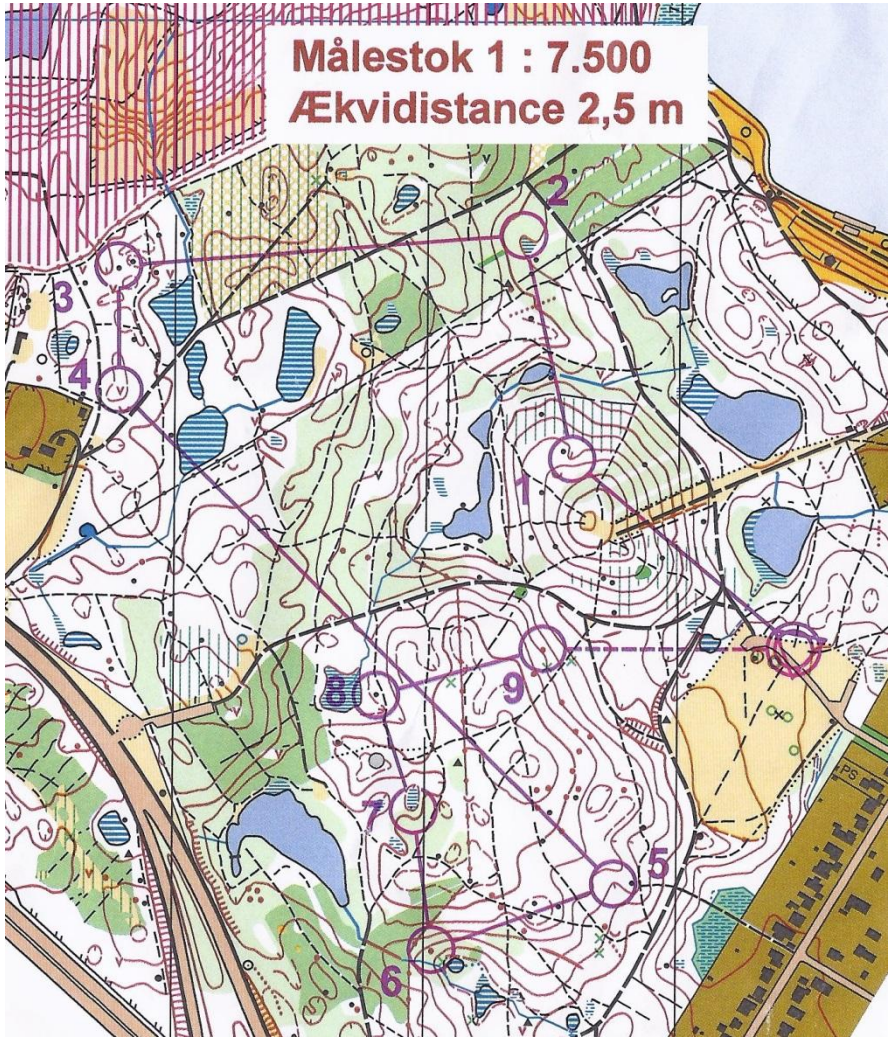
Universet

- fra det nære til det fjerneste

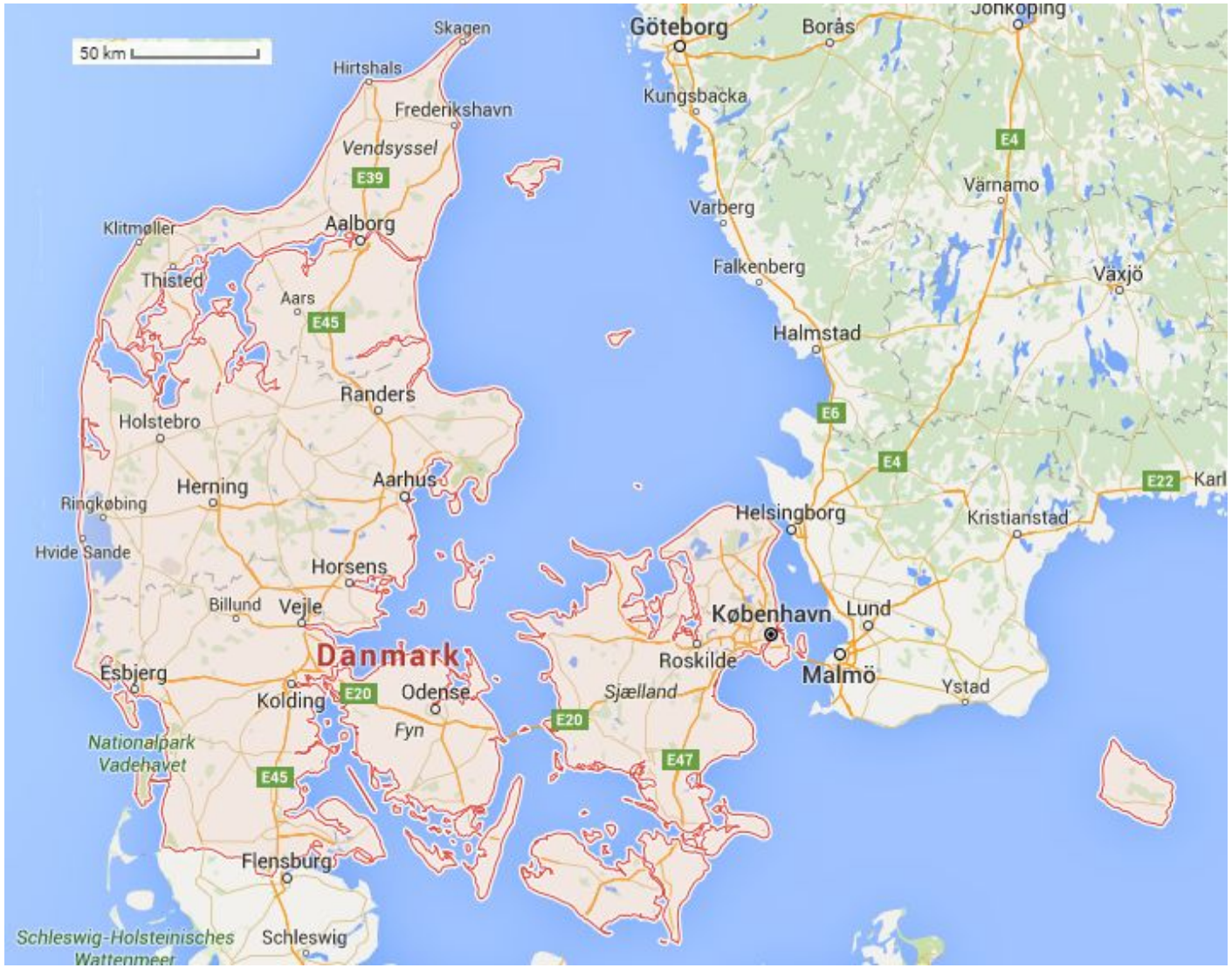
Modul 1

Orbit C s. 184-189

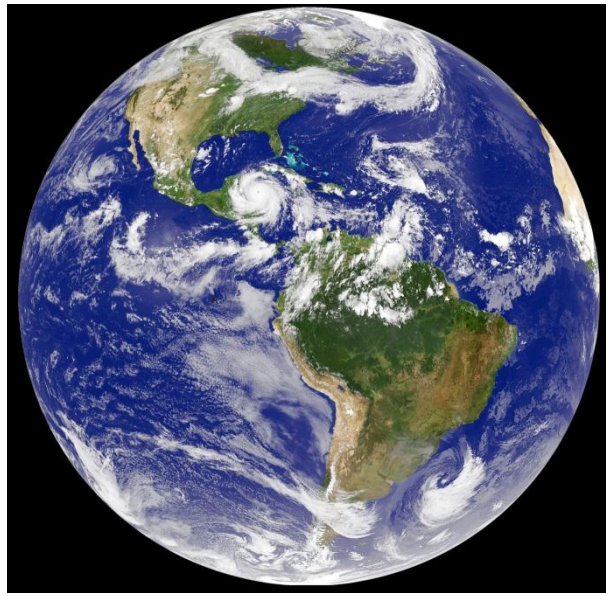
Målestoksforhold



Atlas Danmark



Fakta om Jorden



Rotationstid:

Ækvatorradius:

Masse:

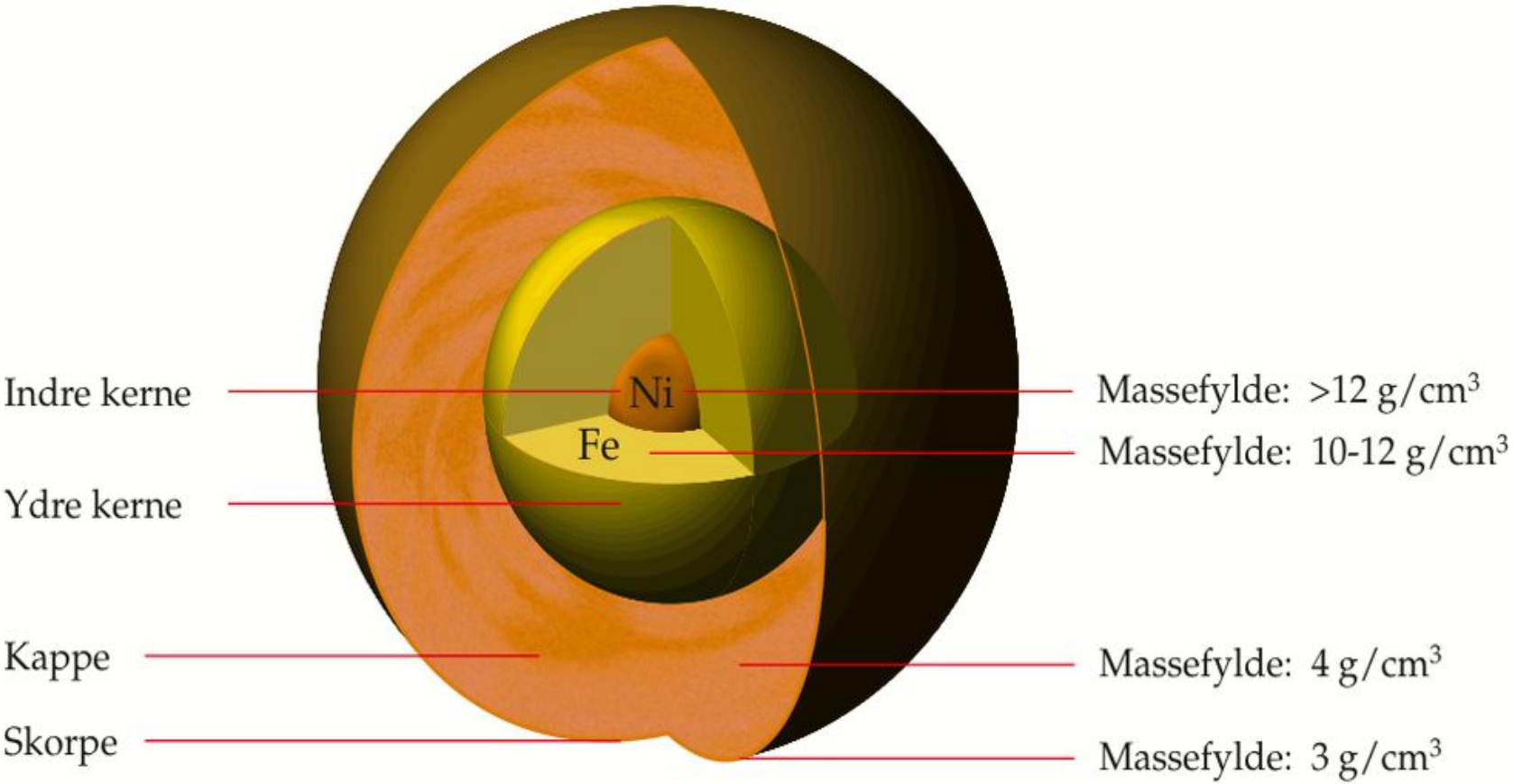
Alder:

Middeltemperatur:

Rotationsaksens hældning:

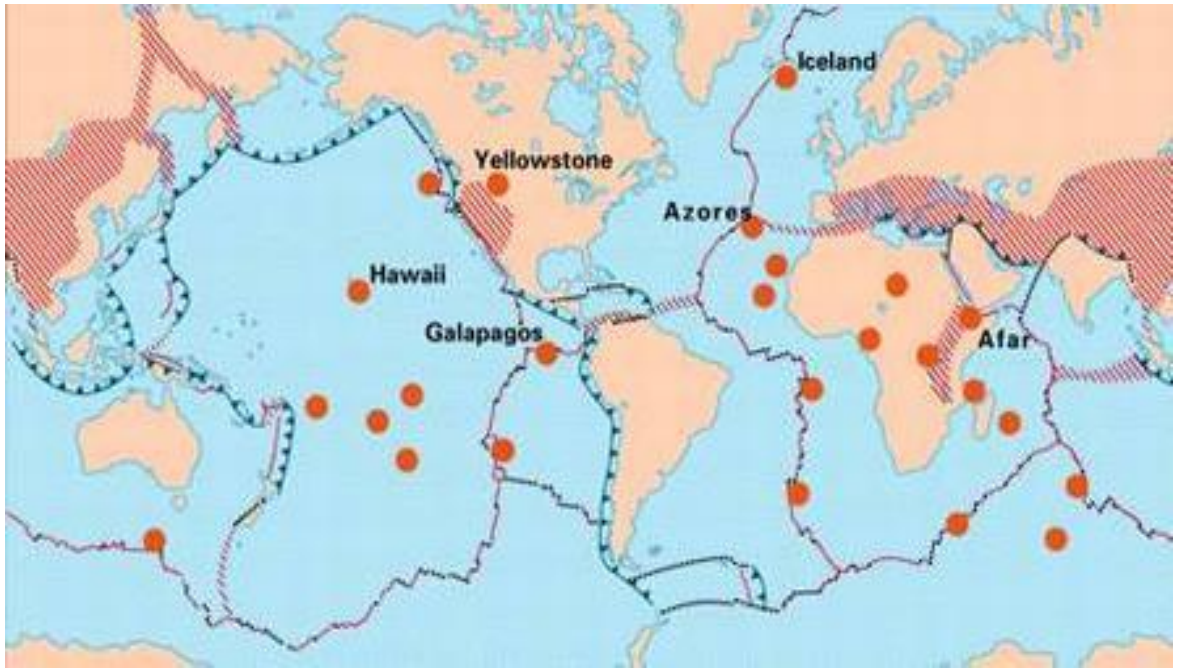
Gennemsnitsafstand til Solen:

Jordens indre

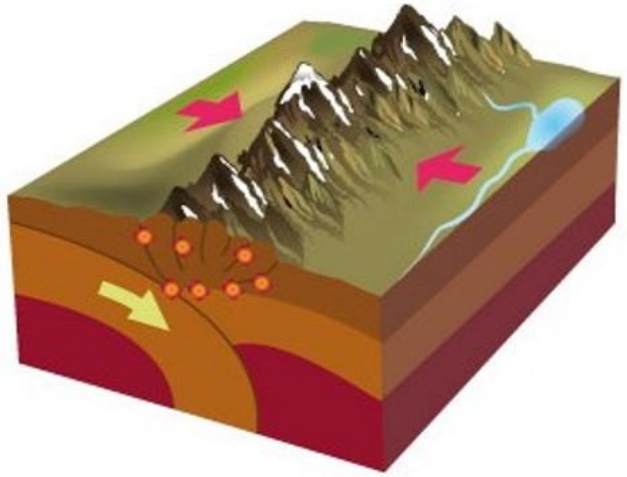


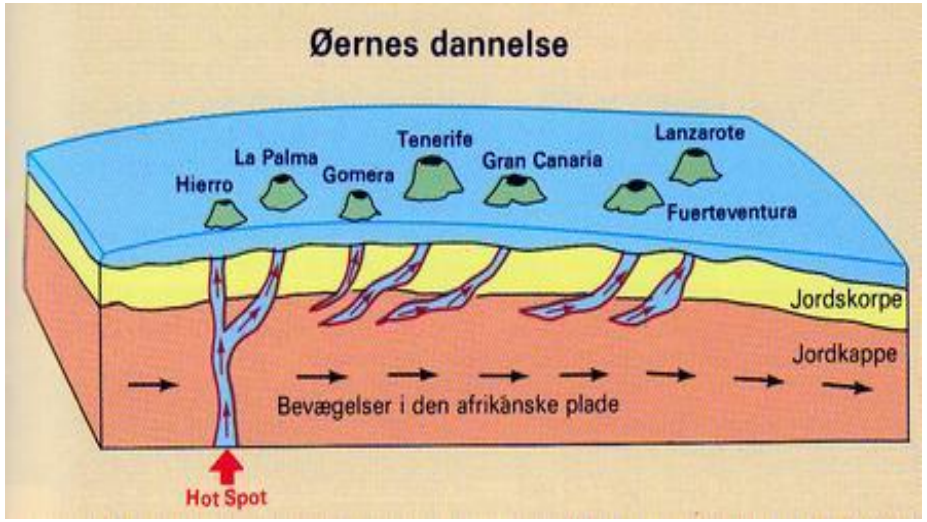
Hvorfor er der varmt i Jordens indre?

Kontinentalplader

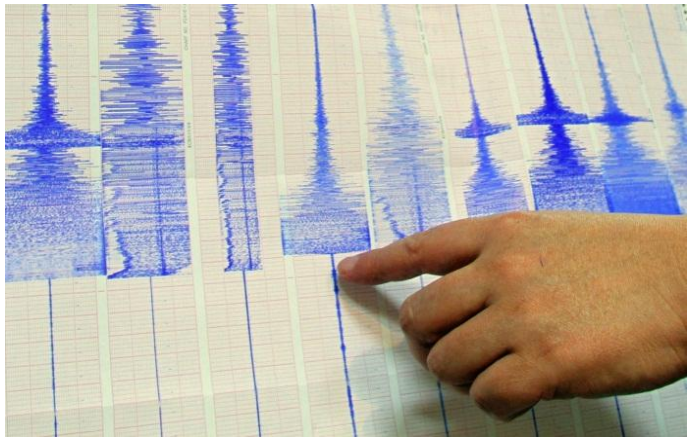


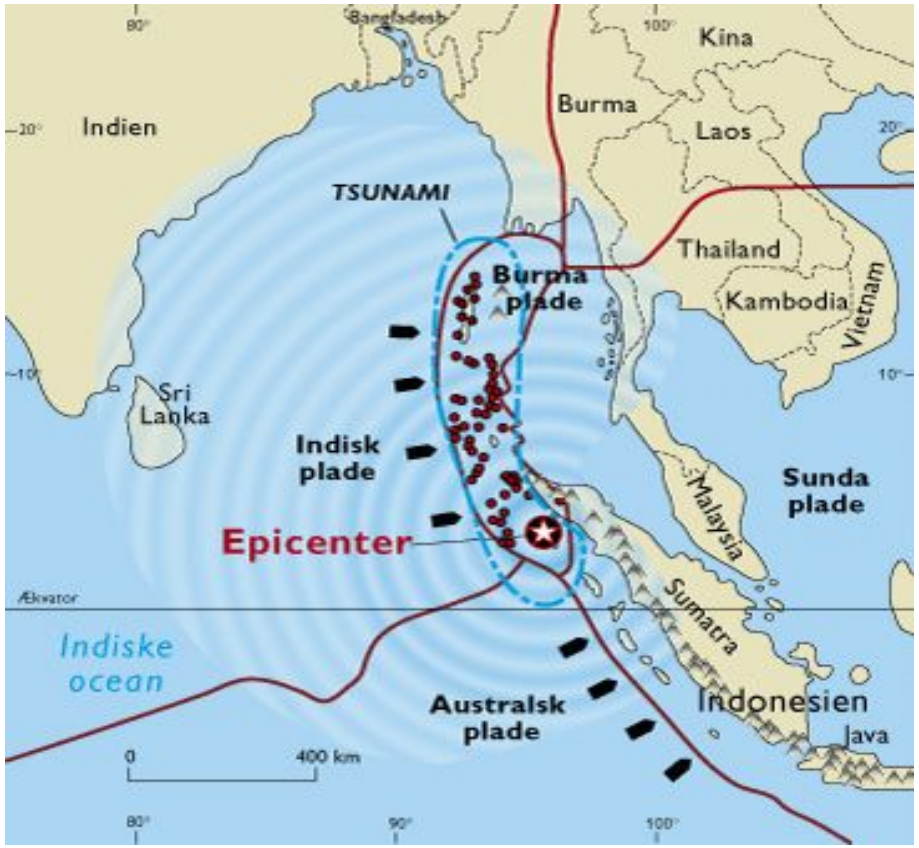
Vulkaner



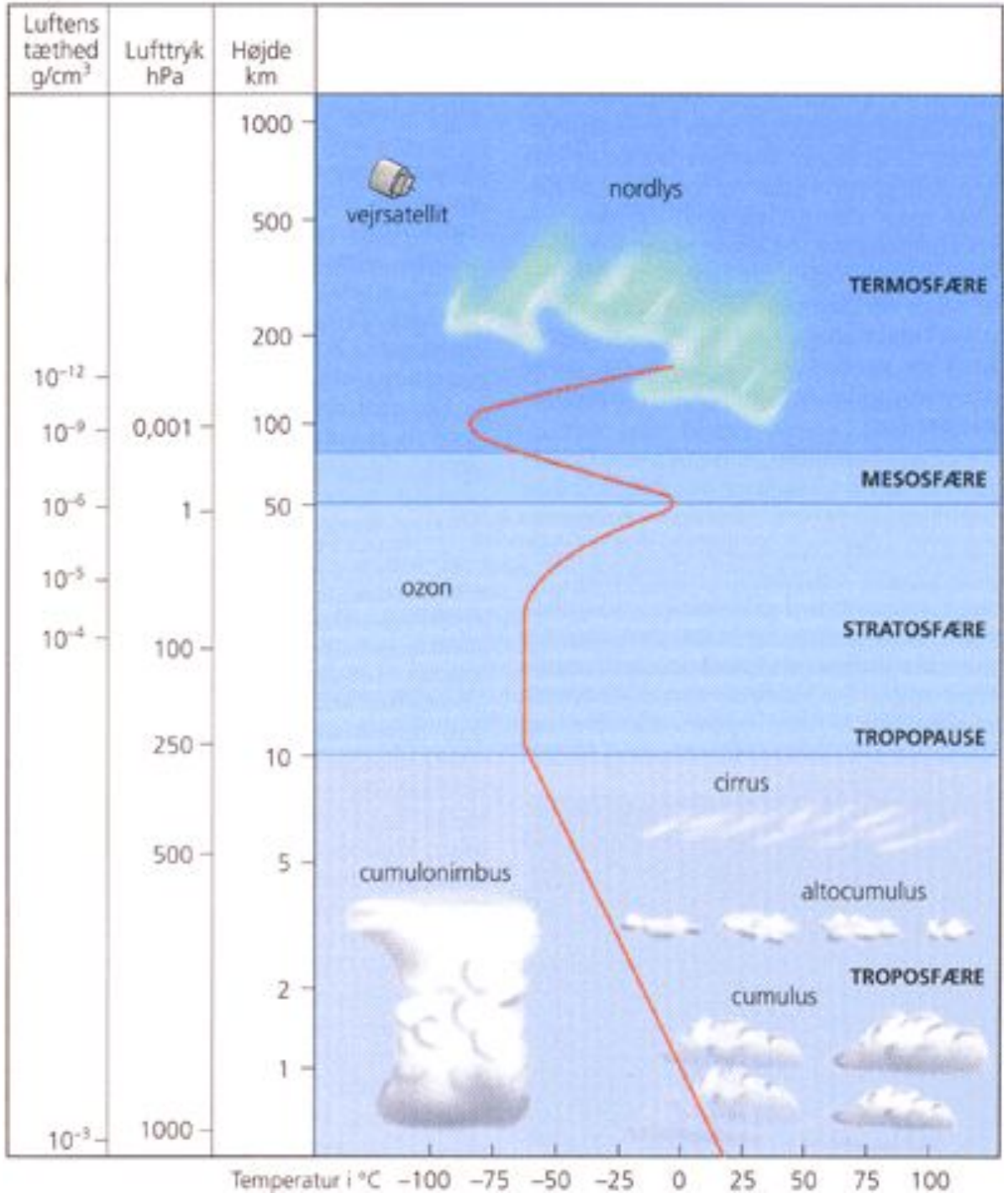

Øernes dannelse
Hierro
La Palma
Gomera
Tenerife
Gran Canaria
Lanzarote
Fuerteventura
Jordskorpe
Jordkappe
Bevægelser i den afrikanske plade
Hot Spot

Jordskælv

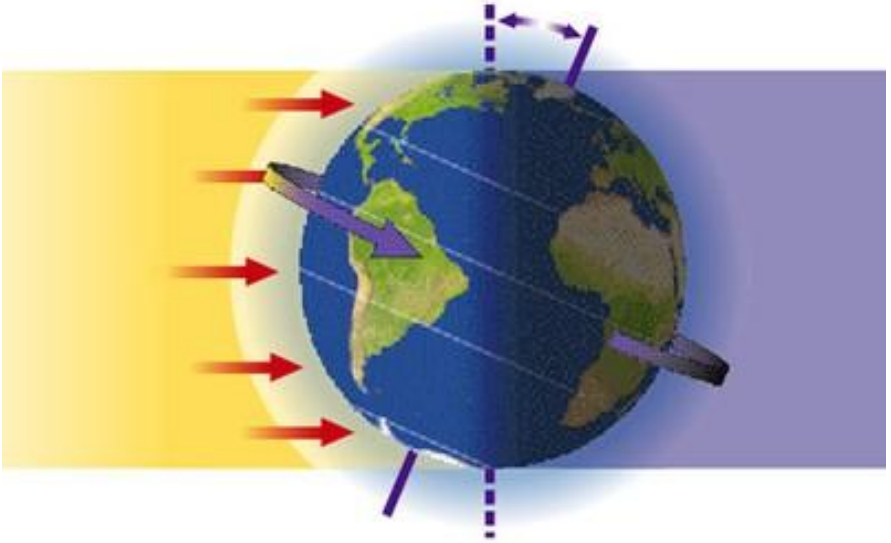



Bangladesh
Kina
Indien
Burma
Laos
TSUNAMI
Thailand
Burma plade
Kambodia
Vietnam
Sri Lanka
Indisk plade
Sunda plade
Malaysia
Epicenter
Ækvator
Sumatra
Indiske ocean
Australsk plade
Indonesien
Java
0
400 km

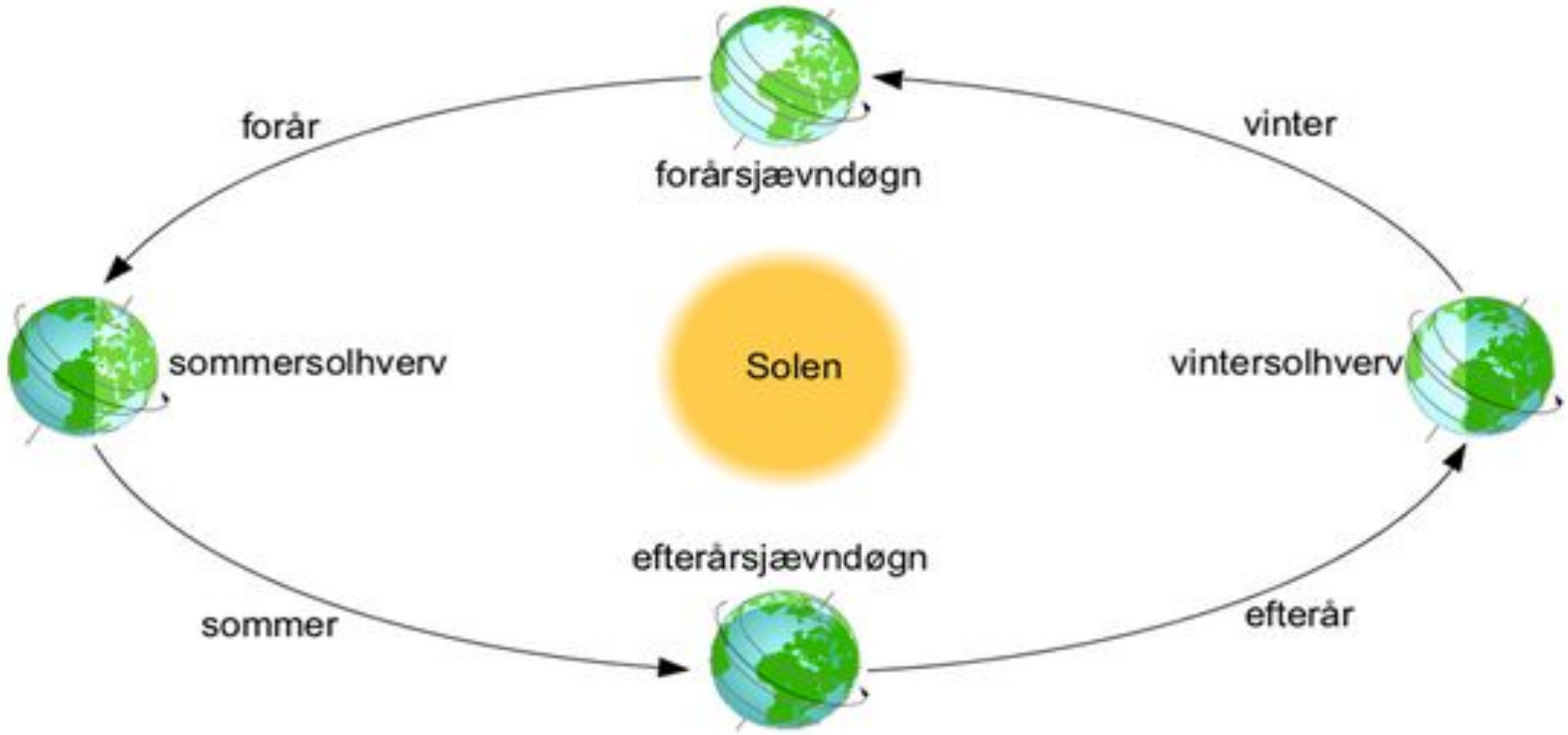
Jordens atmosfære



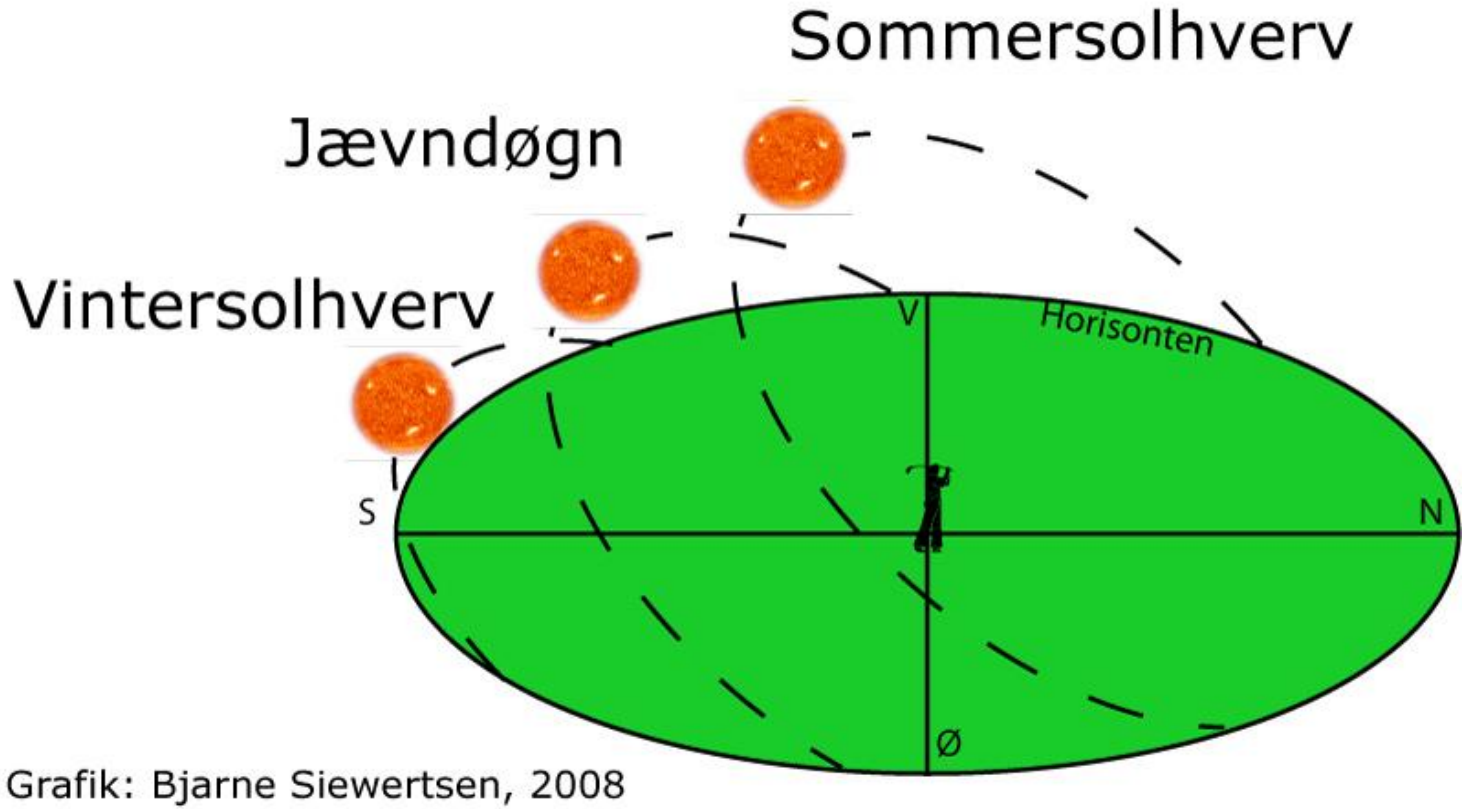
Hvorfor ser stjernehimlen sådan ud?



Døgnet og årstiderne



Solhøjden

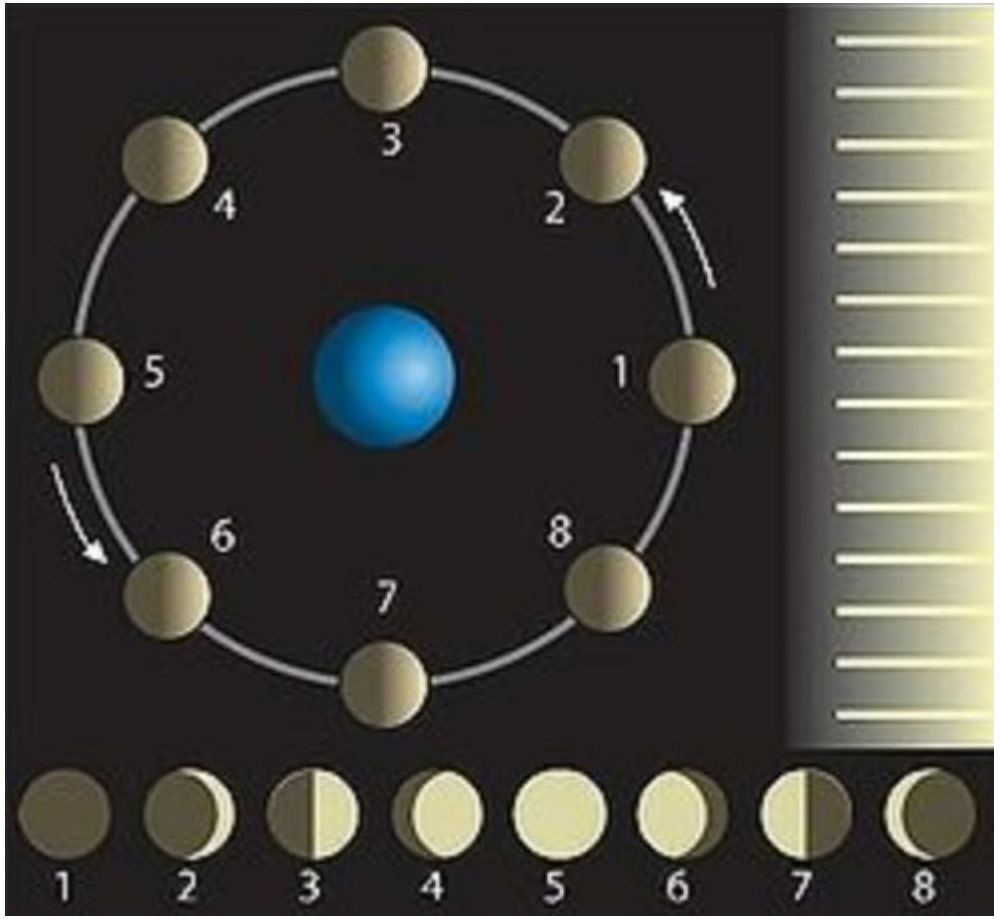


Grafik: Bjarne Siewertsen, 2008

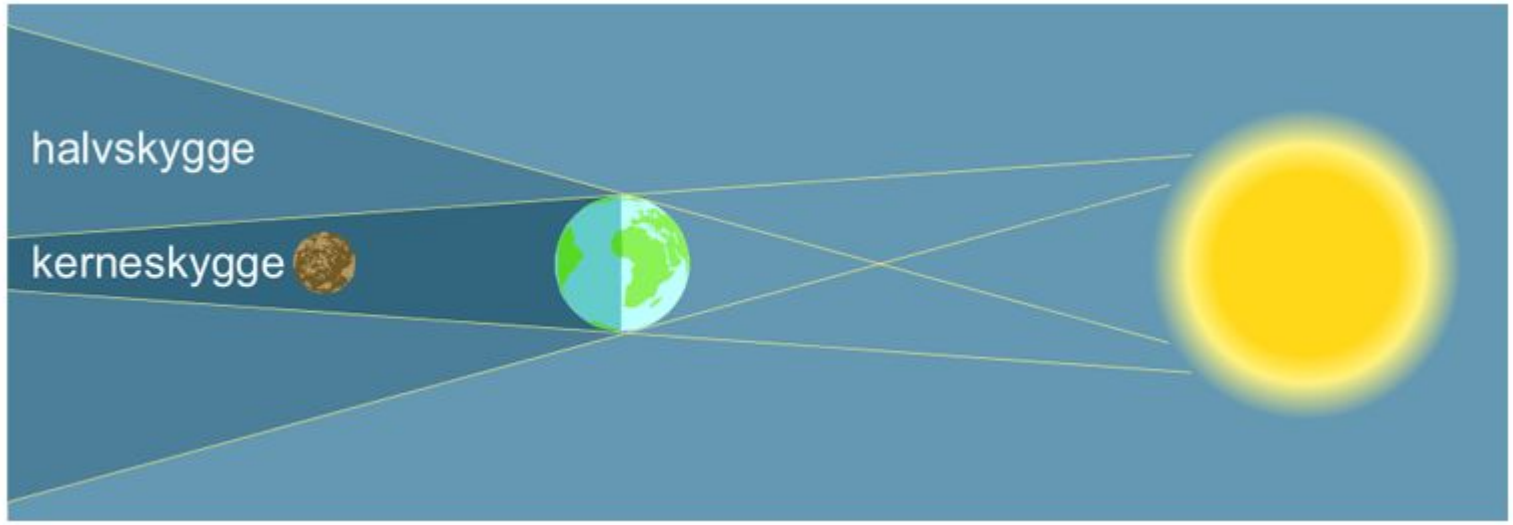
Modul 2 og 3

Orbit C s. 189-196

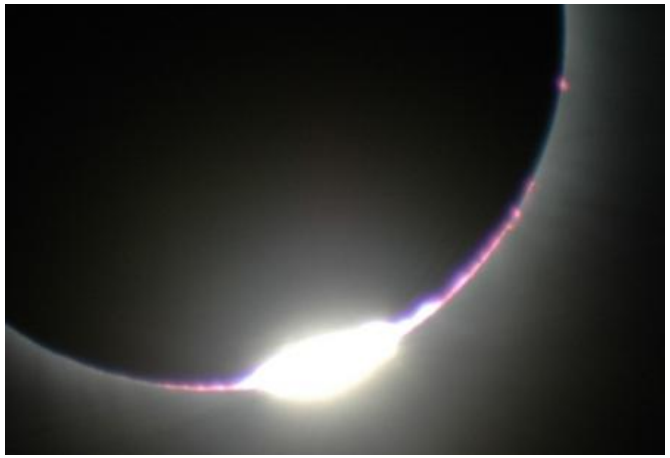
Månens faser



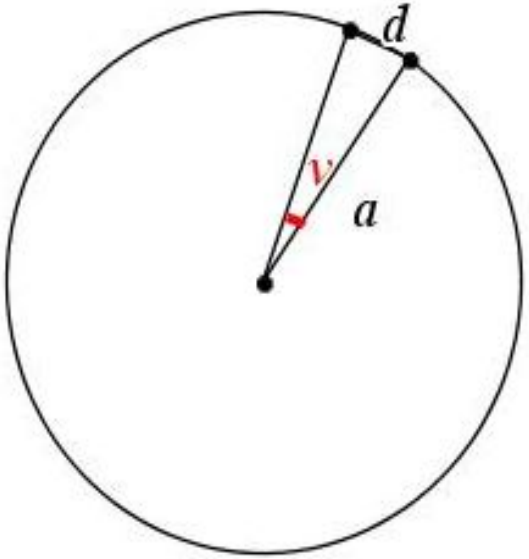
Måneformørkelse

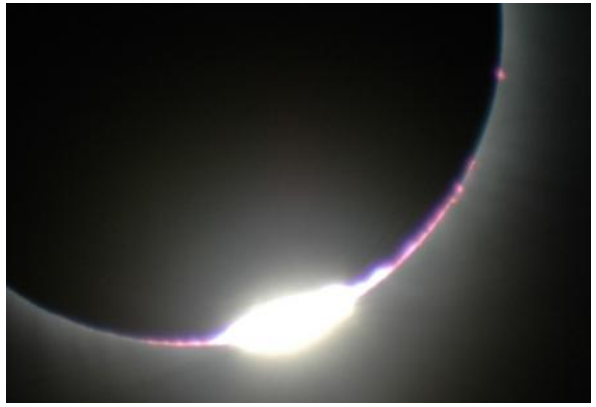


Solformørkelse



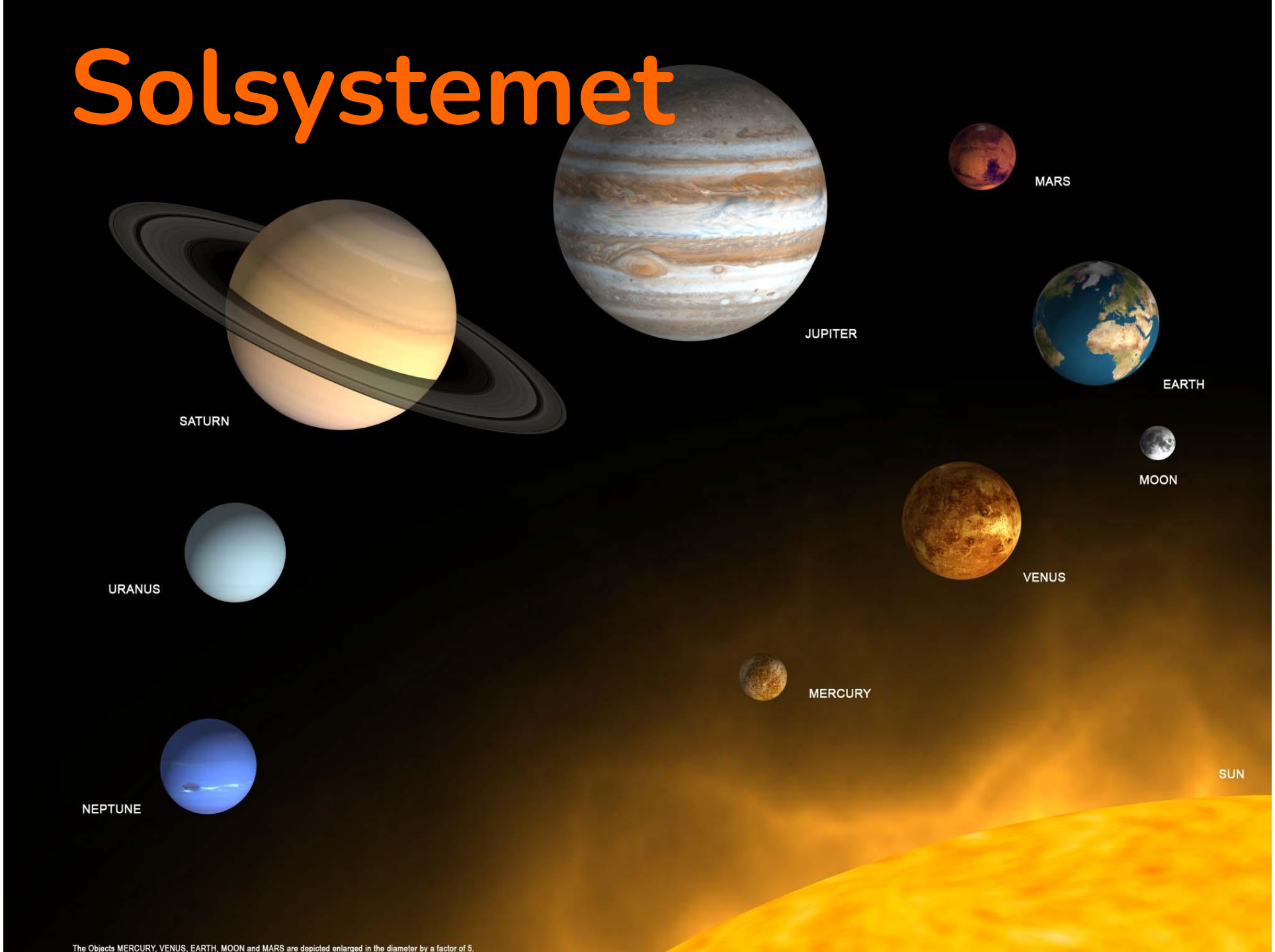
Solen og Månen fylder begge ca. 0,5°





	Afstand i km	Diameter i km
Solen	$1{,}496 \cdot 10^8$	$1{,}392 \cdot 10^6$
Månen	$3{,}844 \cdot 10^5$	3476

Solsystemet



Astronomisk enhed

Definition:

$1AE = 1{,}496 \cdot 10^{11}$ m

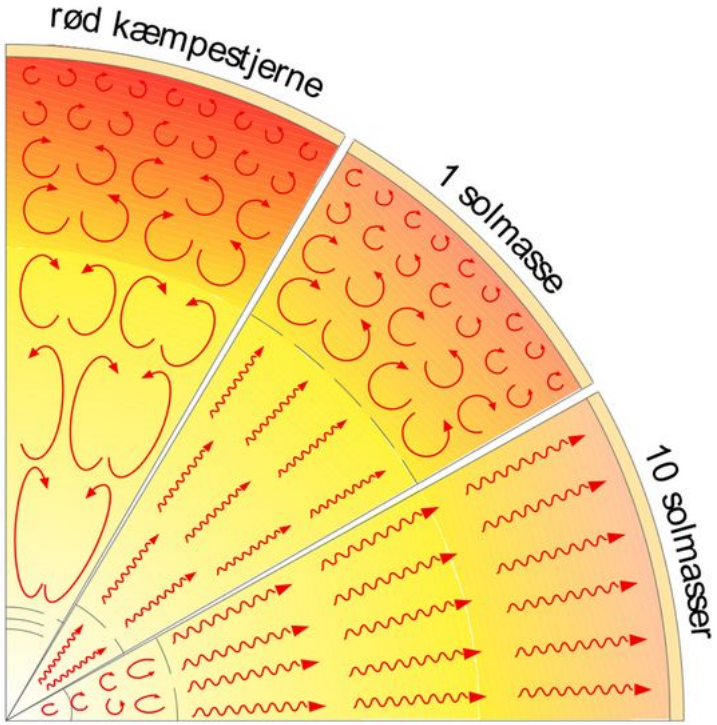
Solsystemet

- Stenplaneter:
- Asteroider
- Gasplaneter:
- Kometer

Planetsti (1:1.000.000.000)

Himmellegeme	Diameter (mio.km)	Afstand til Solen (mio.km)
Solen	1,392	-
Merkur	0,005	57,9
Venus	0,012	108,2
Jorden	0,013	149,6
Mars	0,07	228
Jupiter	0,143	778
Saturn	0,119	1427
Uranus	0,051	2869
Neptun	0,049	4497

Solen



Masse M =

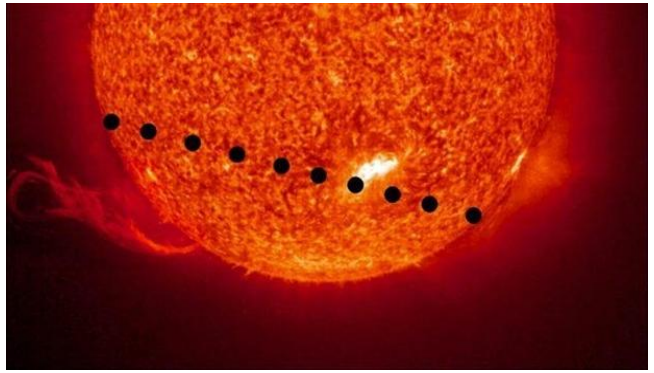
Radius R =

Lysstyrke L =

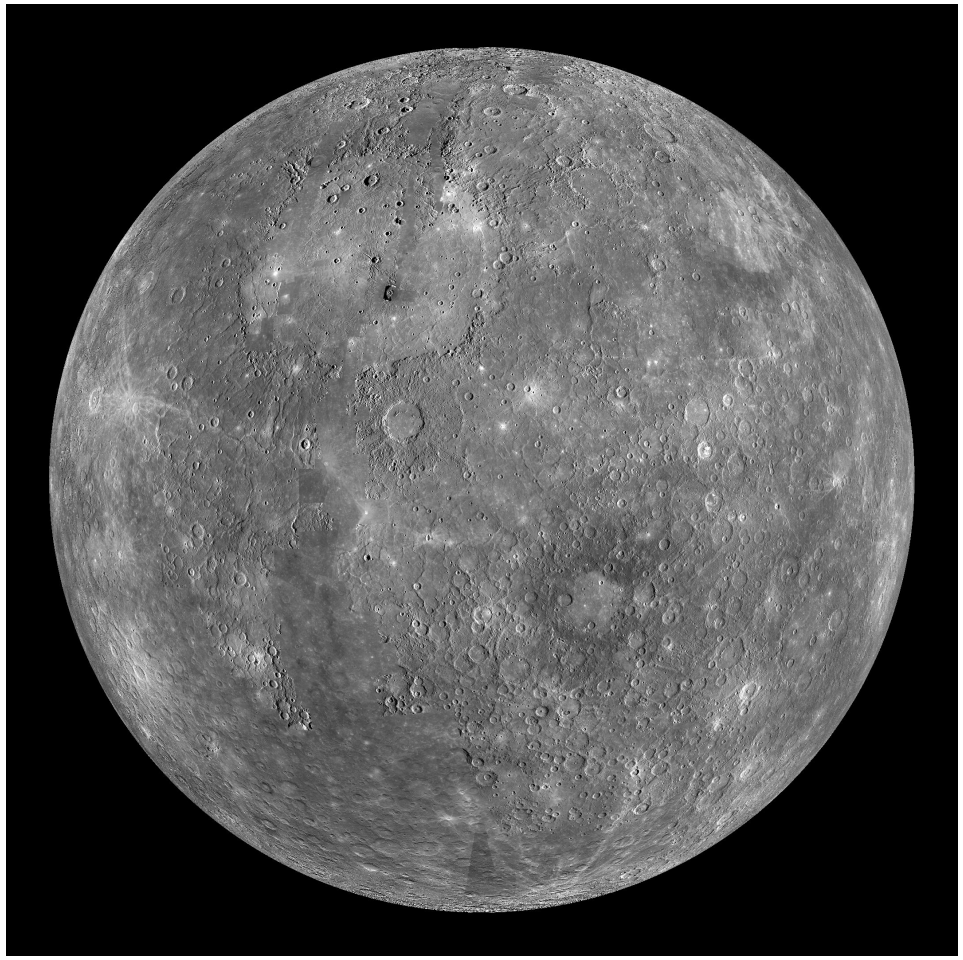
Overfladetemperatur T =

Alder t_0 =

Energiproduktion vha. …



Merkur

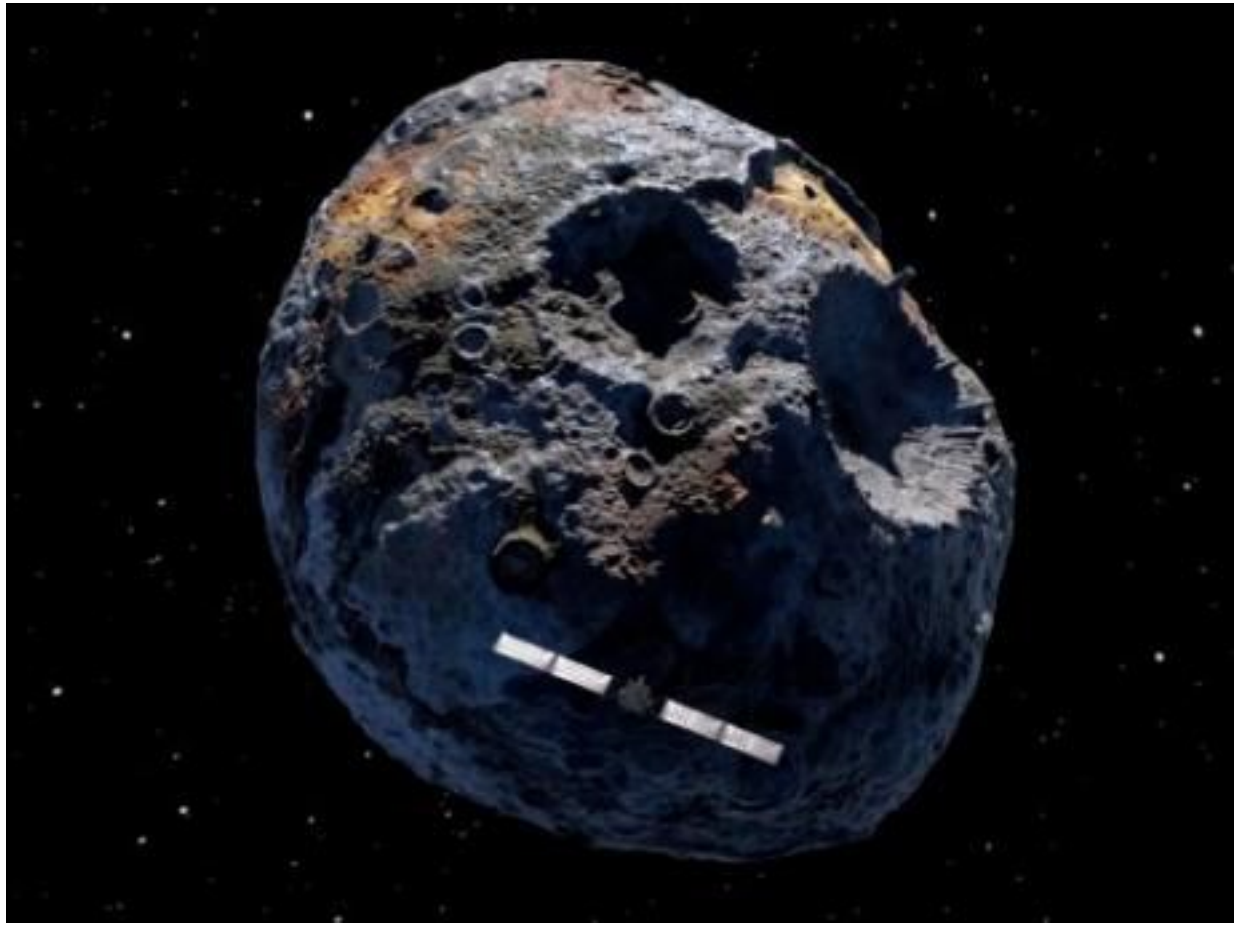


Venus

Jorden

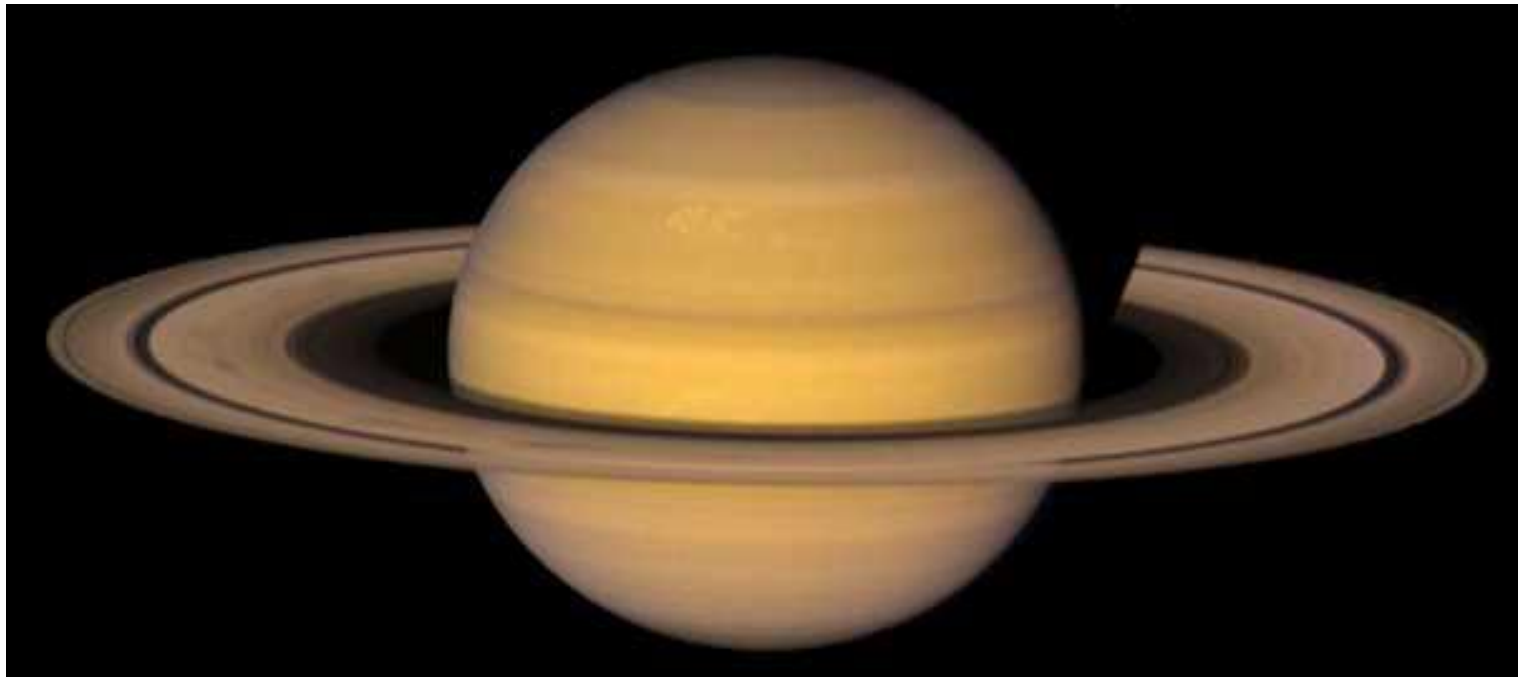
Mars

Asteroidebæltet

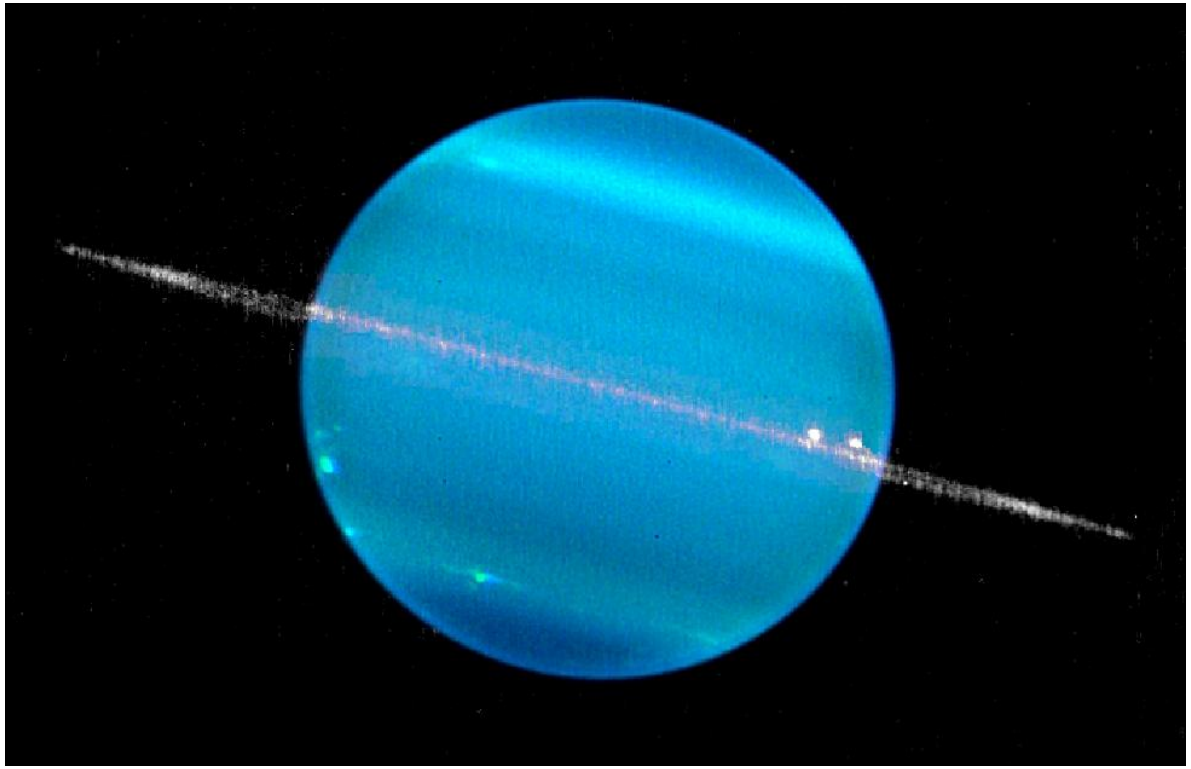


Jupiter

Saturn



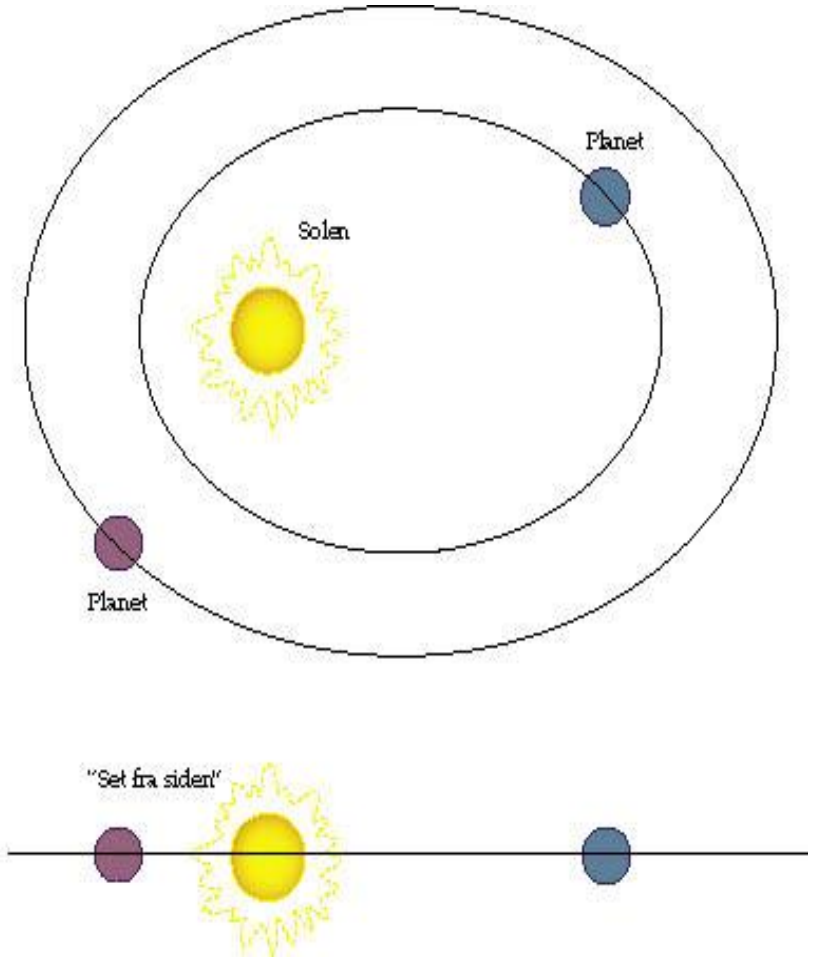
Uranus



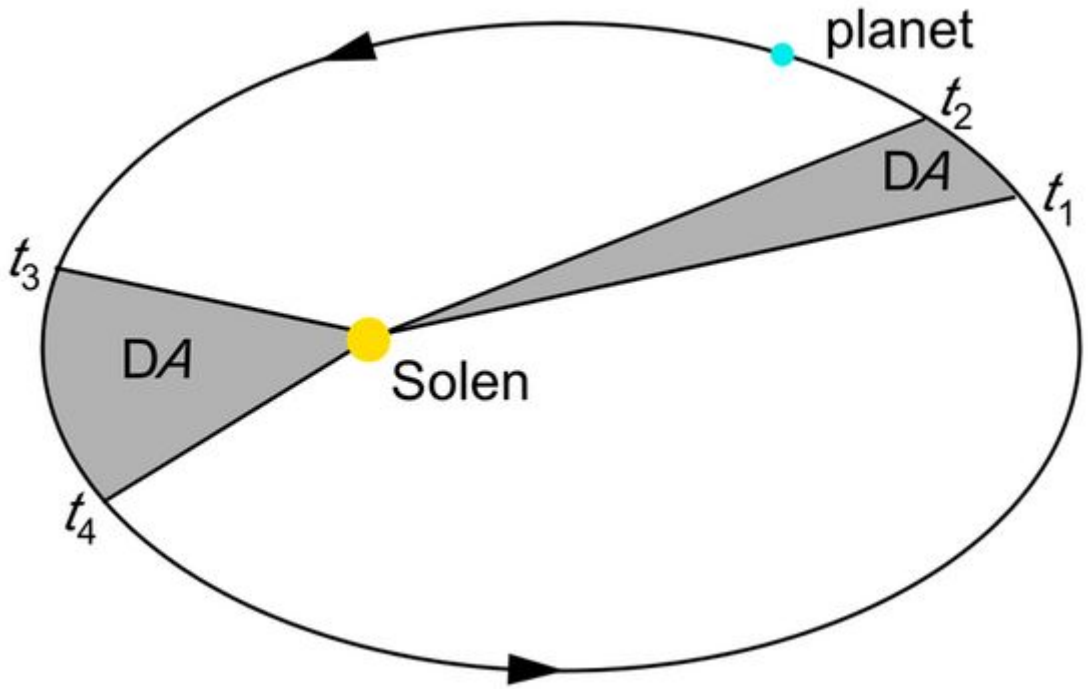
Neptun

Pluto

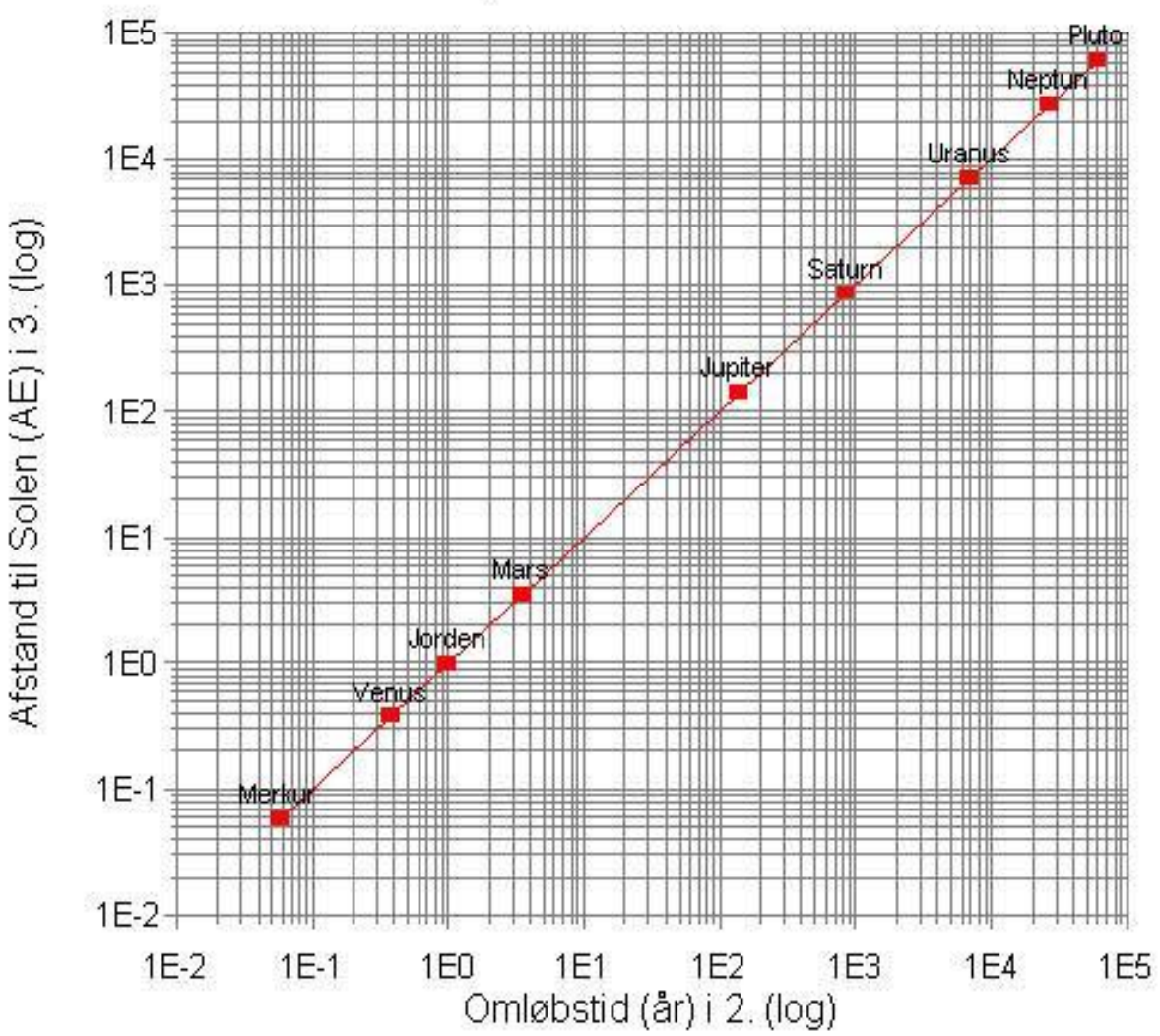
Keplers 1.lov



Keplers 2.lov



Keplers 3.lov

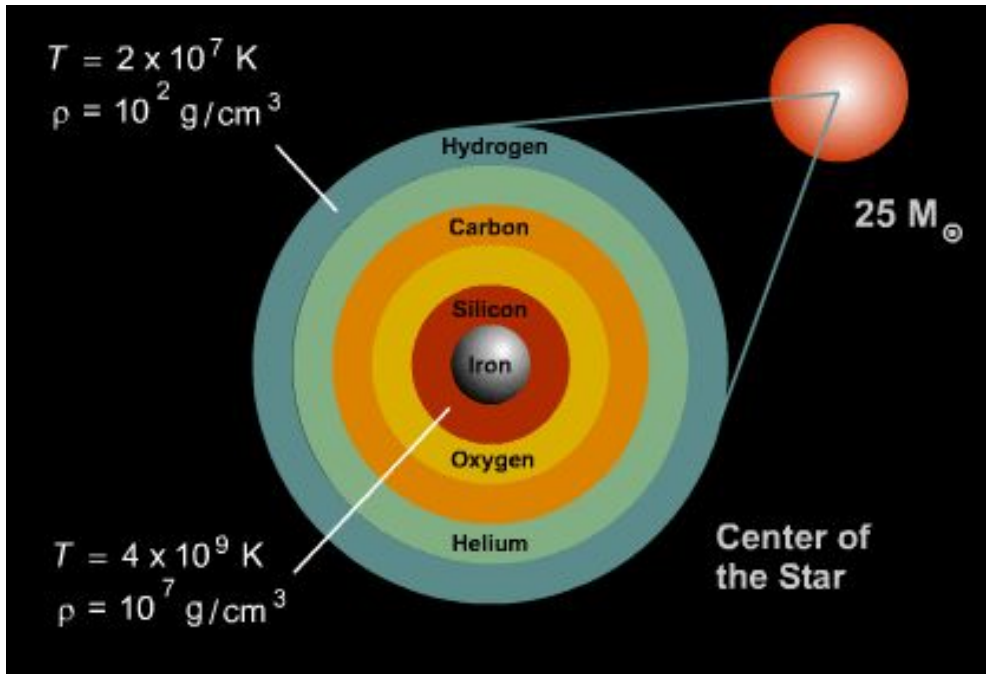


Modul 4

Orbit C s. 200-203

Film: https://www.youtube.com/watch?v=wIL68Pl4who

Kerneprocesser i stjerners indre



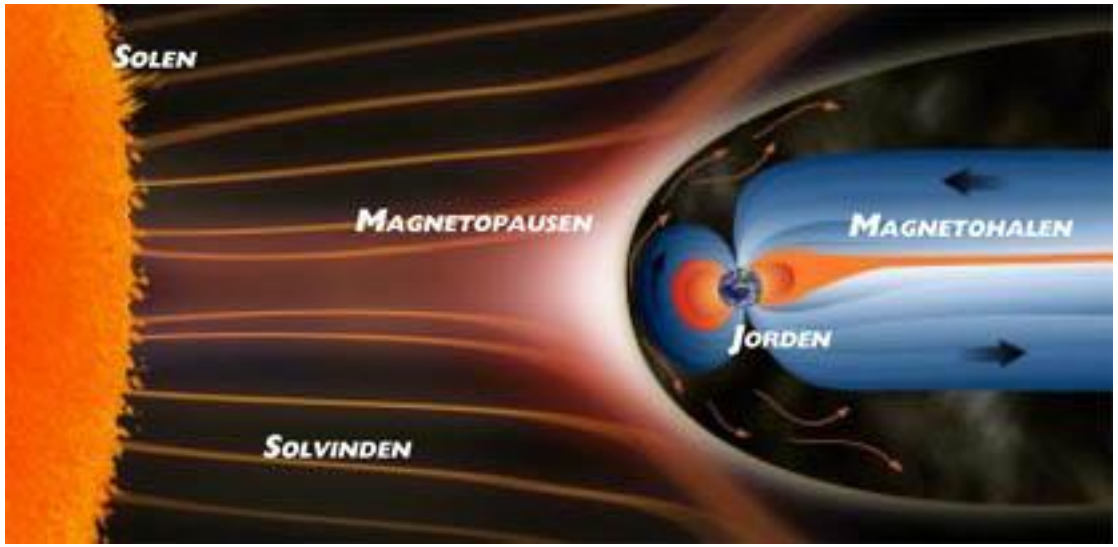
$$4\,{}^{1}_{1}H \rightarrow {}^{4}_{2}He + 2\,{}^{0}_{1}e + \nu$$

$$3\,{}^{4}_{2}He \rightarrow {}^{12}_{6}C$$

Hvorfor lyser stjerner?

Hvorfor lyser planeter?

Solvind og polarlys

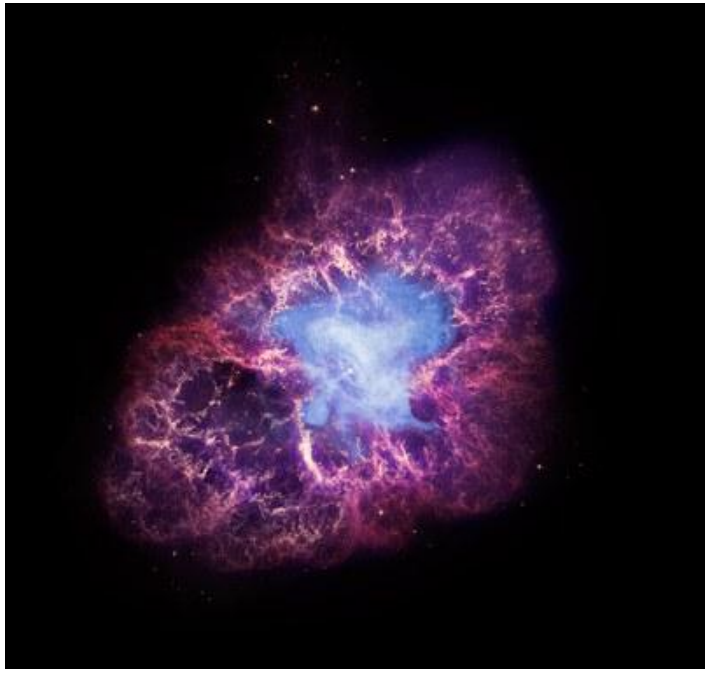


Enheden lysår

Definition:

1 lysår = km

Afstande

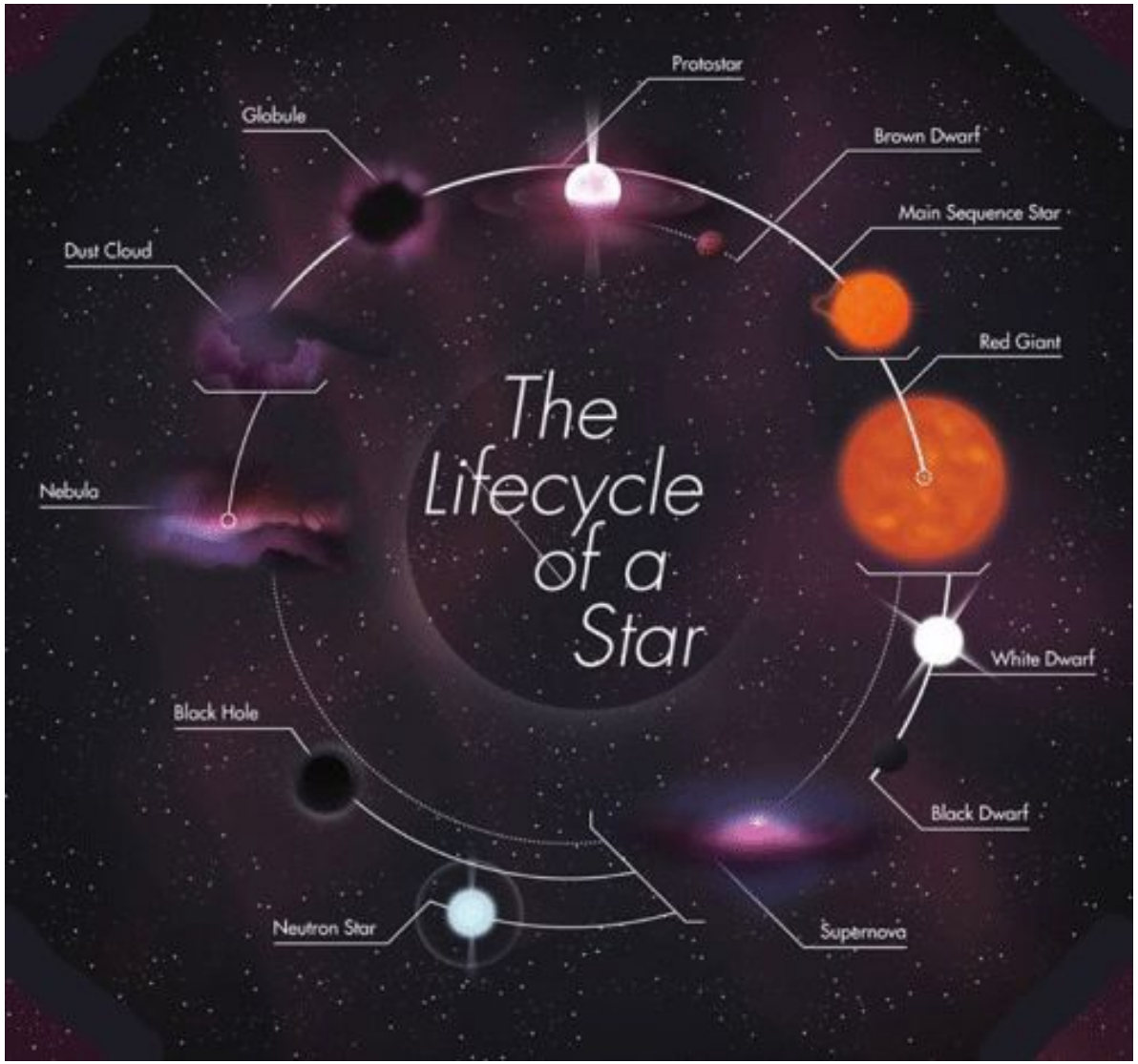


Til nærmeste stjerne (Proxima Centauri) 4,22 ly

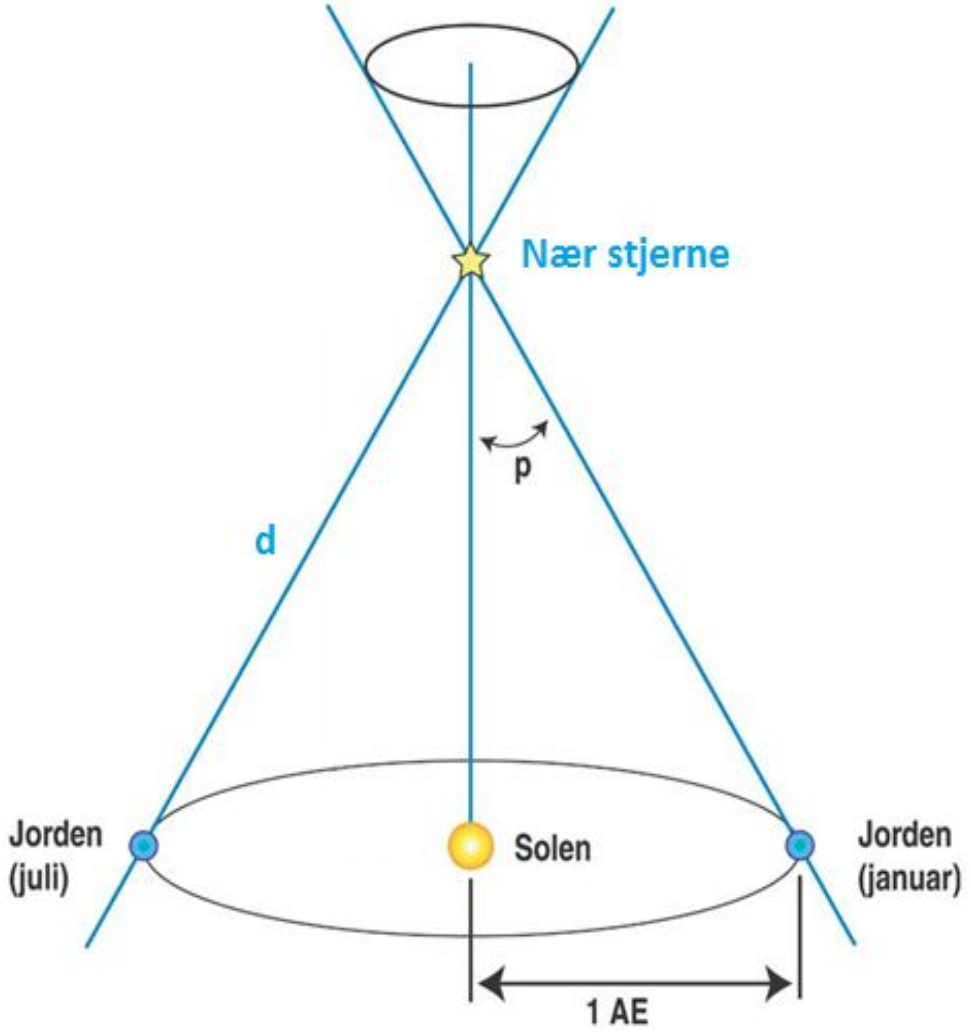
Til Krabbetågen 6500 ly

Til Solen ?

En stjernes udvikling



Parallaksemetoden



For fjernere stjerner er parallaksen p …

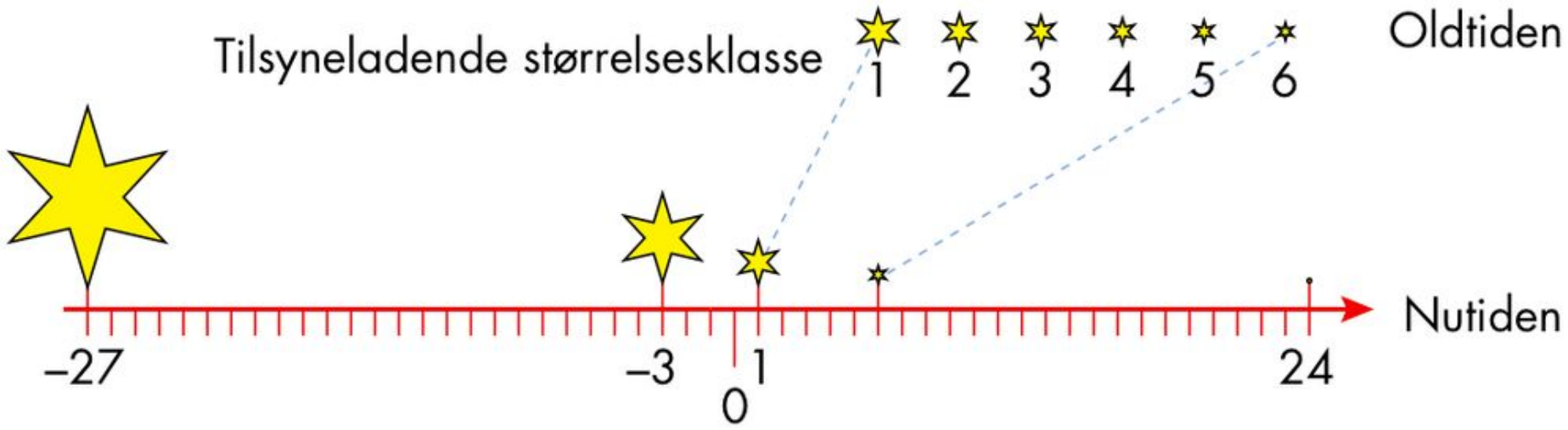
Definition: 1 parsec er

Sammenhæng mellem afstand d og parallakse p:

Modul 5

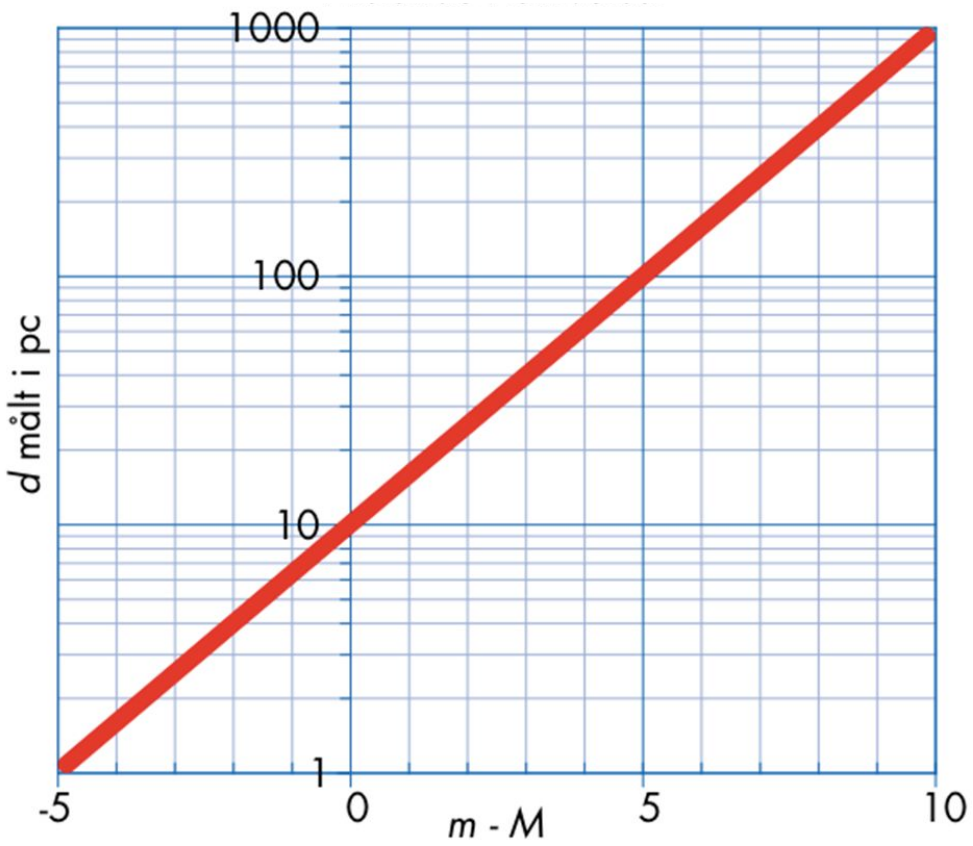
Orbit C s. 203 nederst – 207 øverst

Størrelsesklasser



En stjernes absolutte størrelsesklasse er…

Sammenhæng mellem afstand d og m-M



m – M =

d =

Dobbeltstjernepar med ”kannibal”

Dobbeltstjernepar, hvor den ene (hvid dværg) suger stof til sig fra den anden.

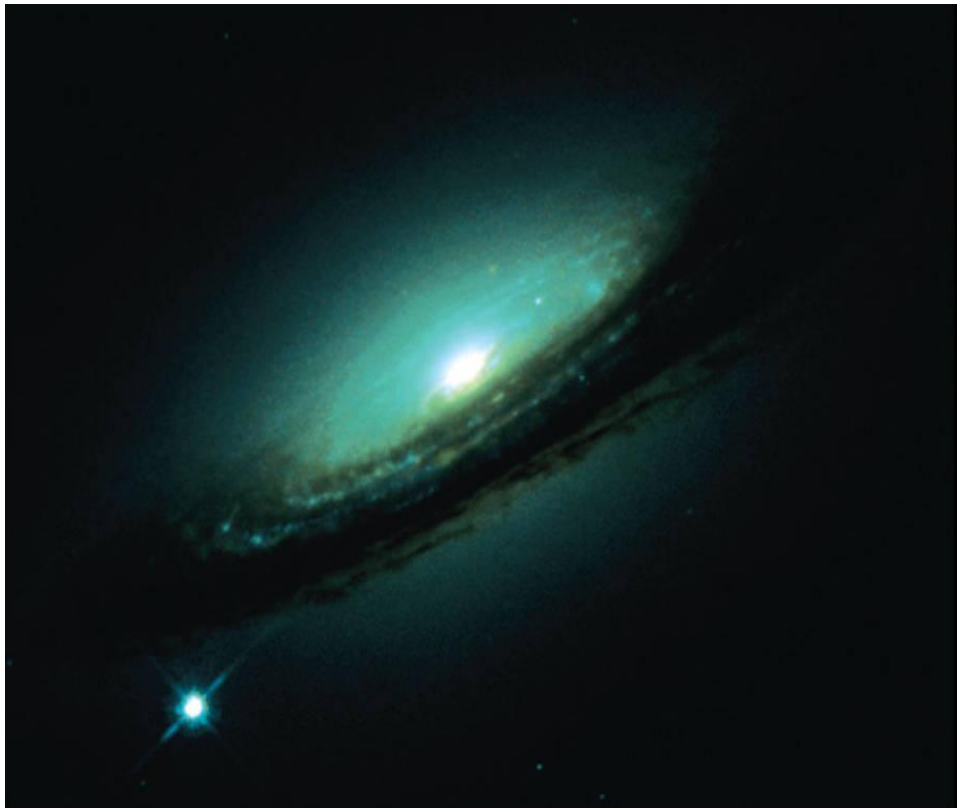
Kan højst få masse på 1,4 gange Solens.

Ender så i type 1a Supernova.

Supernovaer som ”standardlys”

Hvid dværg i dobbeltstjernesystem → Supernova type 1a (M = -20)

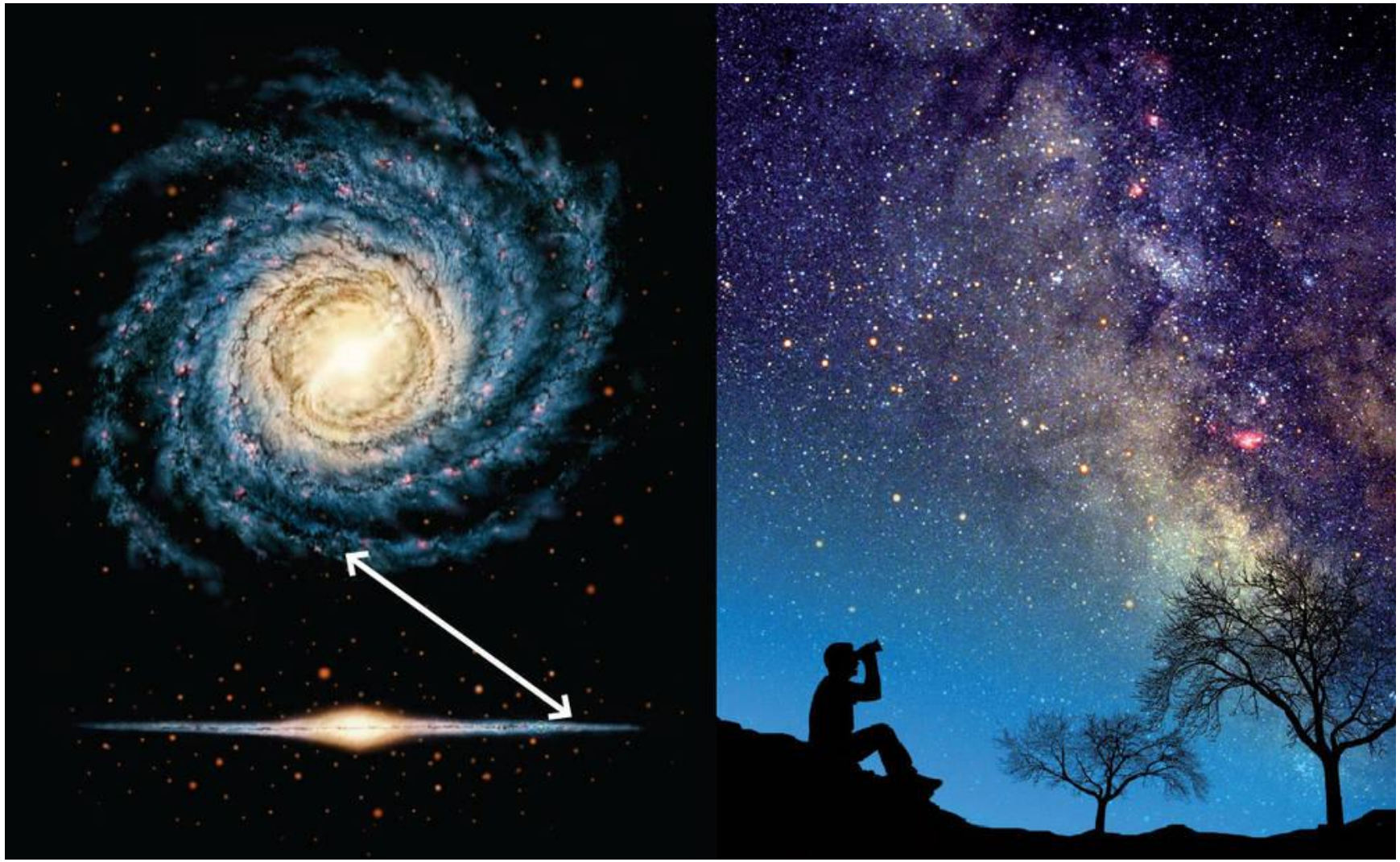
Afstand $d = 10^{(\frac{m-M+5}{5})}$



Modul 6

Orbit C s. 207-211

Vores plads i Mælkevejen

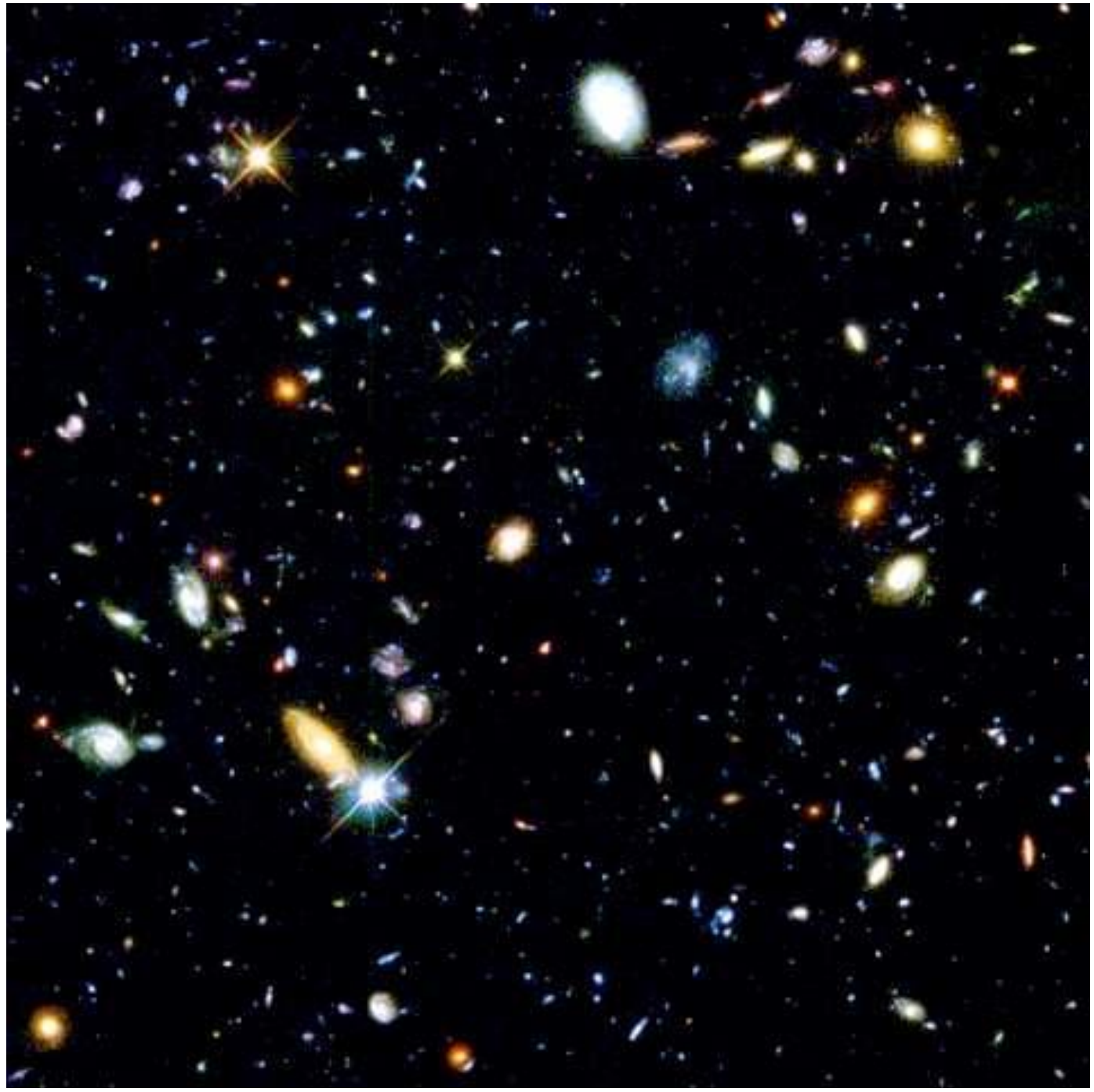


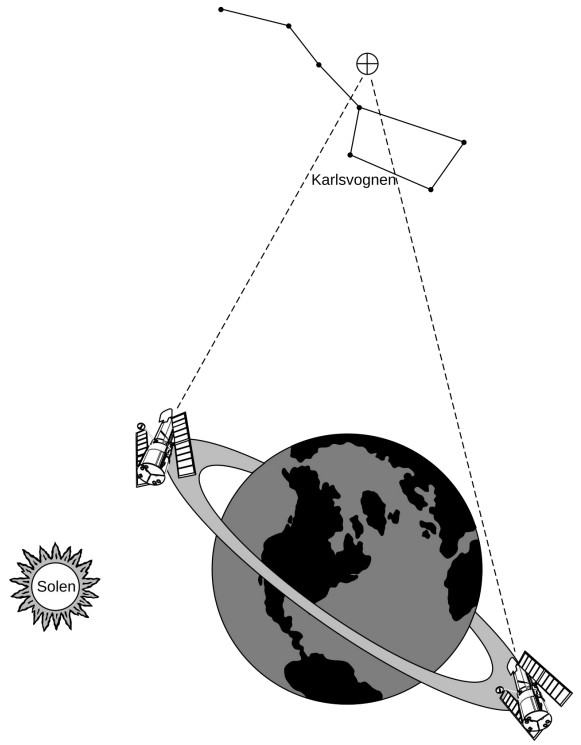
Sombrerogalaksen

Bjælkegalakse

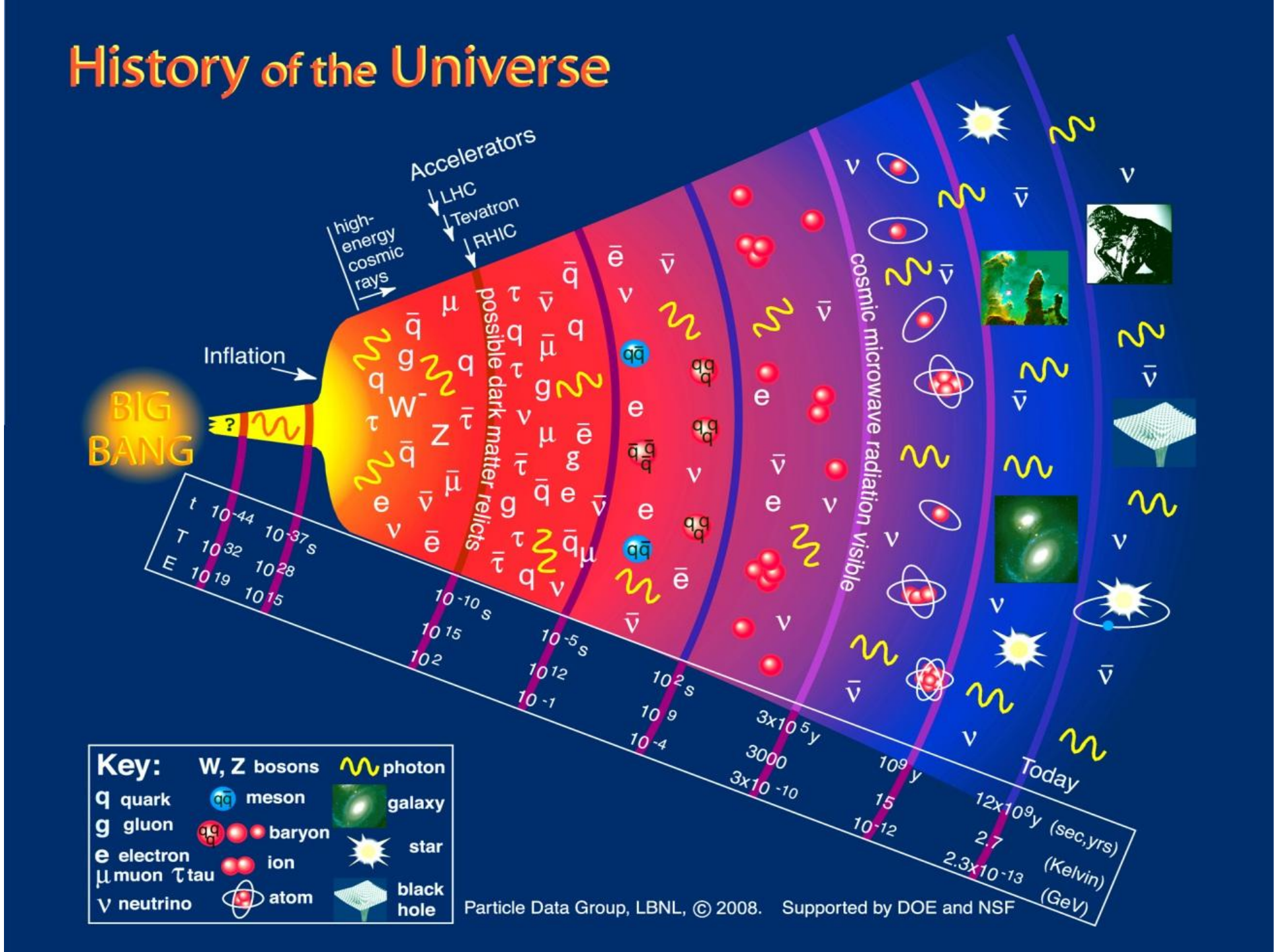
Elliptisk galakse

Galaksehobe





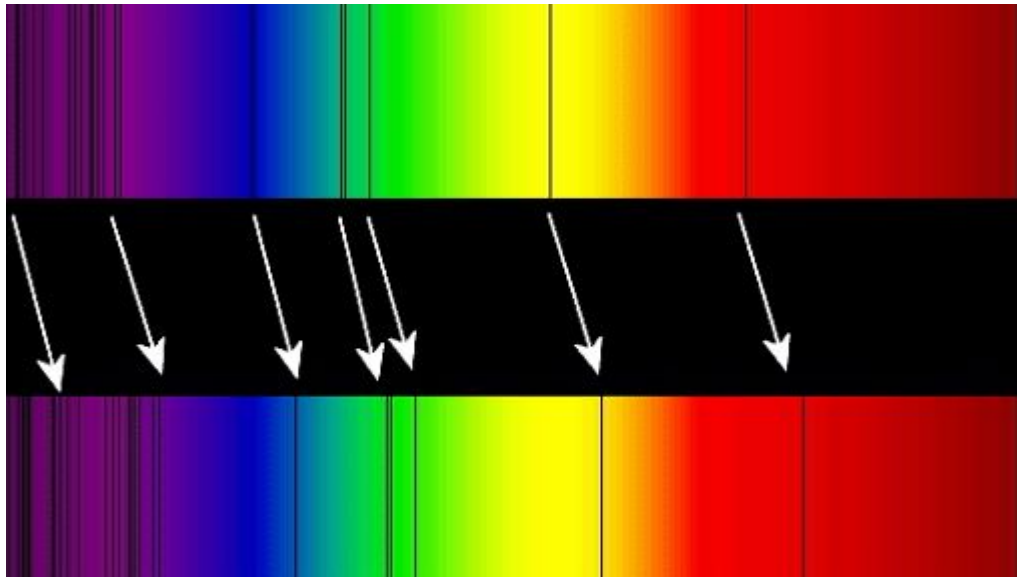
Hubble Deep Field

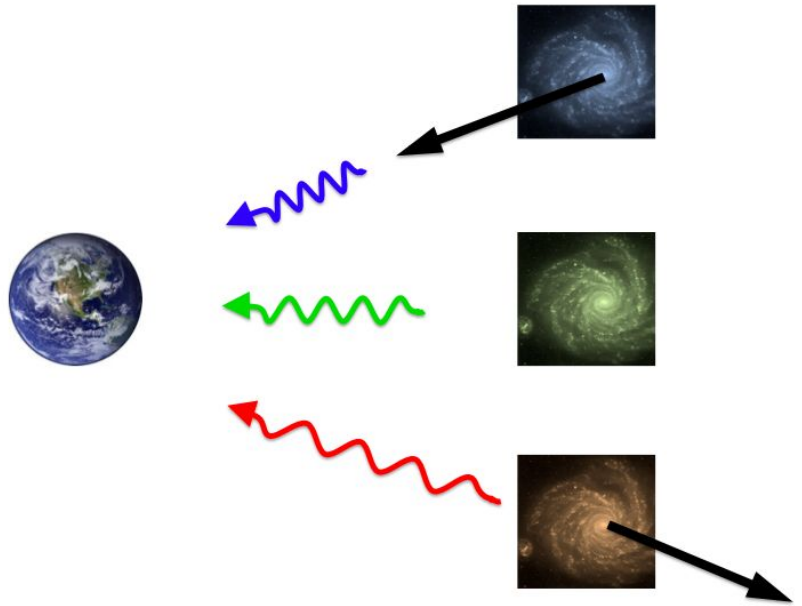

History of the Universe
Accelerators
LHC
Tevatron
RHIC
high-energy cosmic rays
Inflation
BIG BANG
possible dark matter relicts
cosmic microwave radiation visible
Today
t 10-44 10-37 s
T 10 32 10 28
E 10 19 10 15
10 -10 s
10 15
10 2
10 -5 s
10 12
10 -1
10 2 s
10 9
10 -4
3x10 5 y
3000
3x10 -10
10 9 y
15
10 -12
12x10 9 y (sec,yrs)
2.7 (Kelvin)
2.3x10 -13 (GeV)
Key:
q quark
g gluon
e electron
μ muon τ tau
ν neutrino
W, Z bosons
meson
baryon
ion
atom
photon
galaxy
star
black hole
Particle Data Group, LBNL, © 2008. Supported by DOE and NSF

Modul 7

Orbit C s. 211-218

Rødforskydning





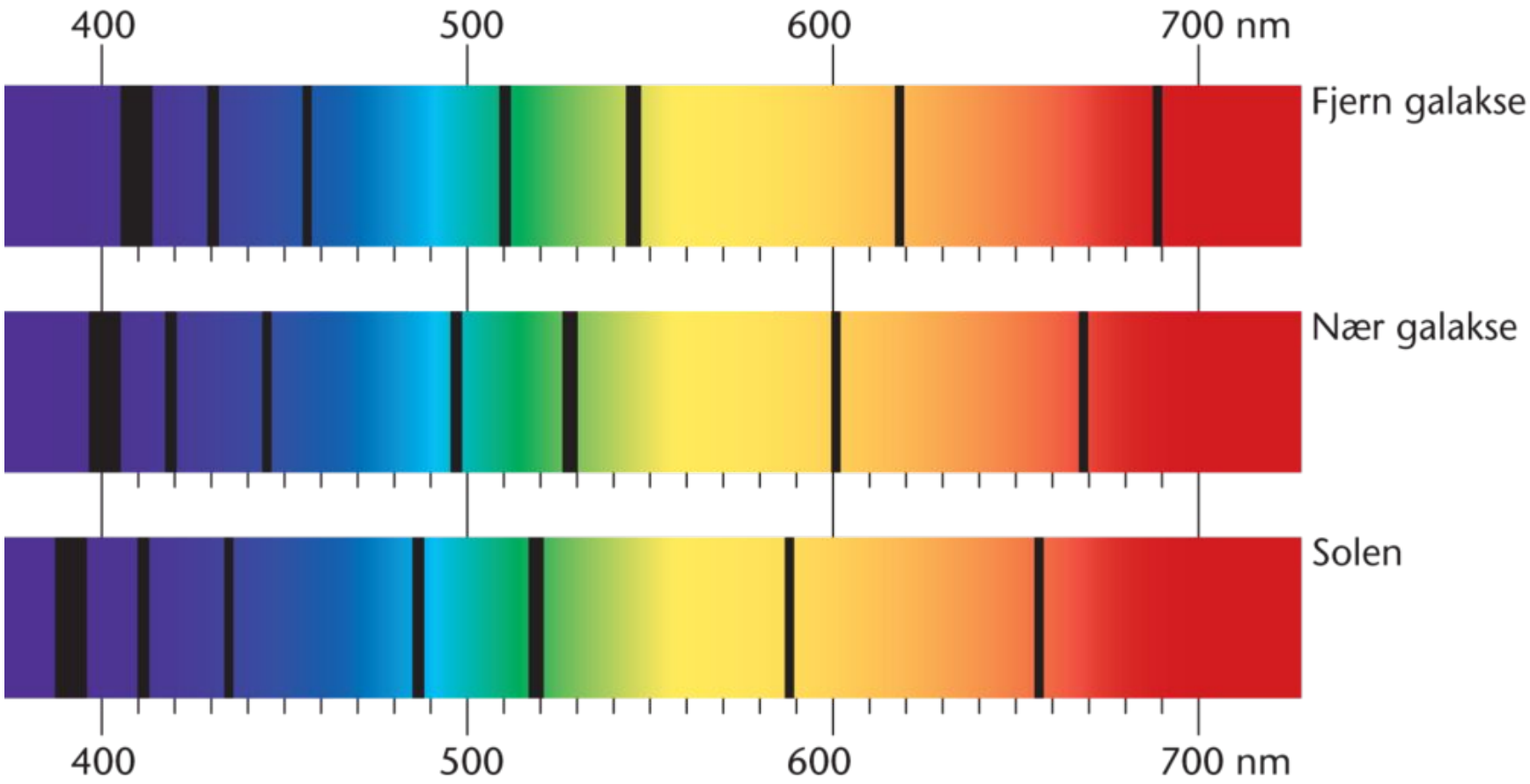
Dopplereffekt

http://www.youtube.com/watch?v=JZTKhswn684

Fly der passerer:

http://www.youtube.com/watch?v=eo_owZ2UK7E&NR=1&feature=fvwp

Stjerne og galaksespektre



Rødforskydning og fart

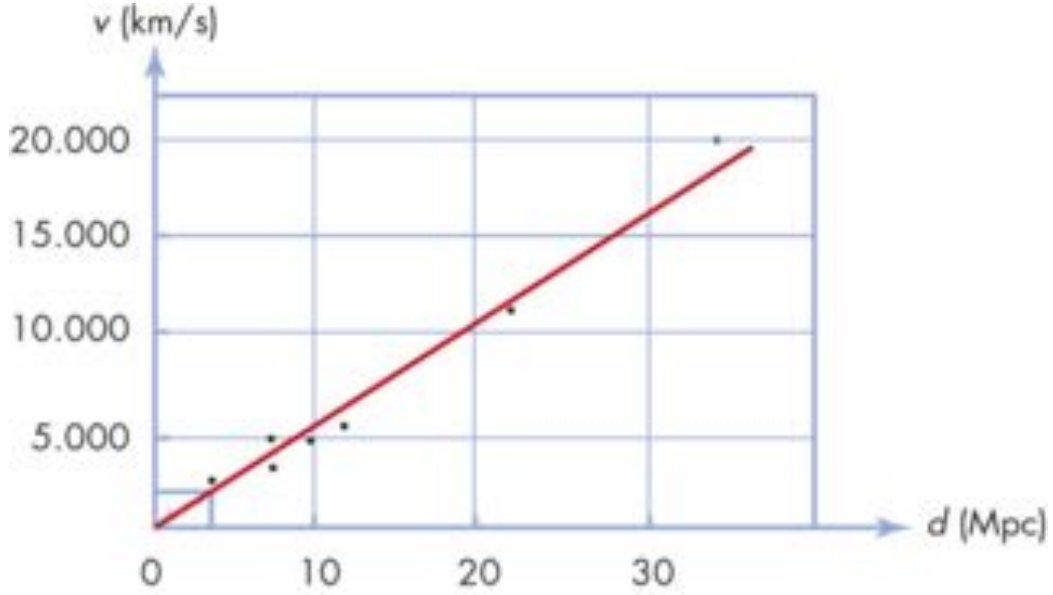
Differensen mellem den målte bølgelængde og bølgelængden i et referencespektrum kaldes $\Delta\lambda$

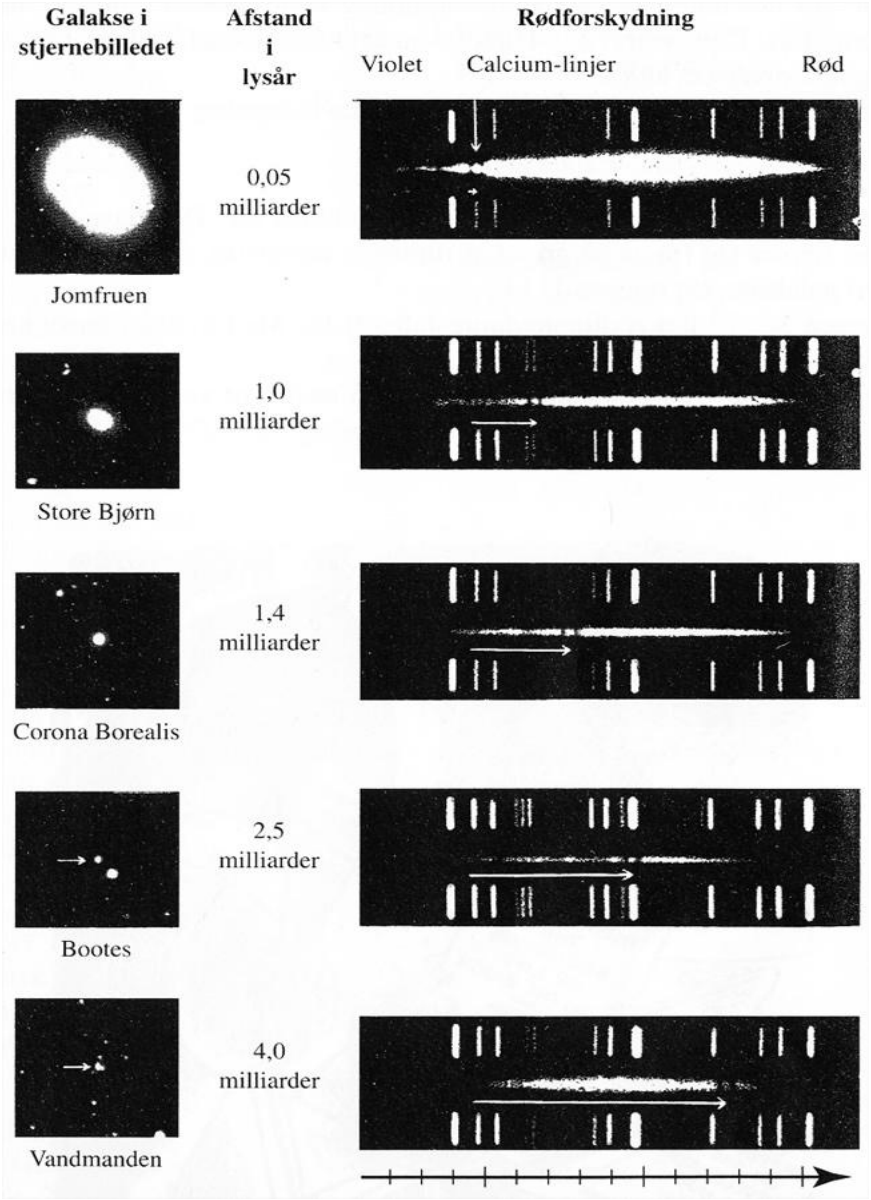
$$\Delta\lambda = \lambda - \lambda_0$$

Rødforskydningstallet $z =$

Galaksens fart $v =$, hvis $z < 1$.

Hubbles lov





Konklusion:

Beregning af Universets alder

Antagelse: Udvidelsen er hele tiden sket med samme fart v.

Universets udvidelse

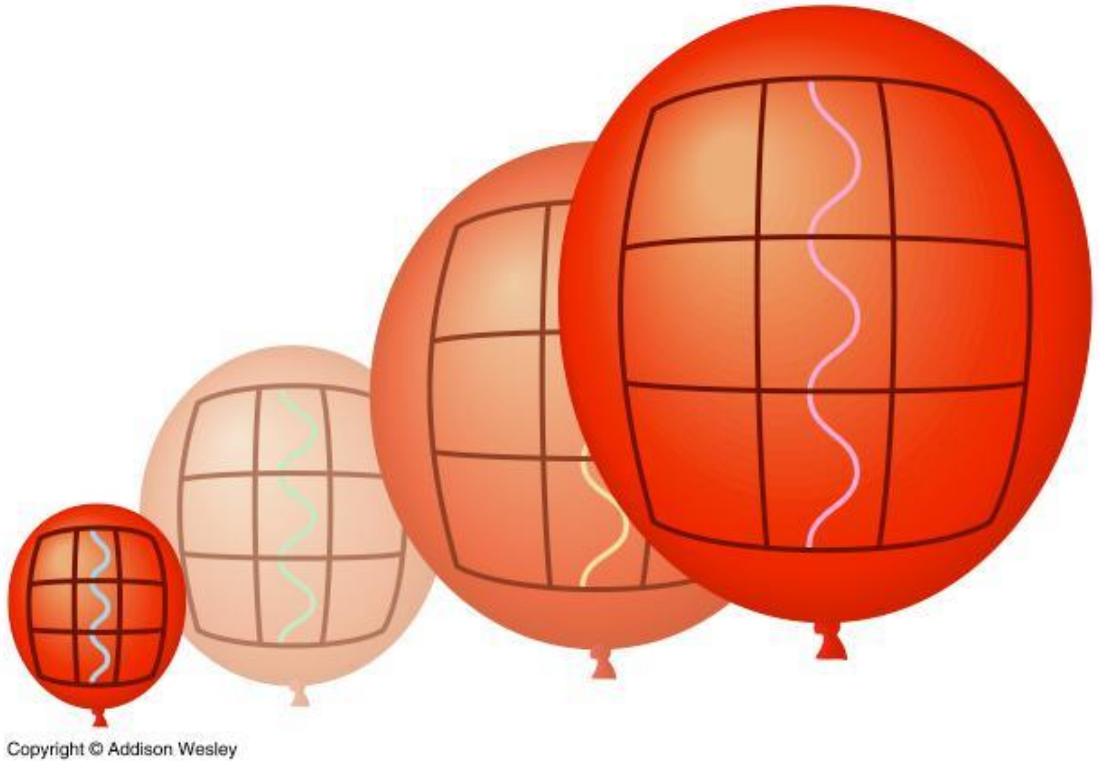
En foton, der blev udsendt fra galakse med bølgelængde λ_0, får øget sin bølgelængde til λ under vejs.

Hvis $z = 0{,}25$ er

$\lambda =$

$v =$

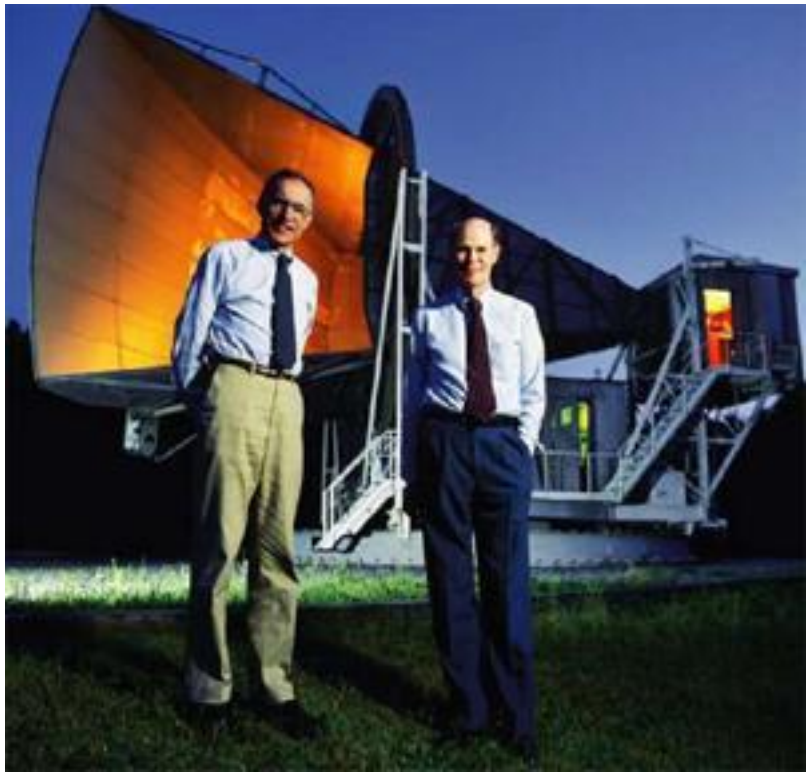
Og afstanden til galaksen er øget med %, mens fotonen har været under vejs.

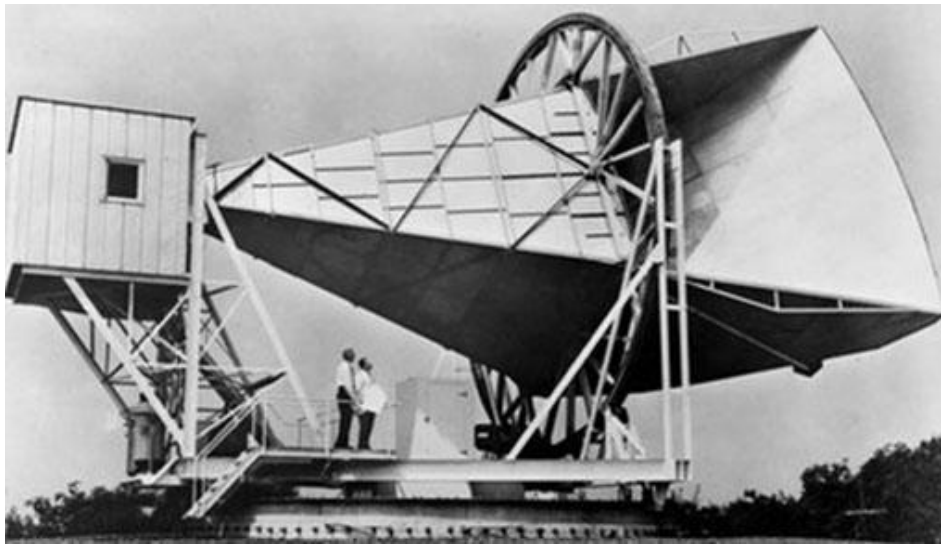


Modul 8

Orbit C s. 218-224

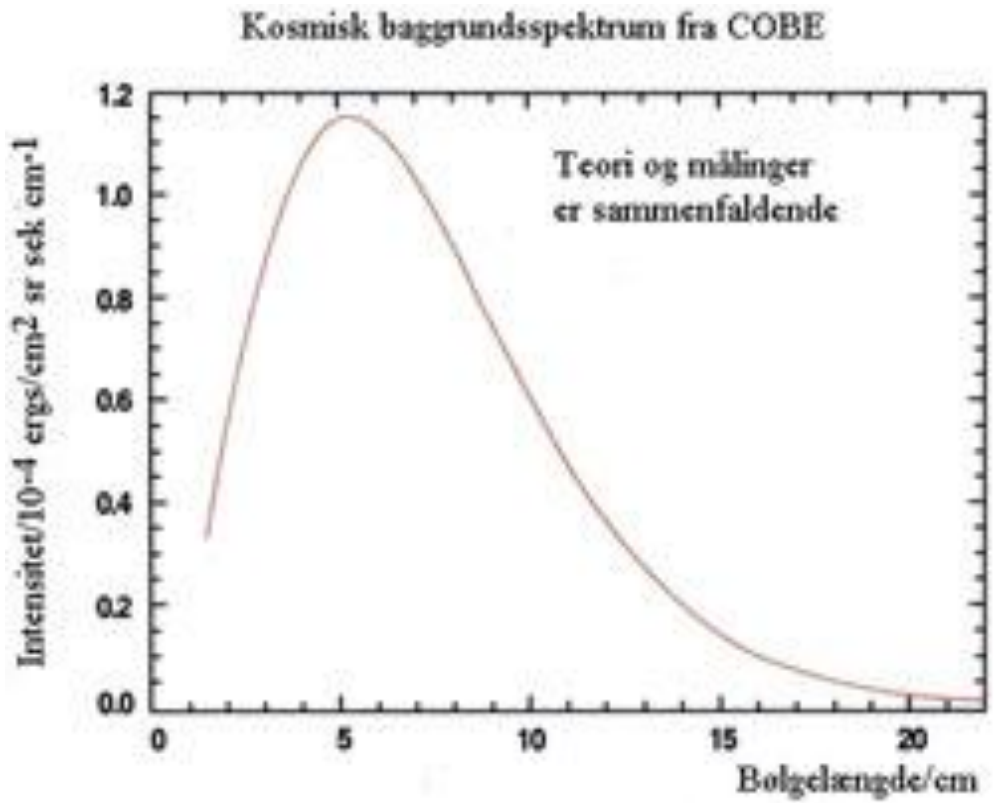
Den kosmiske mikrobølge baggrundsstråling



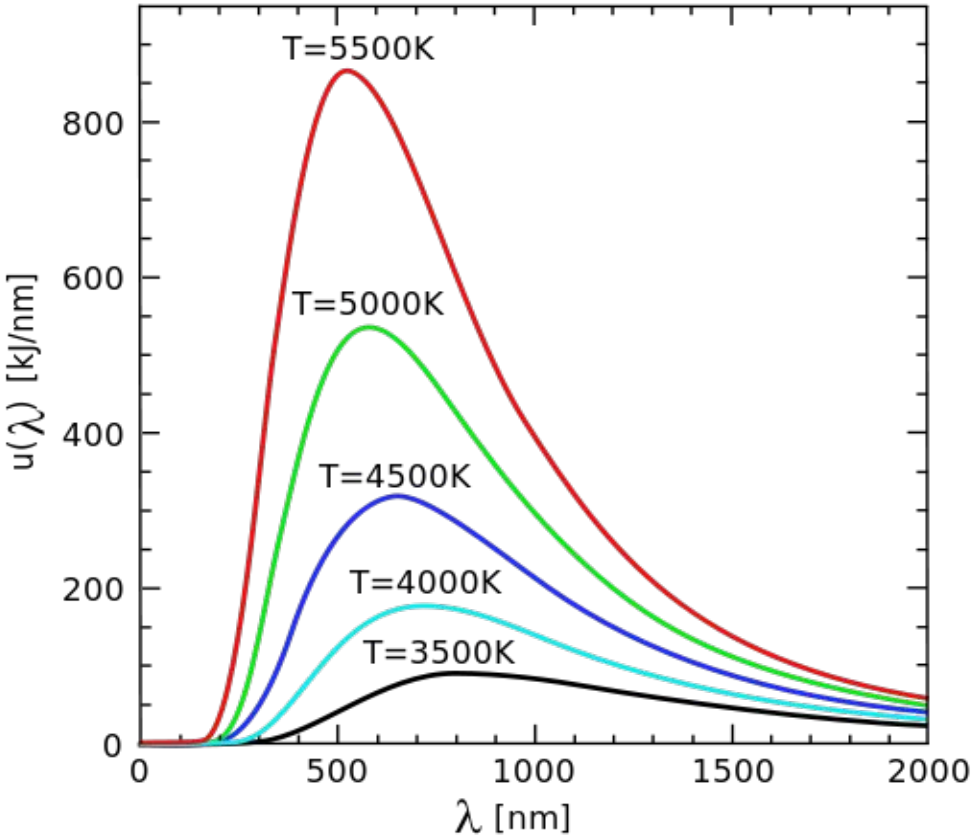


Penzias og Wilson 1965

Den kosmiske baggrundsstråling CMB

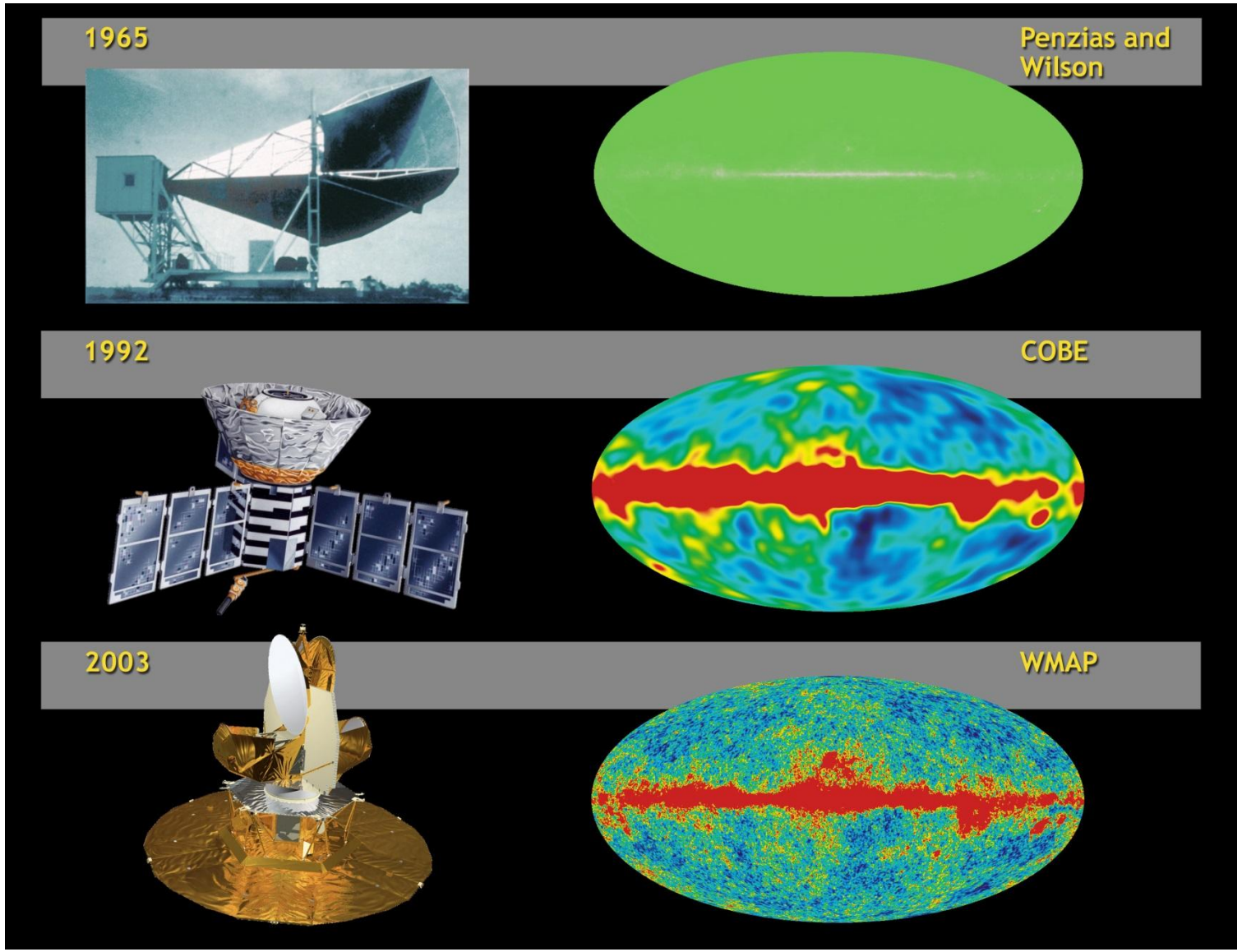


Målt af COBE i 1989

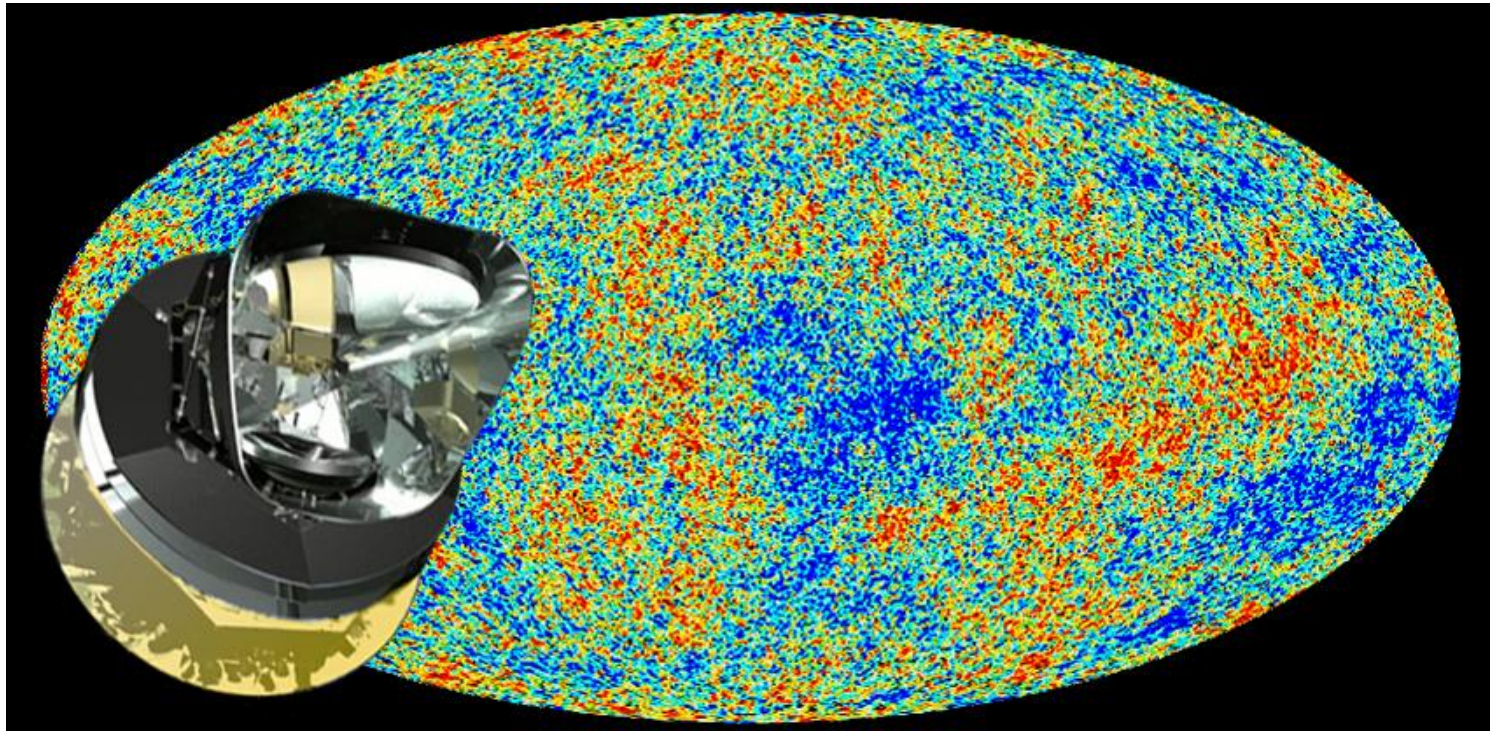


Planck-kurver

Måling af CMB



Planck-rumteleskopet



Resultater:

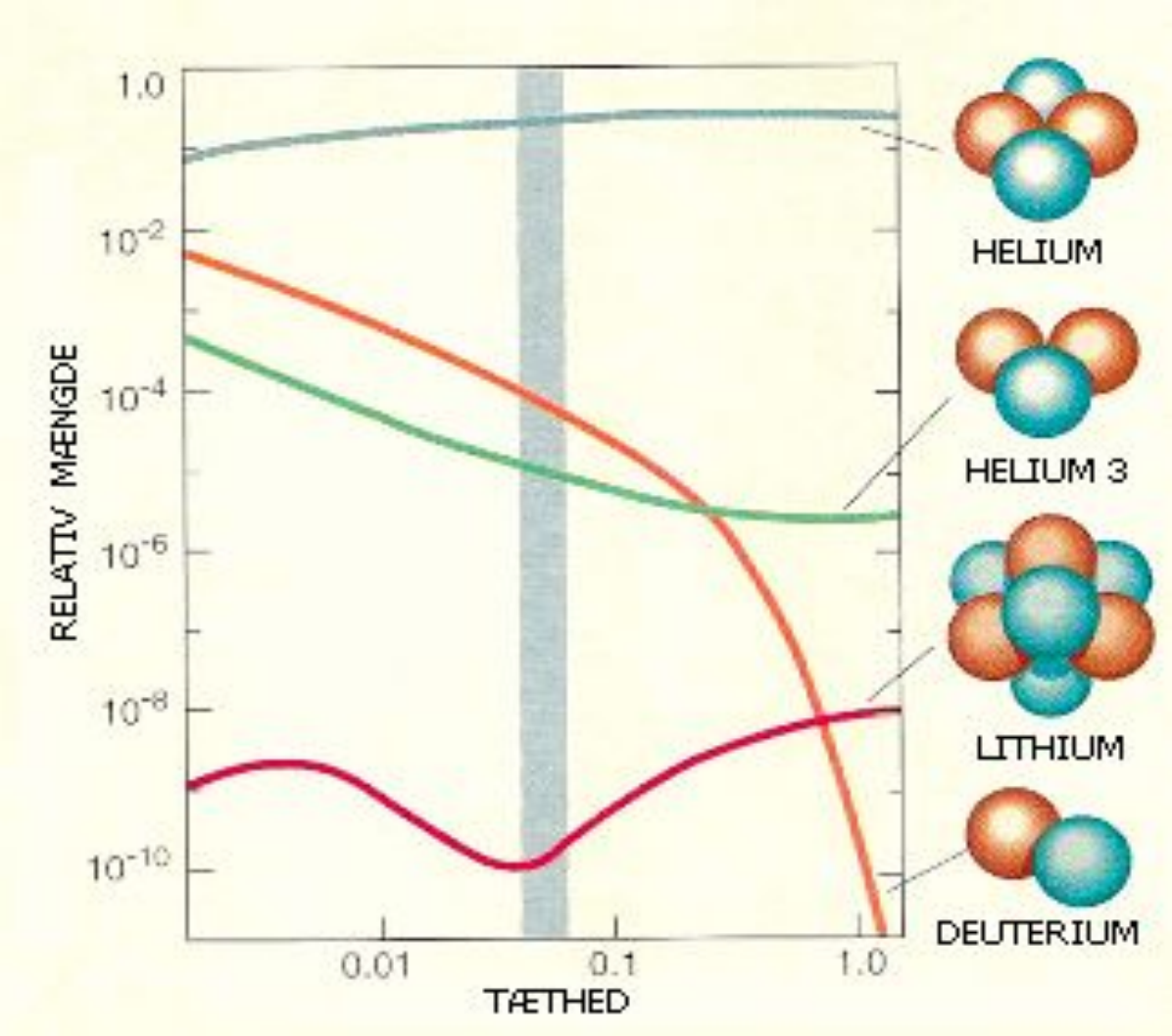
- Universets alder er 13,81 mia. år ± 0,05 mia. år
- Universet består af 4,9 pct. almindeligt stof, 26,8 pct. mørkt stof og 68,3 pct. mørk energi

http://ing.dk/artikel/unikke-satellit-data-fastslaar-universets-alder-med-hidtil-uset-noejagtighed-157331

Grundstoffordelingen i Universet

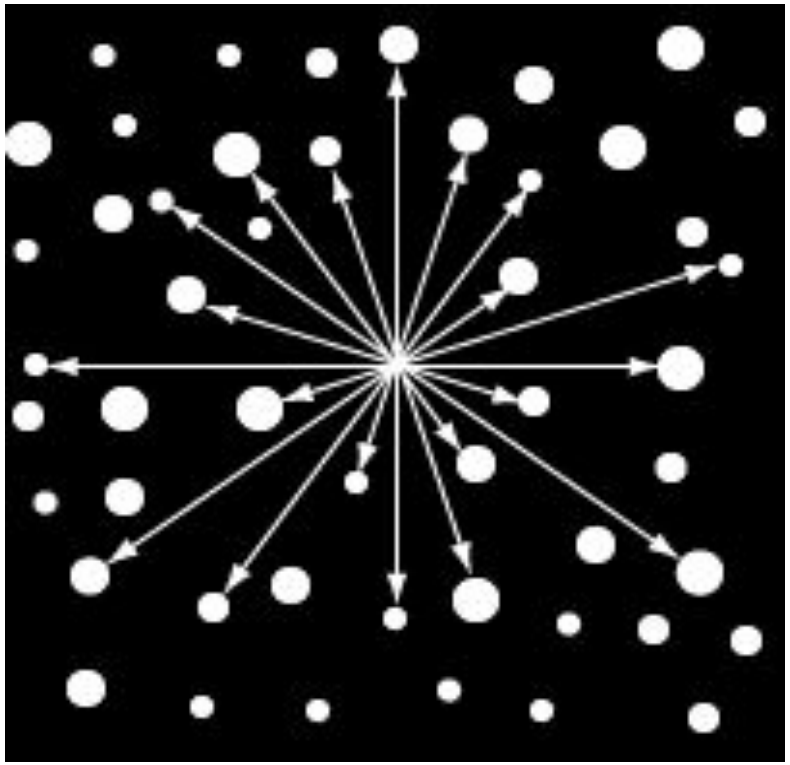
Samme 92 grundstoffer findes overalt i Universet. Samme fordeling (med små variationer) over alt.

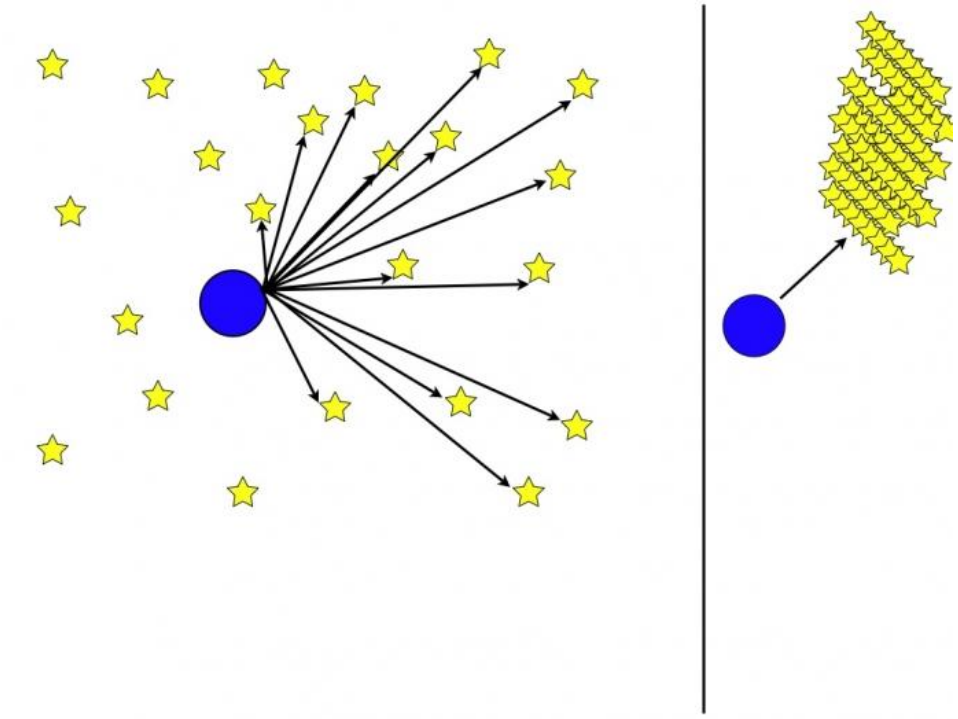
Hydrogen:
Helium:
Tungere grundstoffer:



Olbers paradoks

H. Olbers 1823: Hvis Universet er uendeligt i rum og tid; skal nattehimlen være så lys som Solens overflade.





Konklusion:

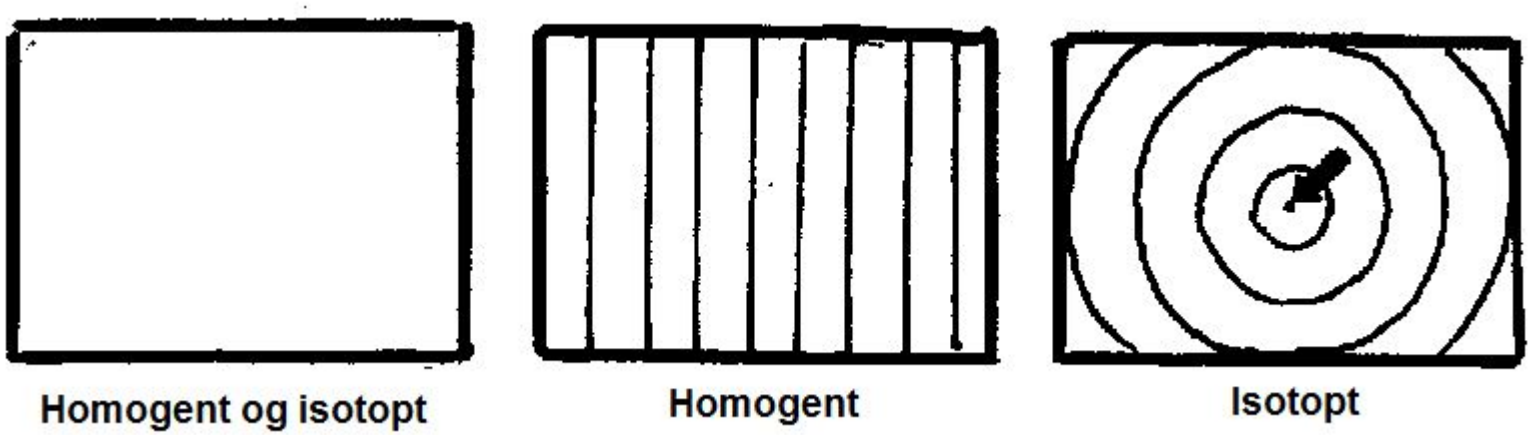
Hvad underbygger Big Bang teorien?

- Universets udvidelse
- Den kosmiske baggrundsstråling
- Mikrostrukturen i baggrundsstrålingen
- Grundstoffordelingen
- Nattehimlen er mørk

Det kosmologiske princip

Vi antager at Universet er homogent og isotropt

- Homogent = Jævnt fordelt
- Isotropt = Ens i alle retninger

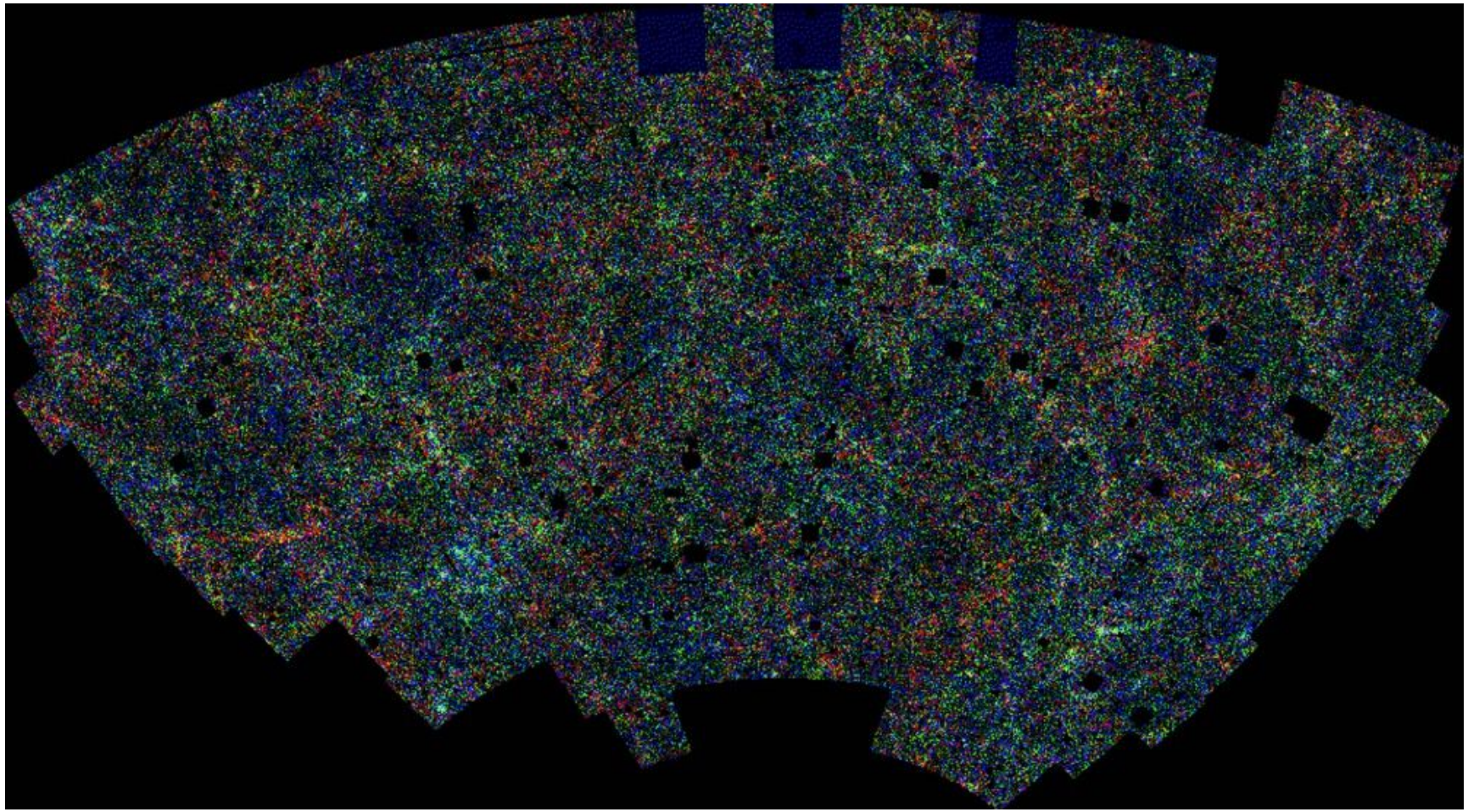


Universets udvidelse har ikke været konstant

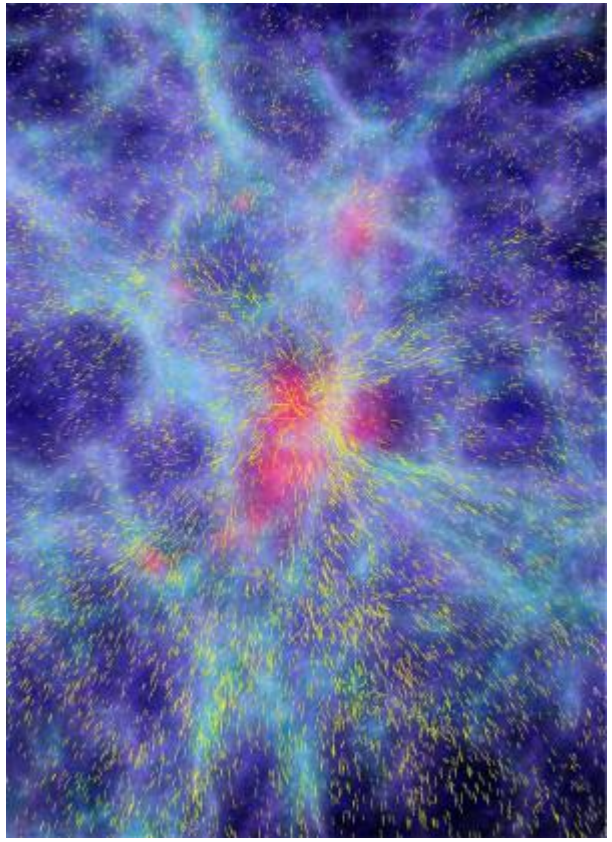
- Universets udvidelse accelererer – pga. en ukendt energi (mørk energi)

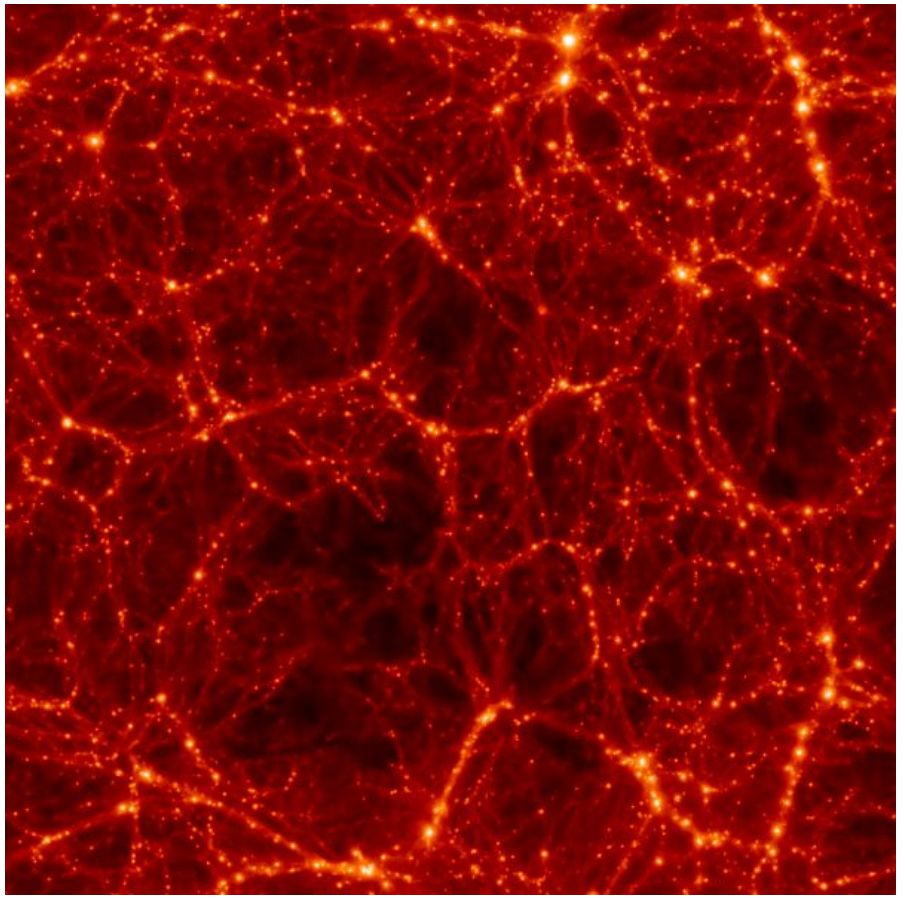
- I en kort periode tidligt i Universets udvikling var udvidelsen meget hurtig for senere at blive langsom igen. Det kaldes inflationsperioden.

Er stoffet så jævnt fordelt?



Stoffets storskalastruktur





Hvad var så Big Bang

- **Ikke** en normal eksplosion
- En udvidelse af rummet – dvs. alle afstande

- Før Big Bang var der intet rum.

Hvad siger religionen til Big Bang?

- Hvad er forskellen på tro og viden?