

# ***Basics on the Structure of the Universe***

A Photo-guided Journey

Dr. Hartmut Renken, <http://renken.de>

February 26, 2009

(bsu\_20090226\_handout.ppt)

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## **Abstract**

"Basics on the Structure of the Universe - A Photo-guided Journey"

We undertake a photo-guided journey from planet Earth to the edge of the visible deep space called "Universe". Building blocks like interstellar dust, stars, star clusters, galaxies or even galaxies clusters are fine to get a guess of the enormous dimensions of the Universe by going stepwise from an inner to an outer structure element. This is not a general role of mother nature "who to build the Universe" but it's a good help to simplify much more complicated things behind.

This presentation is fulfilled with "pretty picture" made by professional astronomers and relatively expensive ground- and space based telescopes as well as pictures which were taken by relatively cheap amateur equipment from the backyard.

In addition we will see some "real stuff" like transportable telescopes. For the case of clear sky some nice celestial objects are our target to be observed in reality. As an example: planet Saturn, comet "Lulin", star cluster "Seven sisters" (Pleiades) and the "Great Orion Nebula" are above the horizon this evening.

## **Outline? - No outline...**

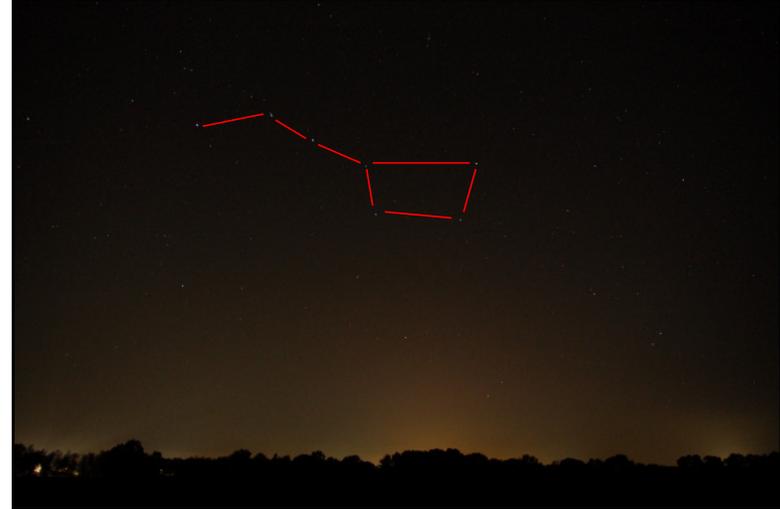
The presentation is a "living" presentation...

Constellation „Big Dipper“

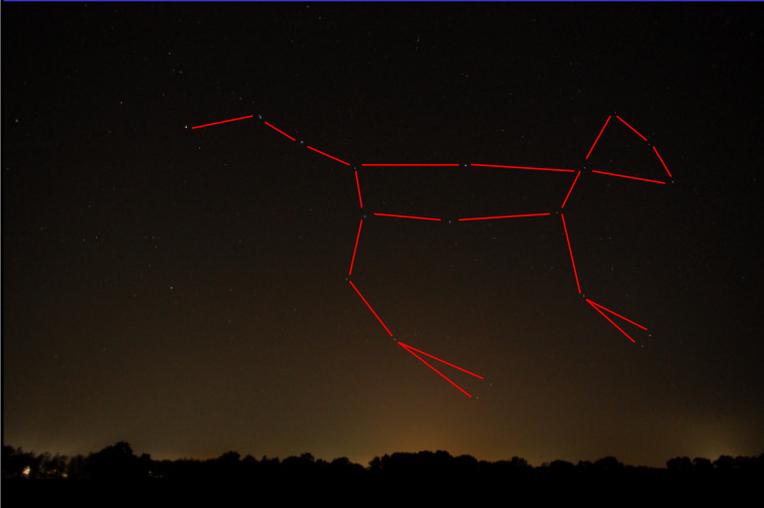


20 seconds exposure; focal length  $f=24$  mm

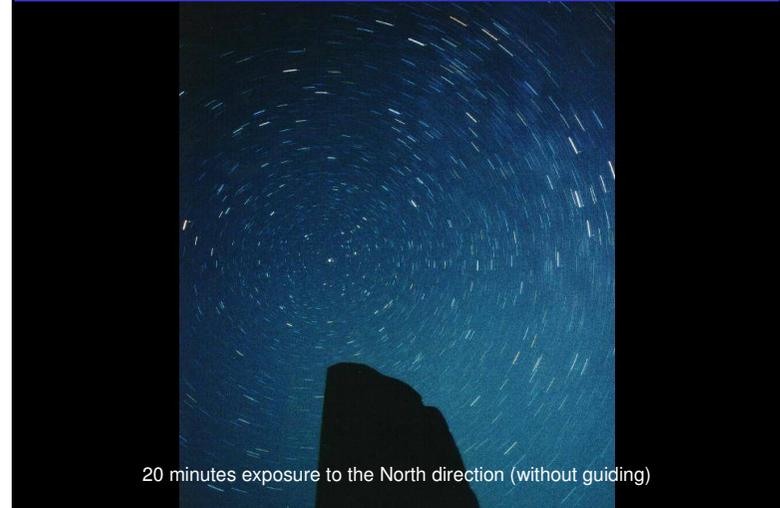
Constellation „Big Dipper“



Constellation „Great Bear“ (Ursa Major)



Just a simple image from a tripod



20 minutes exposure to the North direction (without guiding)

### Rotation of the heaven respectively of the Earth



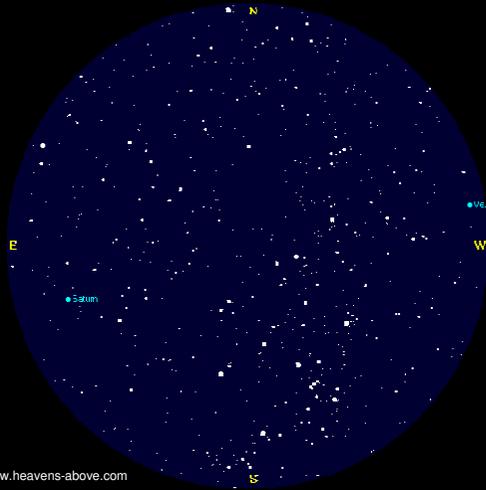
50 minutes exposure to the North direction (without guiding)  
Image by Ulrich Beinert

### Determine the North direction via the Northern Star



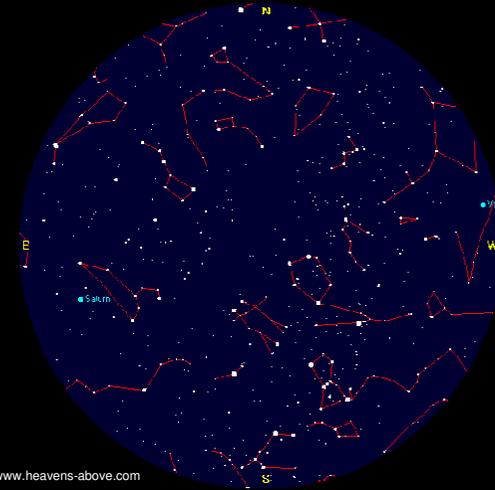
The "Northern Star" is about 0.5 degree next to the real "Northern Pole"  
Note: 0.5 degrees can cause a navigation error of at most 30 nautical miles

### Sky chart: February 25, 2009 - 21:00 - North Germany



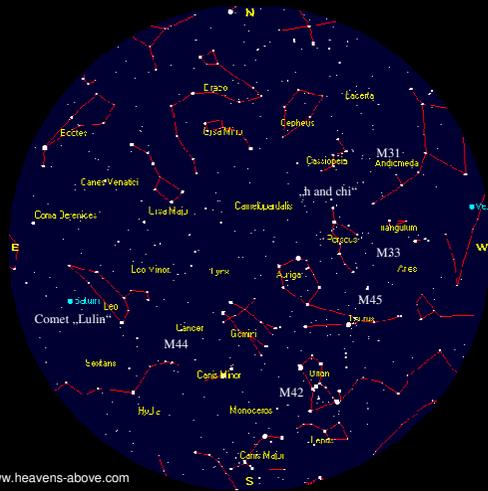
Source of map: [www.heavens-above.com](http://www.heavens-above.com)

### Sky chart: February 25, 2009 - 21:00 - North Germany



Source of map: [www.heavens-above.com](http://www.heavens-above.com)

## Sky chart: February 25, 2009 - 21:00 - North Germany



Source of map: www.heavens-above.com

## Some celestial objects to be observed tonight

Star cluster M45



Saturn

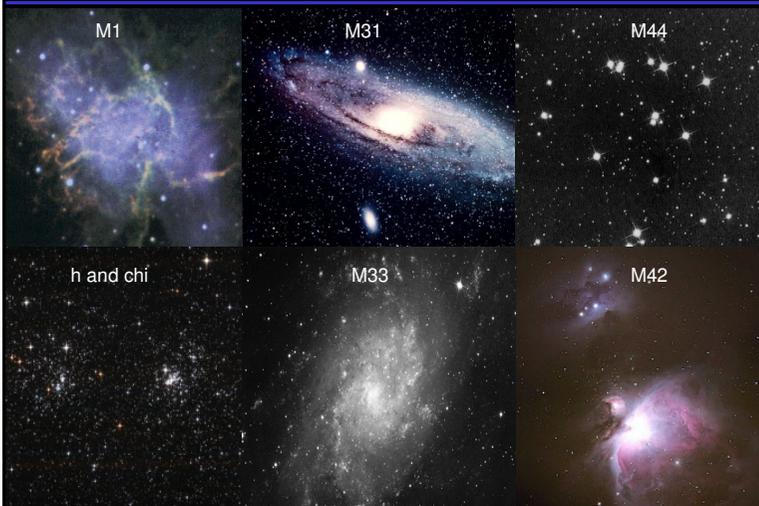


Venus (2009 February 14)



Comet „Lulin“ (2009 February 1)

## Some celestial objects to be observed tonight

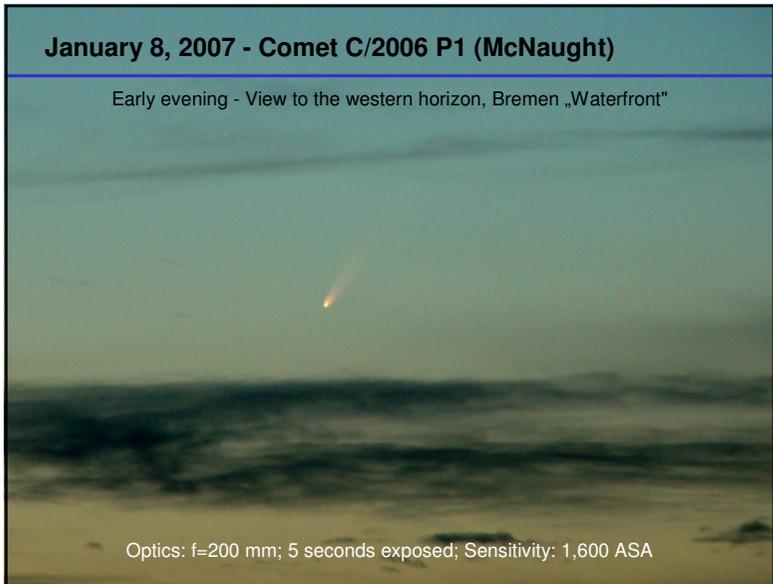
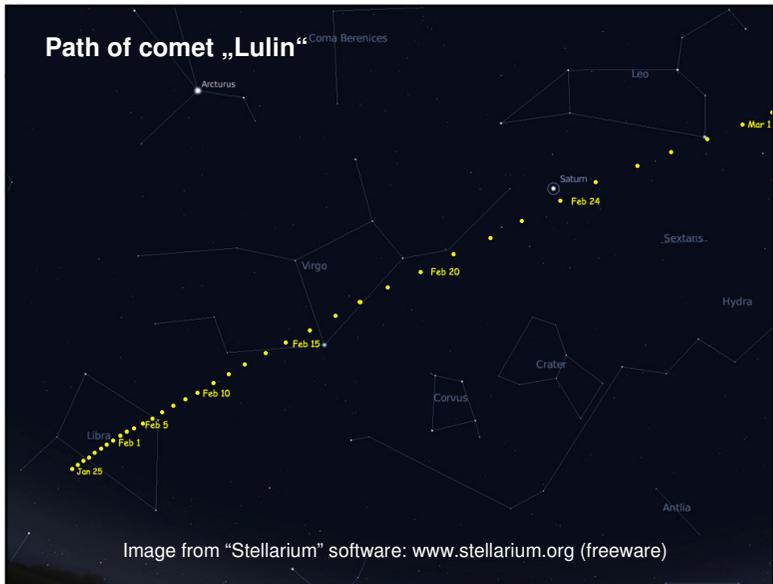


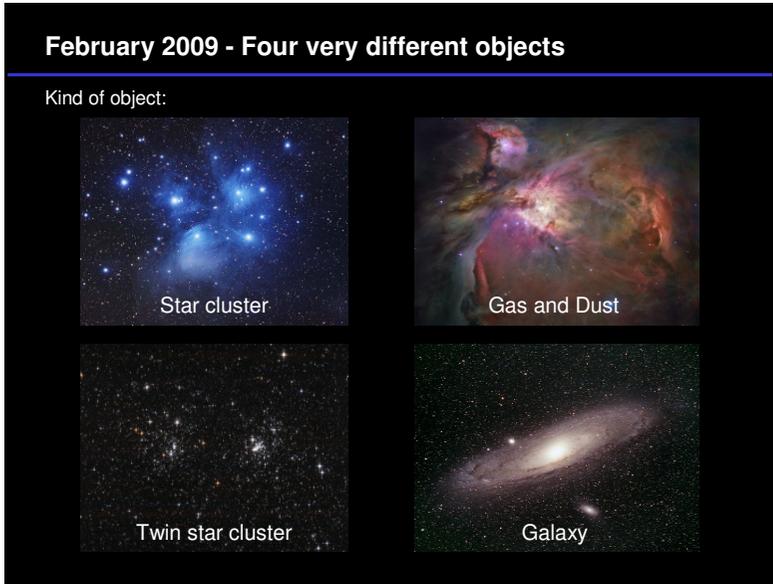
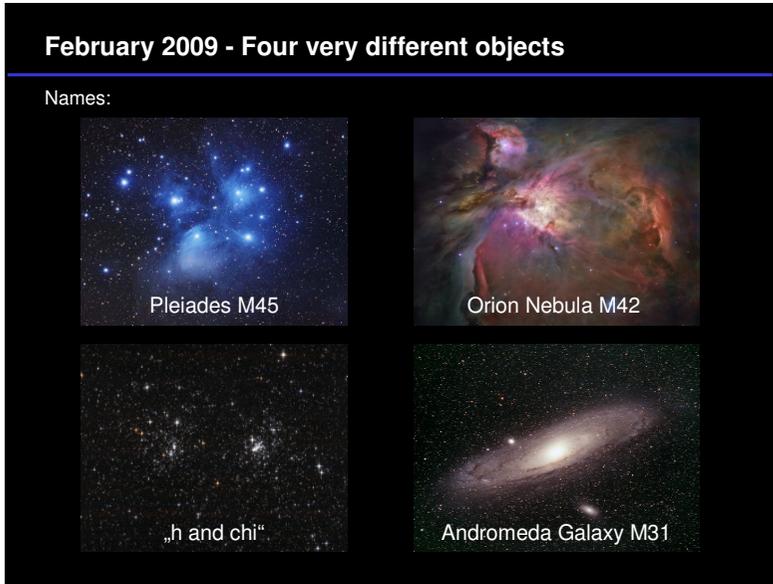
## Celestial objects to be observed tonight - Distances

Object	Distance
Venus	5 light minutes
Saturn	1.2 light hours
Pleiades M45 (open star cluster)	400 light years
M44 (open star cluster)	580 light years
Great Orion Nebula M42 (region of star birth)	1,600 light years
Crab Nebula M1 (supernova remnant)	6,300 light years
h and chi (double star cluster)	7,300 light years
Andromeda Galaxy M31	2,500,000 light years
Galaxy M33	3,000,000 light years

Some other Messier object: e.g. M35, M36, M37, M38, M41, ...

M: Charles Messier (1730 - 1817) - French astronomer, discoverer of !! 21 !! comets, creator of the "Messier catalog" (110 objects)





Winter constellations - Super wide angle



1:2.8/11 mm - 6 min exposed - Slide film Kodak Ektachrome 200 - Early 1985

Winter constellations - Super wide angle

Six stars are building the "Winter hexagon"

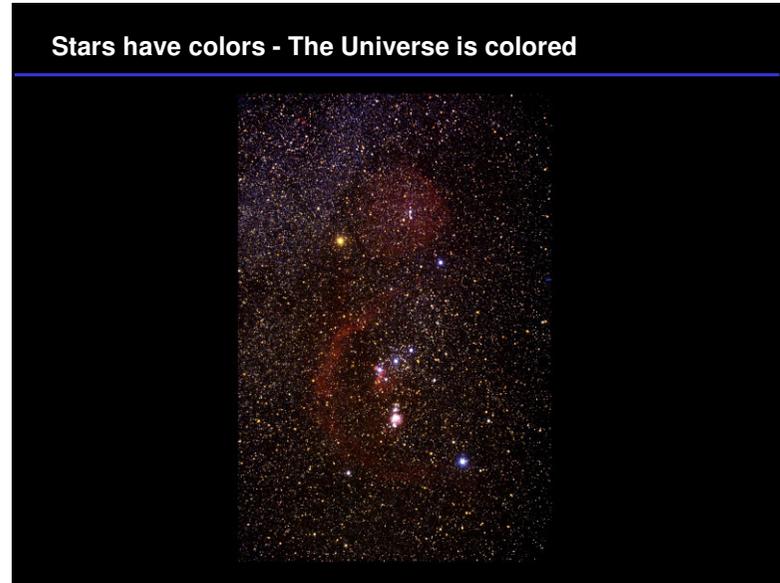


1:2.8/11 mm - 6 min exposed - Slide film Kodak Ektachrome 200 - Early 1985

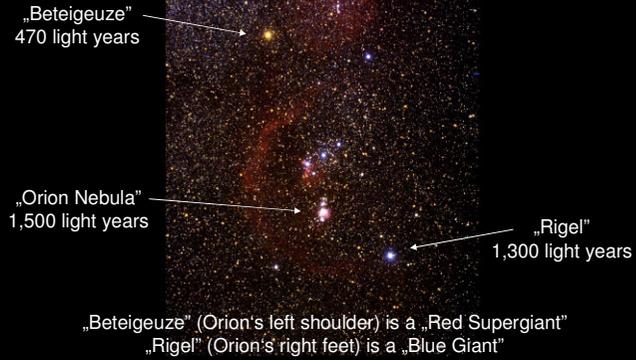
Constellations „Taurus“ (Bull) & „Orion“



Stars have colors - The Universe is colored



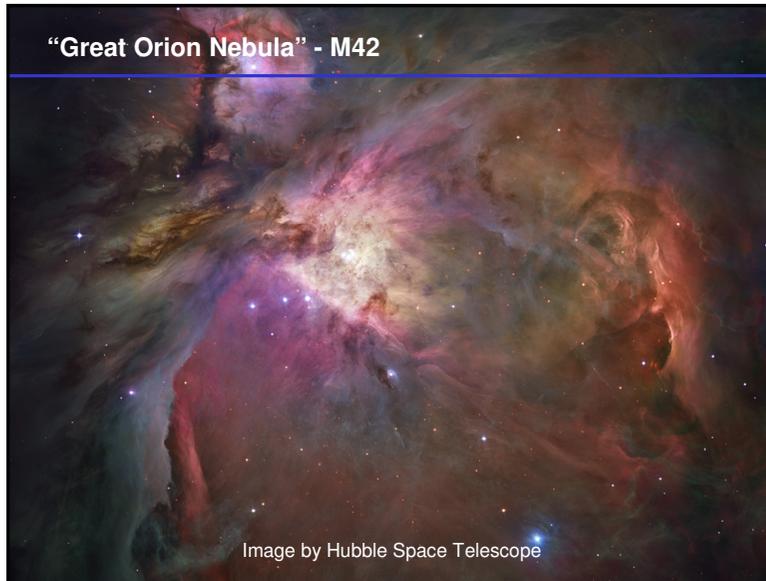
**Stars have colors - The Universe is colored**



**“Great and small Orion Nebula” - M42 & M43**

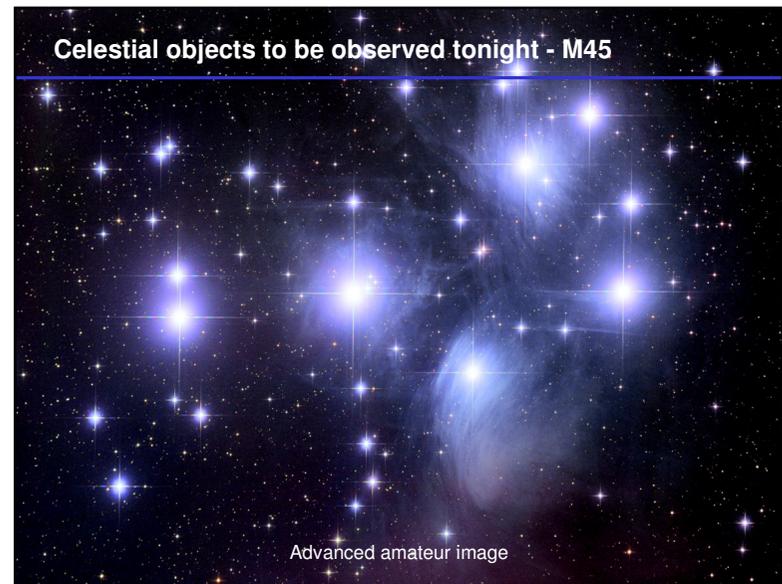
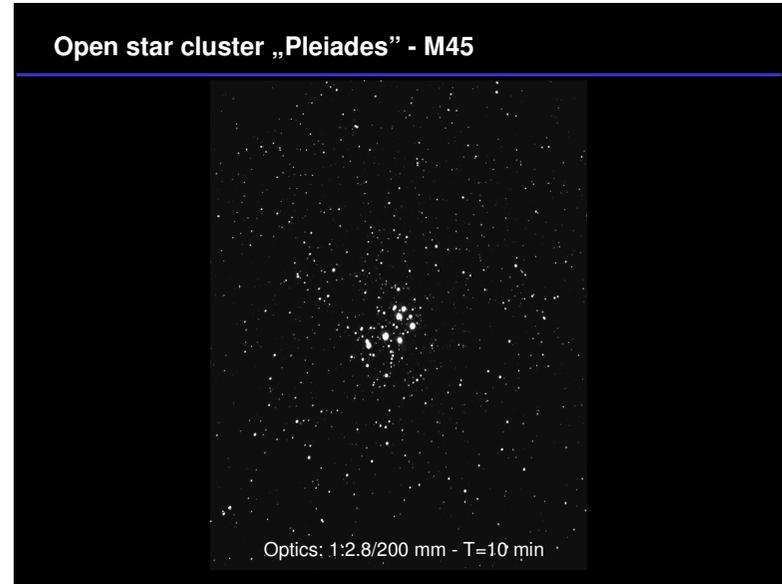


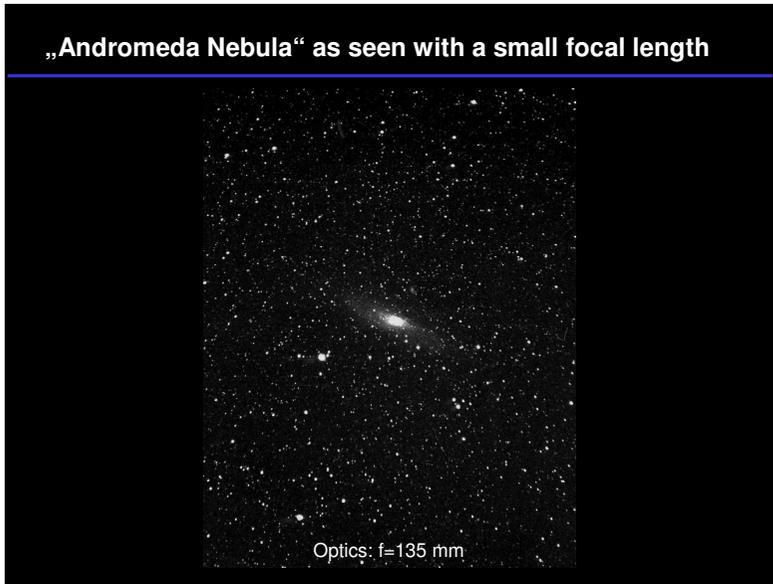
**“Great Orion Nebula” - M42**



**Bright star „Delta Orionis“ & „Horsehead Nebula“**







## „Andromeda Nebula” / „Andromeda Galaxy” M31

!!! Amateur image of M31 !!! Distance: 2,5 Million light years -  
An island of stars that consists of 200 Billion ( $200 \cdot 10^9$ ) members

## Edwin Powell Hubble (1889 – 1953)



Milestones in the scientific life of Edwin Hubble

1923: The “Andromeda Nebula” is an island of stars beyond the “Milky Way”

1929: The Universe is expanding (good to explain with the “Big Bang”)

## Hierarchy of the Universe (1)

- The idea behind: From smaller to bigger structures.

### ”Hierarchy of the Universe” (HU)

- First mentioned by J. H. Lambert in the 18th century.
- The “Hierarchy of the Universe” is only a simple model of description and not a method of construction. But the HU-model is a useful tool to get a better “feeling” for objects, structures and distances within the Universe.
- Here the HU-model has 7 steps and starts with a single star....  
.... like a single star named Sun.

## Hierarchy of the Universe (2)

The 7 steps of the HU-model in general:

- Smaller structure (embedded within all bigger structures)
  1. Single star
  2. Single star with planets, moons, comets, meteorites, ...
  3. Multiple star system (double star .. star cluster)
  4. Galaxy
  5. Galaxy cluster
  6. Super cluster
  7. Universe (space of all visible matter and radiation)
- Bigger structure

### Hierarchy of the Universe (3)

The 7 steps of the HU-model as seen from the Sun - Dimensions / Diameter:

- Smaller structure (embedded within all bigger structures)

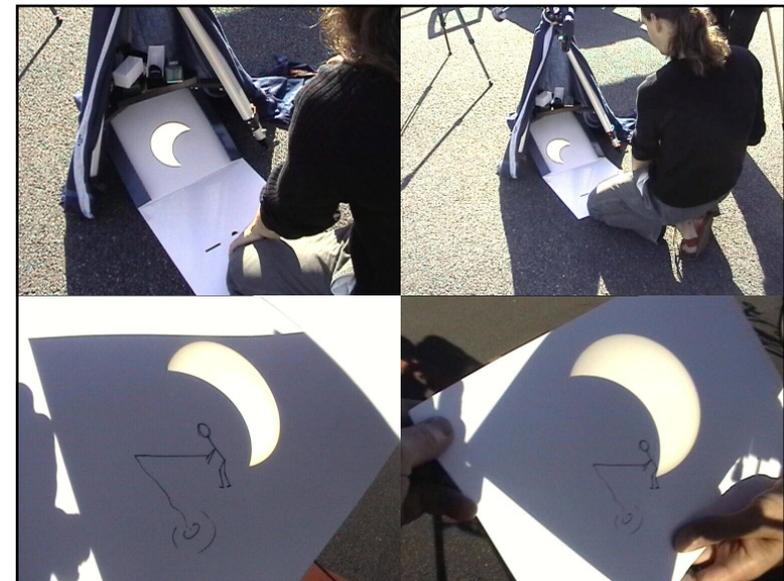
1. Sun	$1.4 \cdot 10^6$ km = 4.6 light seconds
2. Solar System	$15 \cdot 10^{12}$ km = 1.5 light years
3. -	
4. Milky Way Galaxy	$1 \cdot 10^{18}$ km = $100 \cdot 10^3$ light years
5. Local Group	$100 \cdot 10^{18}$ km = $10 \cdot 10^6$ light years
6. Virgo Super Cluster	$5 \cdot 10^{21}$ km = $500 \cdot 10^6$ light years
7. Universe	$300 \cdot 10^{21}$ km = $30 \cdot 10^9$ light years

- Bigger structure

### Single star - The Sun

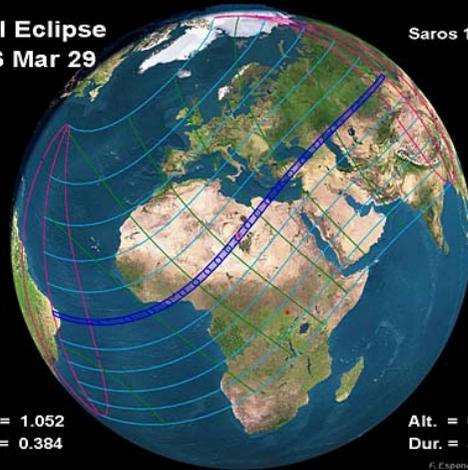
Sometimes a „cool“ solar event occurs - A solar eclipse

Partial solar eclipse above Bremen 2005 October 3



## Total Solar Eclipse, 2006 March 29

Total Eclipse  
2006 Mar 29



Saros 139

Mag. = 1.052  
Gam. = 0.384

Alt. = 67°  
Dur. = 4<sup>m</sup> 07<sup>s</sup>

F. Espenak, NASA's GSFC

## Total Solar Eclipse, 2006 March 29



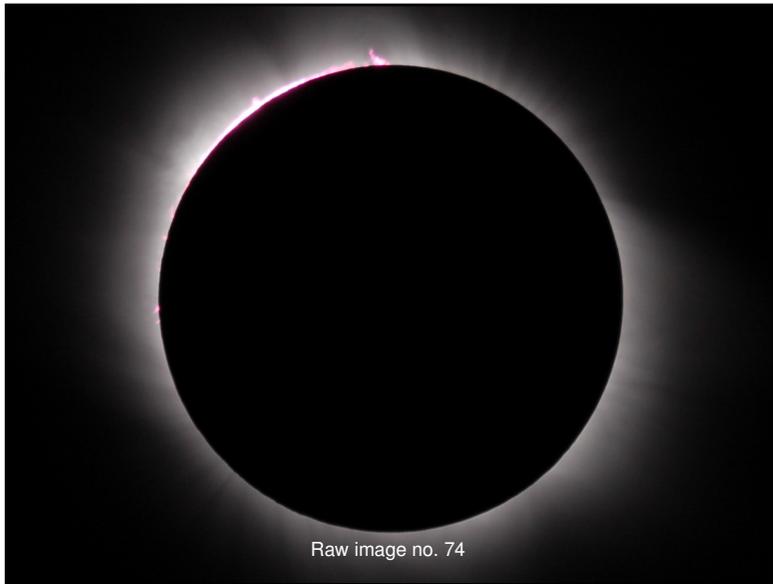
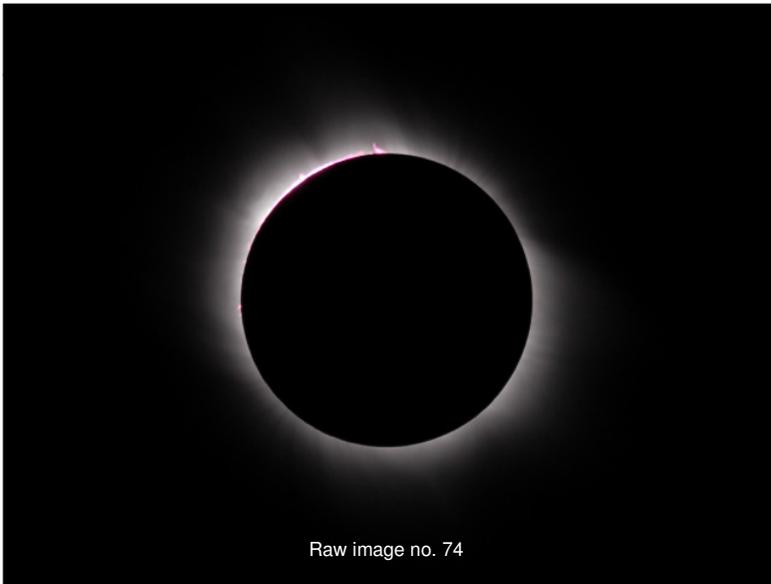
The zone of totality covers „cheap“ vacation regions in turkey

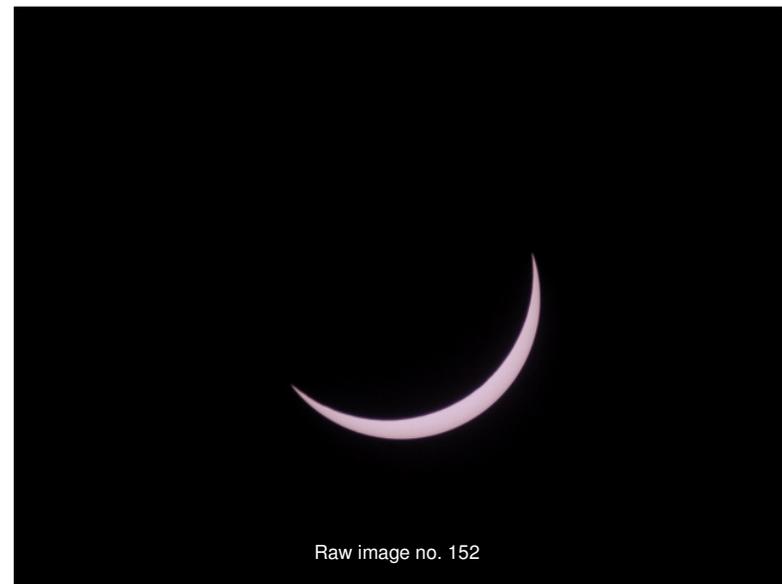
## The „Russentonne“ - a low-cost optics with f=500 mm

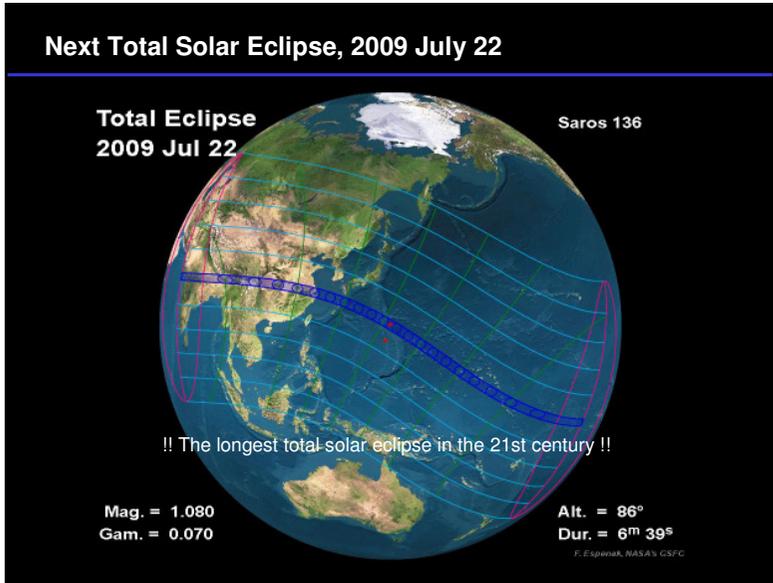


First image of sequence (raw image no. 46)









Moon of planet Earth



Rising Moon over Seattle

Moon of planet Earth - 1978 November 8; 8:00 pm



Optics: 135/1,950 mm - T = 1/250 s - Film Ilford FP4 (125 ASA)

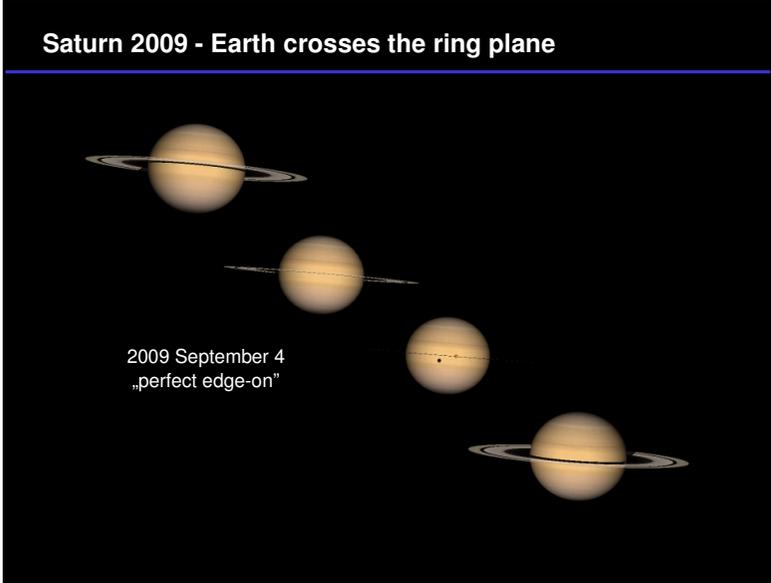
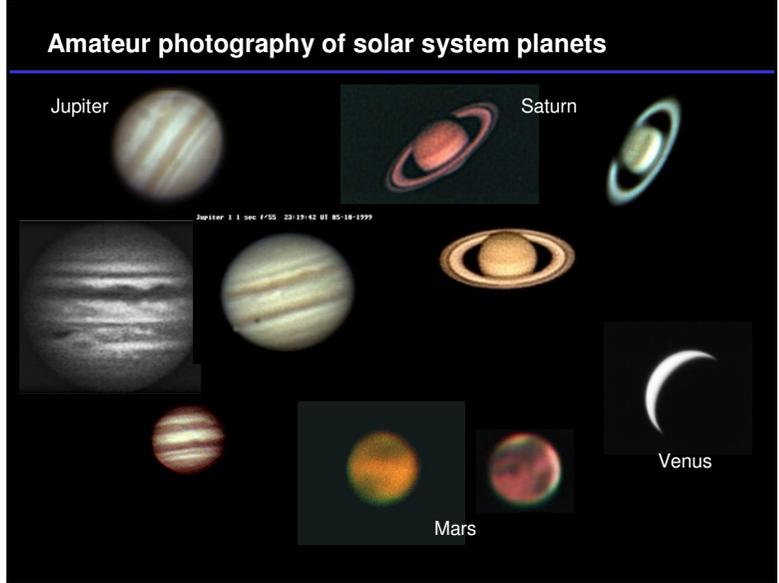
Moon of planet Earth - 1981 February 13; 10:20 pm



Optics: 250/9,500 mm - T = 1.5 s - Film Ilford FP4 (125 ASA)

Moon - Perfect location for astronomical observation





„Dealing“ with stars from a cruise ship



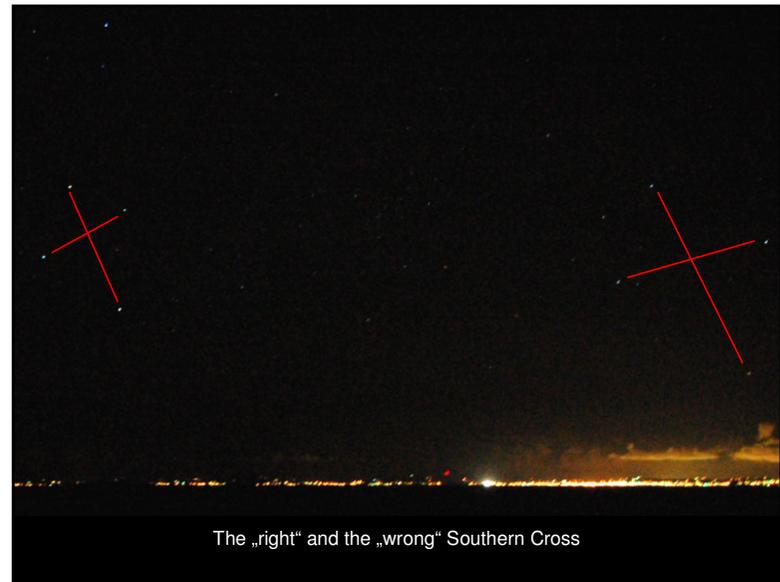
Moon above AIDAvita - 2007 April 14



The „Southern Cross“ by the sea in April 2007  
Cruise ship AIDAvita - Caribbean sea close to US Virgin Islands



The „right“ and the „wrong“ Southern Cross



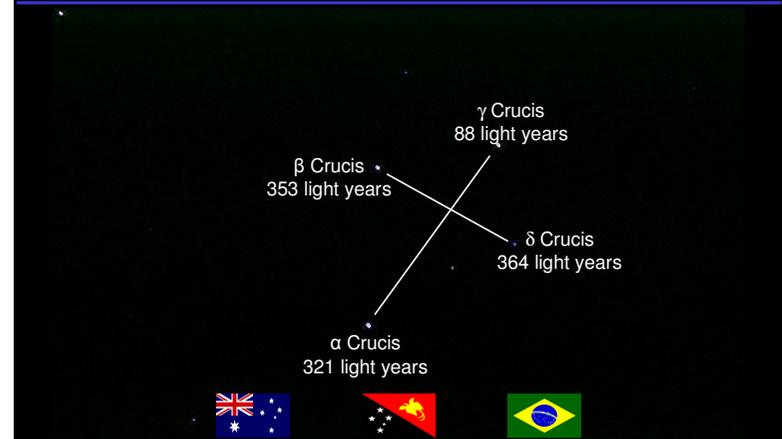
The „right“ and the „wrong“ Southern Cross

### The "Pointer" to ensure the right "Southern Cross"



"Alpha & Beta Centauri" / "Pointer" and the "Southern Cross"  
Imaged from cruise ship AIDAvida, 2007 April 14

### Constellation „Crux“ - „The Southern Cross“



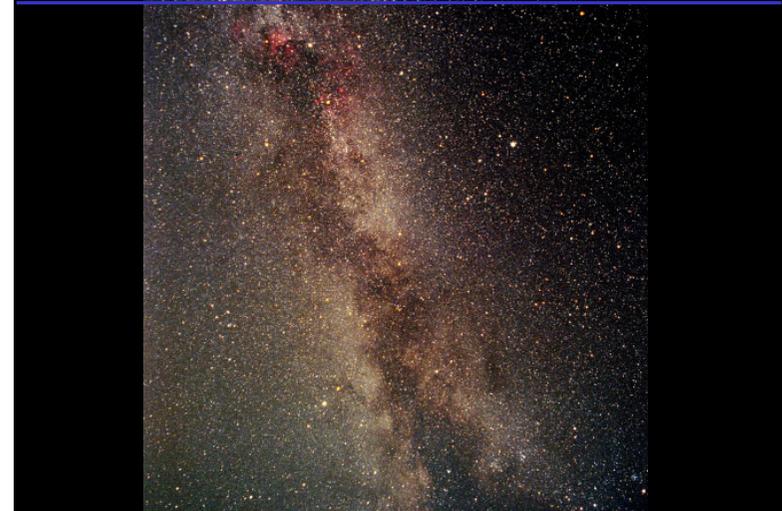
Australia, Papua New Guinea and Brazil are using the „Southern Cross“ for their national flags

### Strip of Milky Way with summer constellations

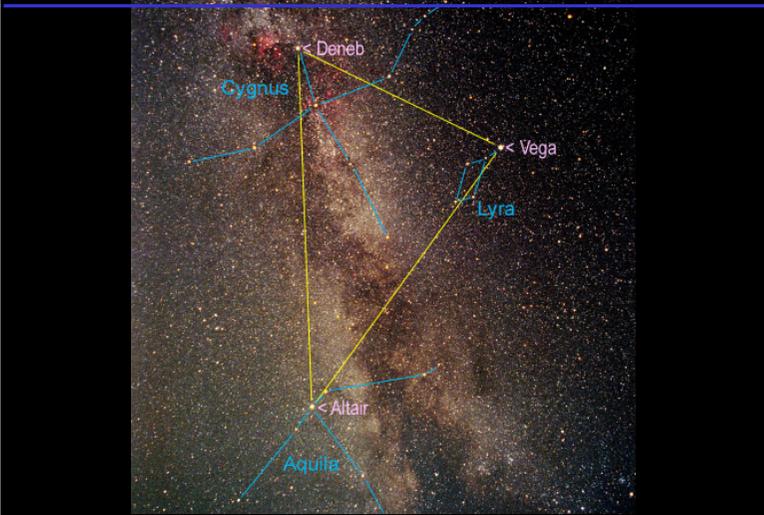


Strip of Milky Way as seen from the fisheye perspective.  
Optics:1:2.8/11 mm - 6 min exposed - Film: Kodak Tri-X Pan (400 ASA)

### „Summer triangle“ and Northern Milky Way



„Summer triangle“ and Northern Milky Way



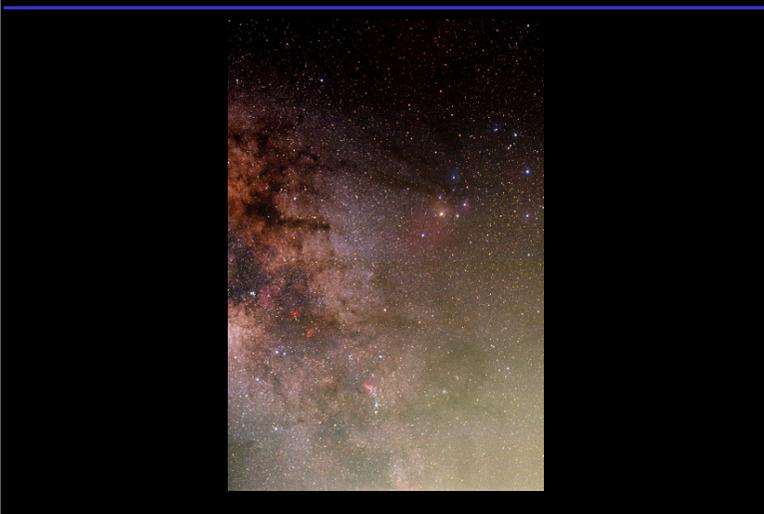
View to the center of the „Milky Way“

A wide angle view to the constellations „Scorpius“ and „Sagittarius“

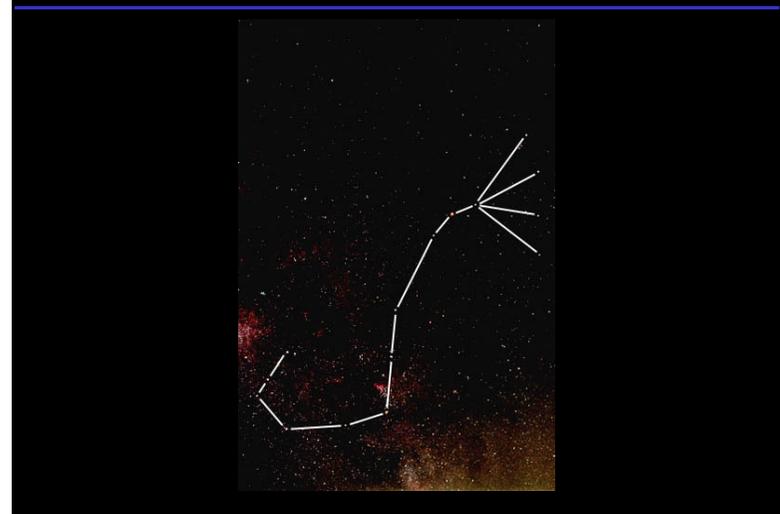


From the sea back to solid ground...

Constellation „Scorpius“ (The Scorpion)



Constellation „Scorpius“ (The Scorpion)

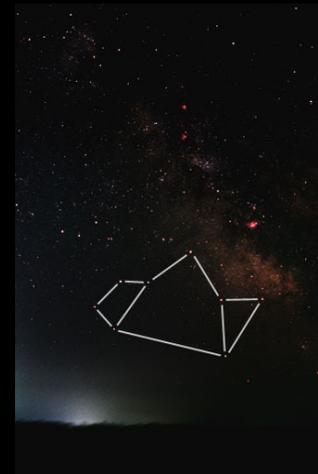


Constellation „Sagittarius“ ... looks like a „teapot“

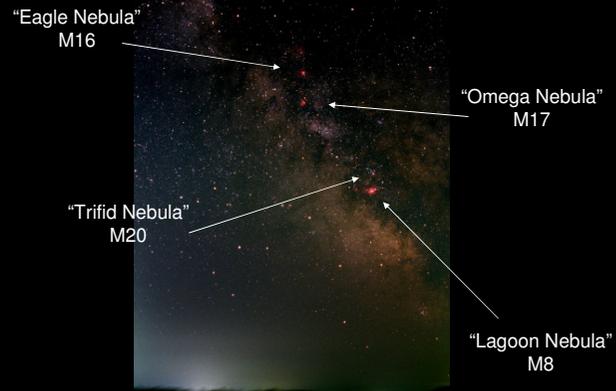


Some "Red Nebulas" are visible

Constellation „Sagittarius“ ... looks like a „teapot“



Constellation „Sagittarius“ with „Red Nebulas“



All four region are "Hydrogen Nebulas"

Constellation „Sagittarius“ - „Eagle Nebula“ M16



Distance: 7,000 light years

Optics: Ø=150 mm; f=900 mm; T=5 min; Sensitivity: 1,600 ASA

## Constellation „Sagittarius“ - „Omega Nebula“ M17

Distance: 5,100 light years



Optics:  $\varnothing=150$  mm;  $f=900$  mm;  $T=5$  min; Sensitivity: 1,600 ASA

## Constellation „Sagittarius“ - „Trifid Nebula“ M20

Distance: 4,000 light years



A Stellar Nursery

Image by R. Jay GaBany (www.cosmotography.com)

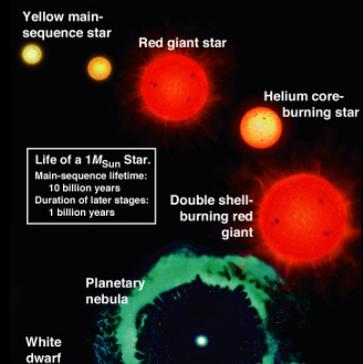
## The Life of a Star - From Birth to Death

The weight at birth decides  
the „Curriculum Vita“ of a Star

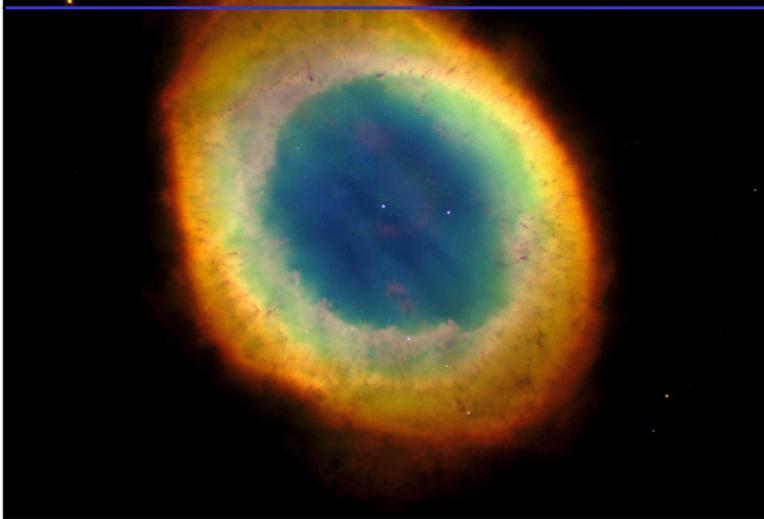
Two „Careers“ are possible:

Light Stars / Heavy Stars

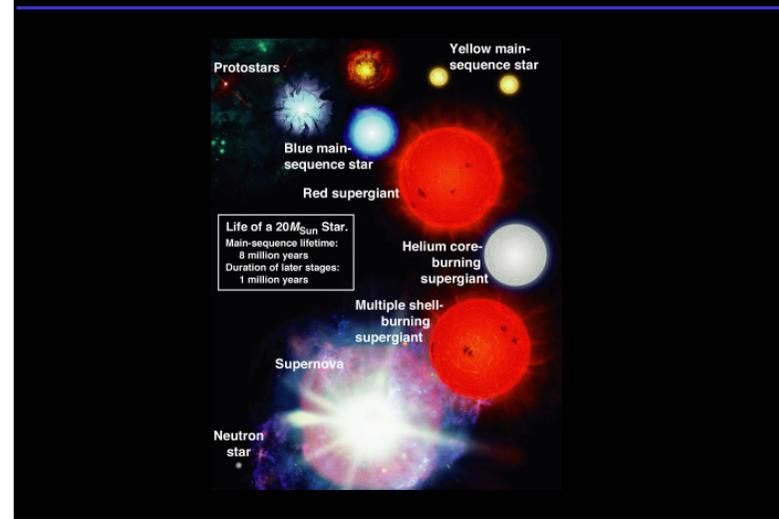
## „CV“ of the Sun (Mass $\sim 2 \cdot 10^{30}$ kg) - A light star



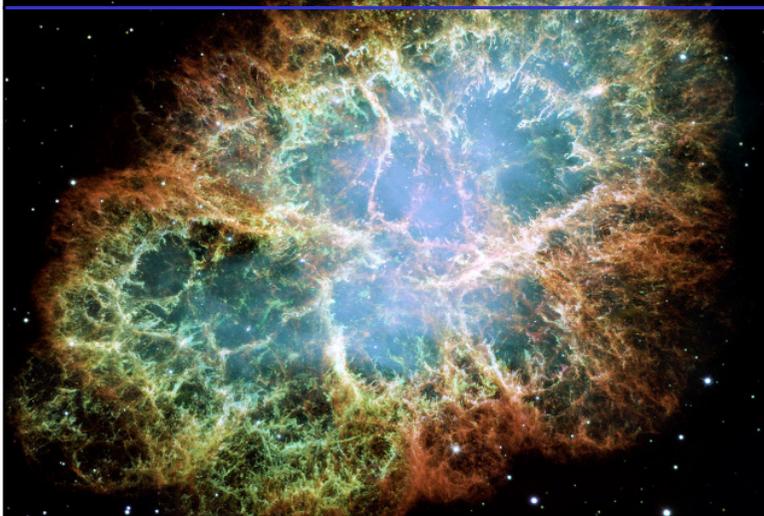
„Ring Nebula“ M57 - White Dwarf in the center



„CV“ of a heavy star



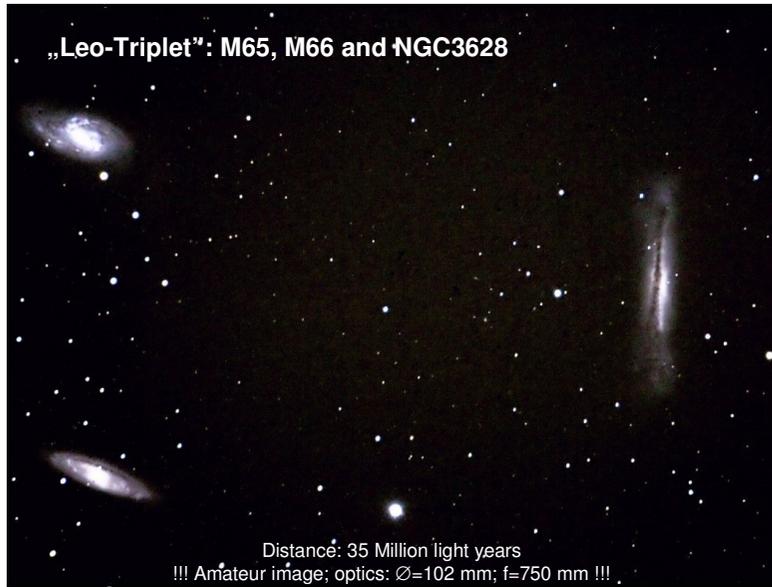
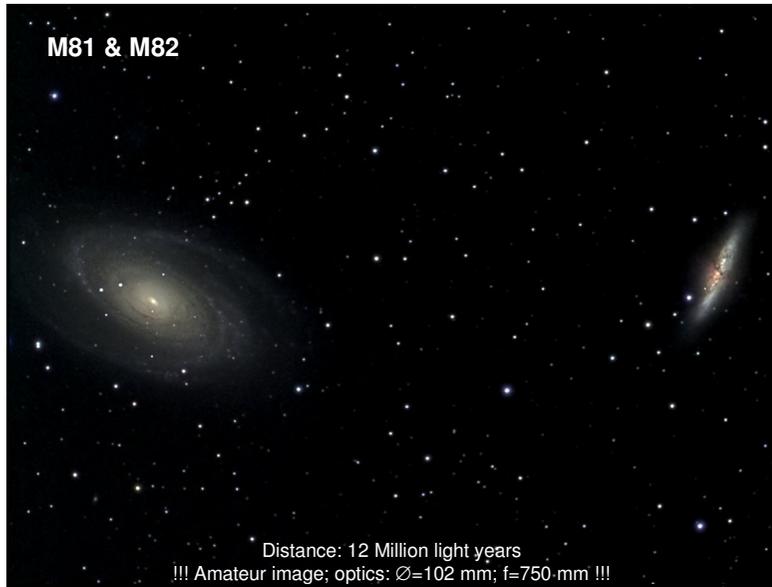
„Crab Nebula“ M1 - Supernova remnant

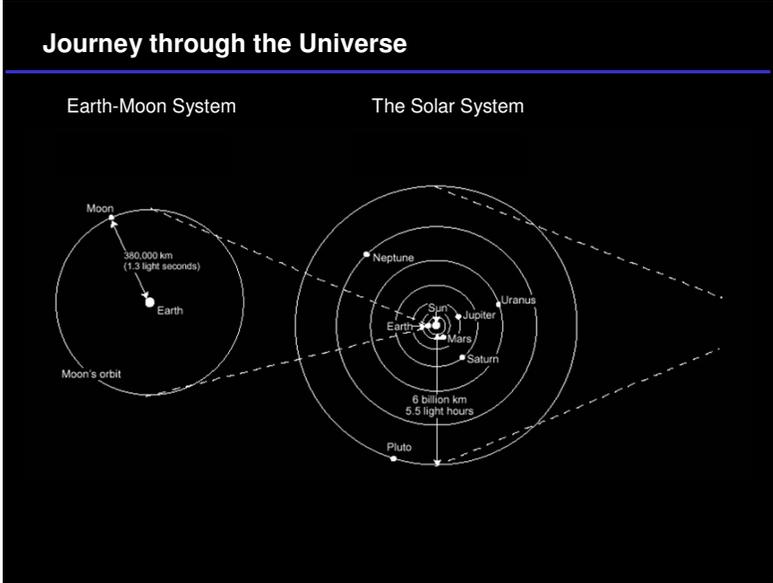
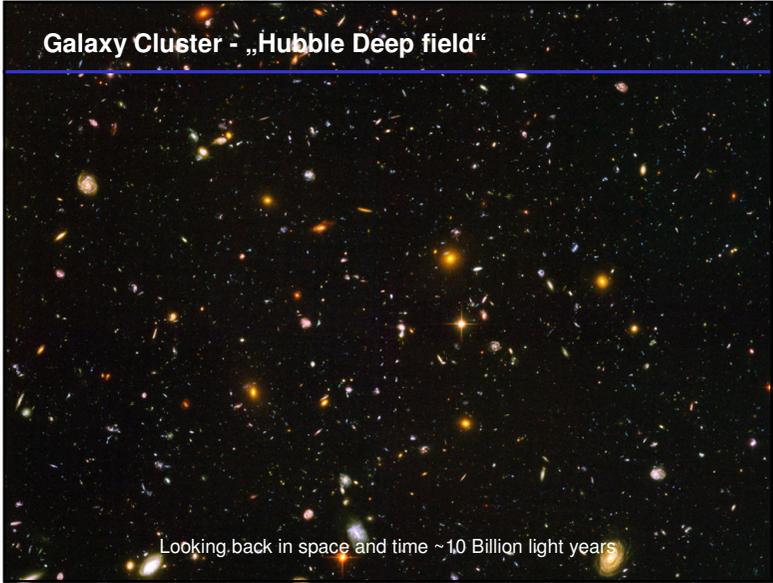
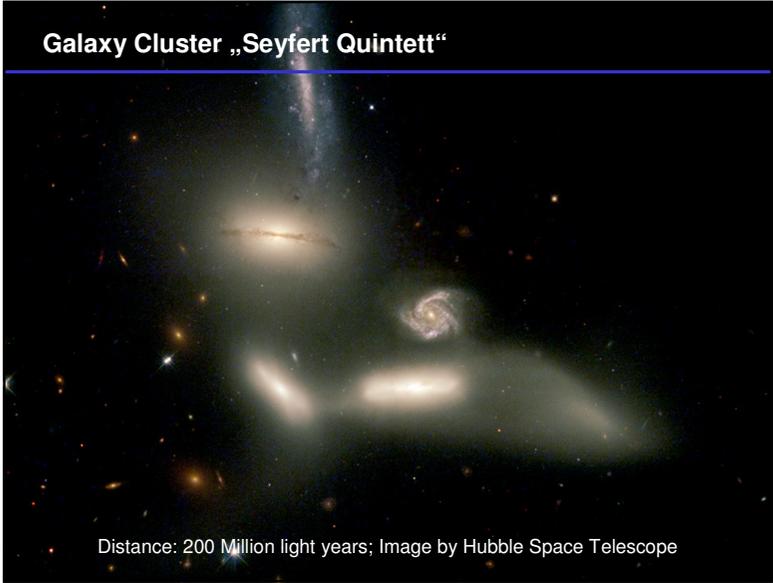


Spiral-Galaxy M33



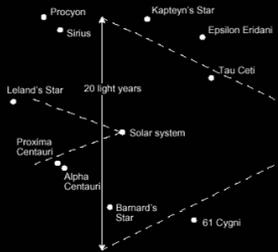
!!! Amateur image of M33 !!! Distance: 3 Million light years



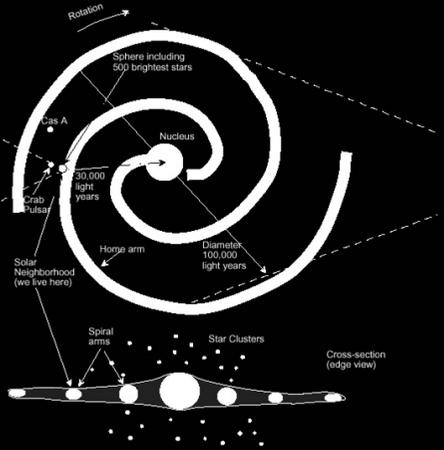


## Journey through the Universe

### The Solar Neighborhood

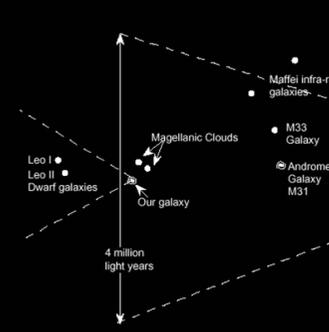


### Our Galaxy "Milky Way"

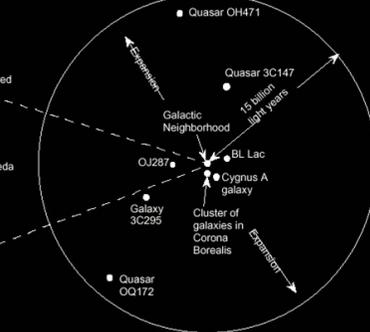


## Journey through the Universe

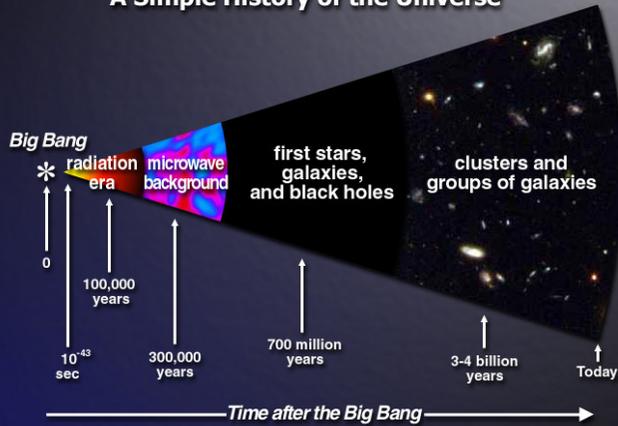
### The Galactic Neighborhood



### The Universe

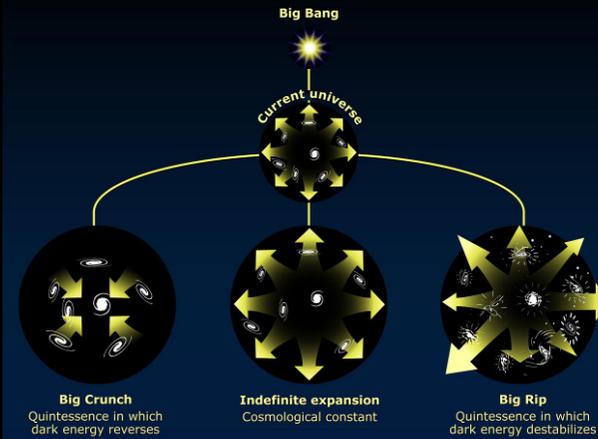


## A Simple History of the Universe



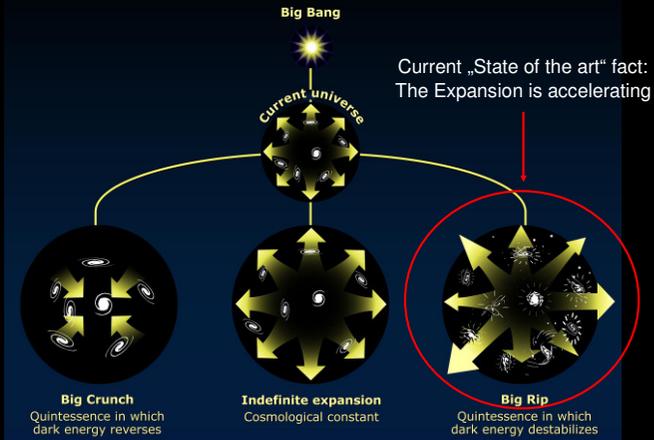
## The Universe is expanding

### Future fates of the dark-energy universe



## The Universe is expanding

### Future fates of the dark-energy universe



## Bruce Margon - Science Director to Hubble Space Teles.

“The energy responsible for accelerating the Universe is of unknown nature“

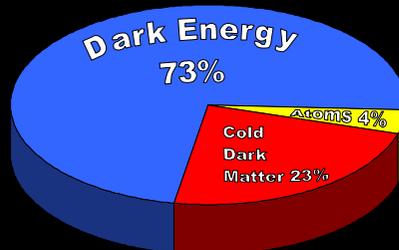
"The Dark Energy"



Dark Energy appears to constitute about 75% of the total matter + energy budget of the Universe

## Bruce Margon - Science Director to Hubble Space Teles.

“The Ultimate Copernican Revolution“



Not only are we not located near the center of the Universe;  
we're not even made of what 96% of the Universe is made of

Thank you for your attention

*Life on Earth may be expensive, but it does include  
an annual free trip around the Sun*