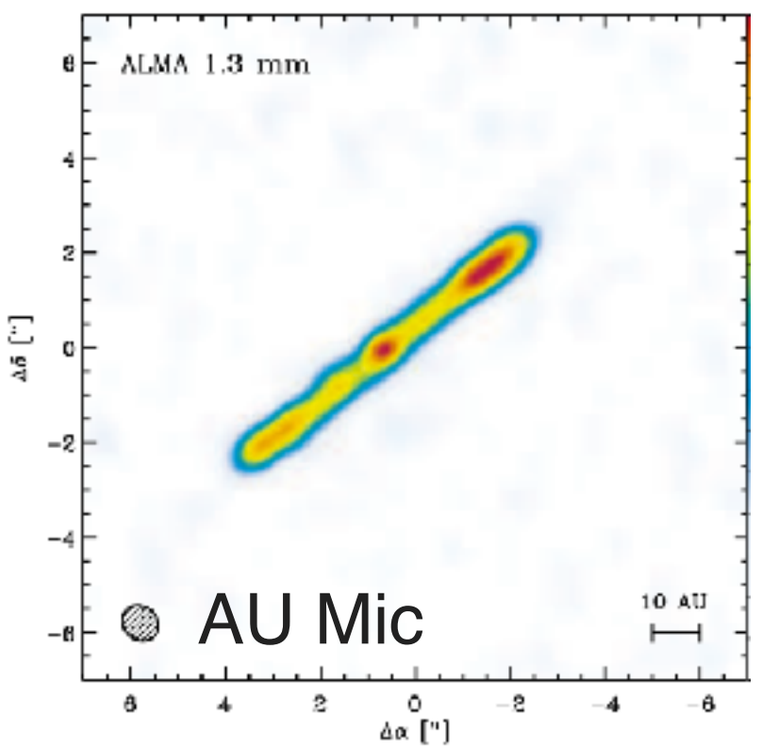


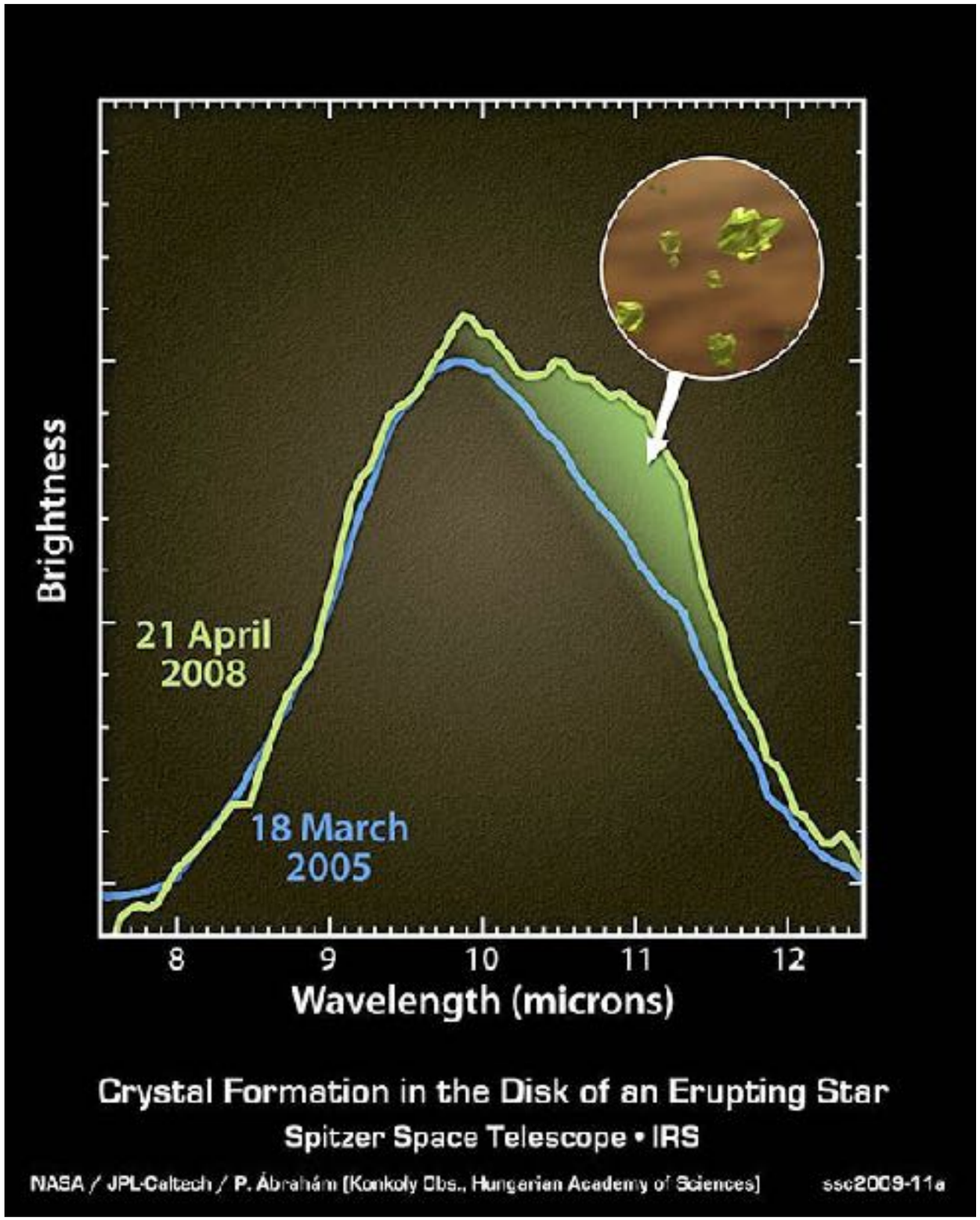



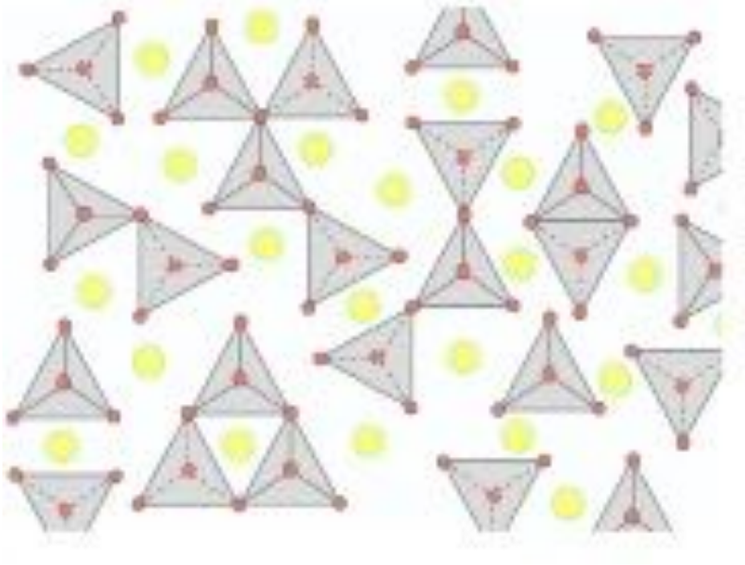



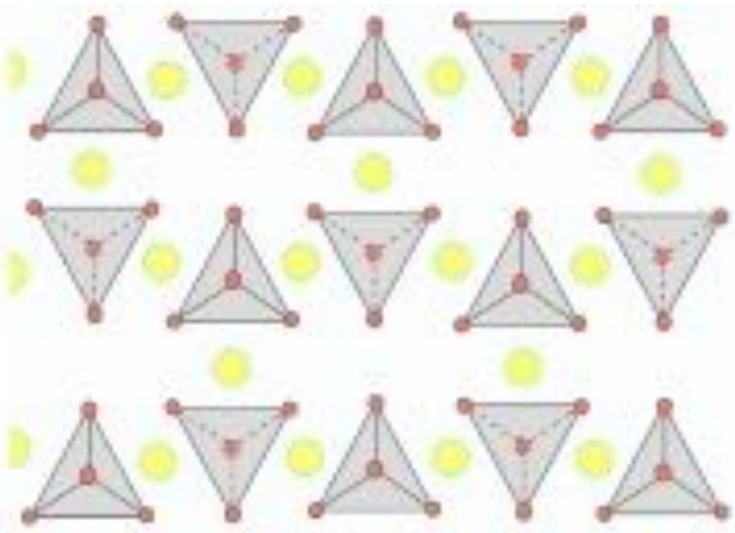
# Kristályos szilikátok



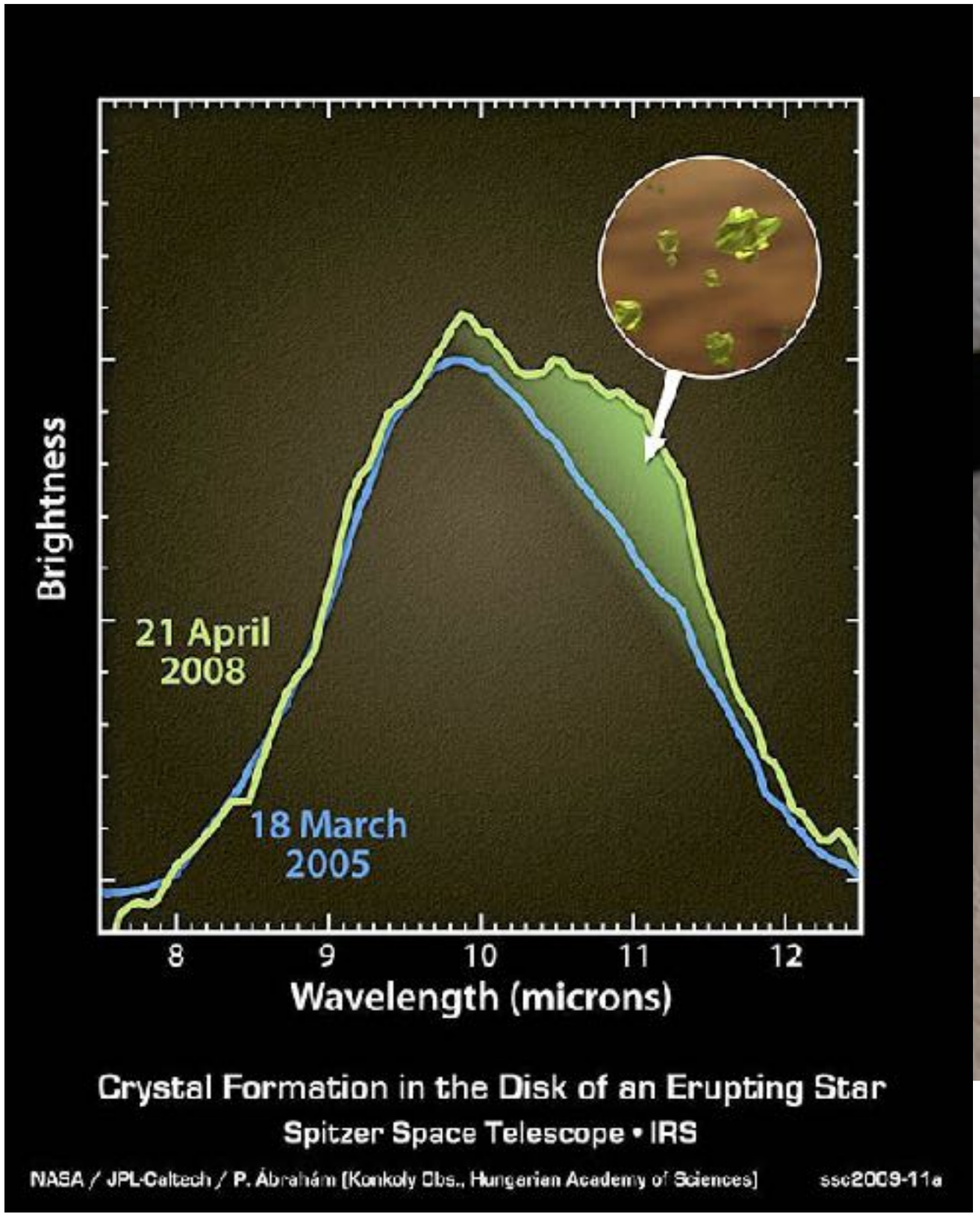

Amorf



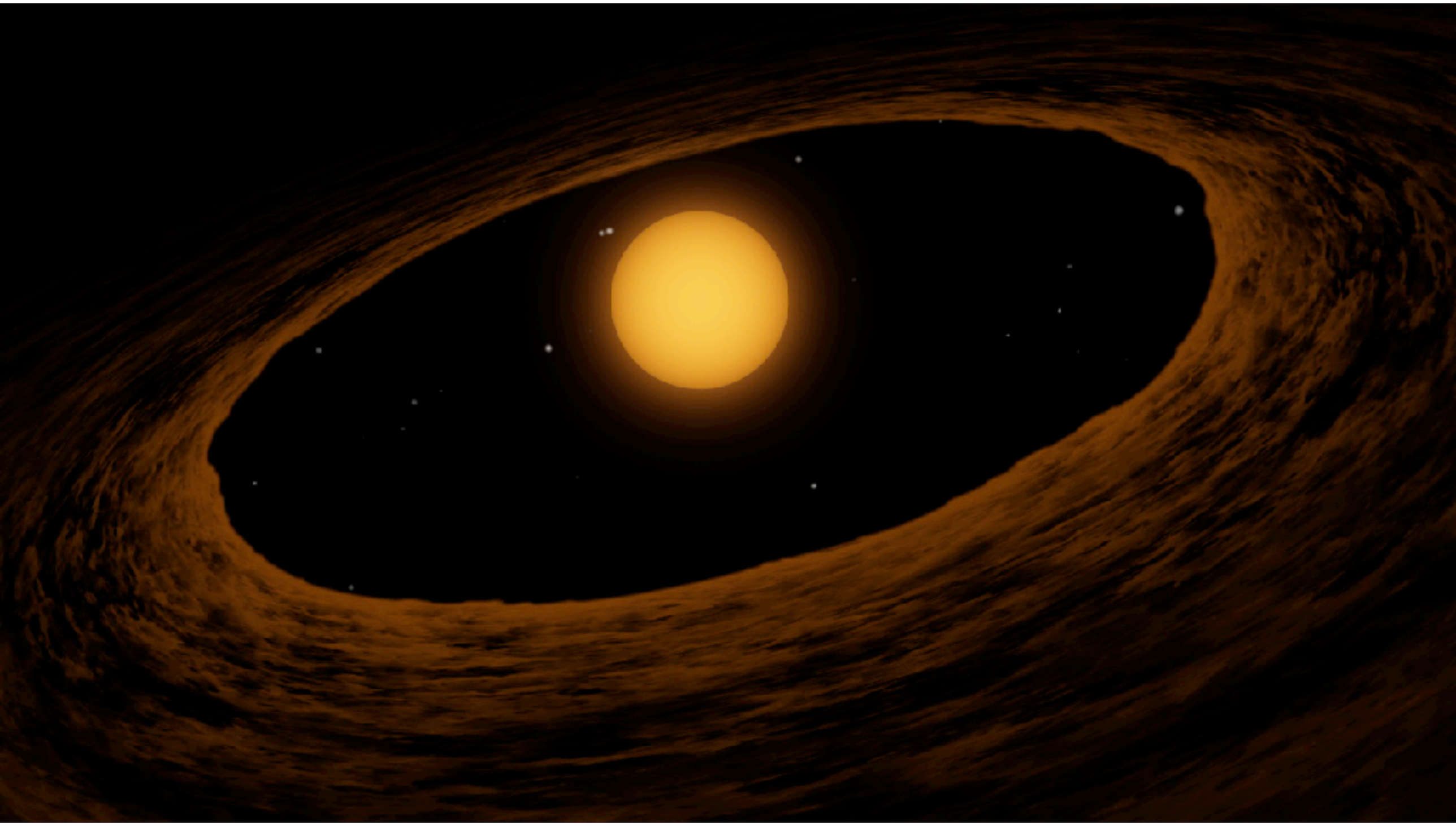
Kristálvos



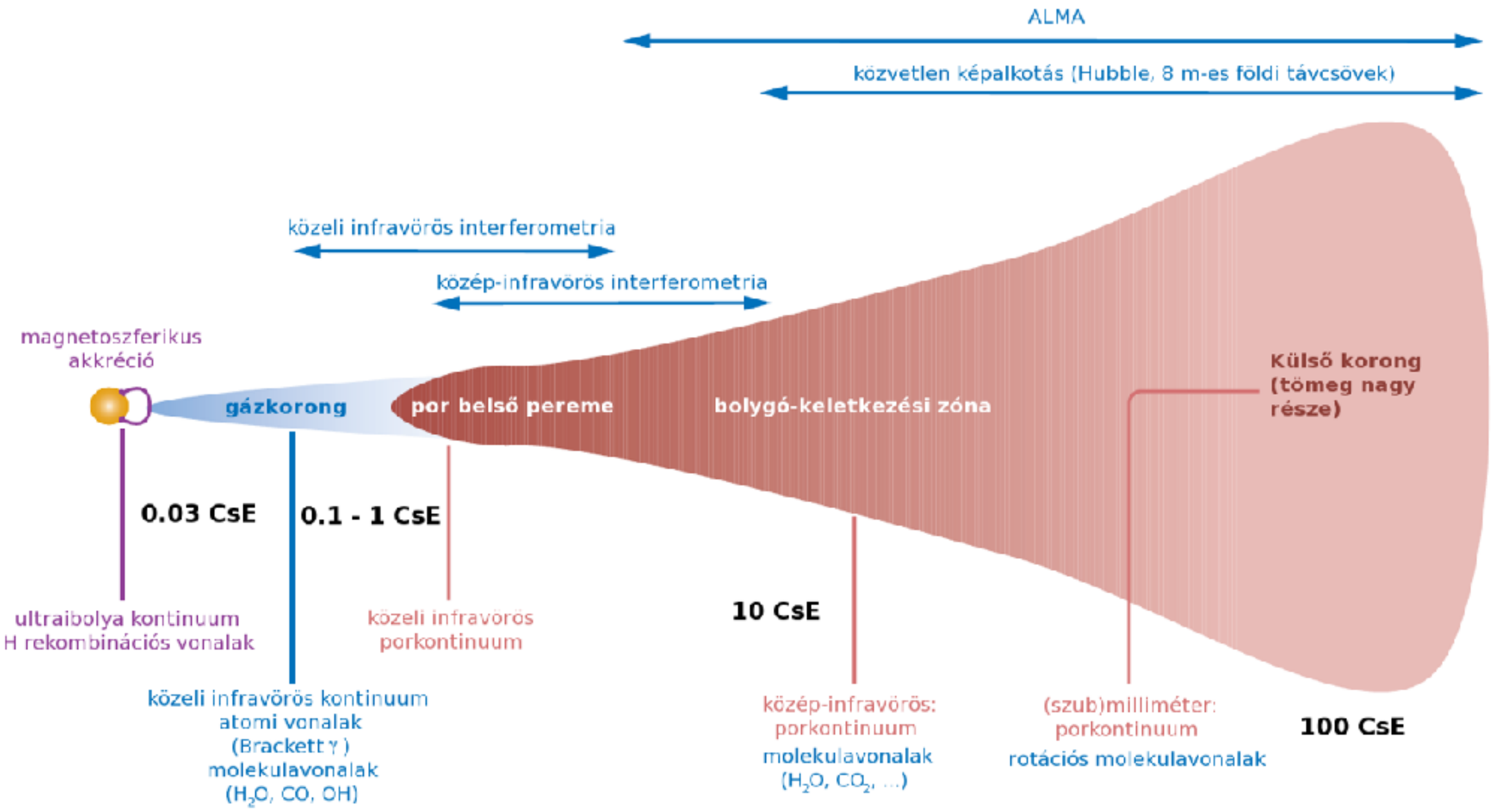
# Kristályos szilikátok




# Kristályosodás a korongban



# A csillagkörüli anyag vizsgálata



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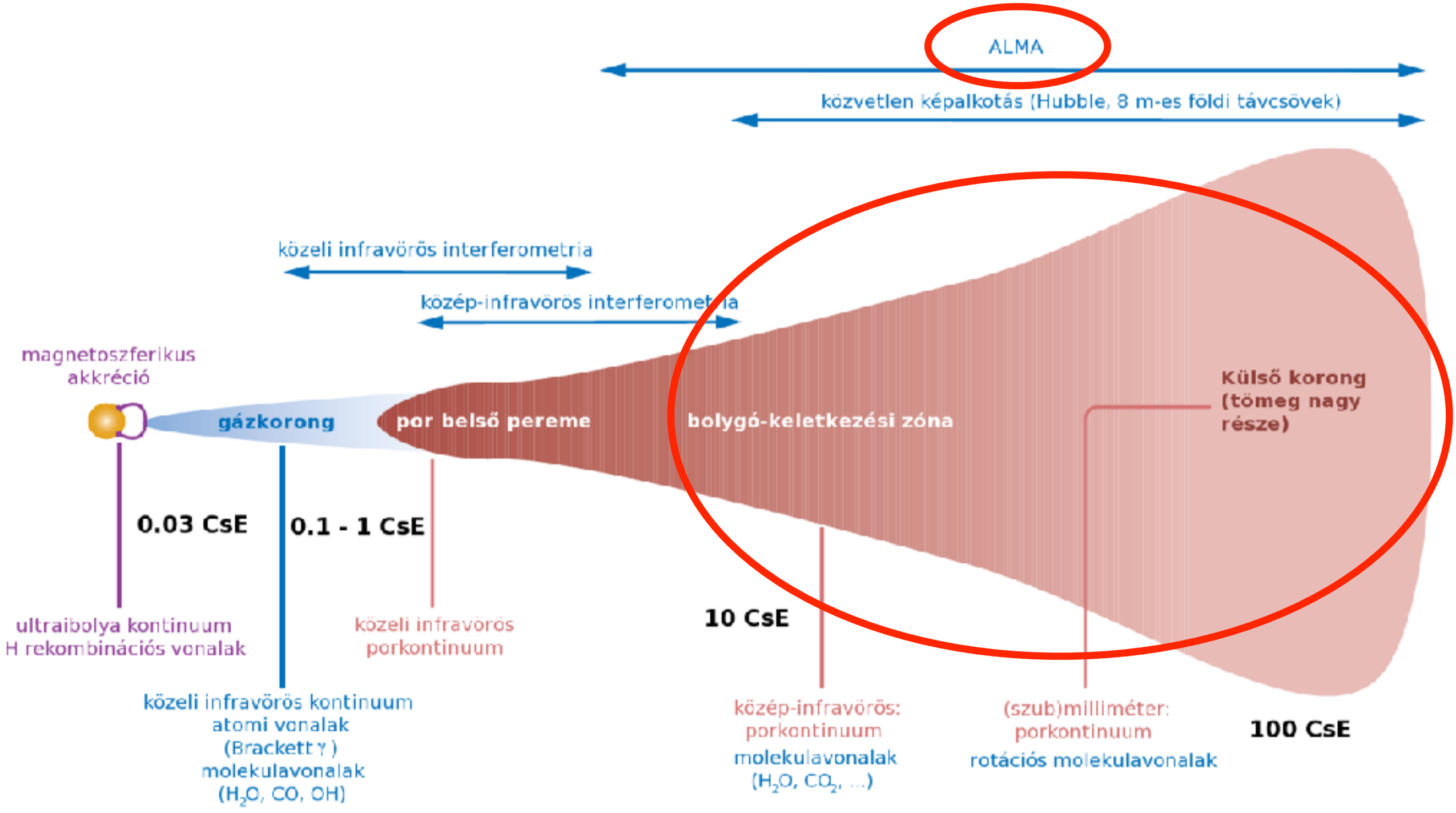
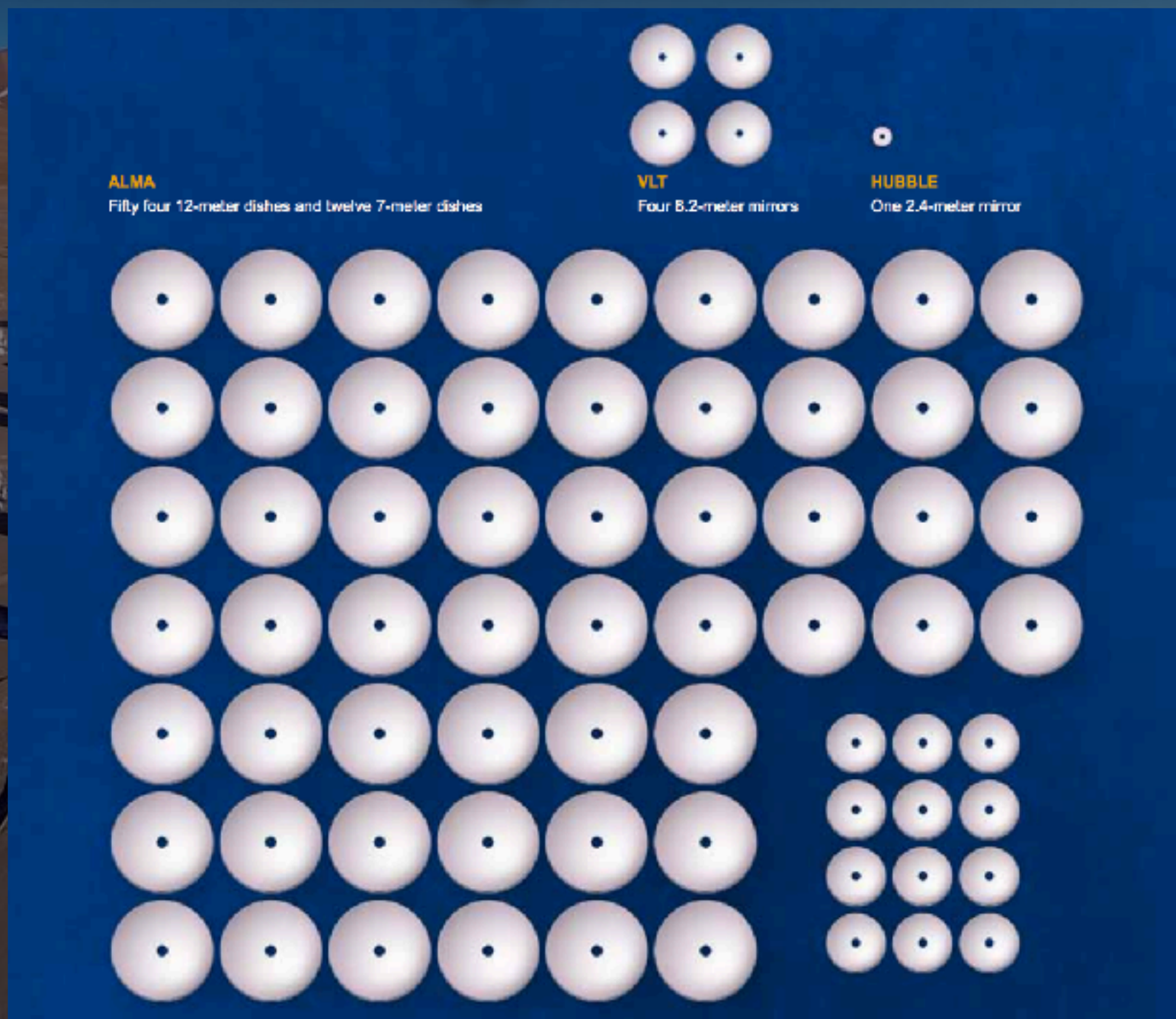


# ALMA

## Atacama Large Millimeter/submillimeter Array

# ALMA

- 54 darab 12 méteres és 12 darab 7 méteres antenna
- Teljes fénygyűjtő felület: 6600 négyzetméter



# ALMA

- 54 darab 12 méteres és 12 darab 7 méteres antenna
- Teljes fénygyűjtő felület: 6600 négyzetméter
- Helyszín: Chile, Atacama sivatag, 5050 méter tengerszint feletti magasságban
- 0.4−3.1 milliméteres hullámhosszú sugárzást mér

# ALMA

- 54 darab 12 méteres és 12 darab 7 méteres antenna
- Teljes fénygyűjtő felület: 6600 négyzetméter
- Helyszín: Chile, Atacama sivatag, 5050 méter tengerszint feletti magasságban
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- Antennák felülete tökéletes parabola (< 20 μm)

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- Térbeli felbontás: 0.006″ (golflabda 1500 km-ről)

# ALMA

- 54 darab 12 méteres és 12 darab 7 méteres antenna
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- 0.4−3.1 milliméteres hullámhosszú sugárzást mér
- Antennák felülete tökéletes parabola (< 20 μm)
- Térbeli felbontás: 0.006″ (golflabda 1500 km-ről)
- Építési költsége: 1 milliárd EUR (globális összefogás)

# Az ALMA korrelátor

# Az ALMA korrelátor

- A világ egyik legnagyobb szuperszámítógépe
- 134 millió processzor
- 17 peta-FLOP sebesség (17000000000000000 művelet másodpercenként)
- Antennákról másodpercenként 1 gigabyte adat érkezik
- 700 terabyte adatot kell tárolni évente

# Az ALMA korrelátor

- A világ egyik legnagyobb szuperszámítógépe
- 134 millió processzor
- 17 peta-FLOP sebesség (17000000000000000 művelet másodpercenként)
- Antennákról másodpercenként 1 gigabyte adat érkezik
- 700 terabyte adatot kell tárolni évente

- Tipikus asztali számítógép vagy laptop
- 1−4 processzor
- 2−8 giga-FLOP sebesség (8000000000 művelet másodpercenként)
- Másodpercenként 1−10 megabyte adat az internetről
- 500 gigás − 1 terás tárolókapacitás

# Az ALMA korrelátor

10 milliószor gyorsabb

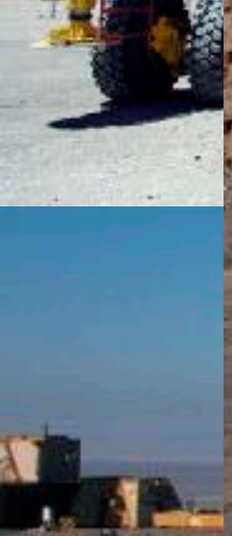
- A világ egyik le kus asztali szuperszámító mítógép vagy laptop
- 134 millió process 1−4 processzor
- 17 peta-FLOP sebesség (17000000000000000 művelet másodpercenként)
- 2−8 giga-FLOP sebesség (8000000000 művelet másodpercenként)
- Antennákról másodpercenként 1 gigabyte adat érkezik
- Másodpercenként 1−10 megabyte adat az internetről
- 700 terabyte adatot kell tárolni évente
- 500 gigás − 1 terás tárolókapacitás

# Az ALMA energiafogyasztása

- Energiaigény: 4,2 MW
- Éves energiafogyasztás: 36,8 GWh (kisebb város teljes fogyasztása)
- Üzemanyag: LPB (cseppfolyós propán-bután)
- Éves üzemanyag-fogyasztás: 17.3 millió liter (7 darab olimpiai úszómedencét töltene ki)
- Éves költség: 10 millió dollár

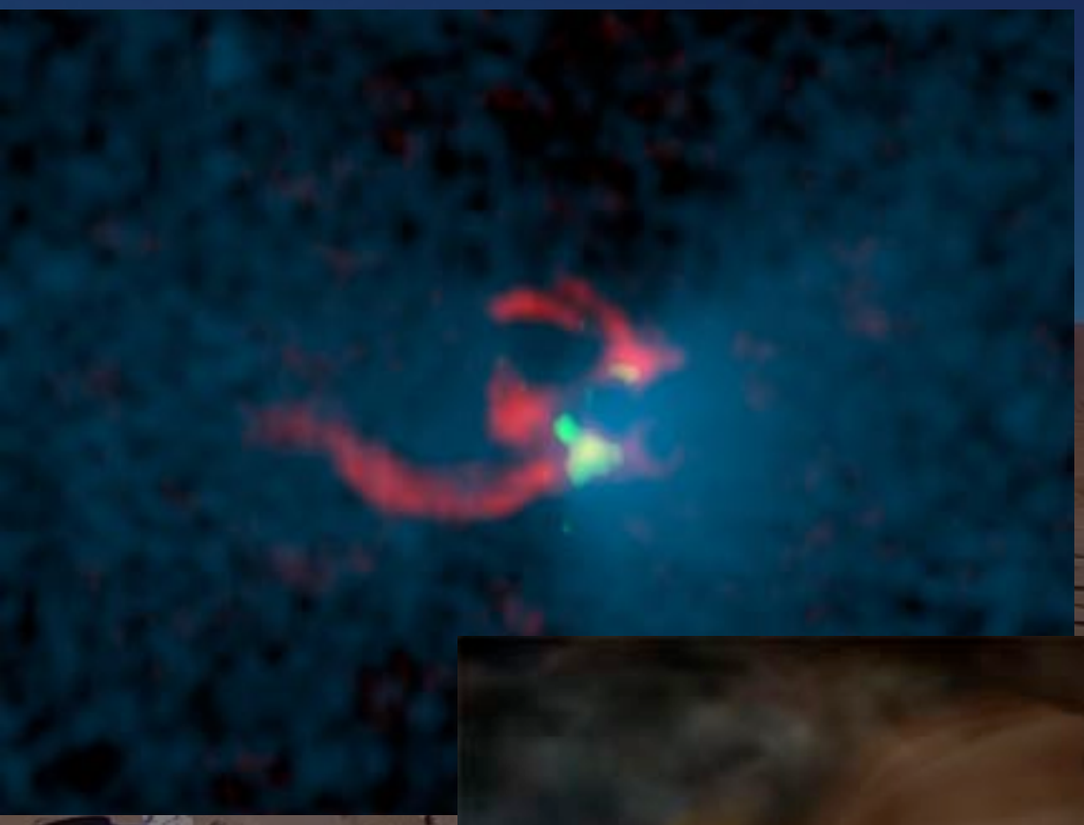
# ALMA transzporterek

# ALMA transzporterek



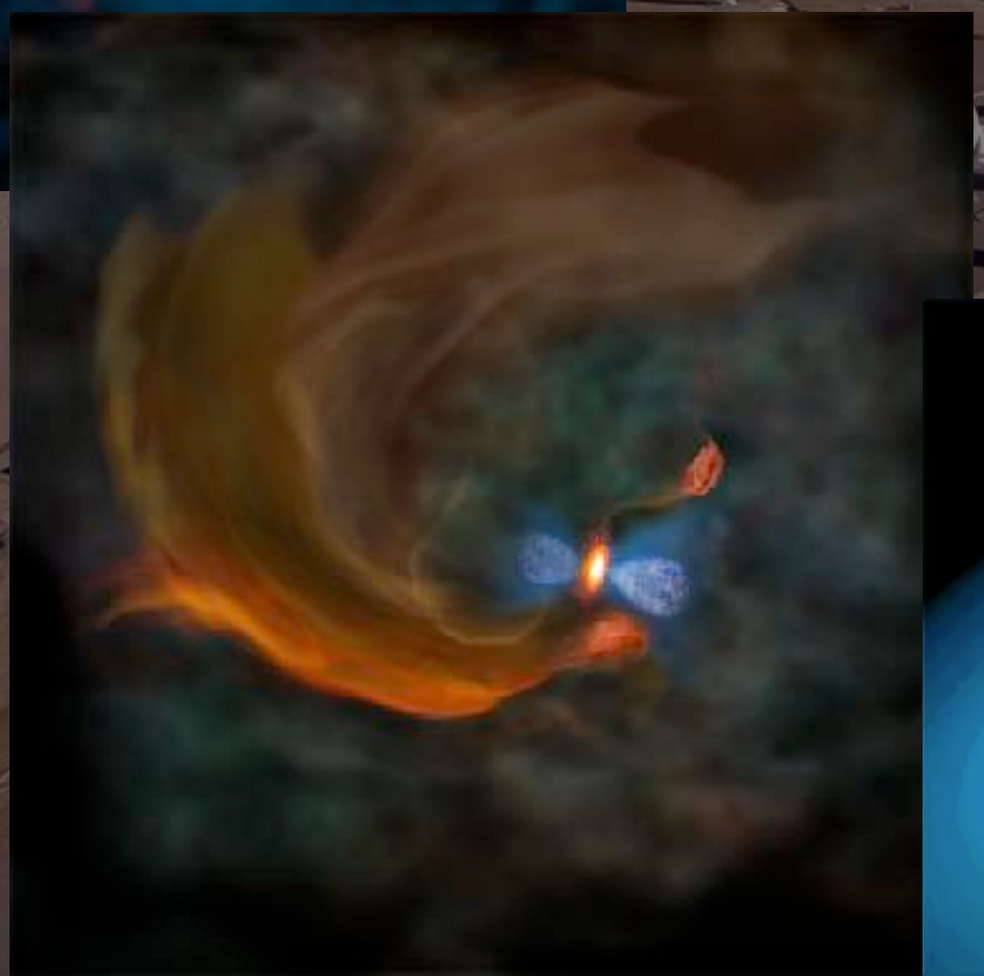
# ALMA transzporterek

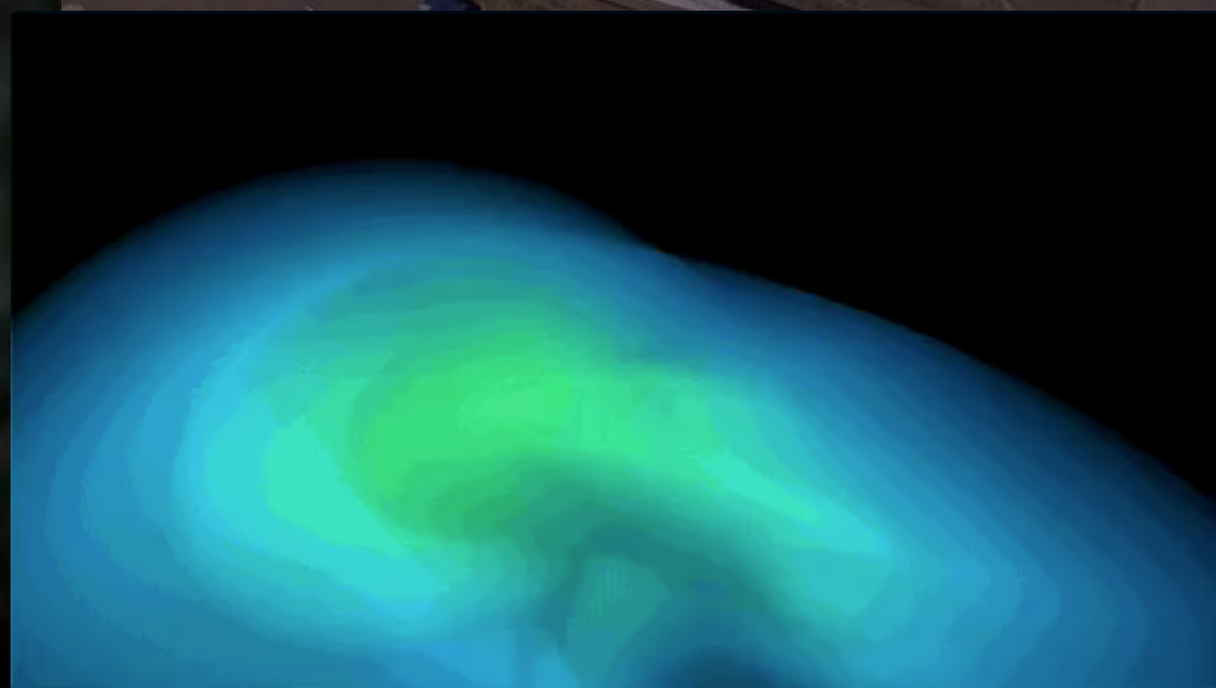
# Korong-kutatás ALMA-val



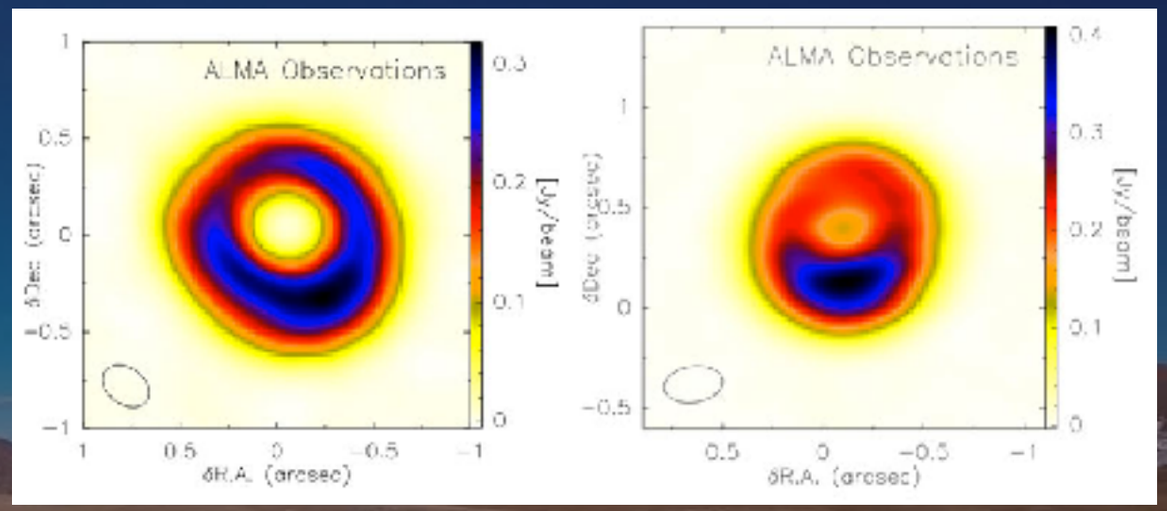
A csillagkeletkezés legkoraibb fázisainak vizsgálata

Hogyan omlanak össze a csillagközi anyag legsűrűbb csomói?





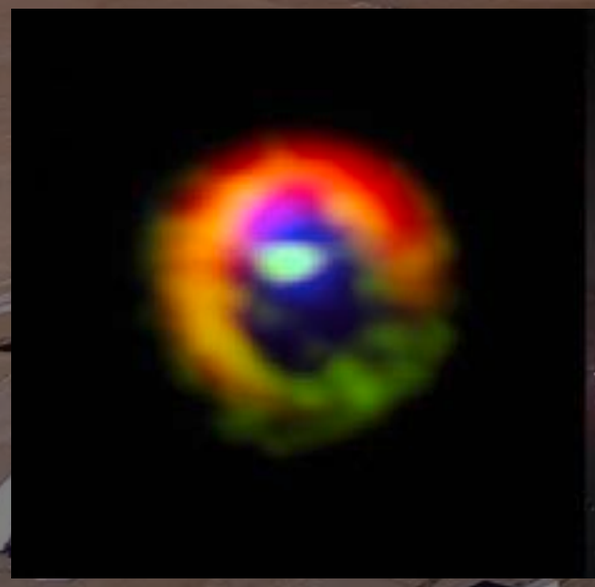
# Korong-kutatás ALMA-val

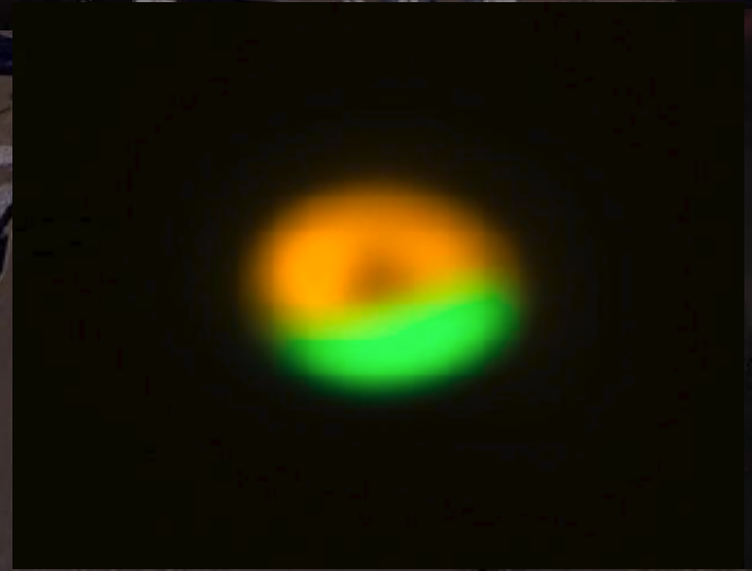



A korongok részletes szerkezete

Mi az aszimmetriák oka?

Bolygók, örvények a korongban?





# Korong-kutatás ALMA-val

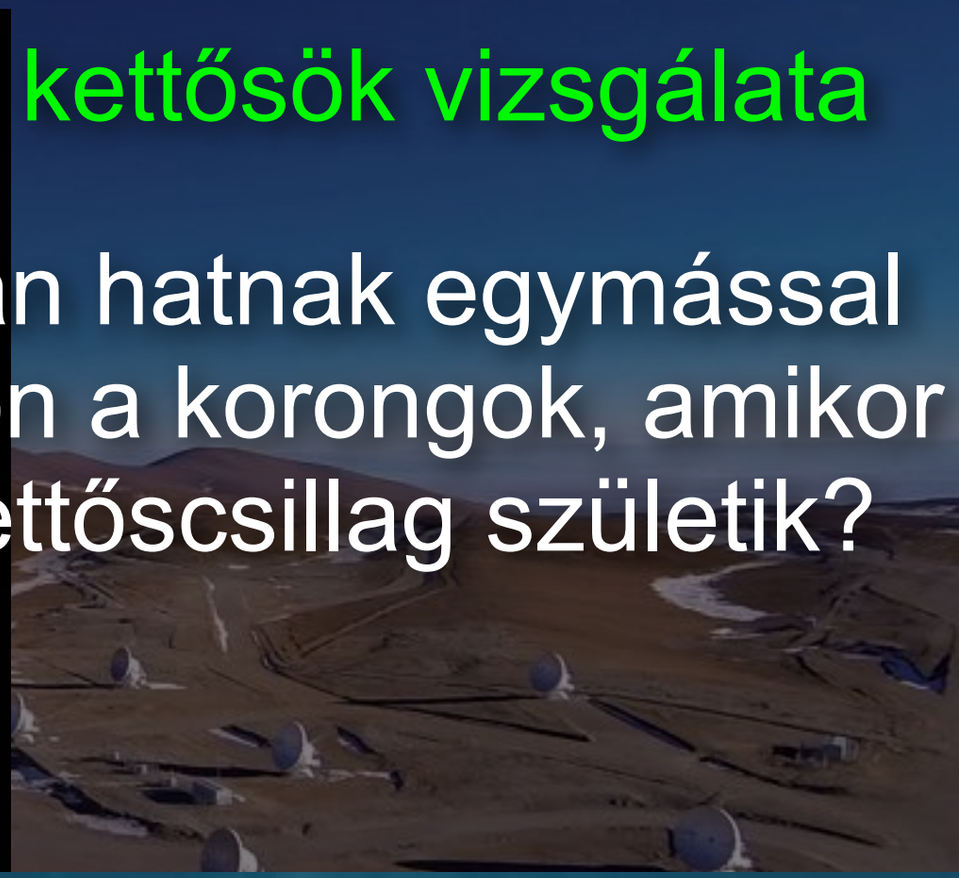
## Közeli kettősök vizsgálata

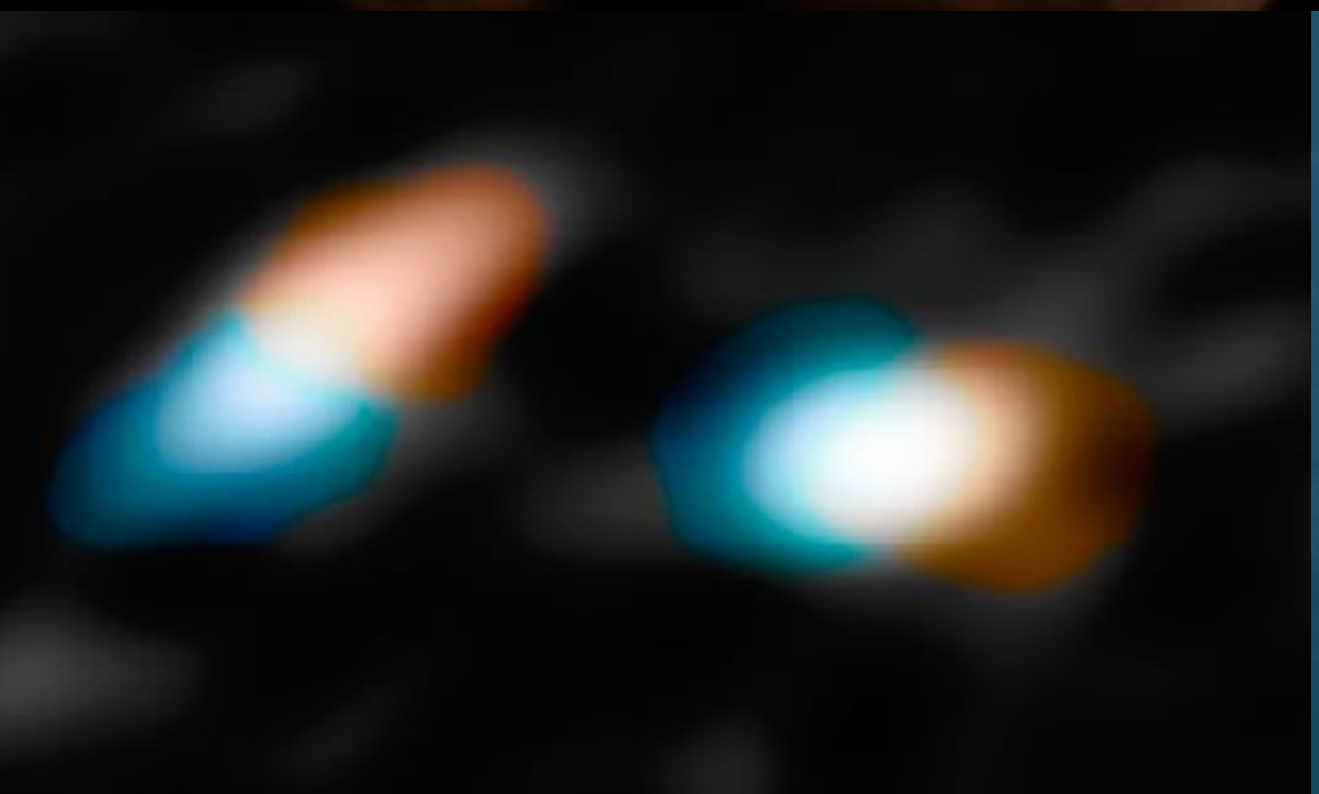
Hogyan hatnak egymással kölcsön a korongok, amikor egy kettőscsillag születik?

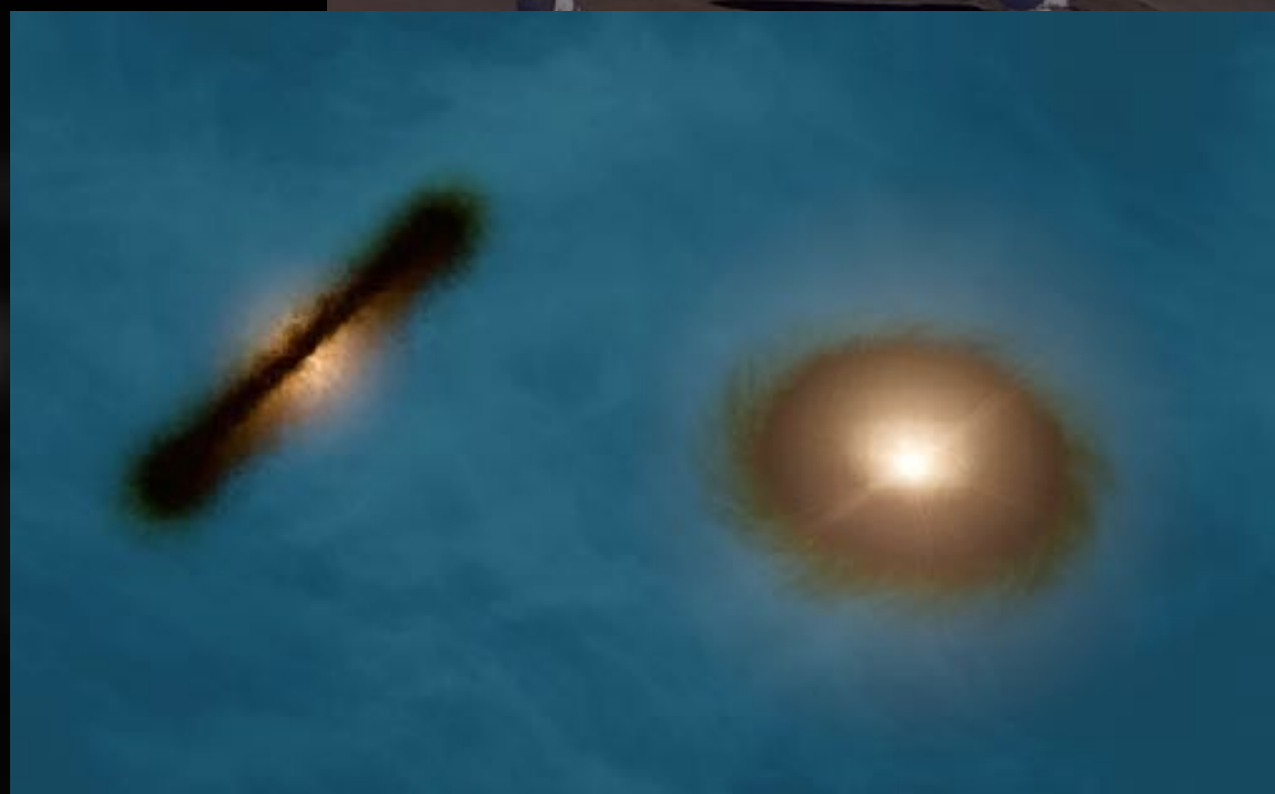
# Korong-kutatás ALMA-val

## Közeli kettősök vizsgálata

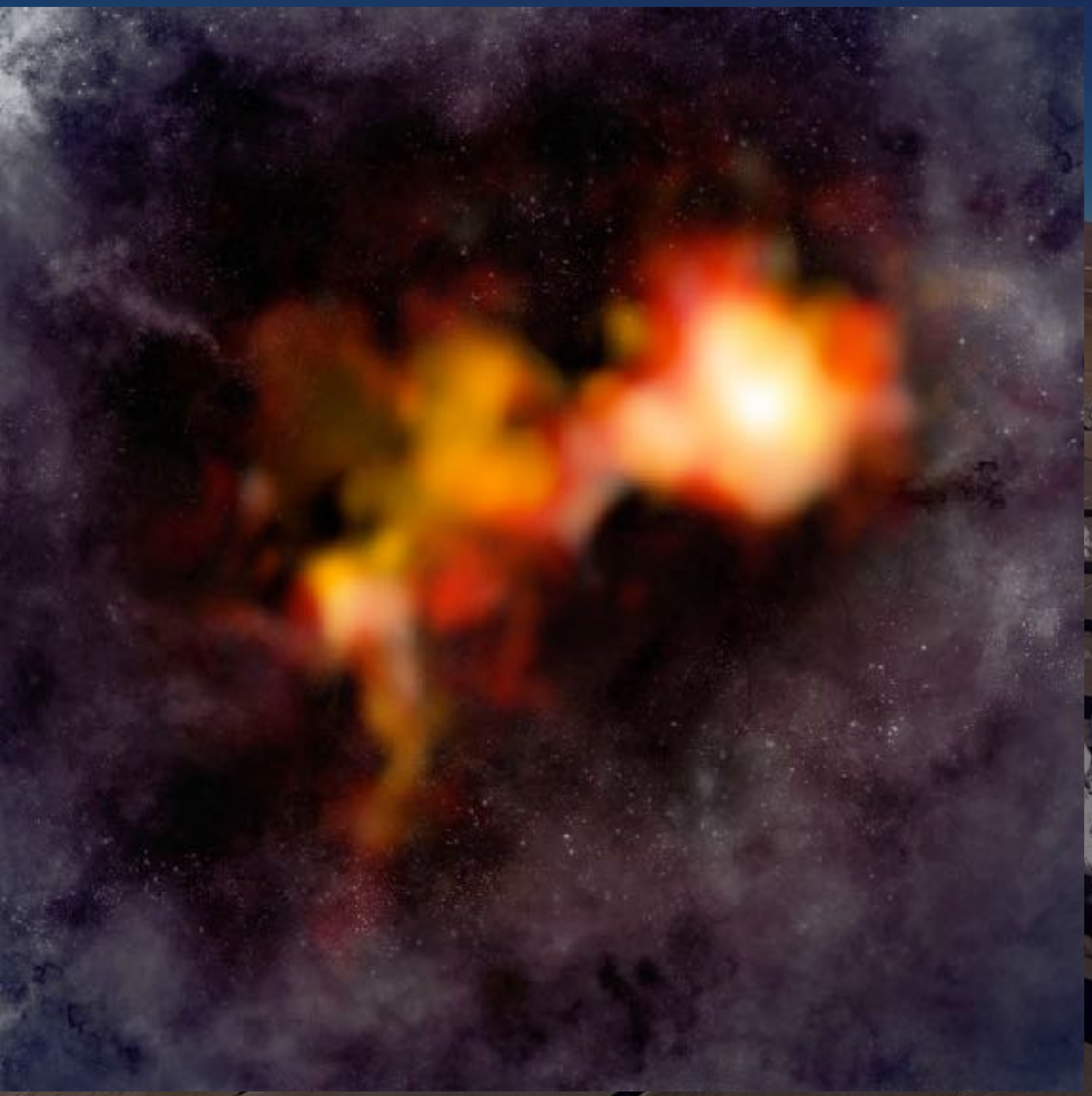
Hogyan hatnak egymással kölcsön a korongok, amikor egy kettőscsillag születik?







# Korong-kutatás ALMA-val



A nagytömegű csillagok keletkezésének vizsgálata

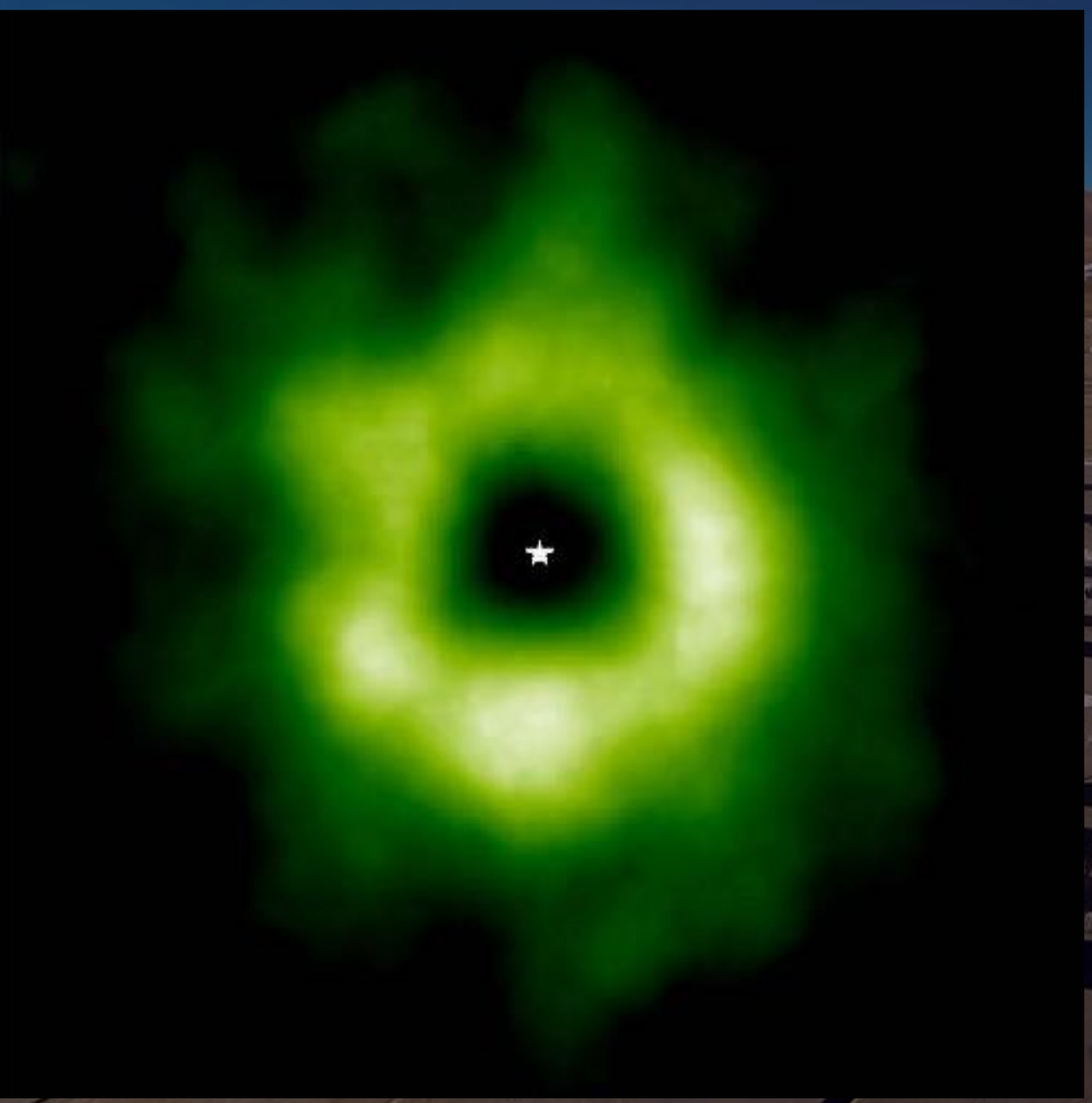
Hogyan keletkeznek 8 naptömegnél nagyobb csillagok?

# Korong-kutatás ALMA-val

## Korongok barna törpék körül

Kialakulhatnak-e Föld-típusú bolygók barna törpék körül?

# Korong-kutatás ALMA-val



## Asztrokémia

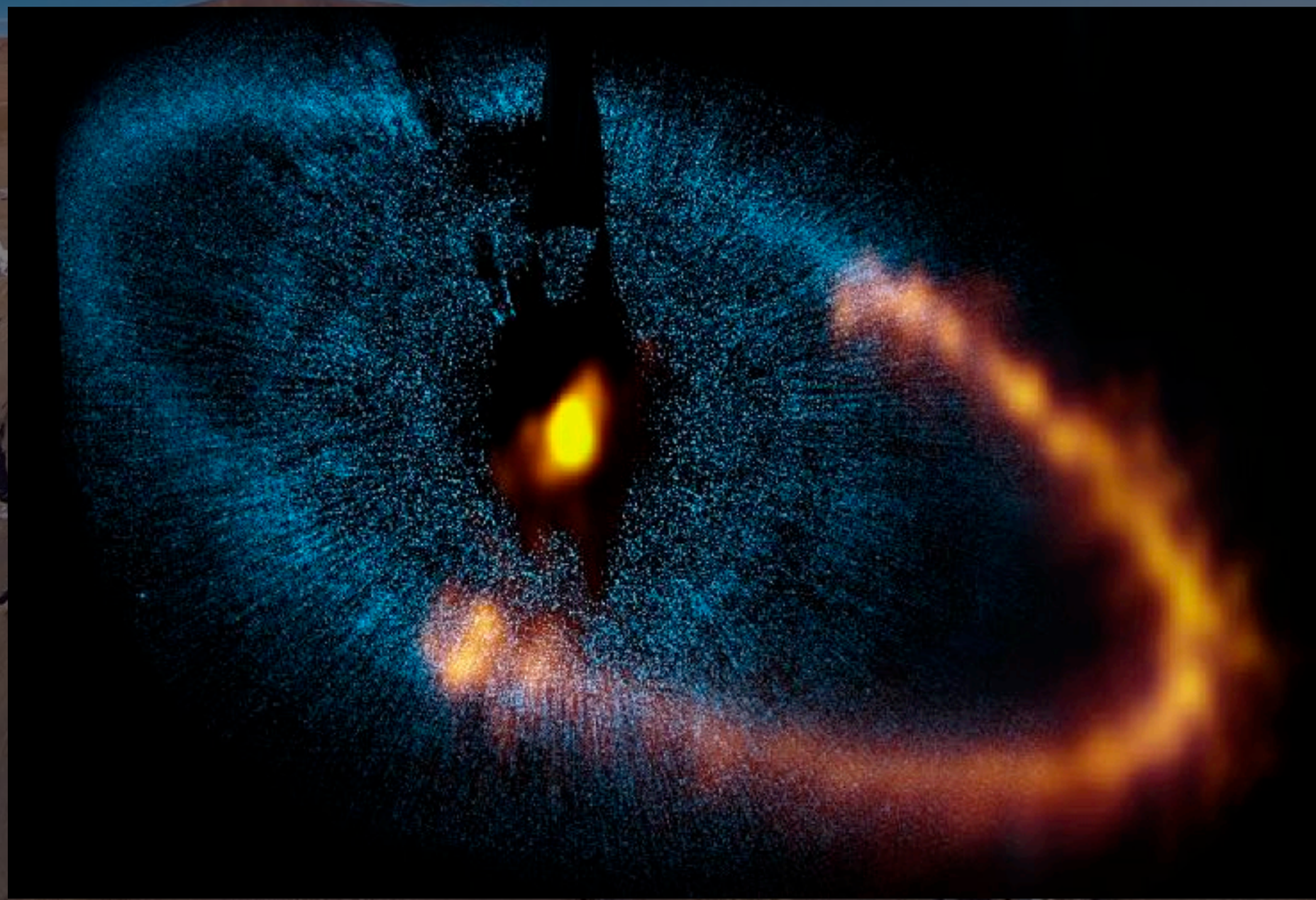
Milyen molekulák találhatók a csillagkörüli anyagban?

$CO$, $OH$, $CO_2$, $CH_4$, $NH_3$, $N_2H^+$, $HCO^+$, $CN$, $CS$, $SO$, $HNCO$, $HCN$, $HC_3N$, $H_2CO$, $CH_3OH$, $CH_3CN$, …

# Korong-kutatás ALMA-val

## Korongok és bolygók kapcsolata

Hogyan hatnak kölcsön az exobolygók a csillagkörüli porral?

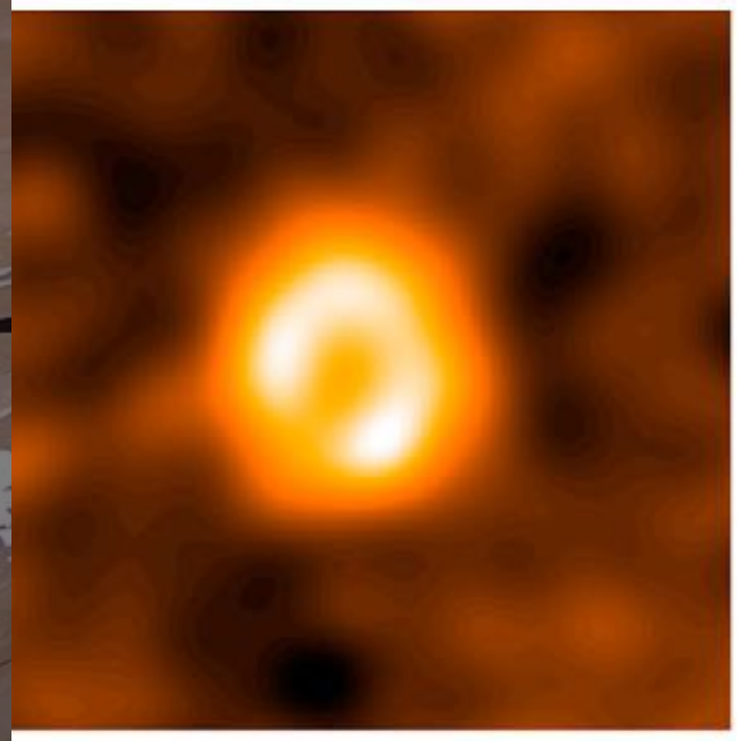


# Korong-kutatás ALMA-val

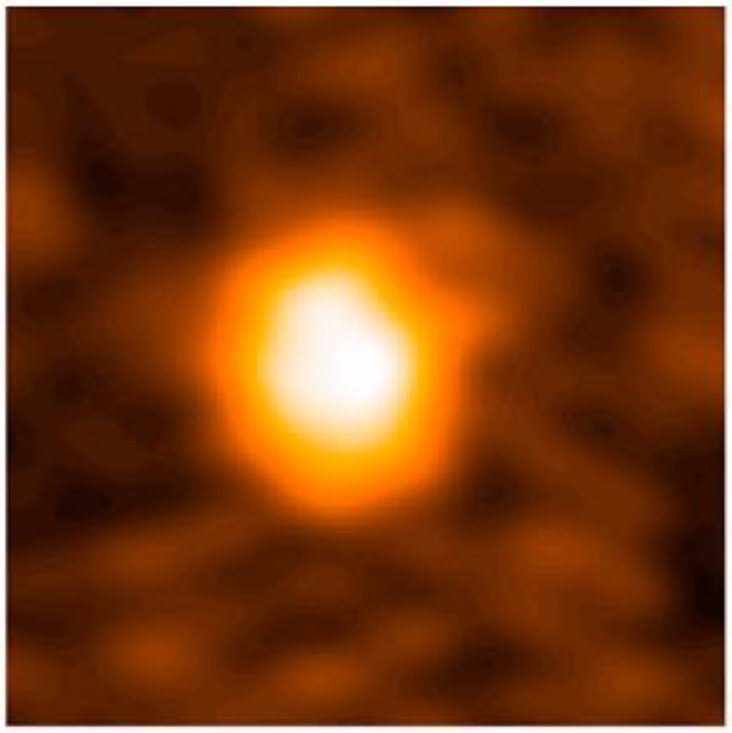
## A korongok eltűnése

Hogyan tűnik el a korong por- és gázanyaga?

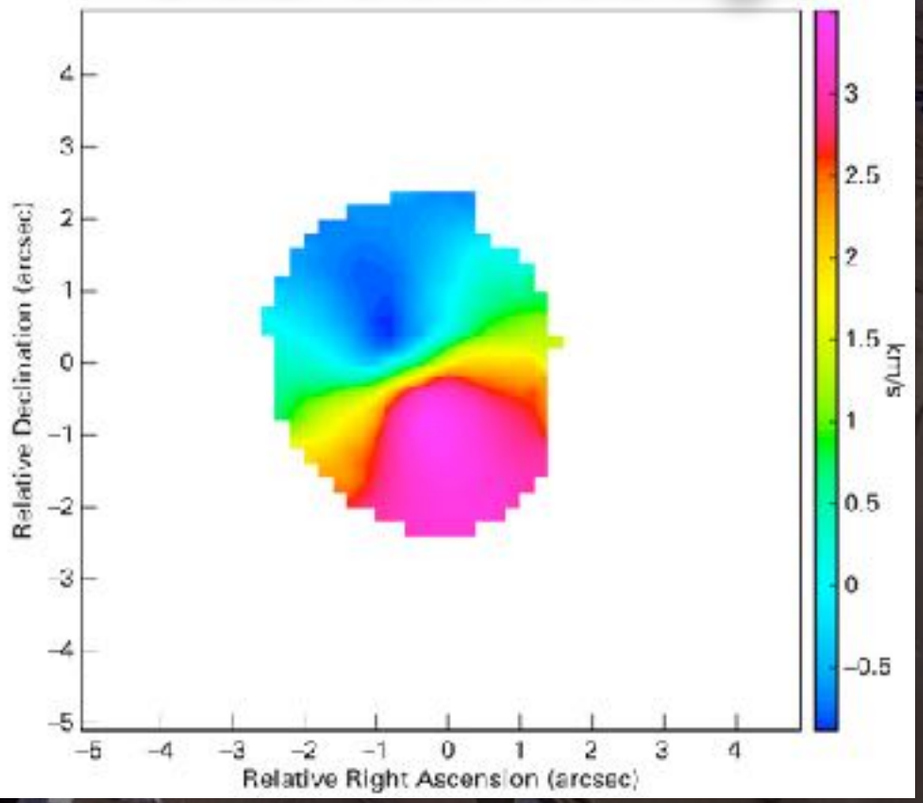
Por



Gáz

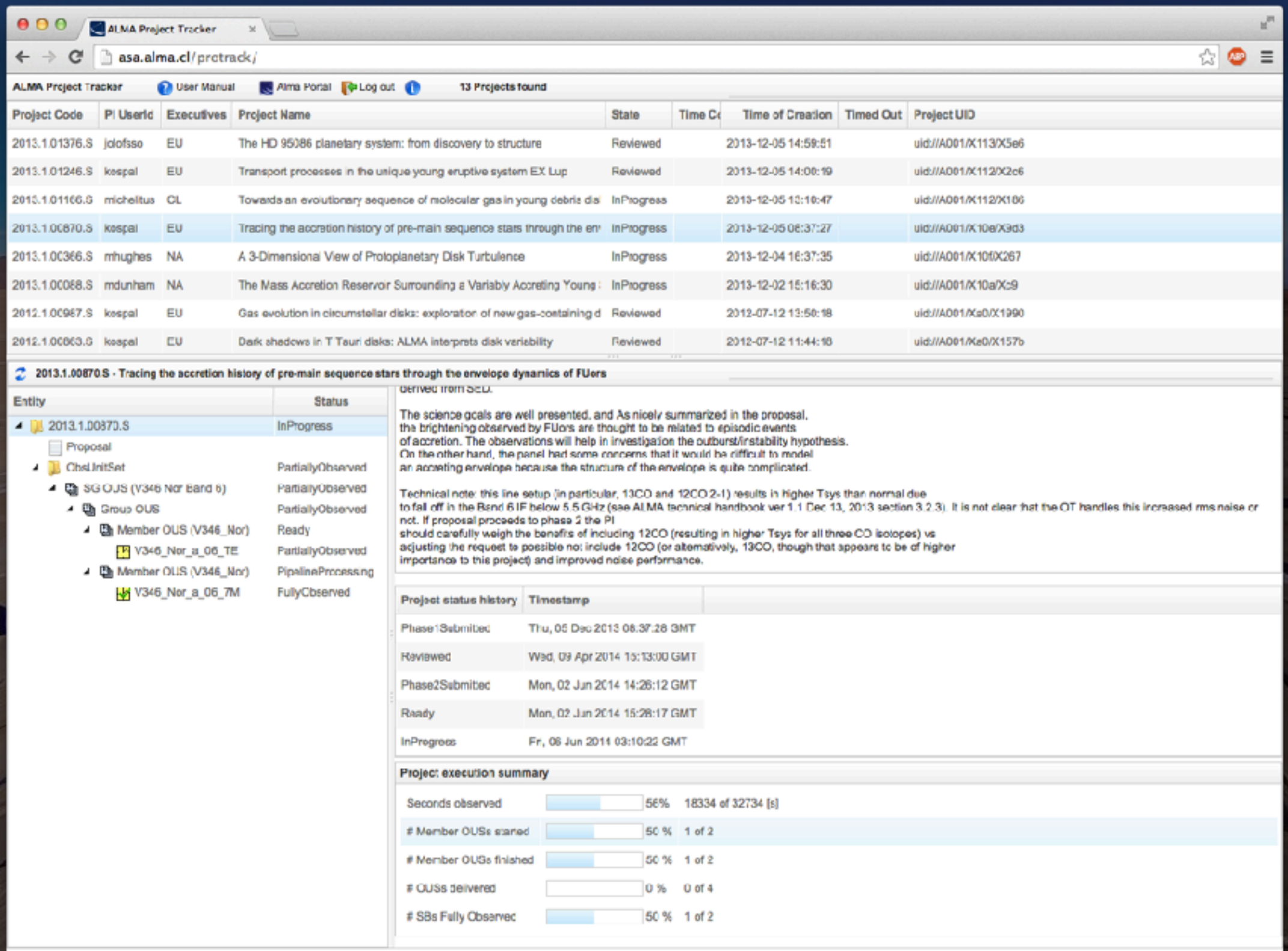


Gáz sebessége




Egyik legelső tudományos ALMA-mérés
Pályázatunk 11-szeres túljelentkezés mellett nyert

# Folyó ALMA projektjeink



# Folyó ALMA projektjeink

ALMA Project Tracker

asa.alma.cl/pretrack/

ALMA Project Tracker | User Manual | Alma Portal | Log out | 13 Projects found

| Project Code | PI Userid | Executives | Project Name | State | Time Cr | Time of Creation | Timed Out | Project UID |
|---|---|---|---|---|---|---|---|---|
| 2013.1.01376.S | jolofsso | EU | The HD 95086 planetary system: from discovery to structure | Reviewed | | 2013-12-05 14:59:51 | | uid://A001/X113/X5e6 |
| 2013.1.01246.S | kospal | EU | Transport processes in the unique young eruptive system EX Lup | Reviewed | | 2013-12-05 14:06:19 | | uid://A001/X112 |
| 2013.1.01166.S | micheltus | CL | Towards an evolutionary sequence of molecular gas in young debris dis | | | | | |
| 2013.1.00870.S | kospal | EU | Tracing the accretion history of pre-main sequence stars through the env | InProgress | | 2013-12-05 08:37:27 | | uid://A001/X10e |
| 2013.1.00366.S | mhughes | NA | A 3-Dimensional View of Protoplanetary Disk Turbulence | InProgress | | 2013-12-04 16:37:35 | | uid://A001/X10f |
| 2013.1.00068.S | mdunham | NA | The Mass Accretion Reservoir Surrounding a Variably Accreting Young | InProgress | | 2013-12-02 15:16:30 | | uid://A001/X10a |
| 2012.1.00987.S | kospal | EU | Gas evolution in circumstellar disks: exploratory of new gas-containing d | Reviewed | | 2012-07-12 13:56:18 | | |
| 2012.1.00063.S | kospal | EU | Dark shadows in T Tauri disks: ALMA interprets disk variability | Reviewed | | 2012-07-12 11:44:10 | | |

2013.1.00870.S - Tracing the accretion history of pre-main sequence stars through the envelope dynamics of FUors

| Entity | Status |
|---|---|
| 2013.1.00870.S | InProgress |
| Proposal | |
| ObsUnitSet | PartiallyObserved |
| SG OUS (V346 Nor Band 6) | PartiallyObserved |
| Group OUS | PartiallyObserved |
| Member OUS (V346_Nor) | Ready |
| V346_Nor_a_06_TE | PartiallyObserved |
| Member OUS (V346_Nor) | PipelineProcessing |
| V346_Nor_a_06_7M | FullyObserved |

derived from SED.

The science goals are well presented, and As nicely summarized in the proposal, the brightening observed by FUors are thought to be related to episodic events of accretion. The observations will help in investigation the outburst/instability hypothesis On the other hand, the panel had some concerns that it would be difficult to model an accreting envelope because the structure of the envelope is quite complicated.

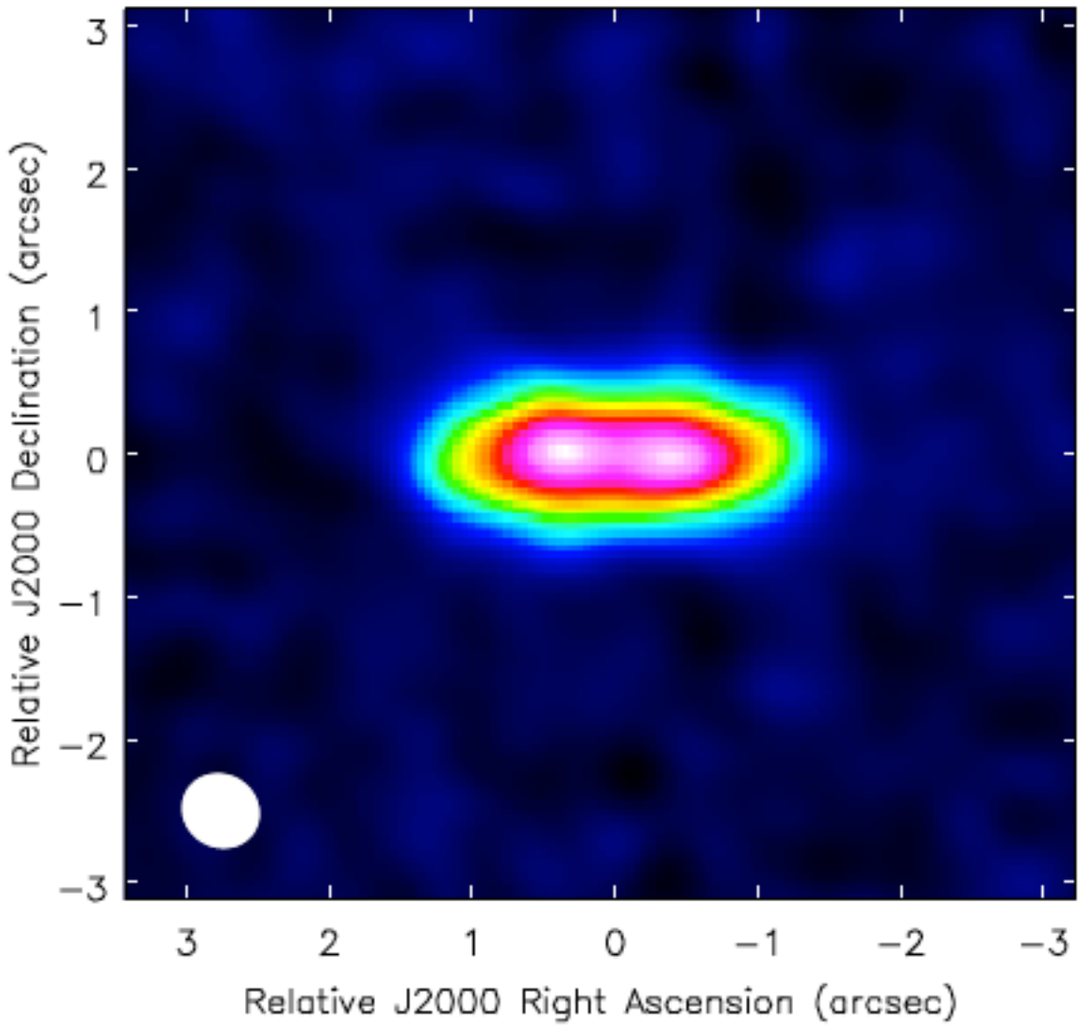
Technical note: this line setup (in particular, 13CO and 12CO 2-1) results in higher Tsys to fall off in the Band 6 IF below 5.5 GHz (see ALMA technical handbook ver 1.1 Dec 13, not. If proposal proceeds to phase 2 the PI should carefully weigh the benefits of including 12CO (resulting in higher Tsys for all thre adjusting the request to possible not include 12CO (or alternatively, 13CO, though that a importance to this project) and improved noise performance.

| Project status history | Timestamp |
|---|---|
| Phase1Submitted | Thu, 05 Dec 2013 08:37:28 GMT |
| Reviewed | Wed, 09 Apr 2014 15:13:00 GMT |
| Phase2Submitted | Mon, 02 Jun 2014 14:26:12 GMT |
| Ready | Mon, 02 Jun 2014 15:28:17 GMT |
| InProgress | Fr, 06 Jun 2014 03:10:22 GMT |

Project execution summary

| | | |
|---|---|---|
| Seconds observed | 56% | 18334 of 32734 [s] |
| # Member OUSs started | 50 % | 1 of 2 |
| # Member OUSs finished | 50 % | 1 of 2 |
| # OUSs delivered | 0 % | 0 of 4 |
| # SBs Fully Observed | 50 % | 1 of 2 |

Hogyan tűnik el a gáz a korongokból?



# Folyó ALMA projektjeink

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asa.alma.cl/pretrack/

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|---|---|---|---|---|---|---|---|---|
| 2013.1.01376.S | jolofsso | EU | The HD 95086 planetary system: from discovery to structure | Reviewed | | 2013-12-05 14:59:51 | | uid://A001/X113/X5e6 |
| 2013.1.01246.S | kospal | EU | Transport processes in the unique young eruptive system EX Lup | Reviewed | | 2013-12-05 14:06:19 | | uid://A001/X112/X2c6 |
| 2013.1.01166.S | michelitus | CL | Towards an evolutionary sequence of molecular gas in young debris dis | InProgress | | 2013-12-05 13:16:47 | | uid://A001/X112/X106 |
| 2013.1.00870.S | kospal | EU | Tracing the accretion history of pre-main sequence stars through the env | InProgress | | 2013-12-05 06:37:27 | | uid://A001/X10a/X9d3 |
| 2013.1.00366.S | mhughes | NA | A 3-Dimensional View of Protoplanetary Disk Turbulence | InProgress | | 2013-12-04 16:37:35 | | uid://A001/X101/X267 |
| 2013.1.00068.S | mdunham | NA | The Mass Accretion Reservoir Surrounding a Variable Accreting Young | InProgress | | 2013-12-02 15:16:30 | | uid://A001/X10a/Xc9 |
| 2012.1.00987.S | kospal | EU | Gas evolution in circumstellar disks: explorato of new gas-containing d | Reviewed | | 2012-07-12 13:56:18 | | uid://A001/Xa0/X1390 |
| 2012.1.00063.S | kospal | EU | Dark shadows in T Tauri disks: ALMA in prots disk variability | Reviewed | | 2012 | | |

2013.1.00870.S - Tracing the accretion history of pre-main sequence stars through the envelope dynamics of FUors

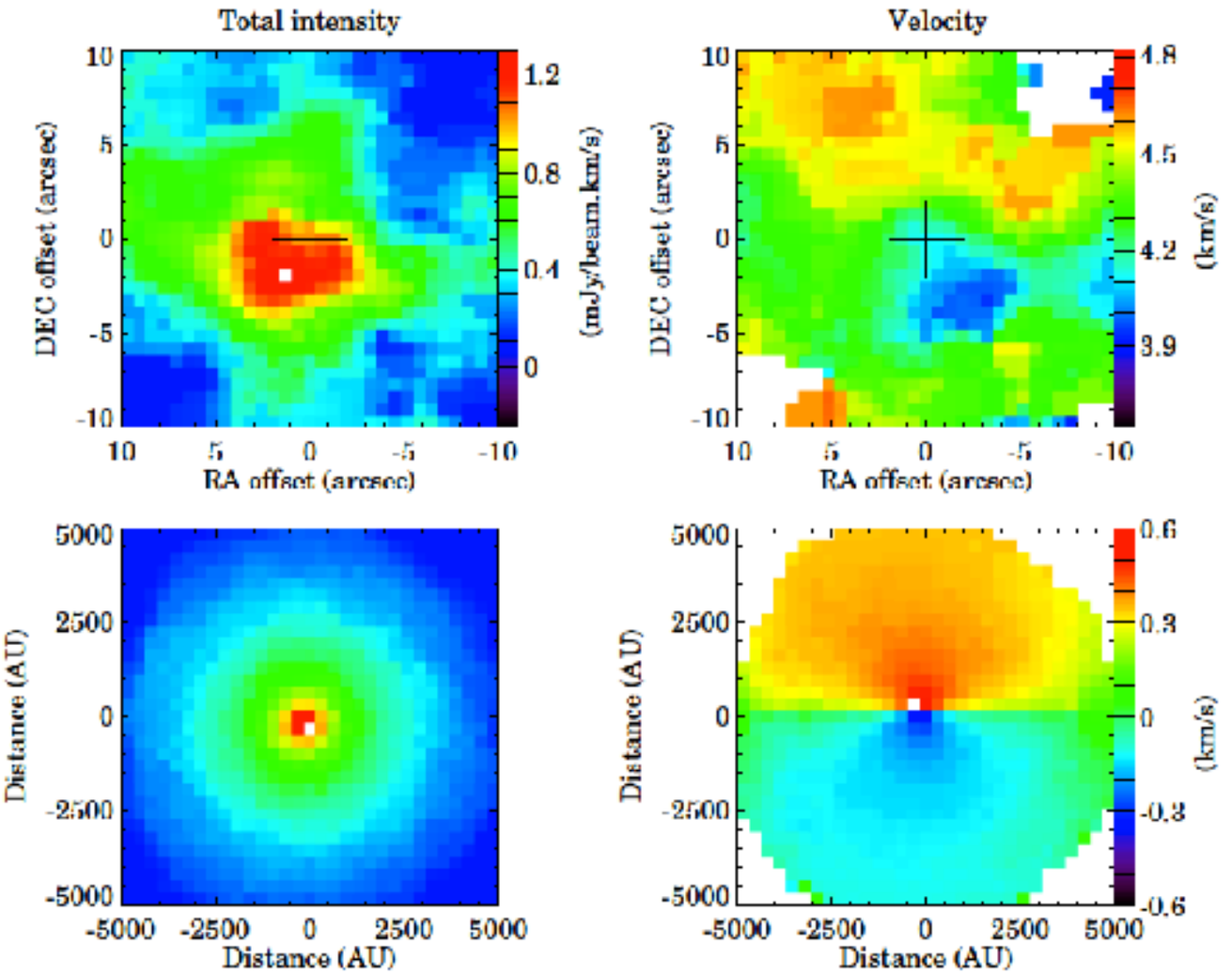
| Entity | |
|---|---|
| 2013.1.00870.S | InProgr |
| Proposal | |
| ChsLInitSet | Partially |
| SG OUS (V346 Nor band 6) | Partially |
| Group OUS | Partially |
| Member OUS (V346_Nor) | Ready |
| V346_Nor_a_06_TE | Partially |
| Member OUS (V346_Nor) | Pipeline |
| V346_Nor_a_06_7M | FullyCb |

| | |
|---|---|
| Ready | Mon, 02 Jun 2014 15:28:17 GMT |
| InProgress | Fr, 06 Jun 2014 03:10:22 GMT |

Project execution summary

| | | |
|---|---|---|
| Seconds observed | 56% | 18334 of 327 |
| # Member OUSs stared | 50 % | 1 of 2 |
| # Member OUSs finished | 50 % | 1 of 2 |
| # OUSs delivered | 0 % | 0 of 4 |
| # SBs Fully Observed | 50 % | 1 of 2 |

## Hogyan zajlik a tömegbefogás fiatal eruptív csillagok körül?



# Folyó ALMA projektjeink

ALMA Project Tracker

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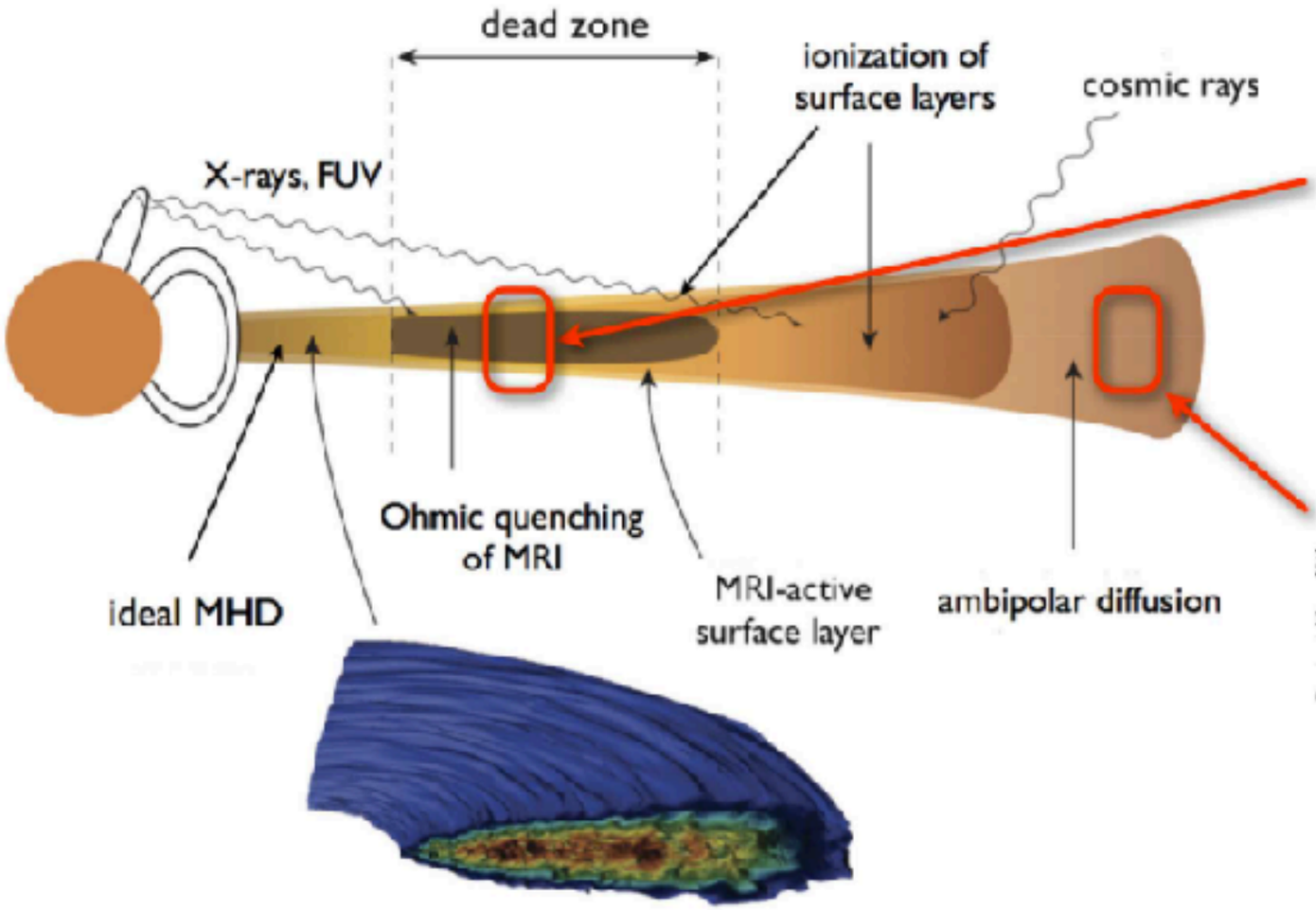
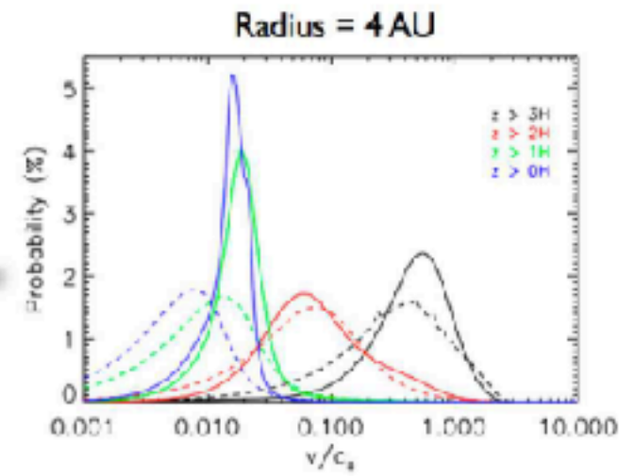
| 2013.1.01246.S | kospal | EU | Transport processes in the unique young eruptive system EX Lup | Reviewed | | 2013-12-05 14:06:19 | | uid://A001/X112/X2c6 |
| 2013.1.01166.S | micheltus | CL | Towards an evolutionary sequence of molecular gas in young debris dis | InProgress | | 2013-12-05 13:16:47 | | uid://A001/X112/X106 |
| 2013.1.00870.S | kospal | EU | Tracing the accretion history of pre-main sequence stars through the en | InProgress | | 2013-12-05 08:37:27 | | uid://A001/X10a/X9d3 |
| 2013.1.00366.S | mhughes | NA | A 3-Dimensional View of Protoplanetary Disk Turbulence | InProgress | | | | |
| 2013.1.00068.S | mdunham | NA | The Mass Accretion Reservoir Surrounding a Variably Accreting Young | InProgress | | | | |
| 2012.1.00987.S | kospal | EU | Gas evolution in circumstellar disks: exploratory of new gas-containing d | Reviewed | | | | |
| 2012.1.00063.S | kospal | EU | Dark shadow | | | | | |

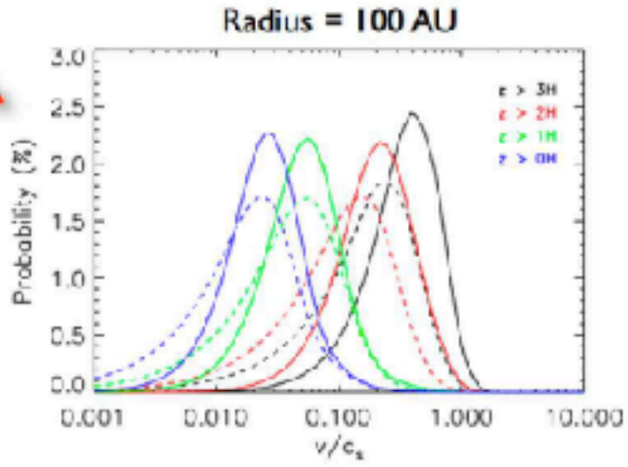
2013.1.00870.S - Tracing the accretion history of pre-m

| Entity | |
|---|---|
| 2013.1.00870.S | InProg |
| Proposal | |
| ChsInitSet | Partia |
| SG OUS (V346 Nor band 6) | Partia |
| Group OUS | Partia |
| Member OUS (V346_Nor) | Ready |
| V346_Nor_a_06_TE | Partia |
| Member OUS (V346_Nor) | Pipeli |
| V346_Nor_a_06_7M | FullyC |

Turbulencia vizsgálata 3D-ben



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|---|---|---|---|---|---|---|
| 2013.1.01376.S | jolofsso | EU | The HD 95086 planetary system: from discovery to structure | Reviewed | | 2013-12-05 14 |
| 2013.1.01246.S | kospal | EU | Transport processes in the unique young eruptive system EX Lup | Reviewed | | 2013-12-05 1 |
| 2013.1.01166.S | micheltus | CL | Towards an evolutionary sequence of molecular gas in young debris dis | InProgress | | 2013-12-05 13 |
| 2013.1.00870.S | kospal | EU | Tracing the accretion history of pre-main sequence stars through the en | InProgress | | 2013-12-05 08 |
| 2013.1.00366.S | mhughes | NA | A 3-Dimensional View of Protoplanetary Disk Turbulence | InProgress | | 2013-12-04 16 |
| 2013.1.00068.S | mdunham | NA | The Mass Accretion Reservoir Surrounding a Variably Accreting Young | InProgress | | 2013-12-02 15 |
| 2012.1.00987.S | kospal | EU | Gas evolution in circumstellar disks: exploratory of new gas-containing d | Reviewed | | 2012-07-12 13 |
| 2012.1.00063.S | kospal | EU | Dark shadows in T Tauri disks: ALMA interprets disk variability | Reviewed | | 2012-07-12 11 |

2013.1.00870.S - Tracing the accretion history of pre-main sequence stars through the envelope dynamics of FUors

| Entity | Status |
|---|---|
| 2013.1.00870.S | InProgress |
| Proposal | |
| ObsUnitSet | PartiallyObserved |
| SG OUS (V346 Nor Band 6) | PartiallyObserved |
| Group OUS | PartiallyObserved |
| Member OUS (V346_Nor) | Ready |
| V346_Nor_a_06_TE | PartiallyObserved |
| Member OUS (V346_Nor) | PipelineProcessing |
| V346_Nor_a_06_7M | FullyObserved |

derived from SED.

The science goals are well presented, and As nicely summarized in the proposa
the brightening observed by FUors are thought to be related to episodic events
of accretion. The observations will help in investigation the outburst/instability hy
On the other hand, the panel had some concerns that it would be difficult to mod
an accreting envelope because the structure of the envelope is quite complicate

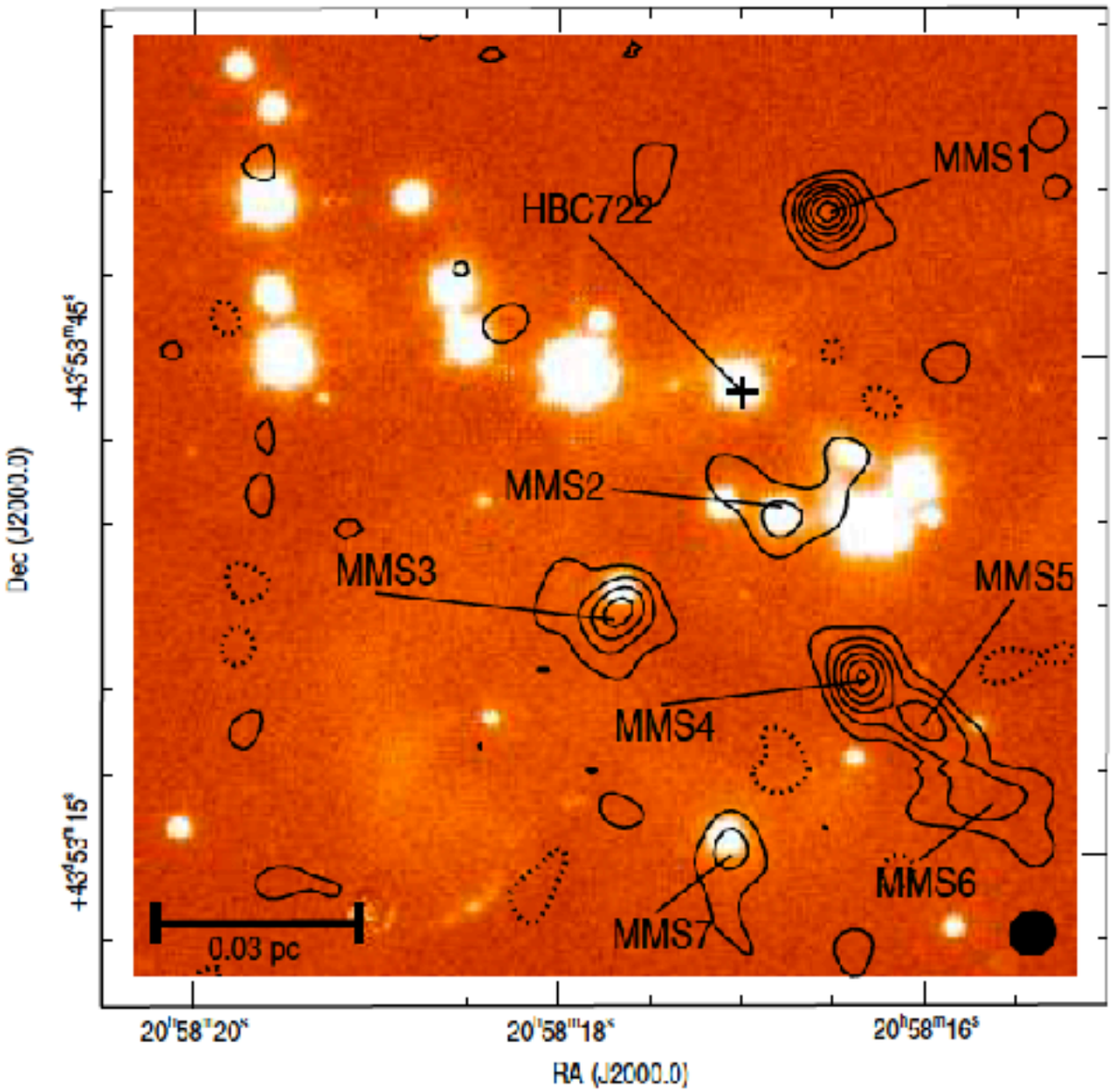
Technical note: this line setup (in particular, 13CO and 12CO 2-1) results in high
to fall off in the Band 6 IF below 5.5 GHz (see ALMA technical handbook ver 1.1
not. If proposal proceeds to phase 2 the PI
should carefully weigh the benefits of including 12CO (resulting in higher Tsys fo
adjusting the request to possible not include 12CO (or alternatively, 13CO, thoug
importance to this project) and improved noise performance.

| Project status history | Timestamp |
|---|---|
| Phase1Submitted | Thu, 05 Dec 2013 08:37:28 GMT |
| Reviewed | Wed, 09 Apr 2014 15:13:00 GMT |
| Phase2Submitted | Mon, 02 Jun 2014 14:26:12 GMT |
| Ready | Mon, 02 Jun 2014 15:28:17 GMT |
| InPregress | Fr, 06 Jun 2014 03:10:22 GMT |

Project execution summary

| | | |
|---|---|---|
| Seconds observed | 56% | 18334 of 32734 [s] |
| # Member OUSs started | 50 % | 1 of 2 |
| # Member OUSs finished | 50 % | 1 of 2 |
| # OUSs delivered | 0 % | 0 of 4 |
| # SBs Fully Observed | 50 % | 1 of 2 |

## Hol raktározzák az anyagot a fiatal eruptív csillagok?



# Tudomány az ALMÁ-val

- Kozmológia
- Nagy vöröseltolódású galaxisok
- Közeli galaxisok
- Csillagközi anyag
- Csillagfejlődés
- Szupernóvák
- Naprendszerbeli objektumok
- Nap

www.almaobservatory.org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