VOM KLEINEN UND GROSSEN.

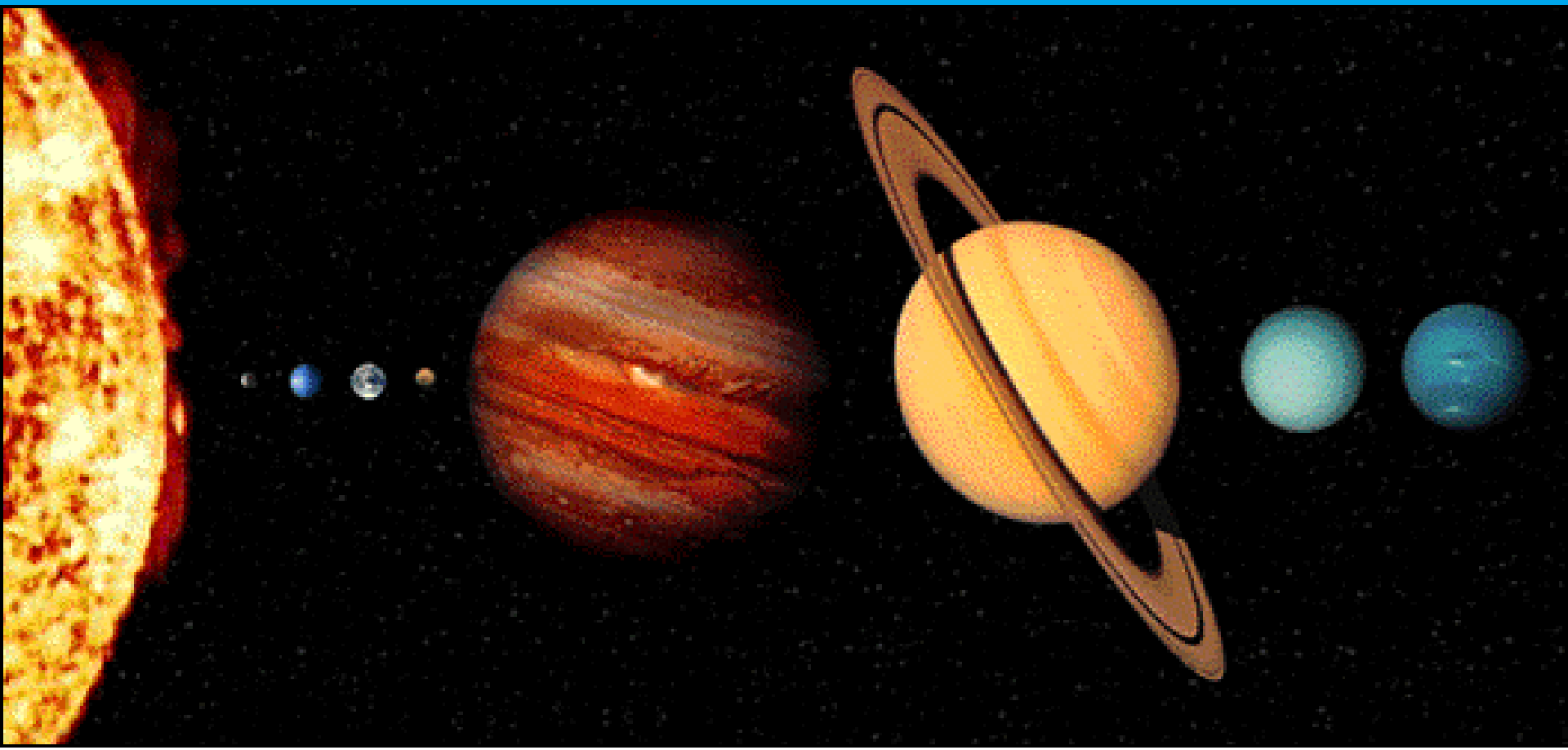
Elementarteilchen, Kräfte und das Universum

Christian Stegmann
Zeuthen, 2. Mai 2012

HELMHOLTZ
GEMEINSCHAFT

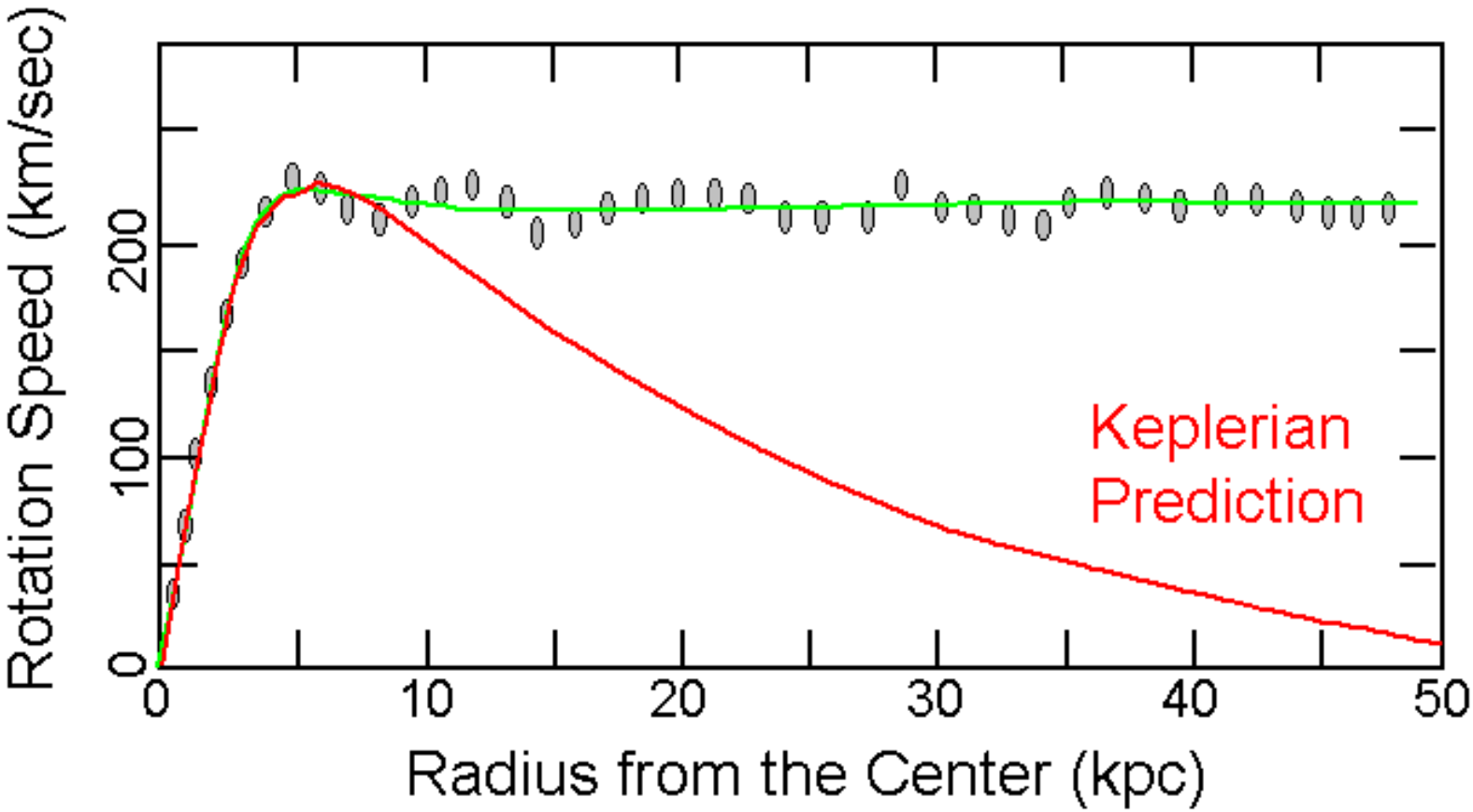
DESY

Unser Planetensystem

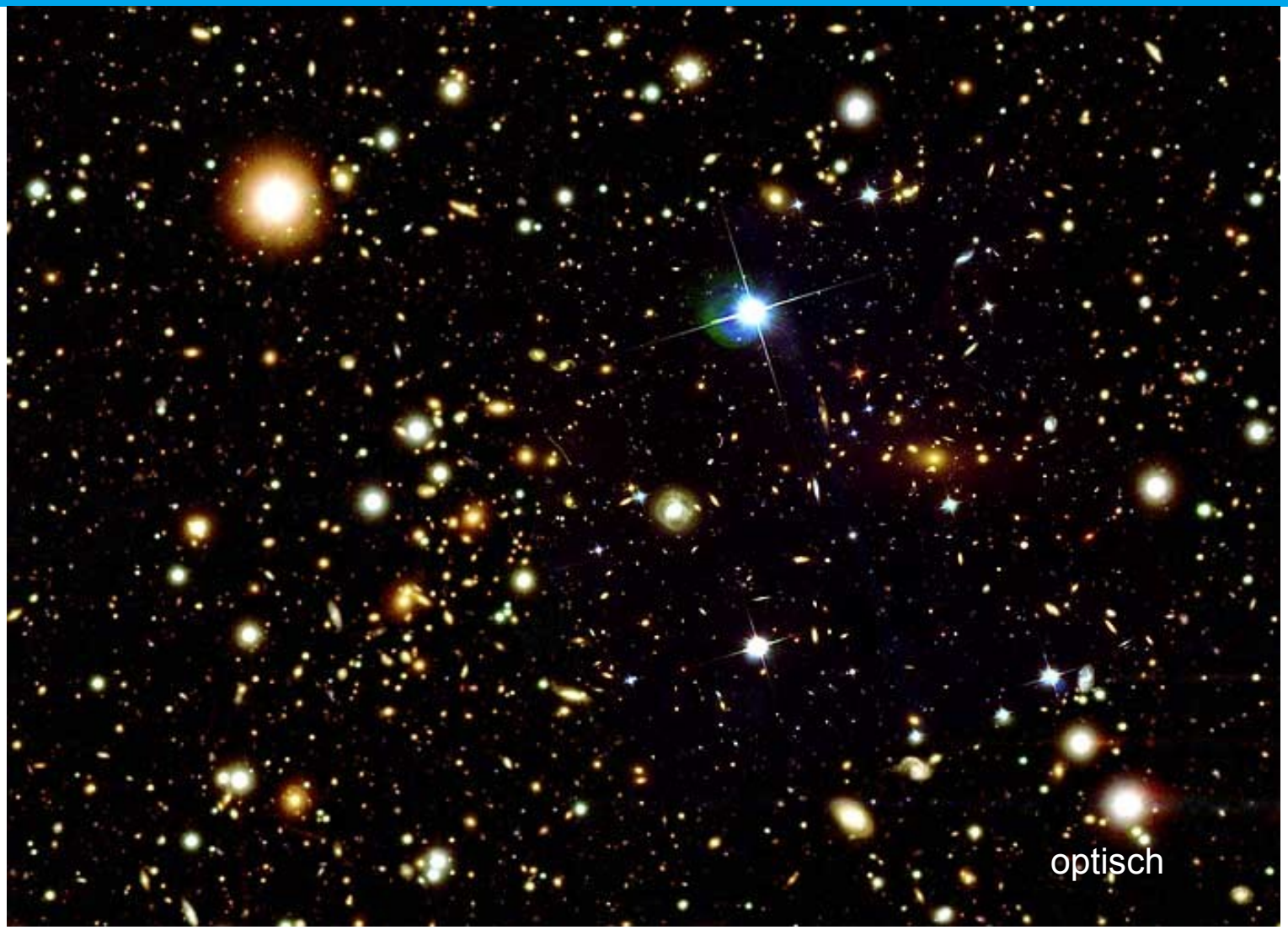


Der Andromedanebel – unsere Nachbargalaxie

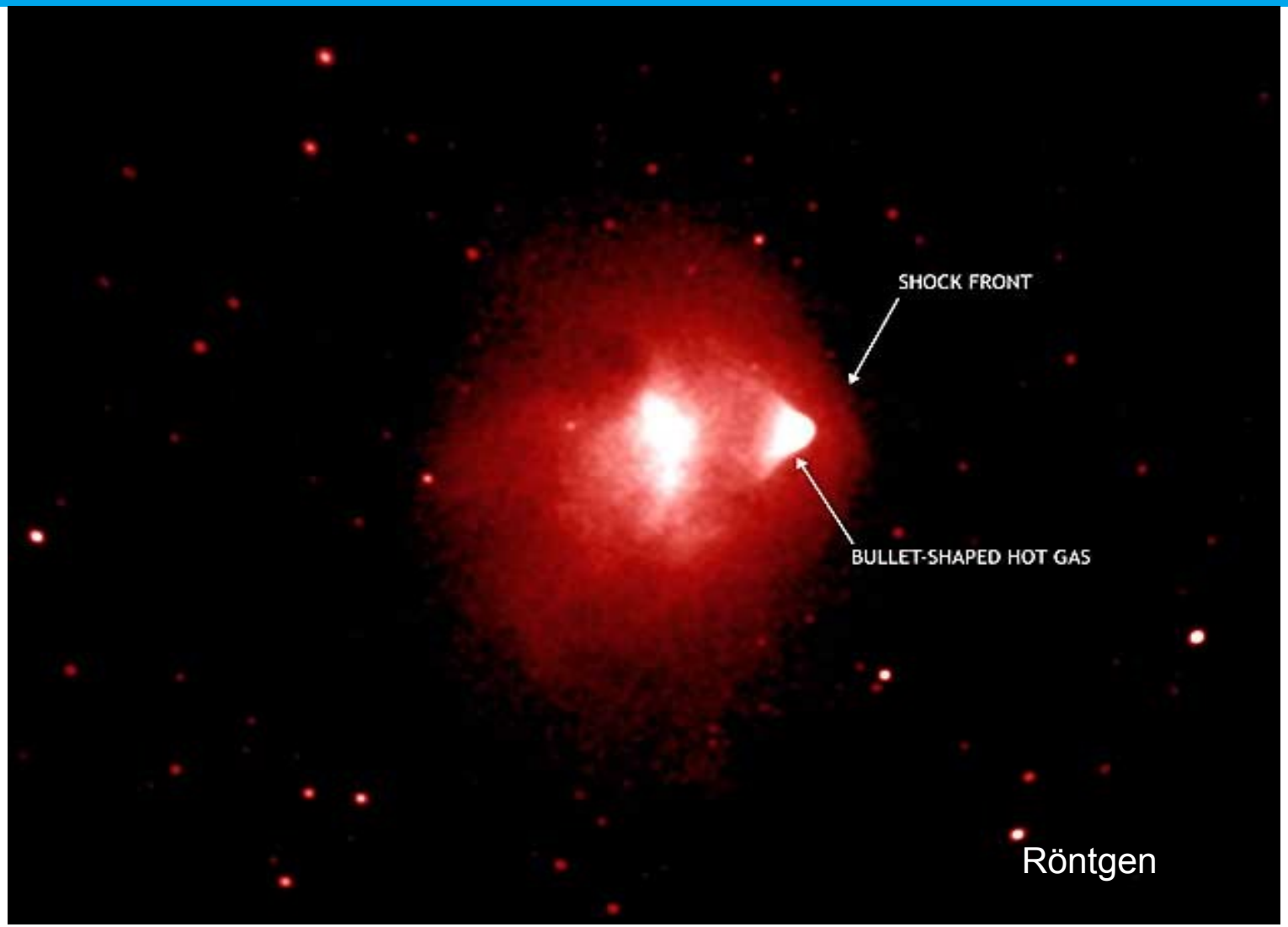
Rotationskurven



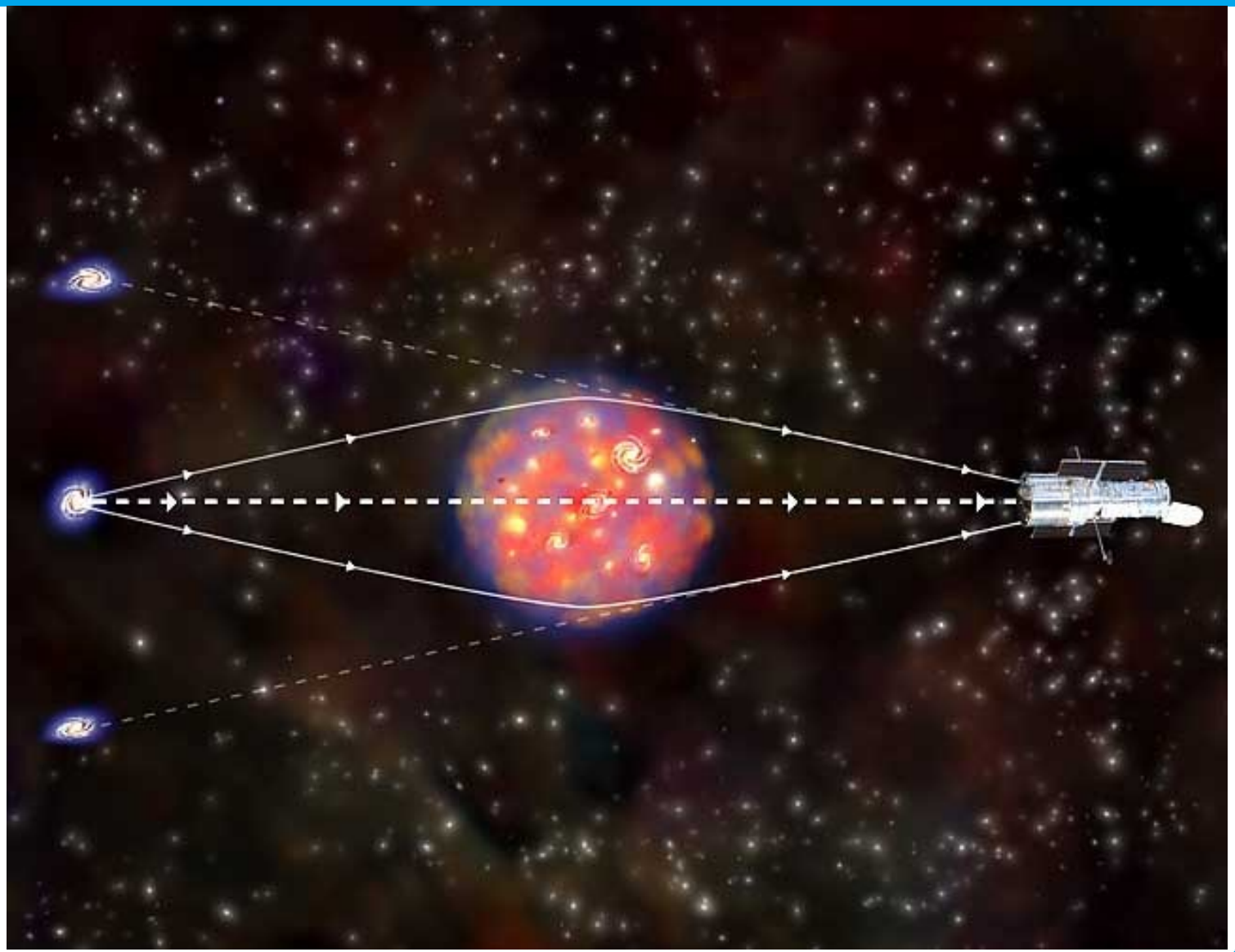
Galaxien-Cluster 1E 0657-56



Galaxien-Cluster 1E 0657-56



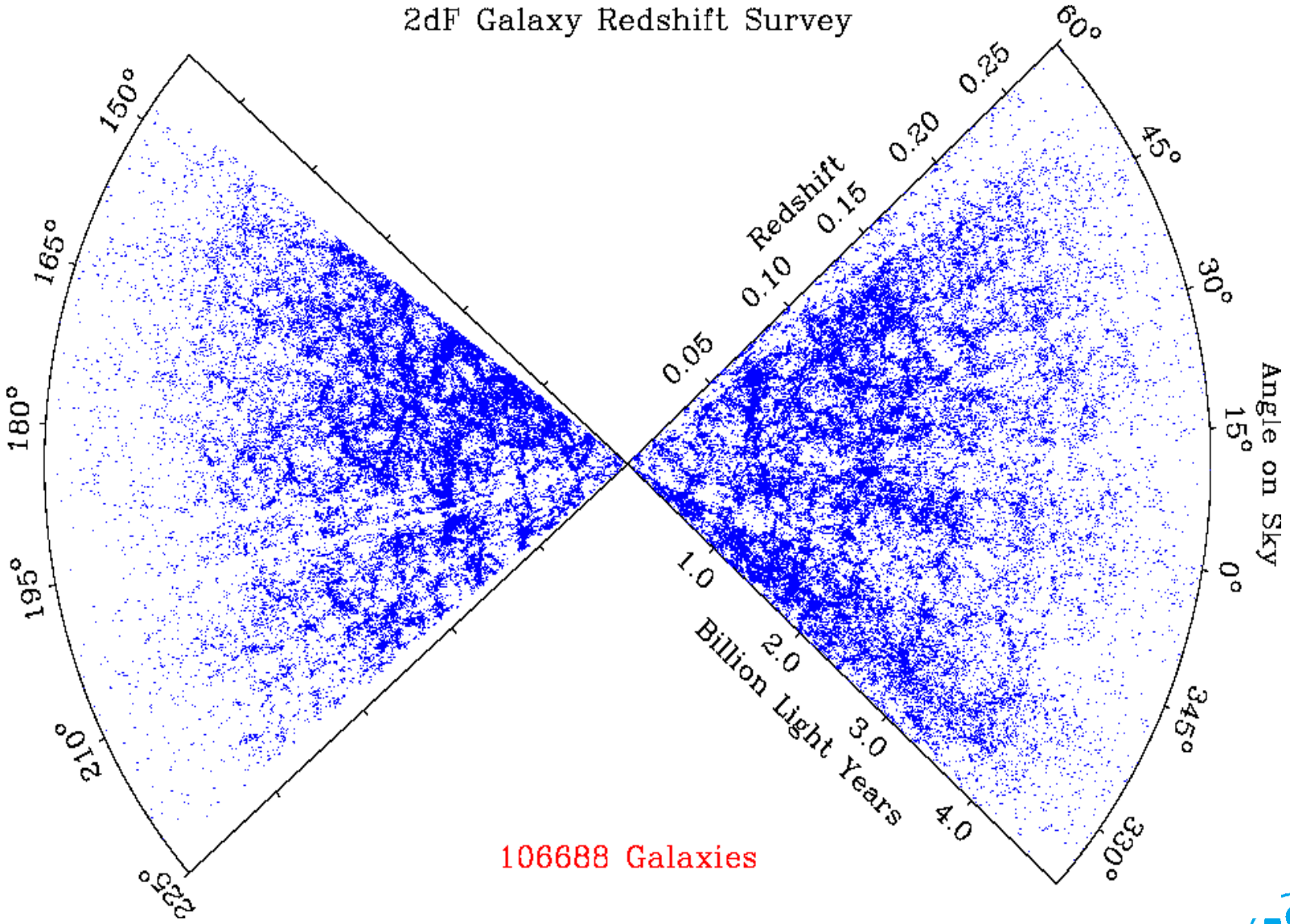
Gravitationslinsen

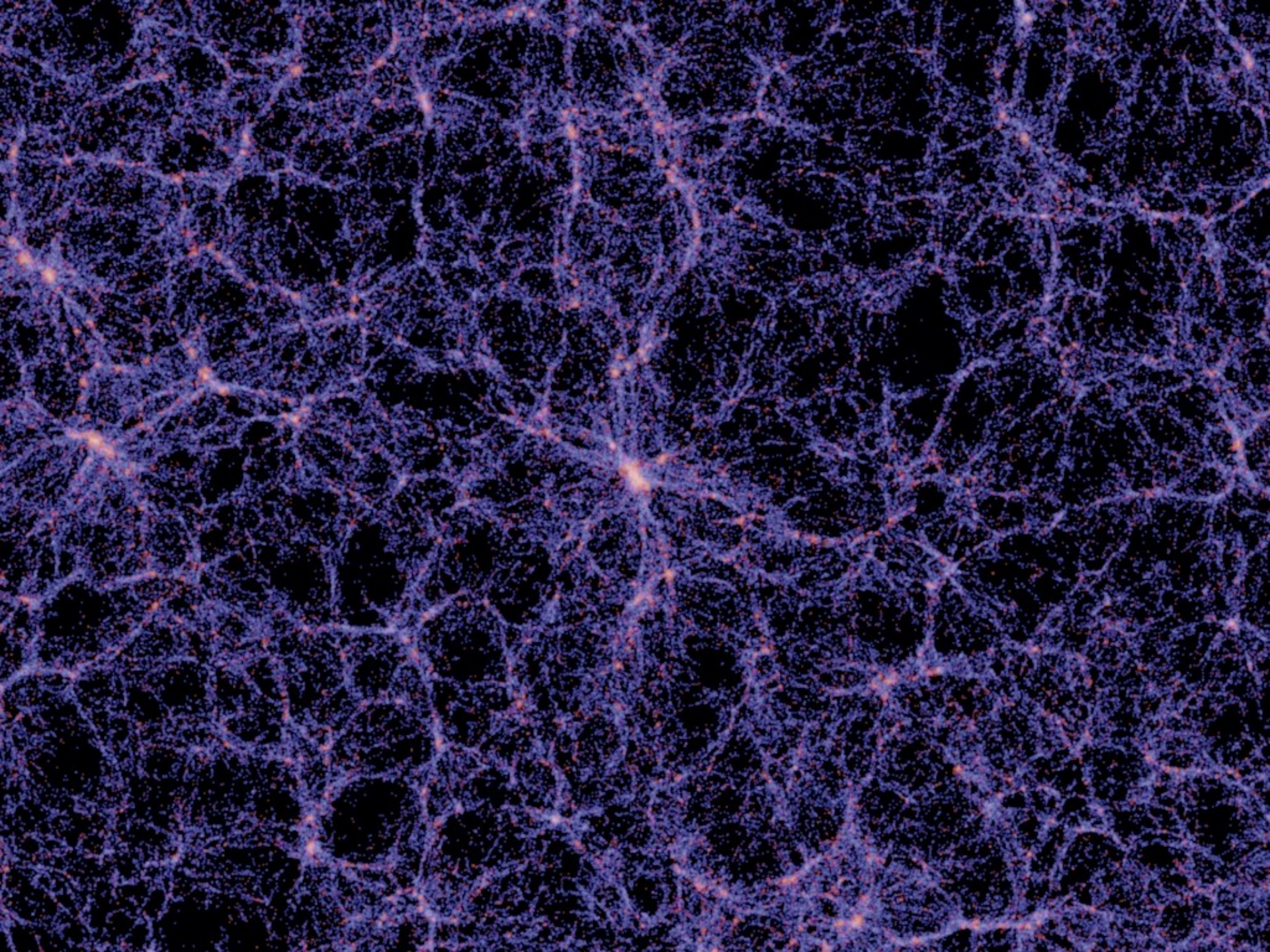


Galaxien-Cluster 1E 0657-56

Galaxien

Großräumige Strukturen





Die Suche nach der dunklen Materie

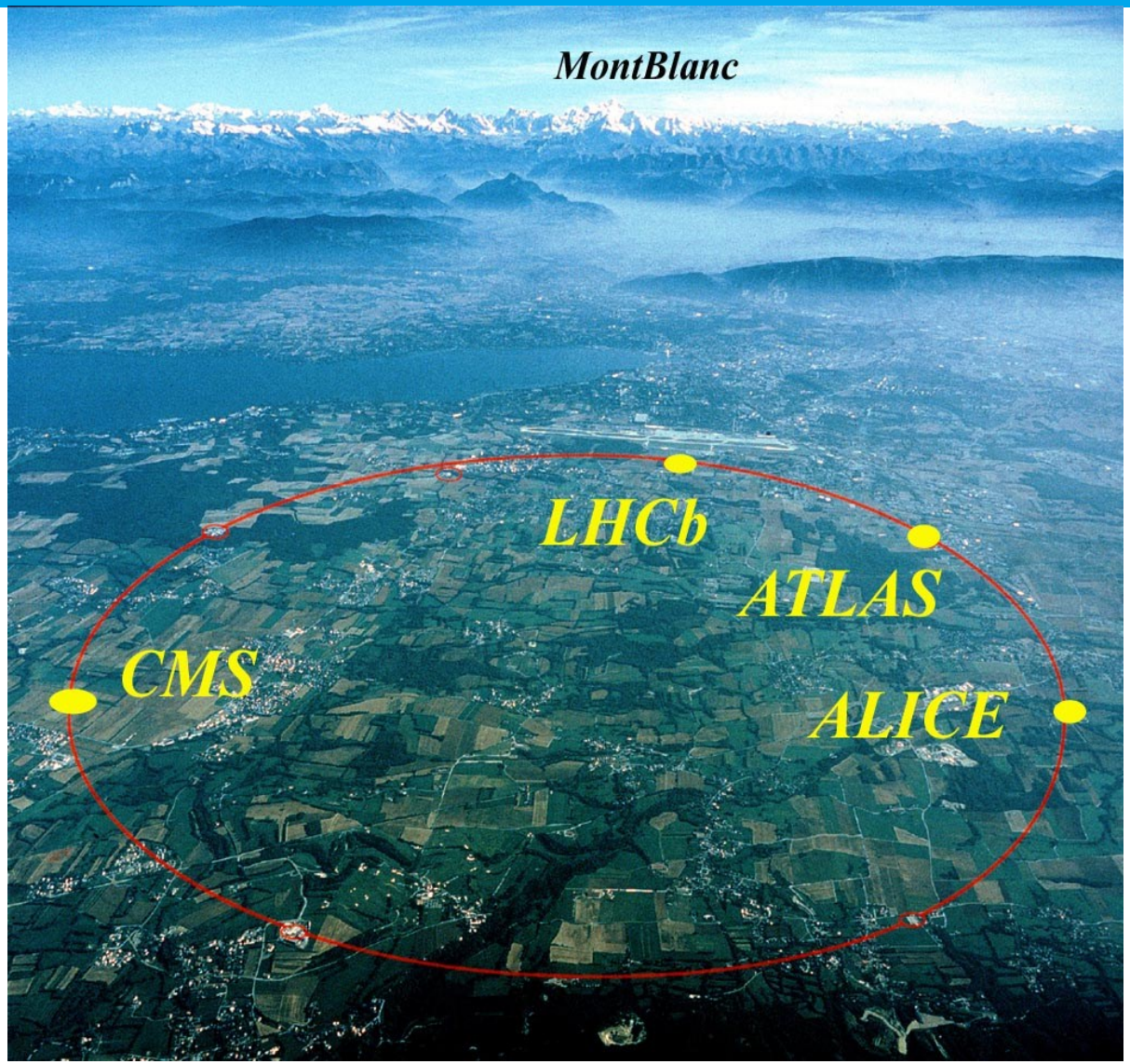
- Dunkle Materie besteht aus einer neuen Art von fundamentalen Teilchen

- Die Teilchen sind schwer

- Diese Teilchen lassen sich künstlich erzeugen

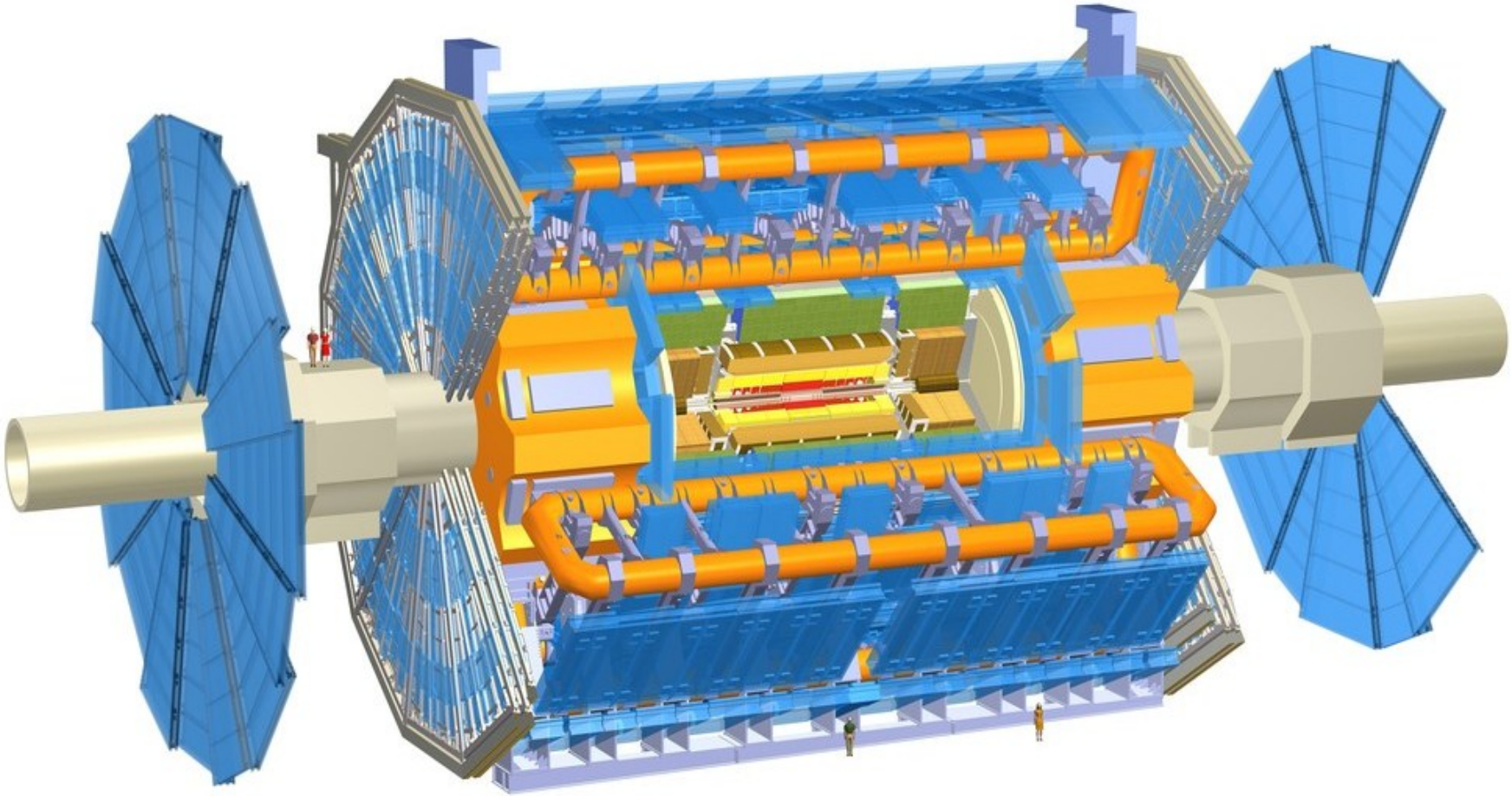
$$E = mc^2$$

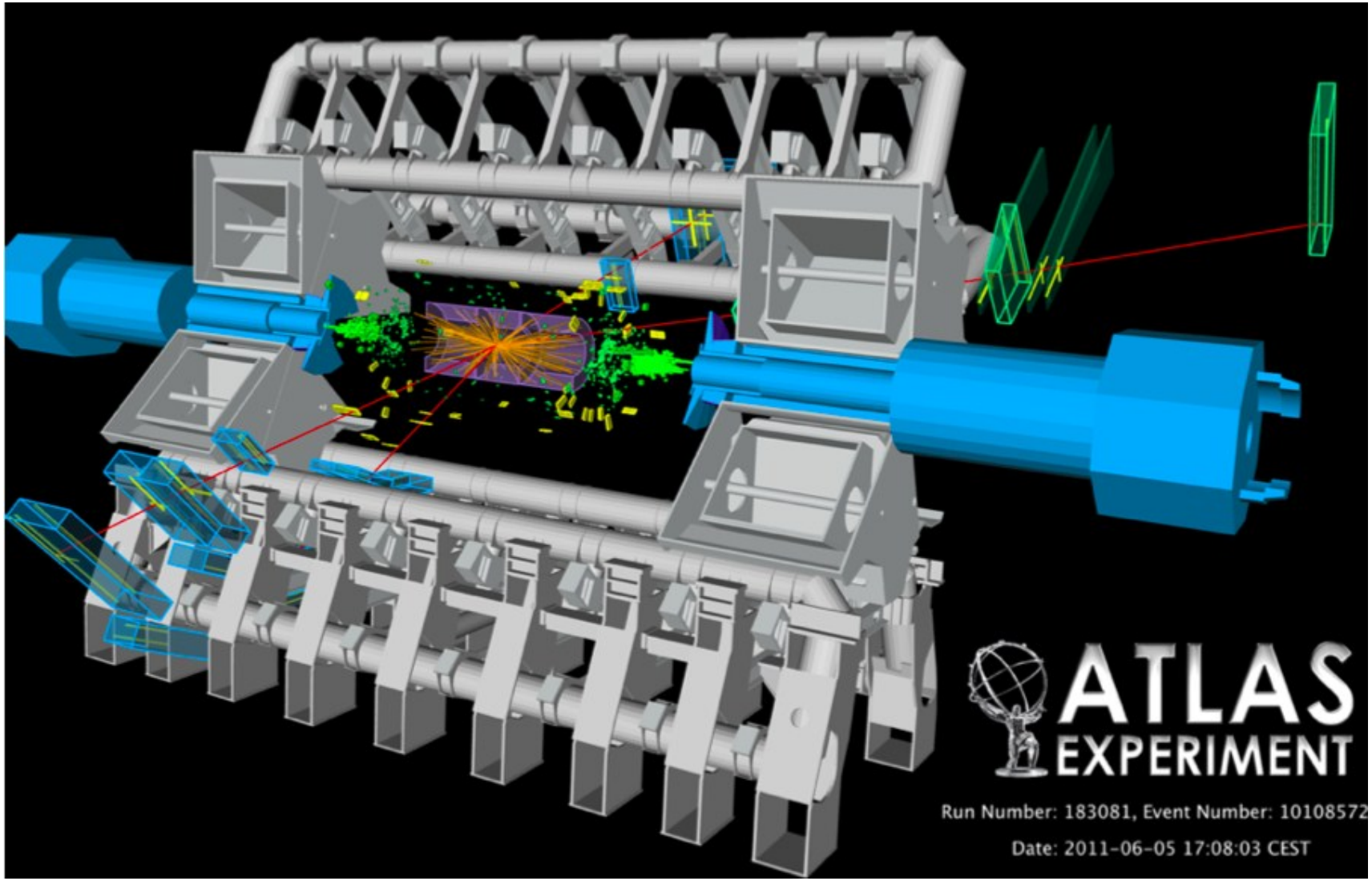
Die Weltmaschine – Der Large Hardon Collider



Der LHC und Zeuthen

ATLAS

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EXPERIMENT
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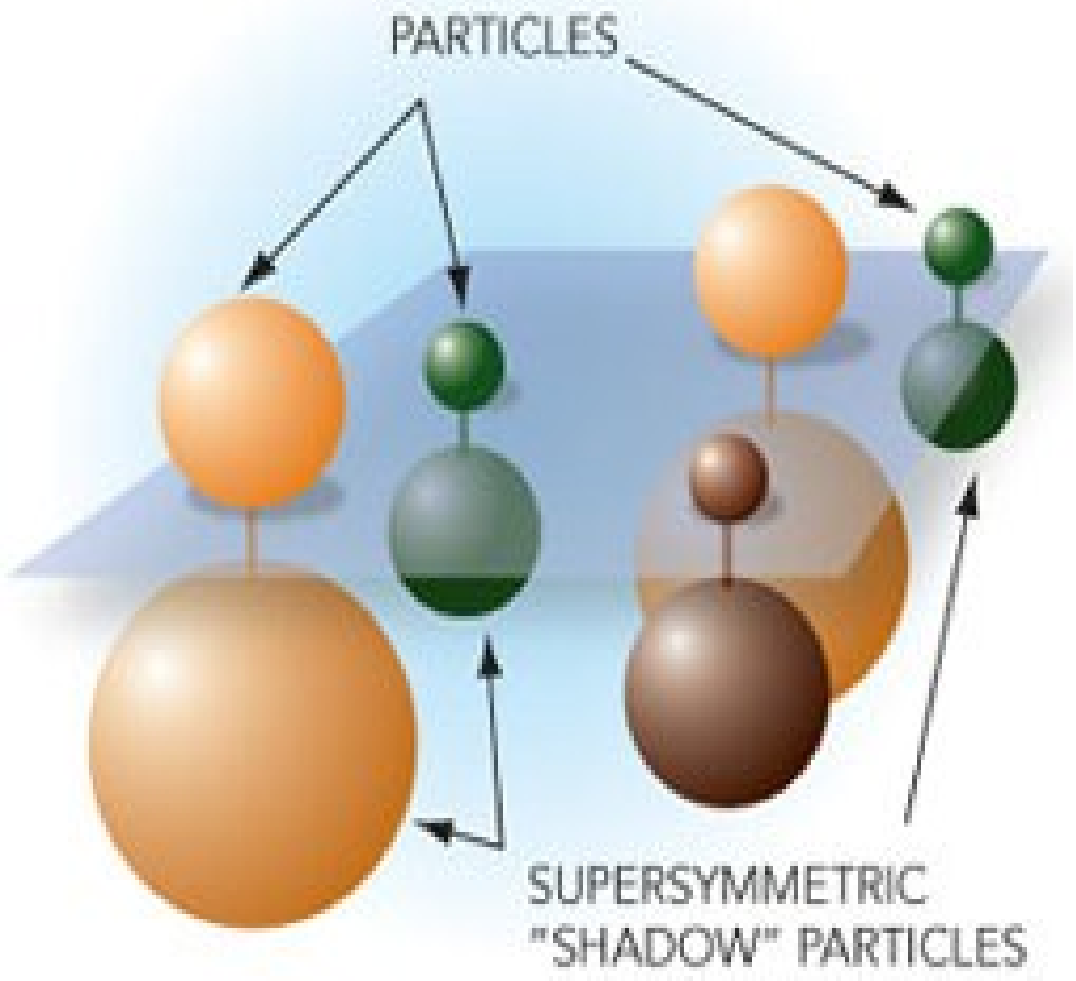
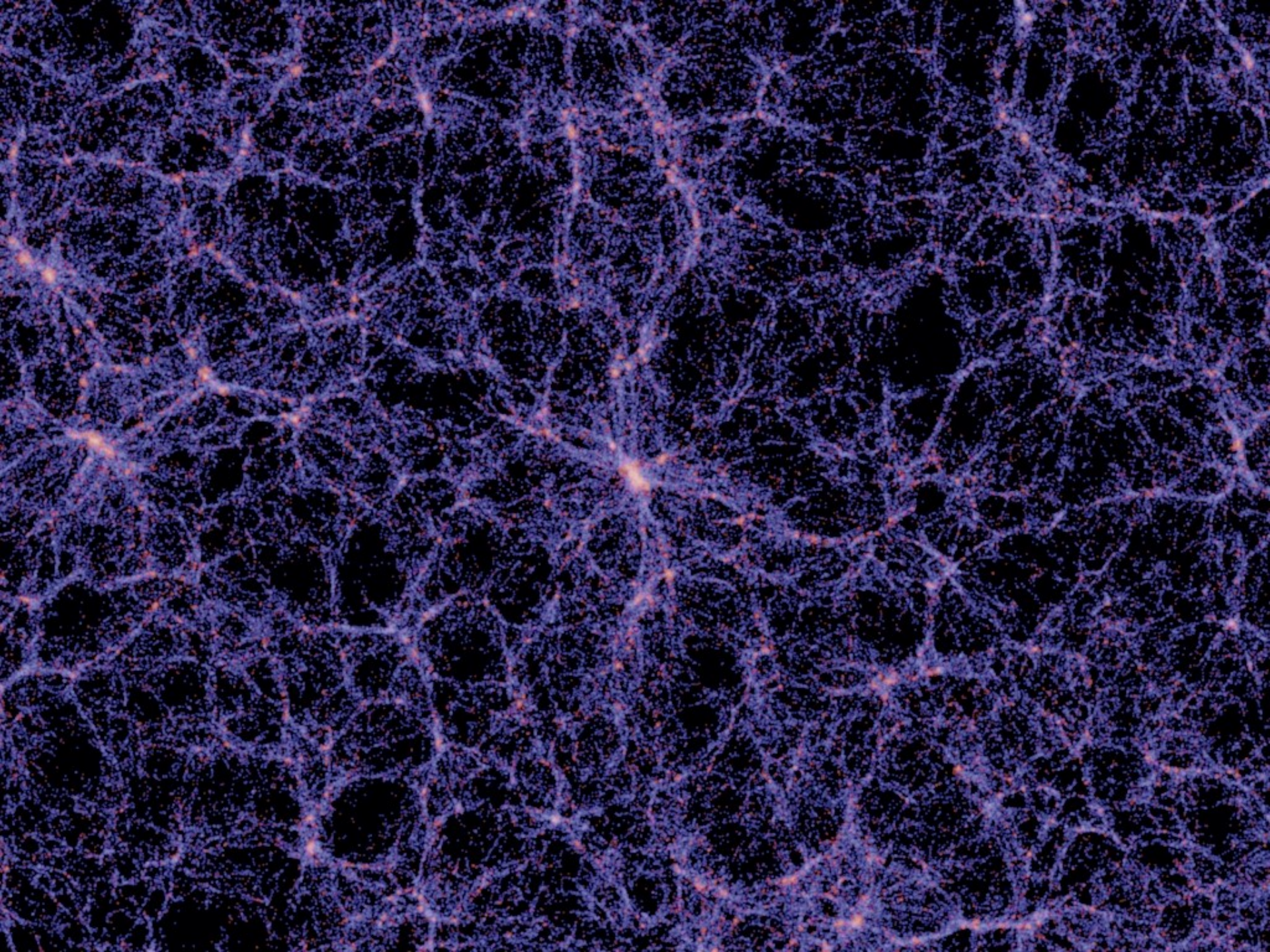
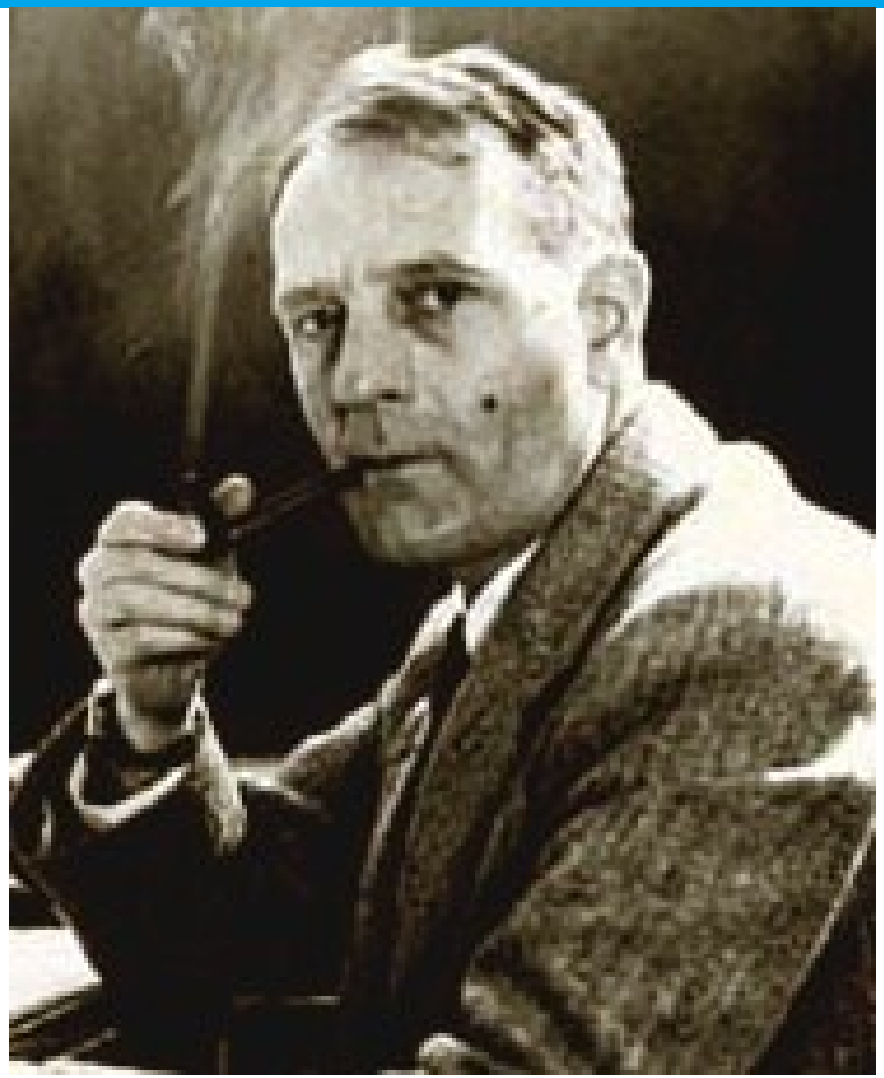
Supersymmetrie





Woher wissen wir wie viel Zeit das Universum für die Bildung von Strukturen hatte?

Edwin Hubble und die Expansion des Weltraums



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Das Hubble-Diagramm

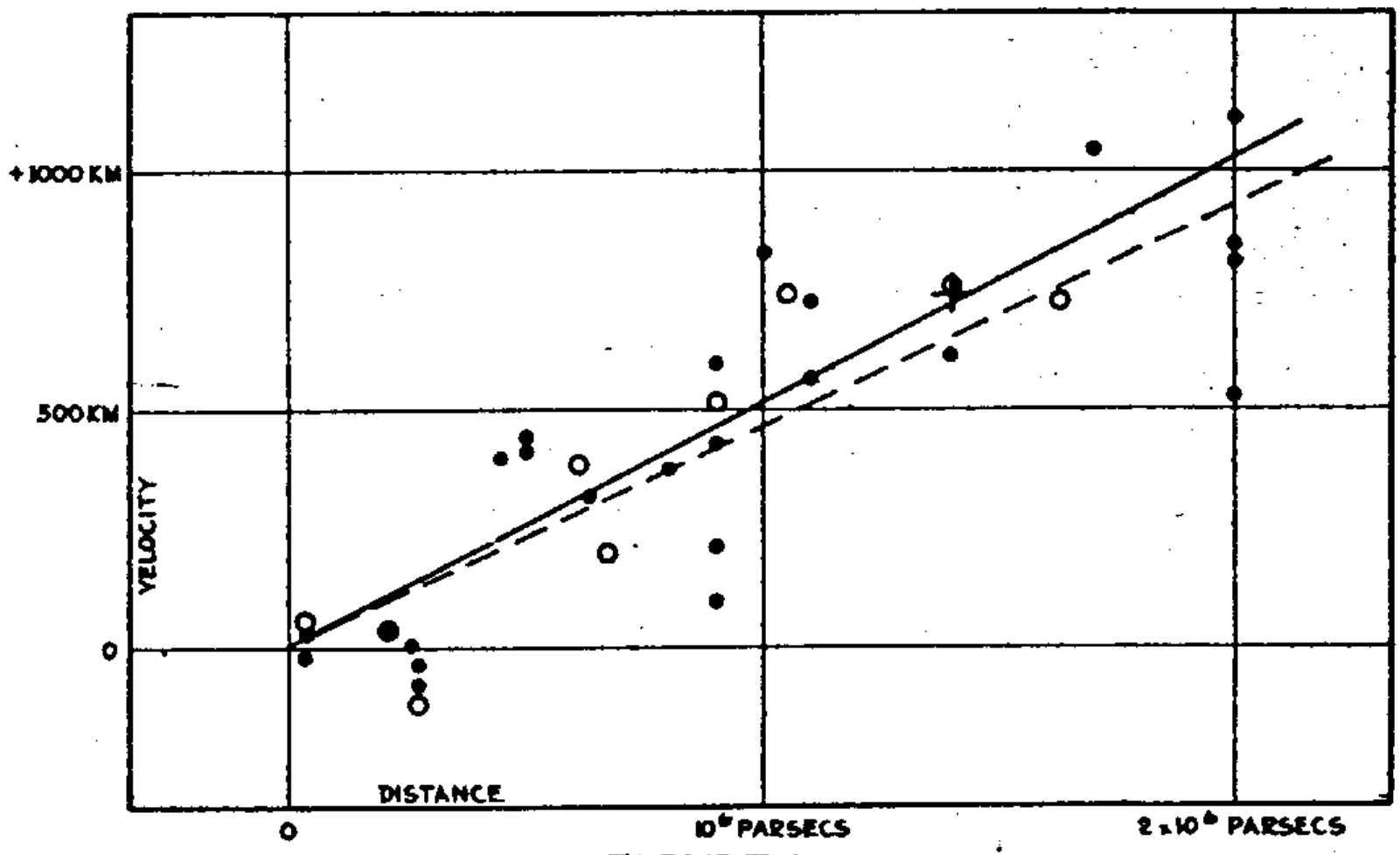
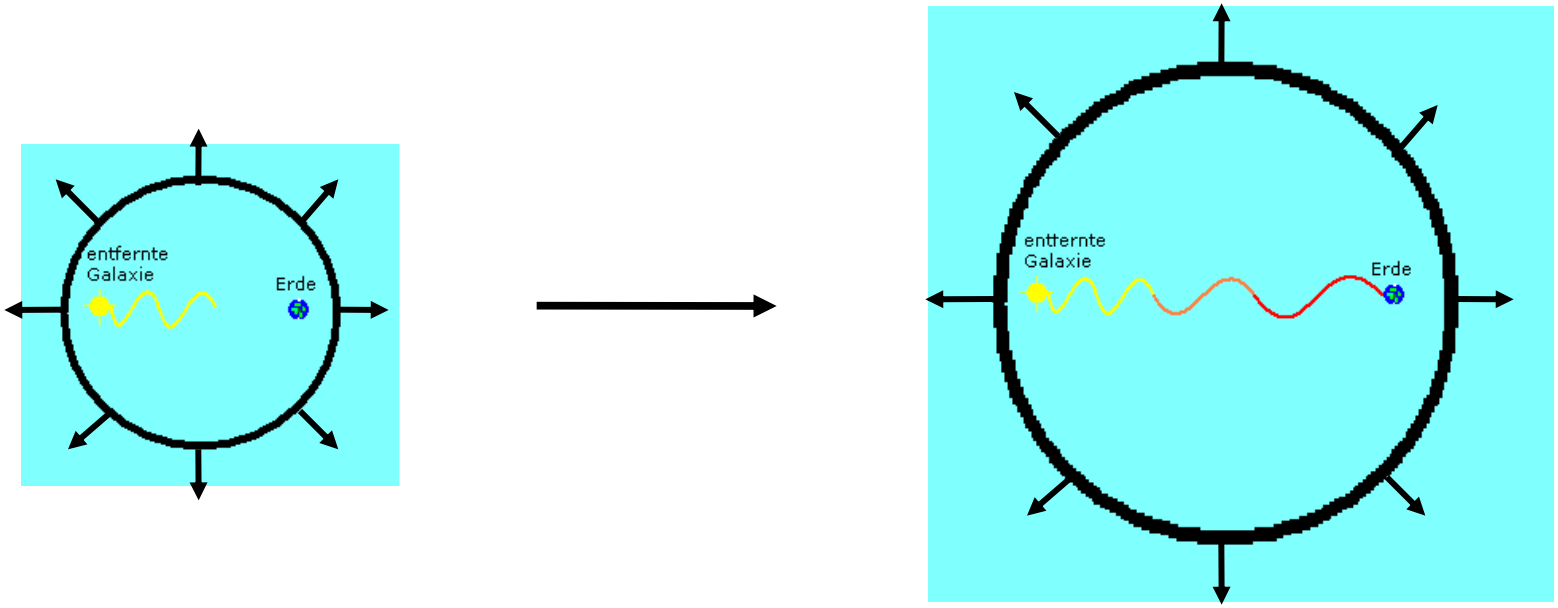
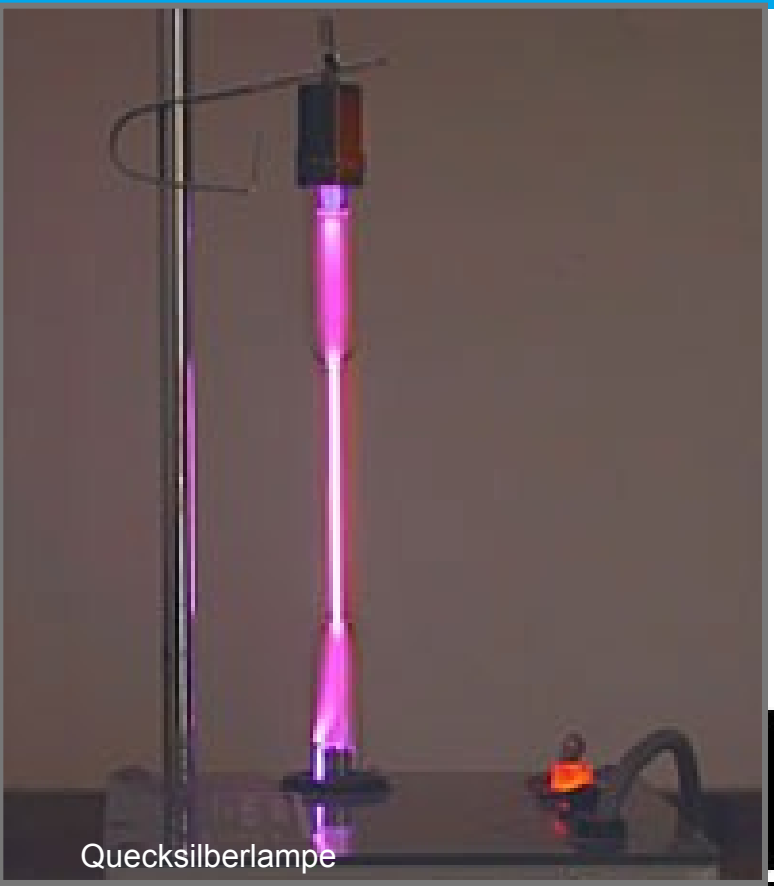


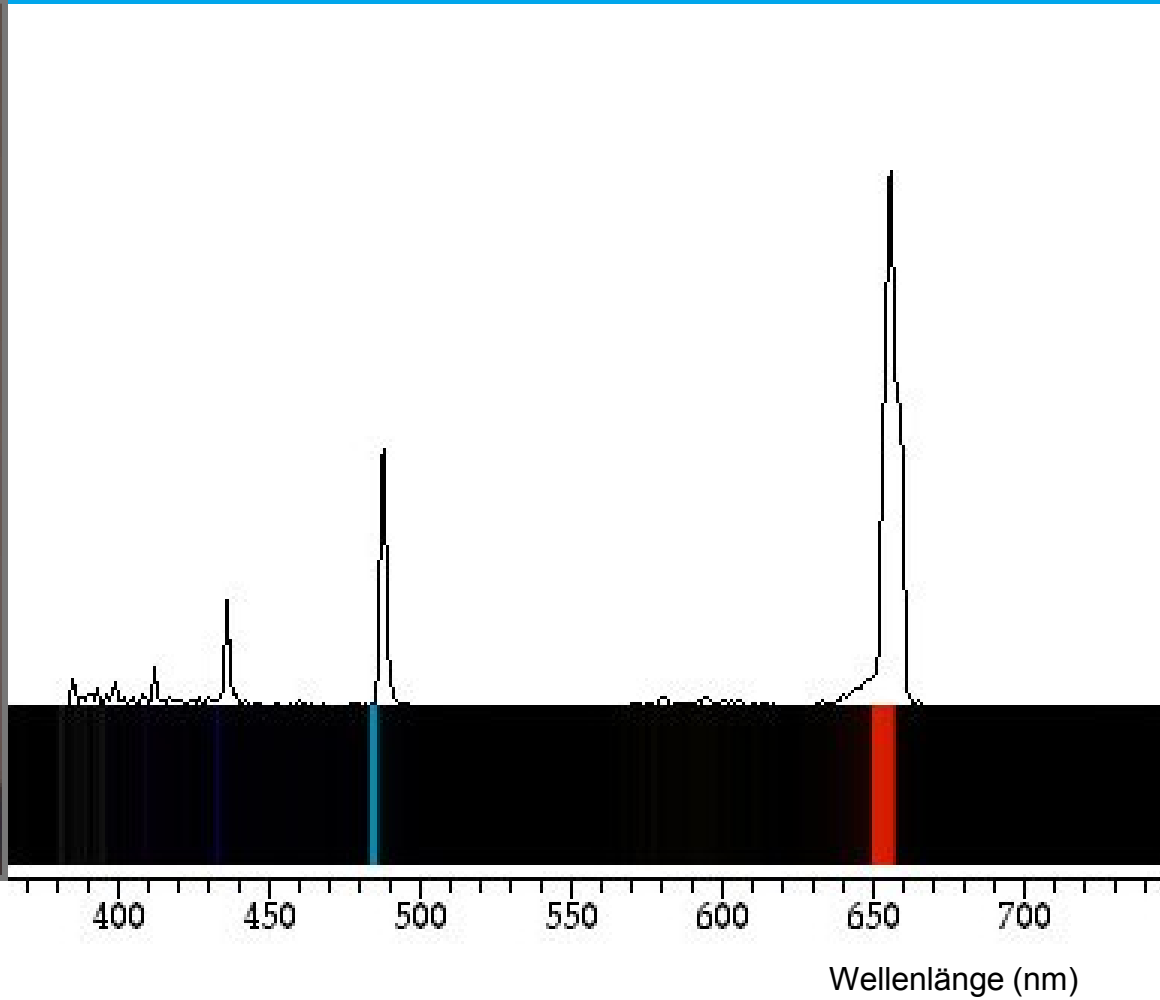
FIGURE 1

Kosmologische Rotverschiebung

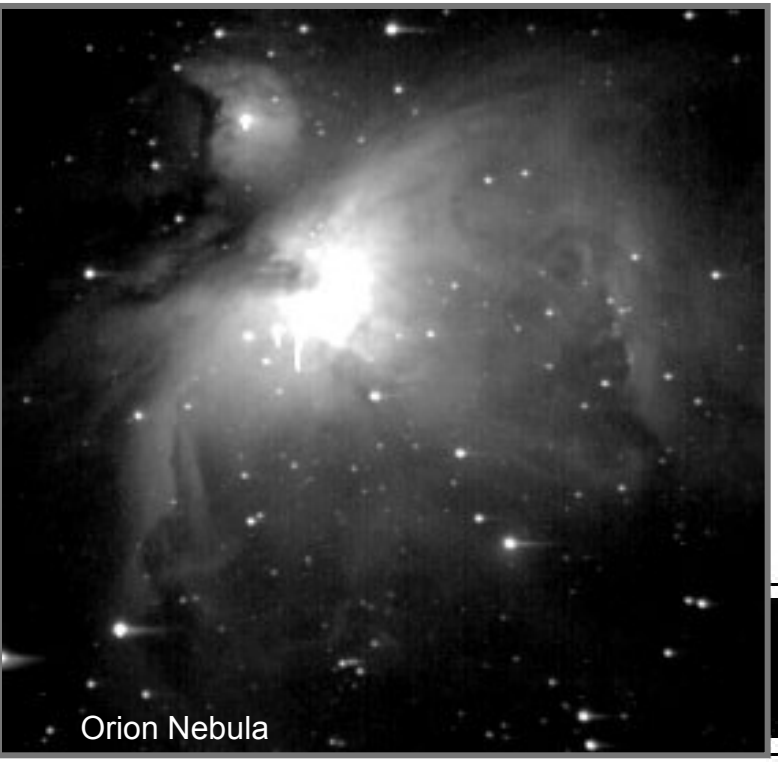


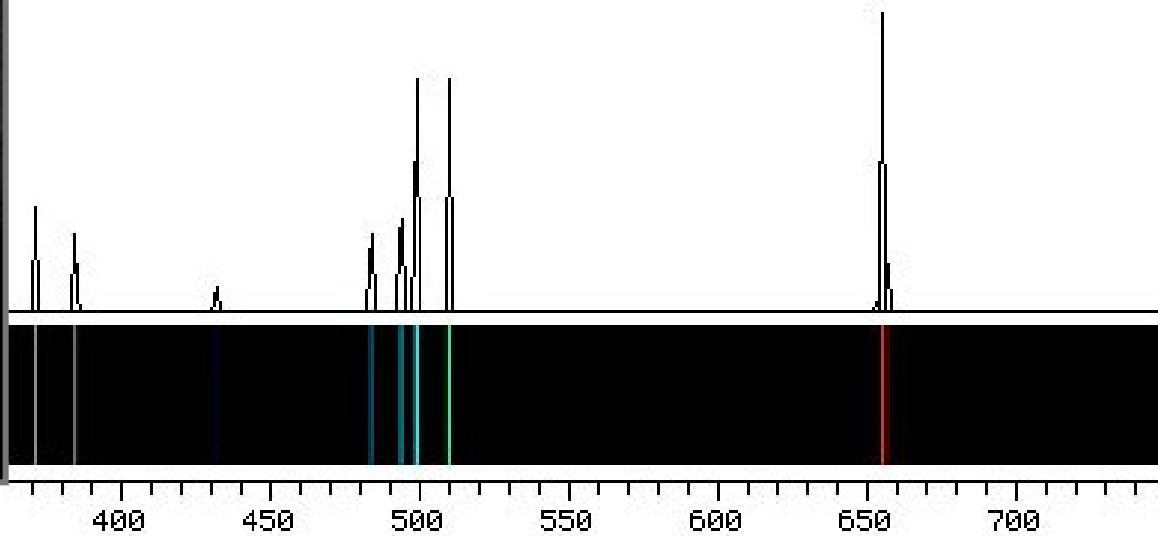
Das expandierende Universum





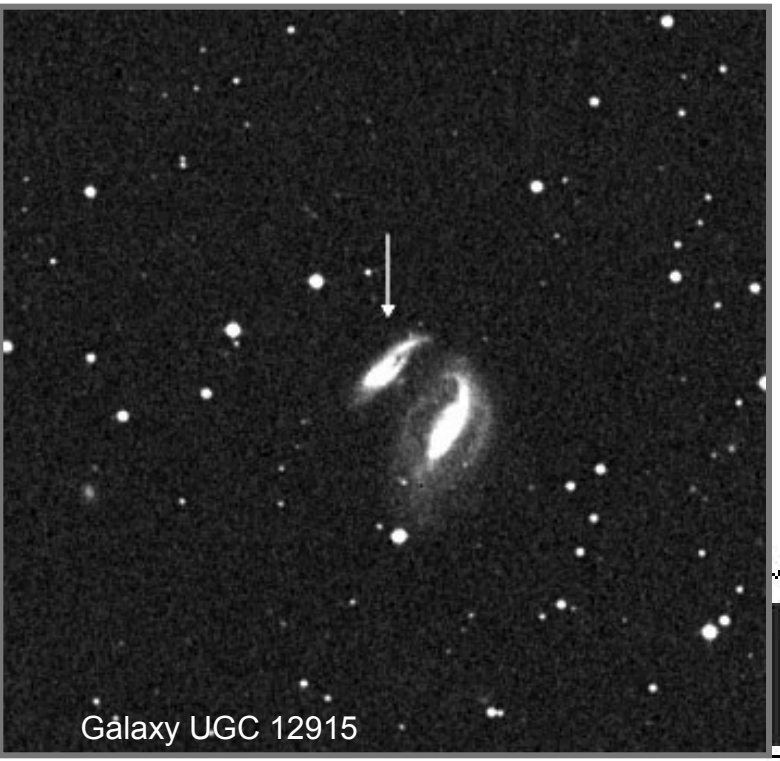
Das expandierende Universum

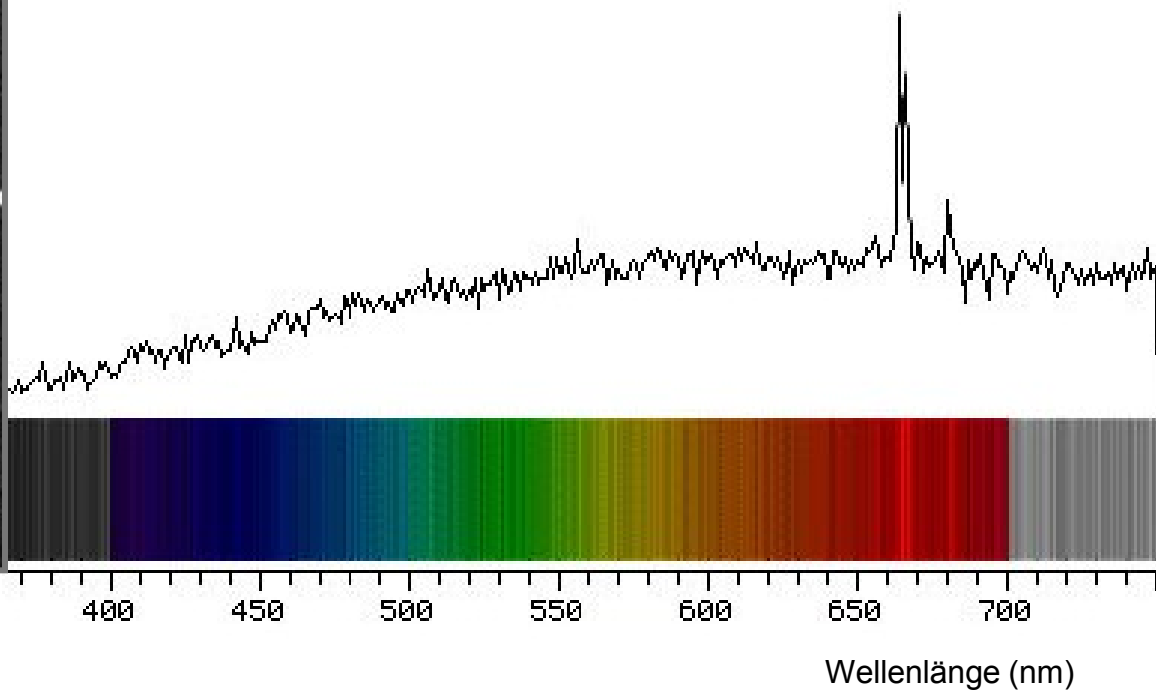




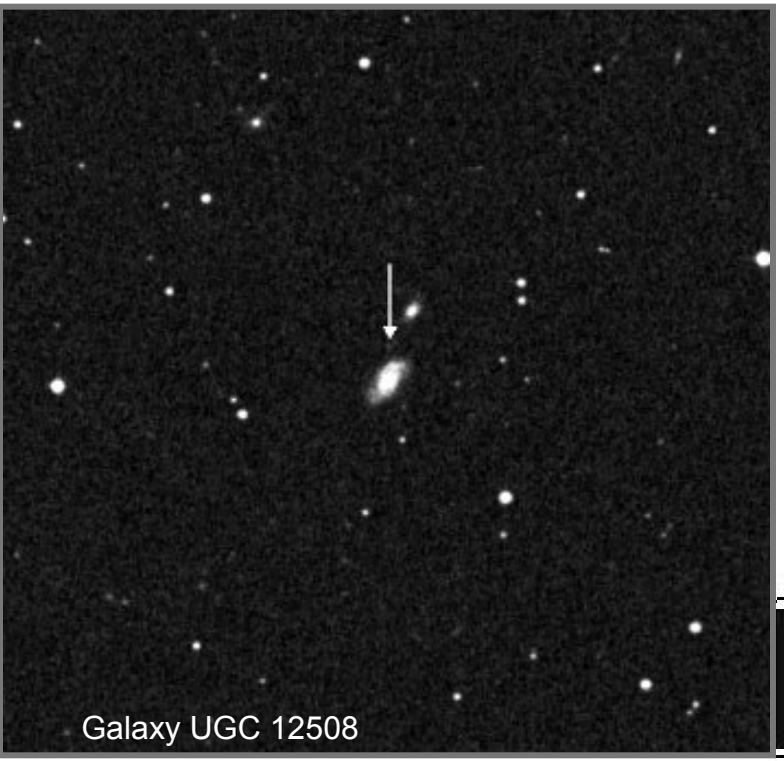
Wellenlänge (nm)

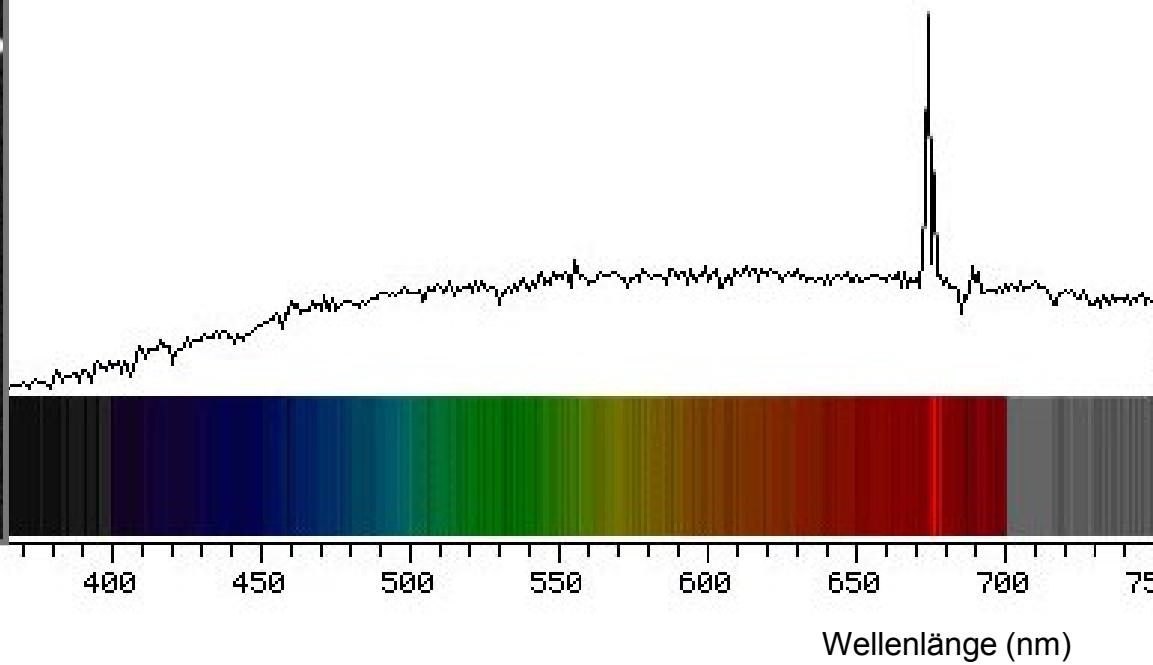
Das expandierende Universum



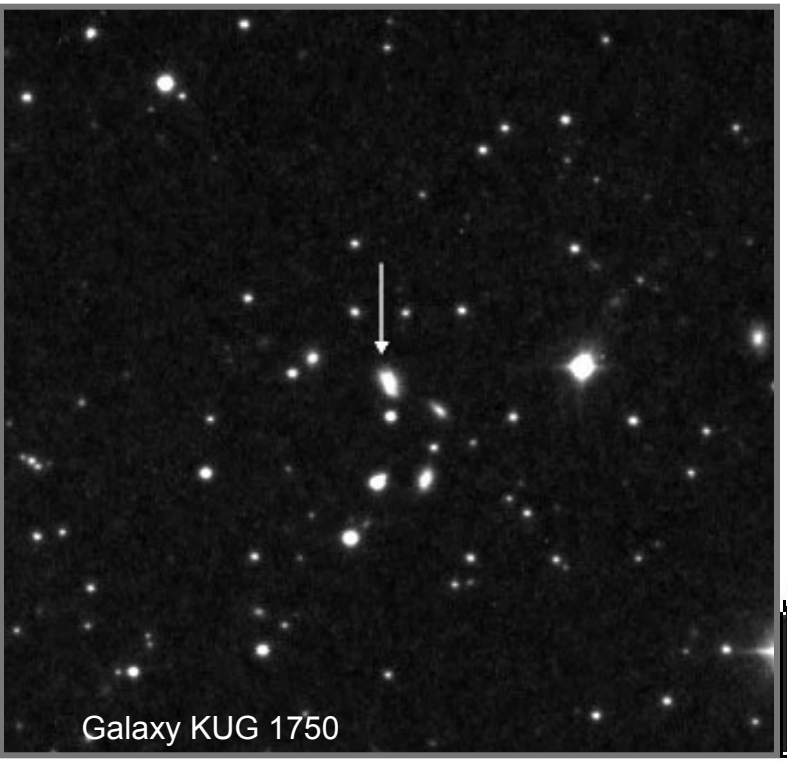


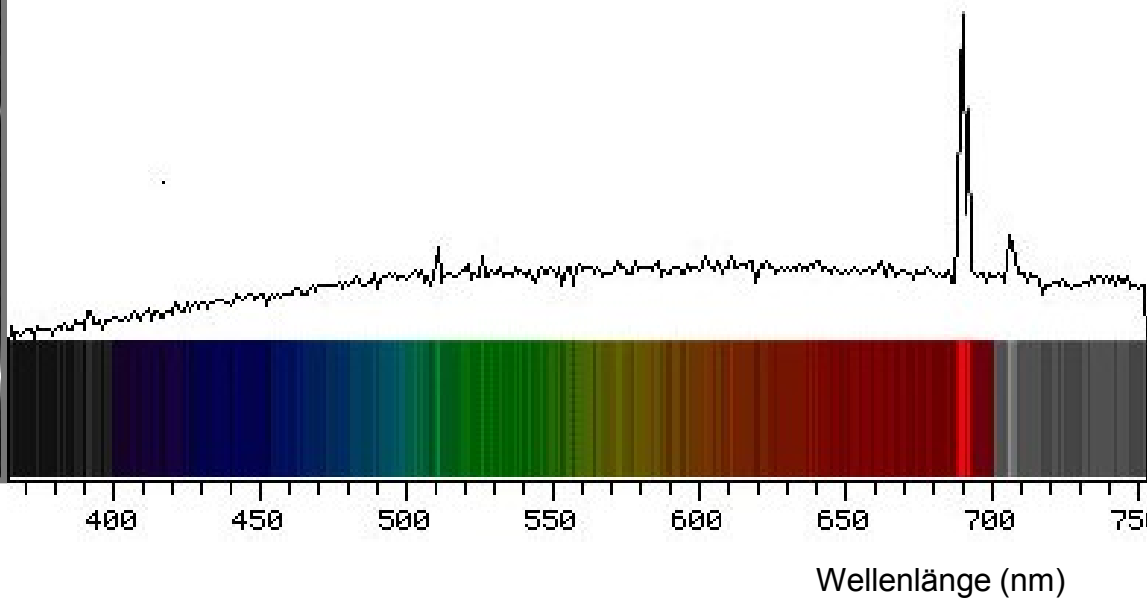
Das expandierende Universum



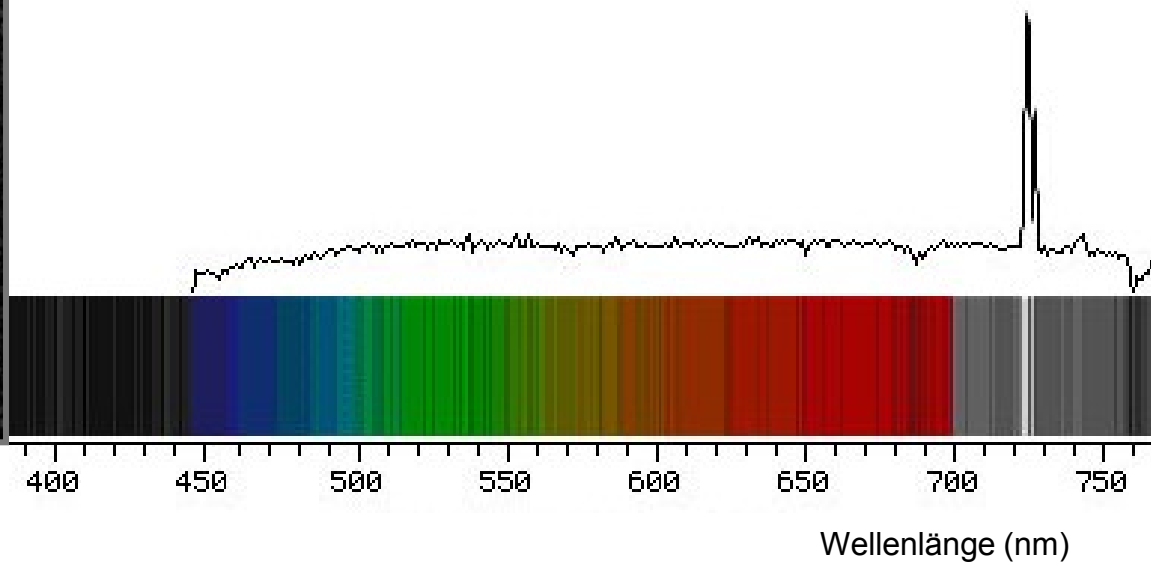


Das expandierende Universum

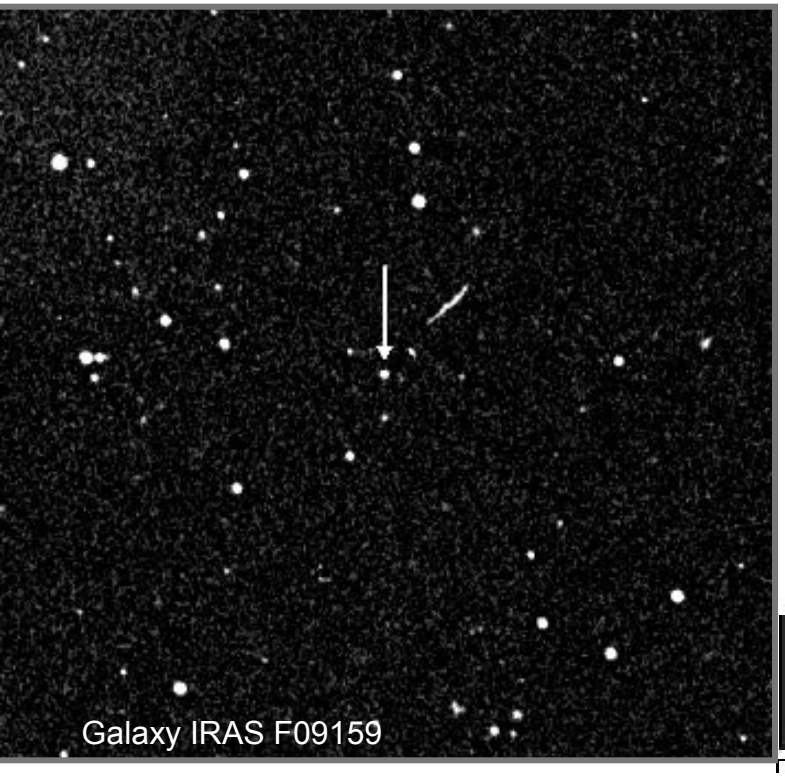


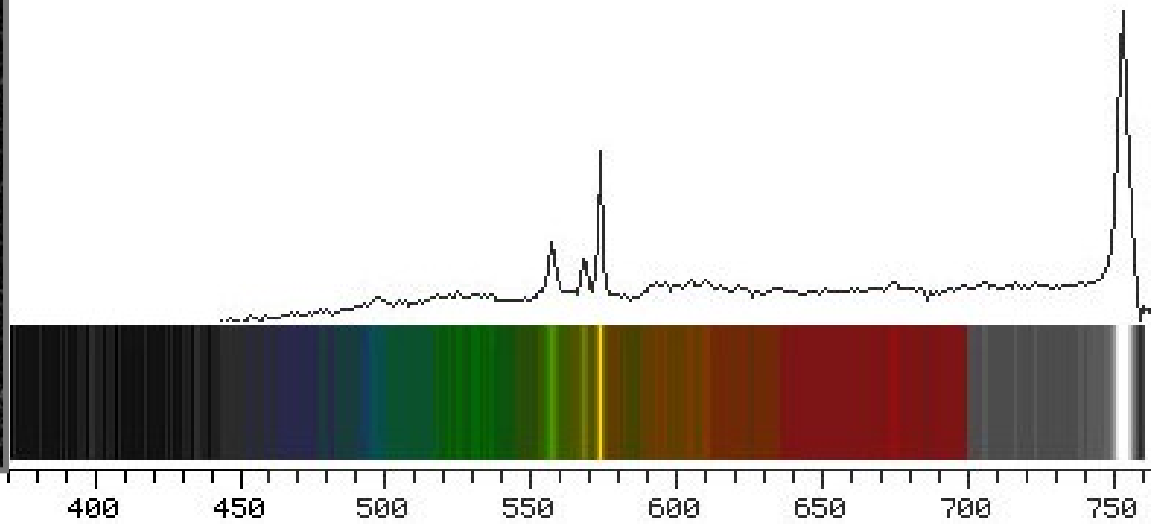


Das expandierende Universum



Das expandierende Universum





Wellenlänge (nm)

Das Hubble-Diagramm

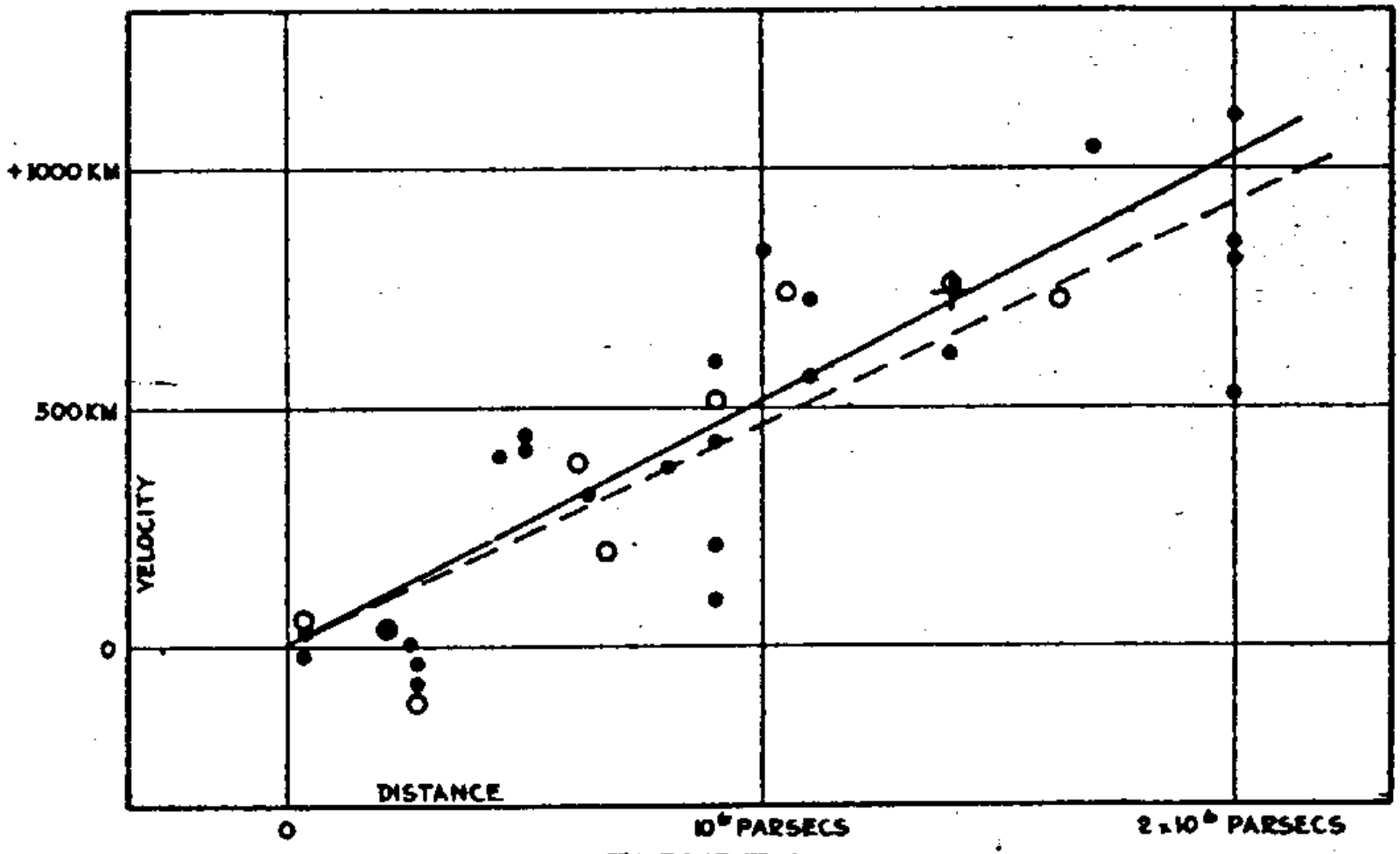
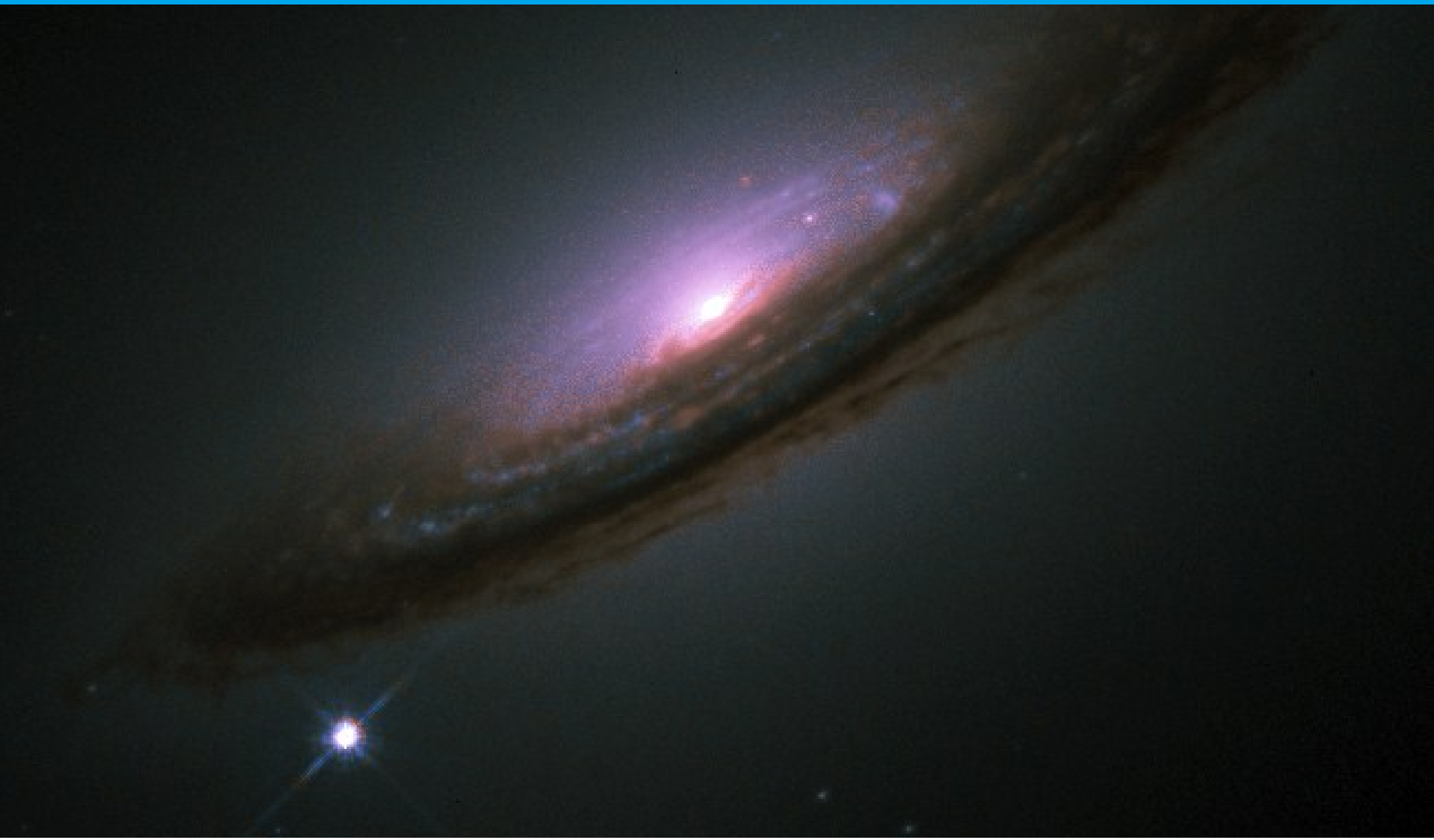
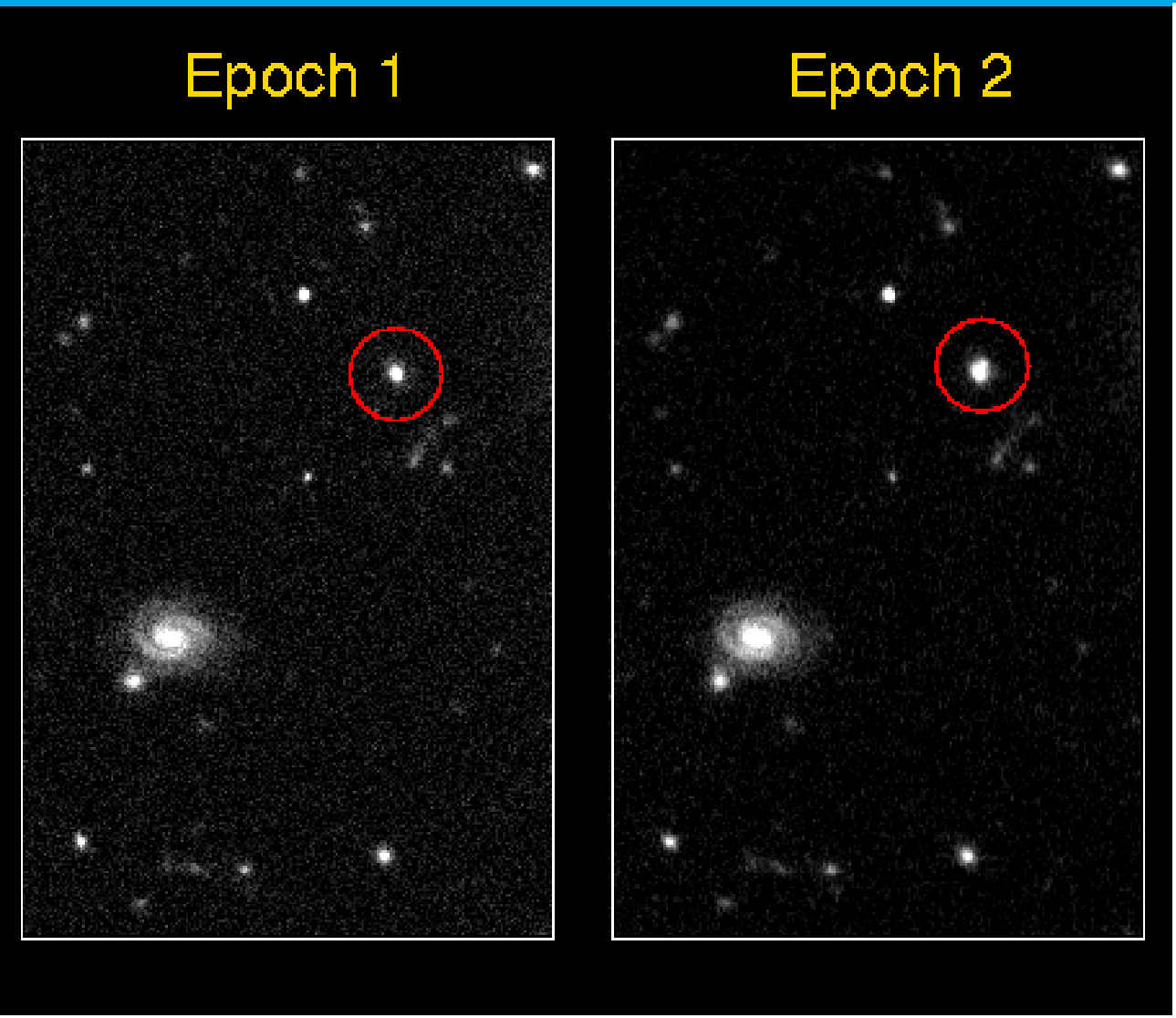


FIGURE 1

Eine Supernova

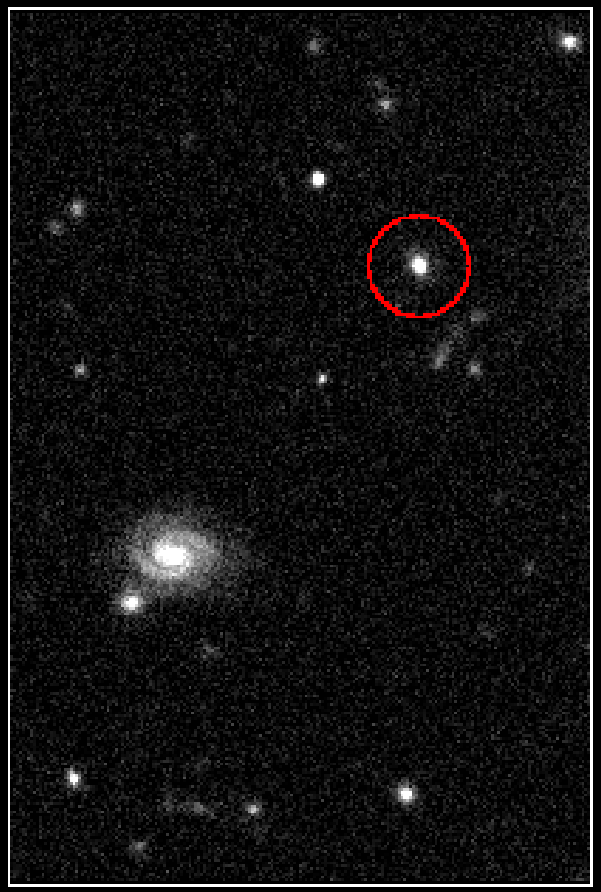


Wo ist die Supernova?

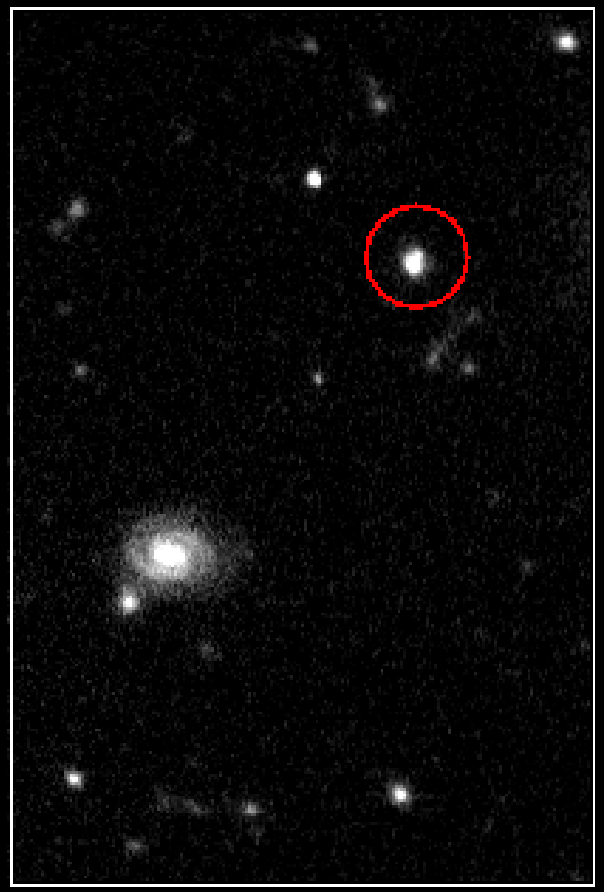


Hier

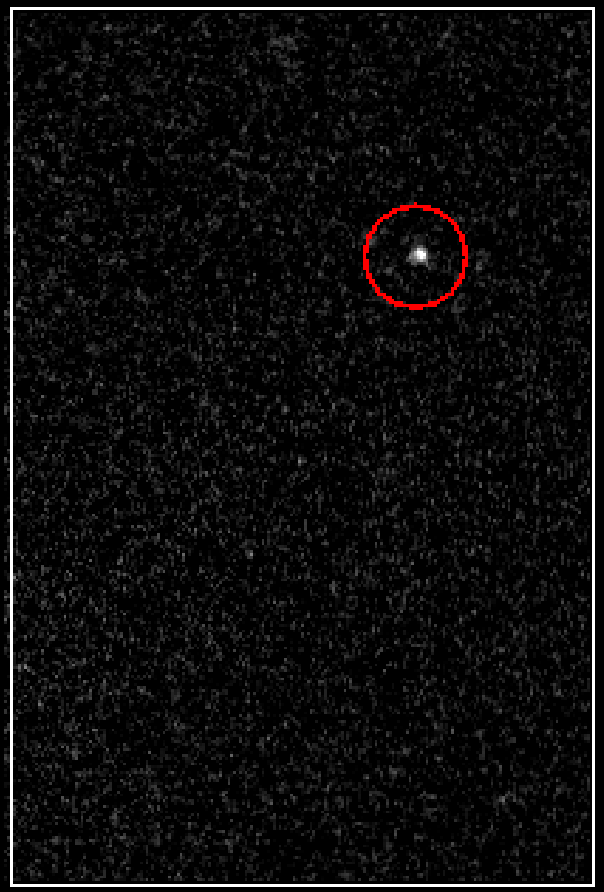
Epoch 1



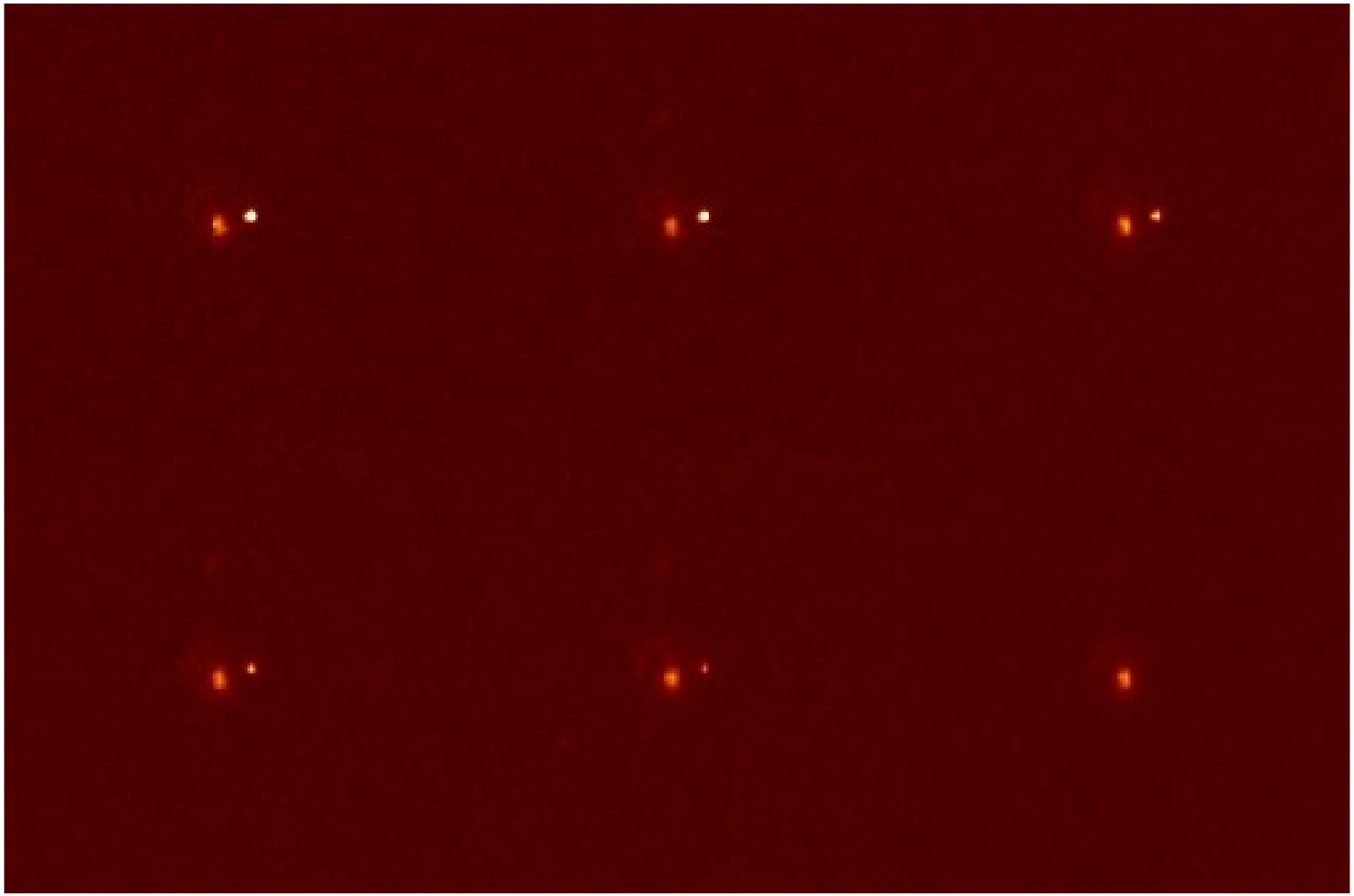
Epoch 2



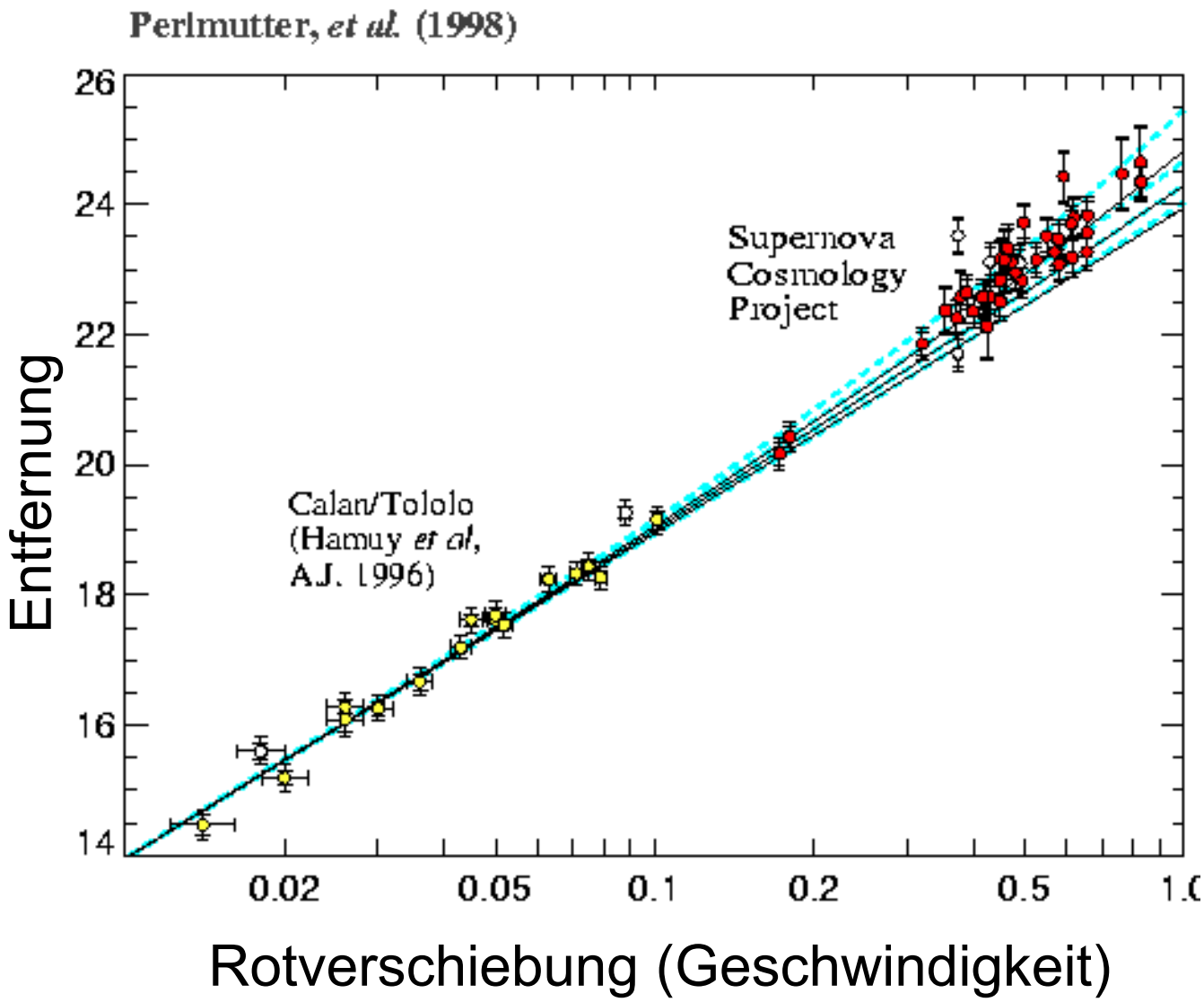
Epoch 2 - Epoch 1



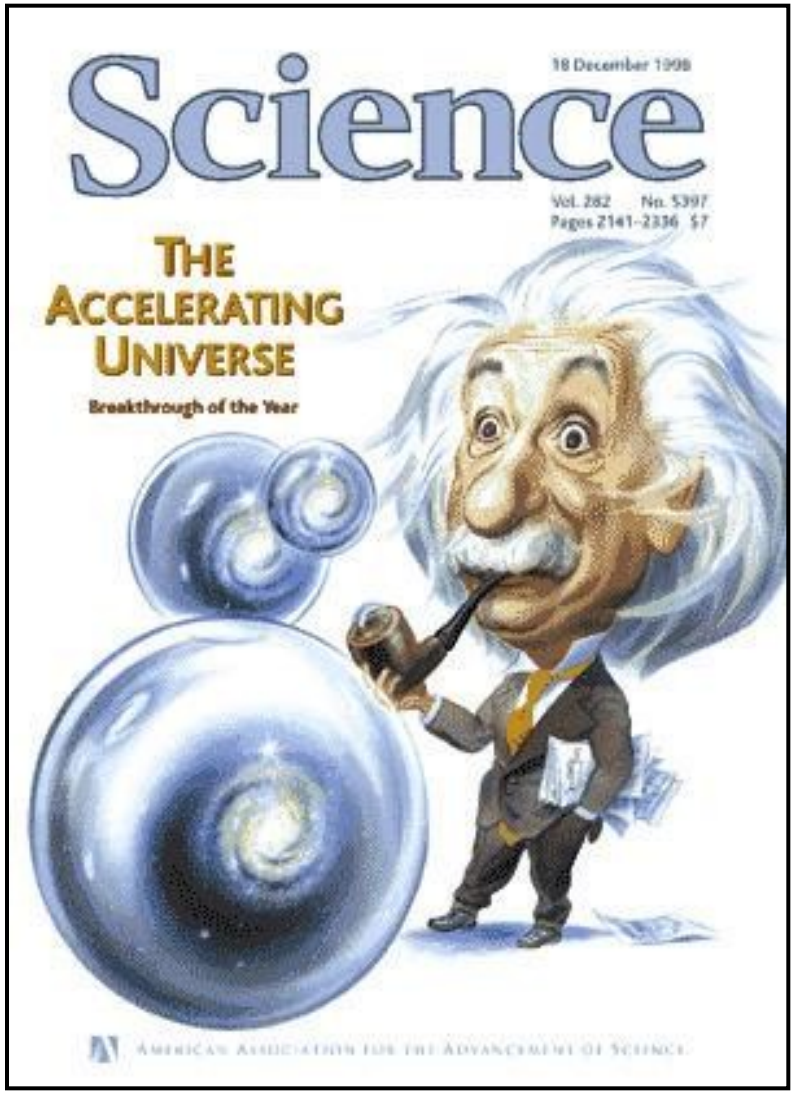
Eine Supernova

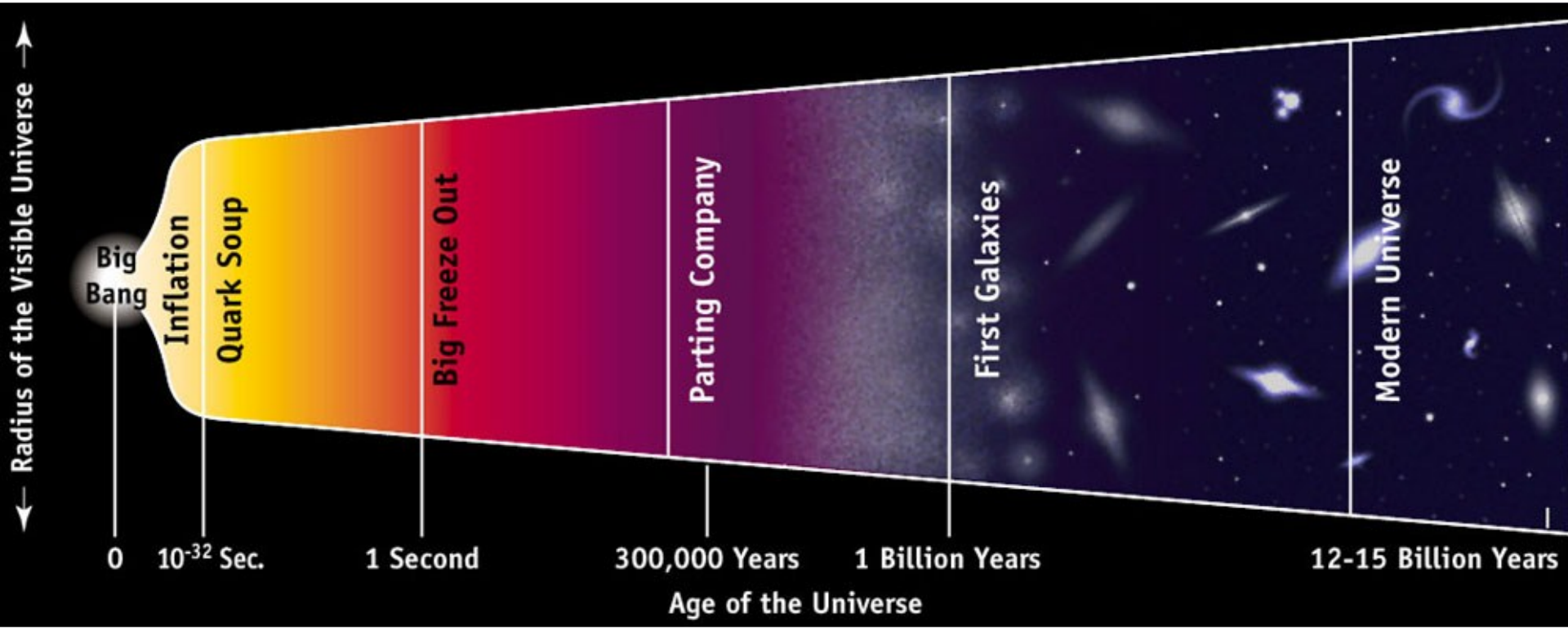


Ein modernes Hubble-Diagramm



Das beschleunigte Universum

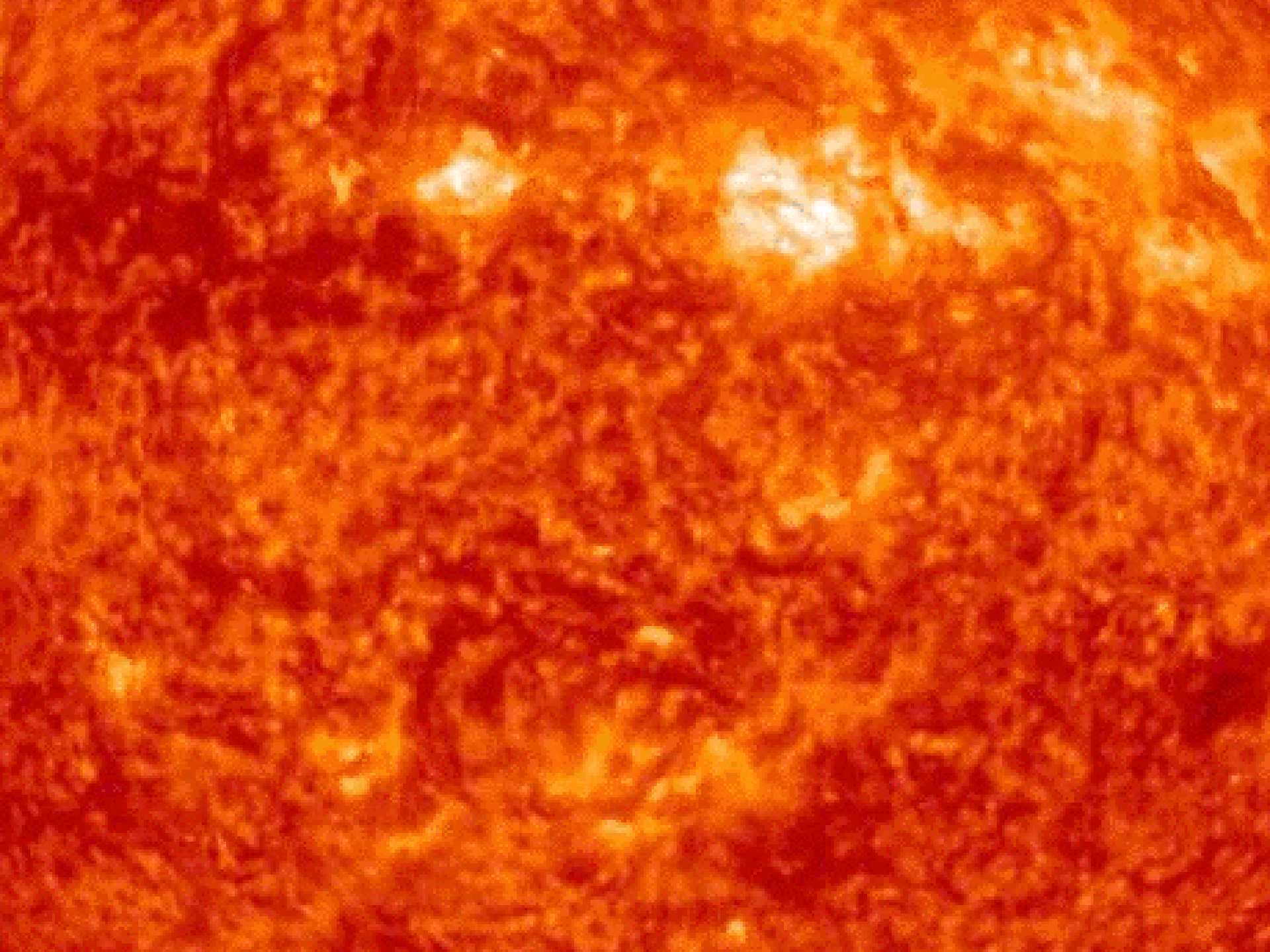



Radius of the Visible Universe
Big Bang
Inflation
Quark Soup
Big Freeze Out
Parting Company
First Galaxies
Modern Universe
0
10-32 Sec.
1 Second
300,000 Years
1 Billion Years
12-15 Billion Years
Age of the Universe

Blick in die Vergangenheit

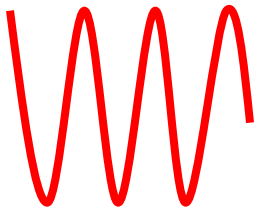
Blick in die Vergangenheit

Blick in die Vergangenheit

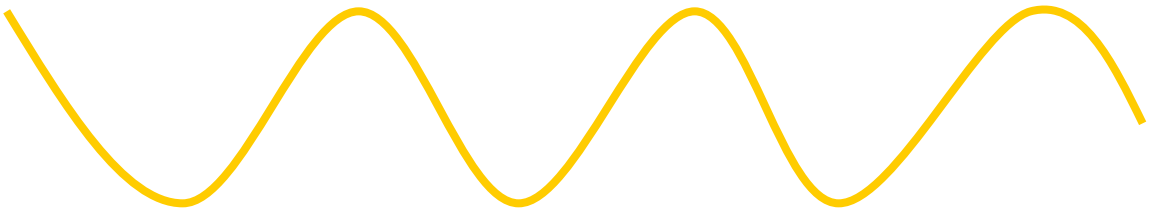


Der Urknall damals – heute

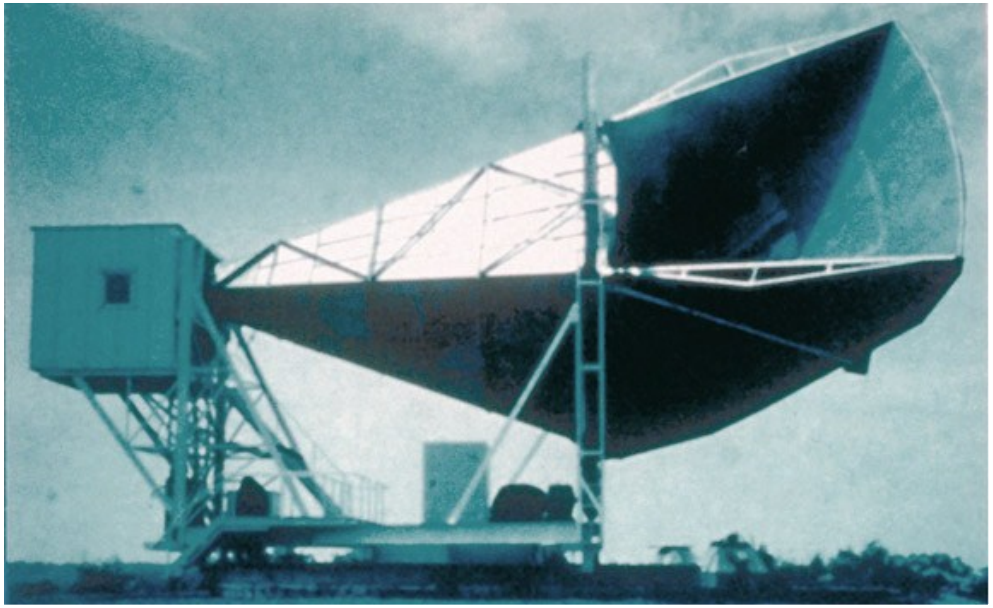
Damals: Licht 3000 K

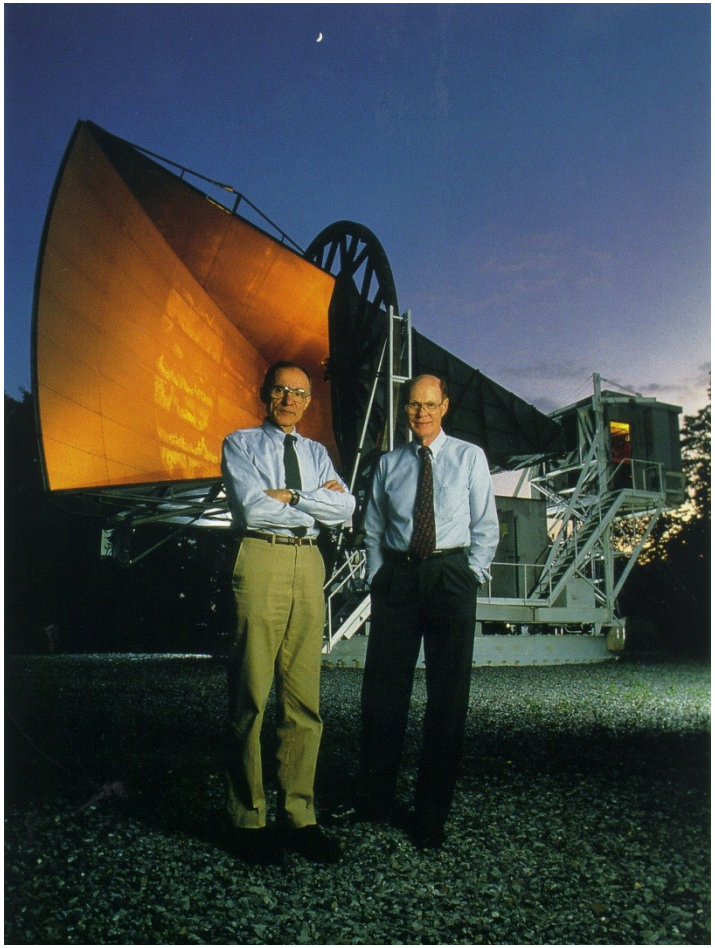


Heute: Mikrowellen 3 K

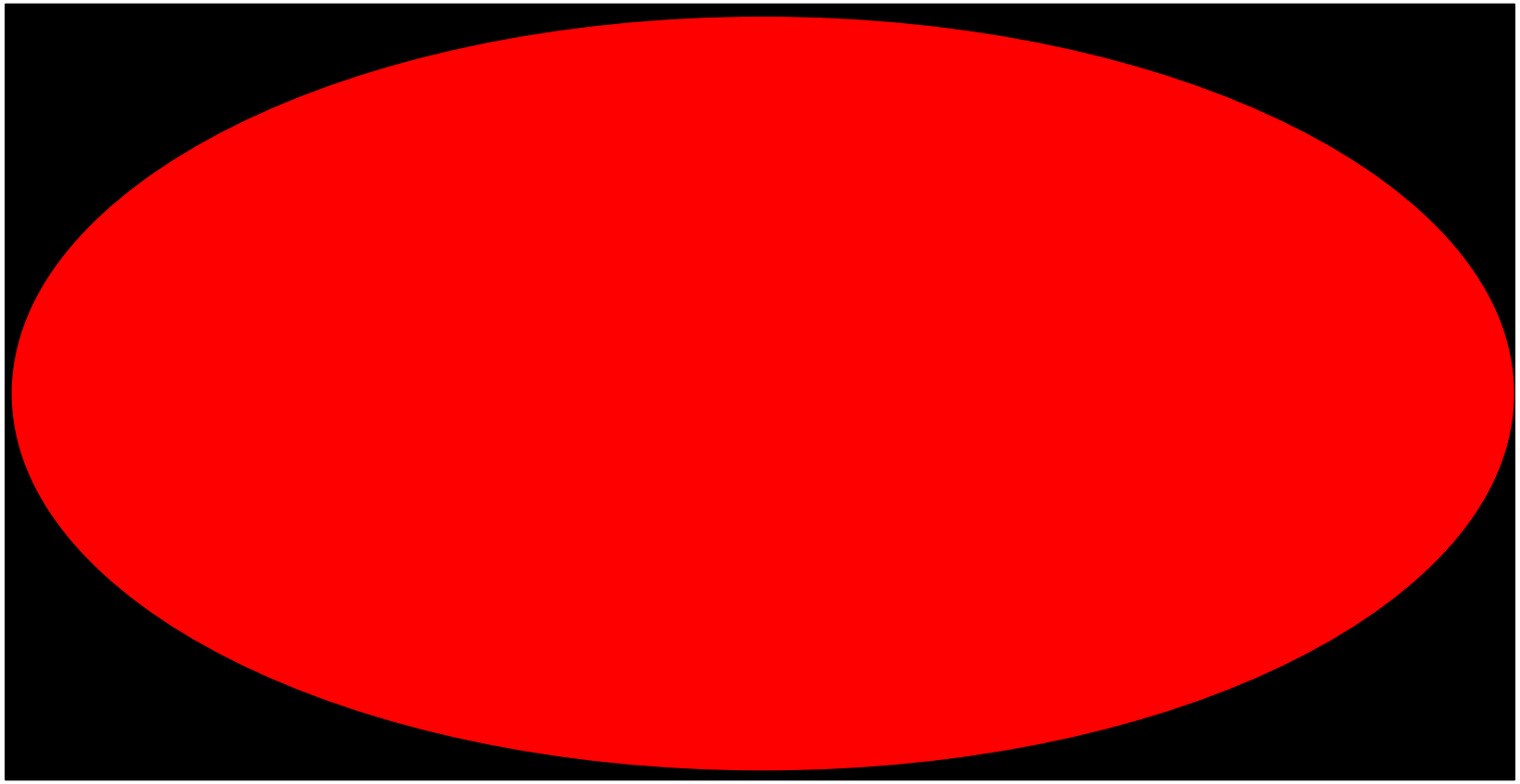


Die Entdeckung: 1965

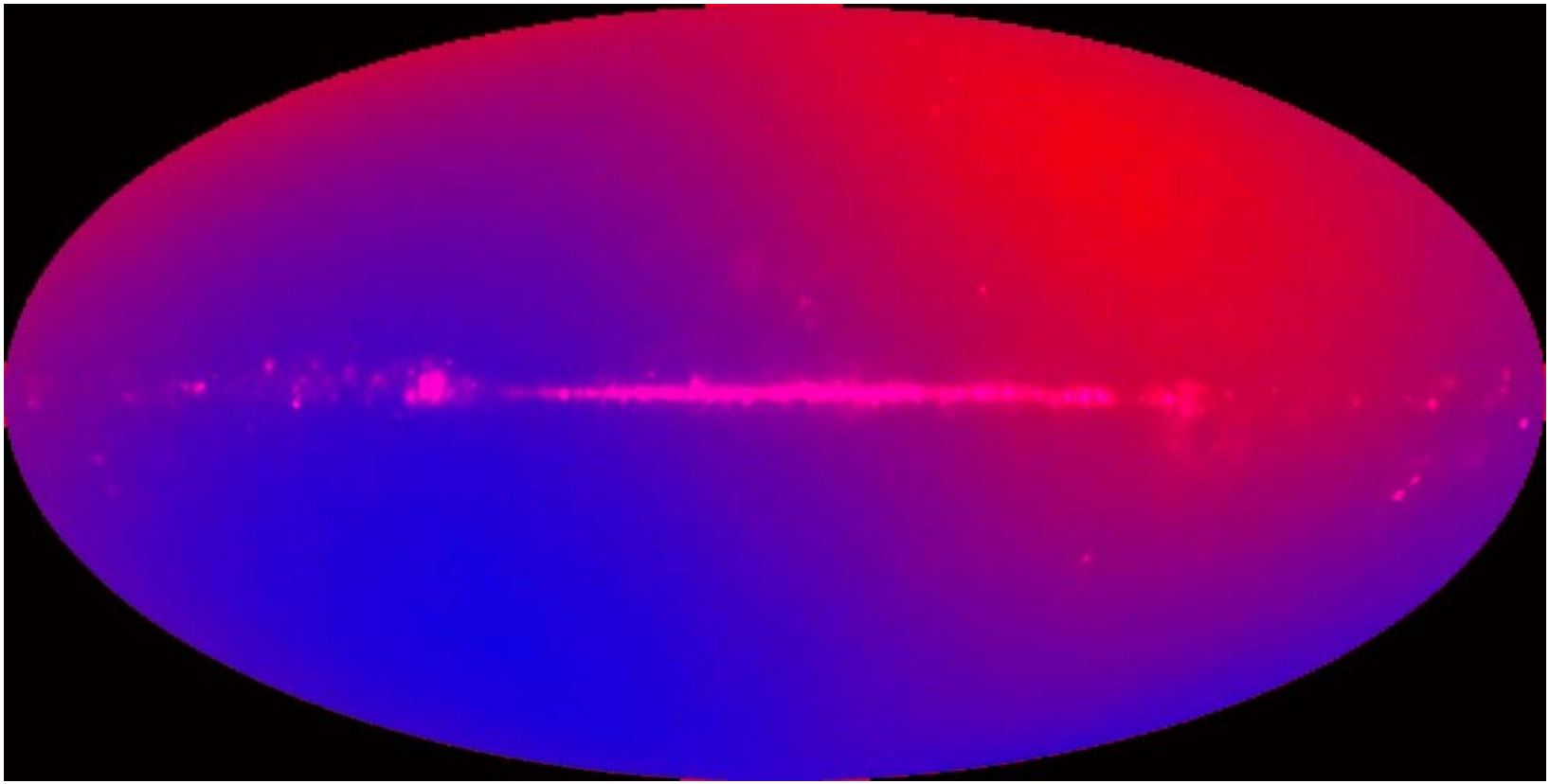




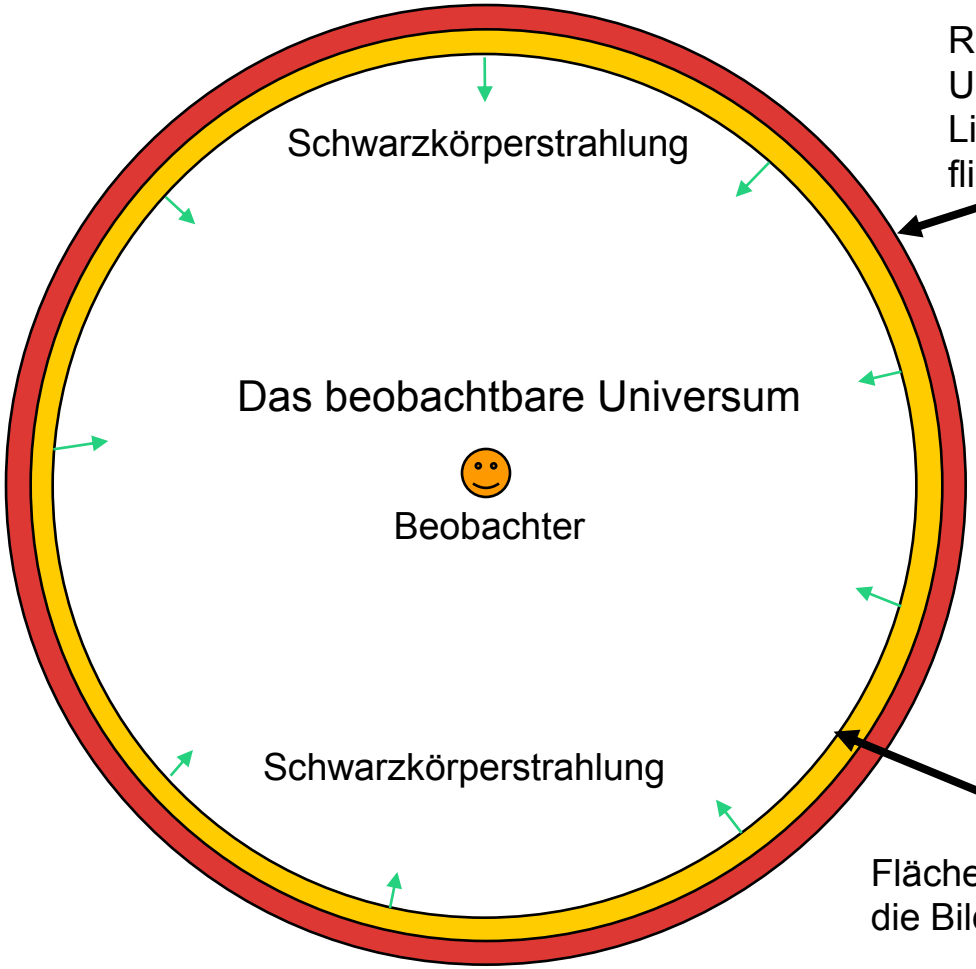
Der Mikrowellenhintergrund



Die Erde bewegt sich



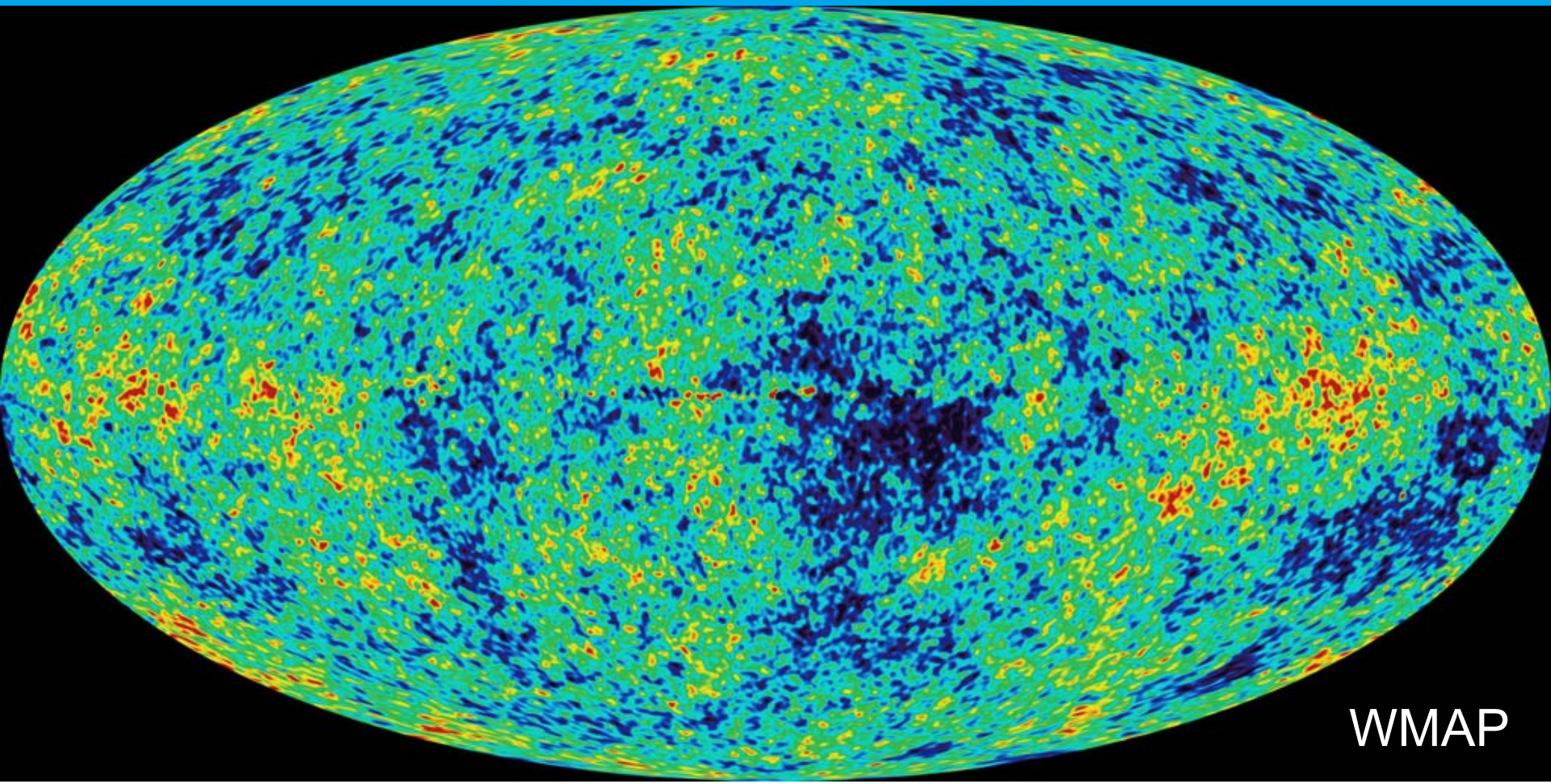
Die Geschichte der kosmischen Hintergrundstrahlung

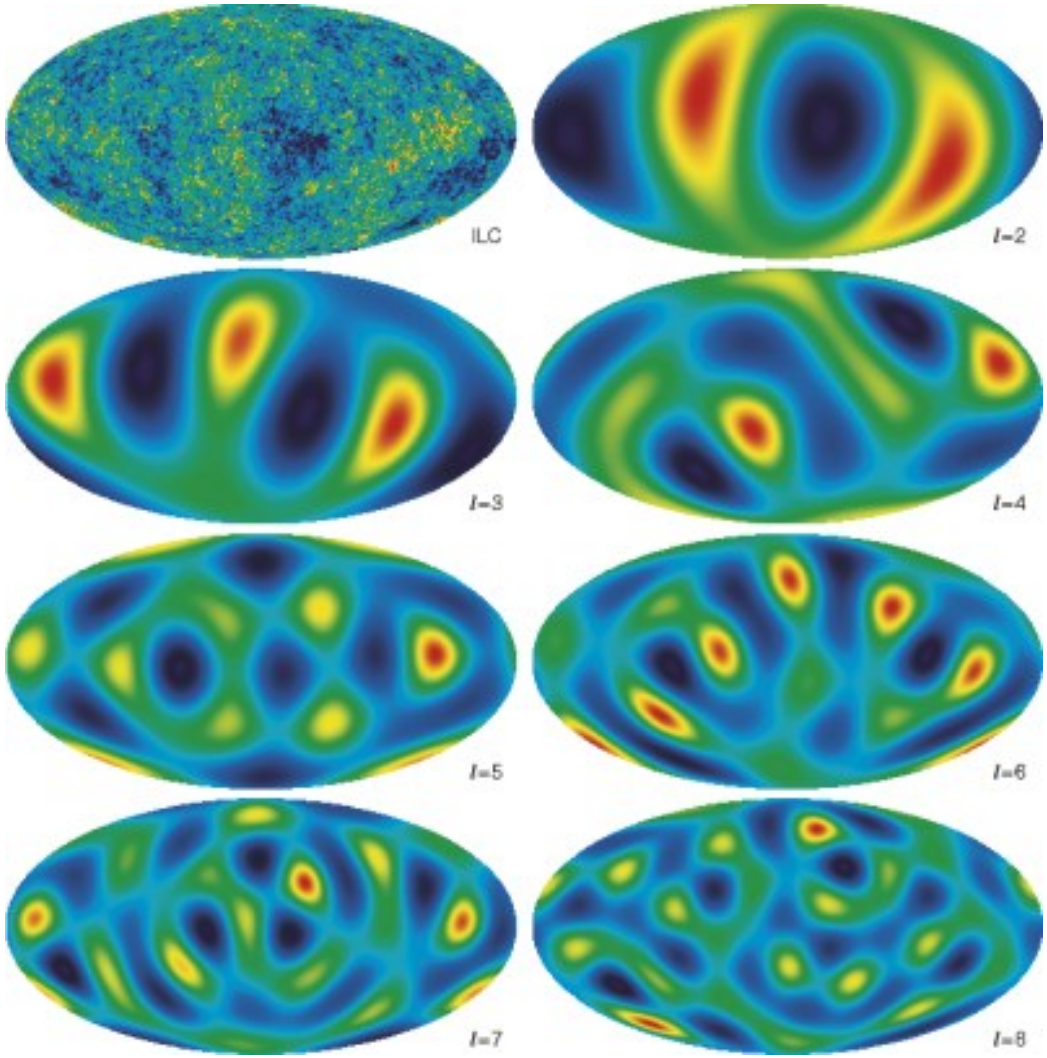


Rand des beobachtbaren Universum – Distanz, die Licht im Alter des Universums fliegen konnte.

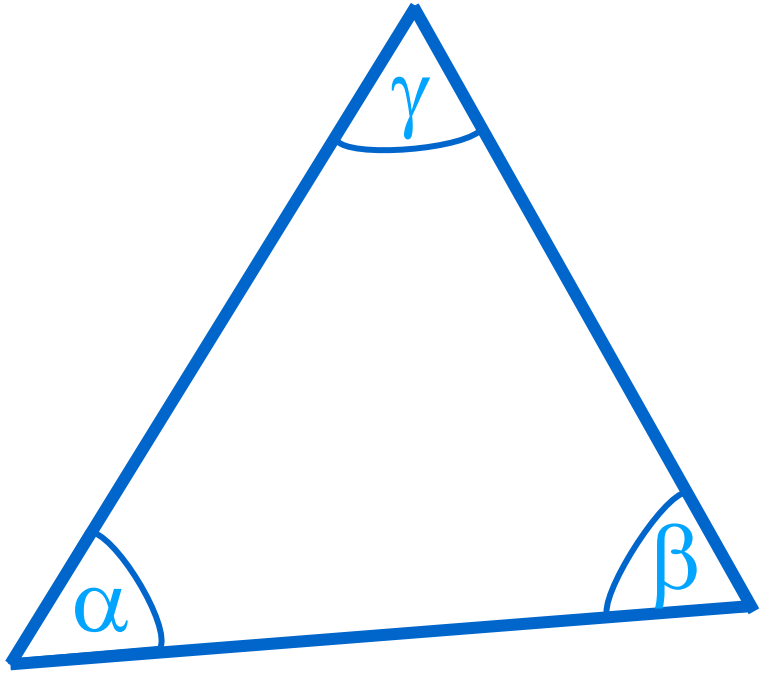
Fläche der letzten Streuung, wo die Bildung der Atome stattfand.

Das Echo des Urknalls



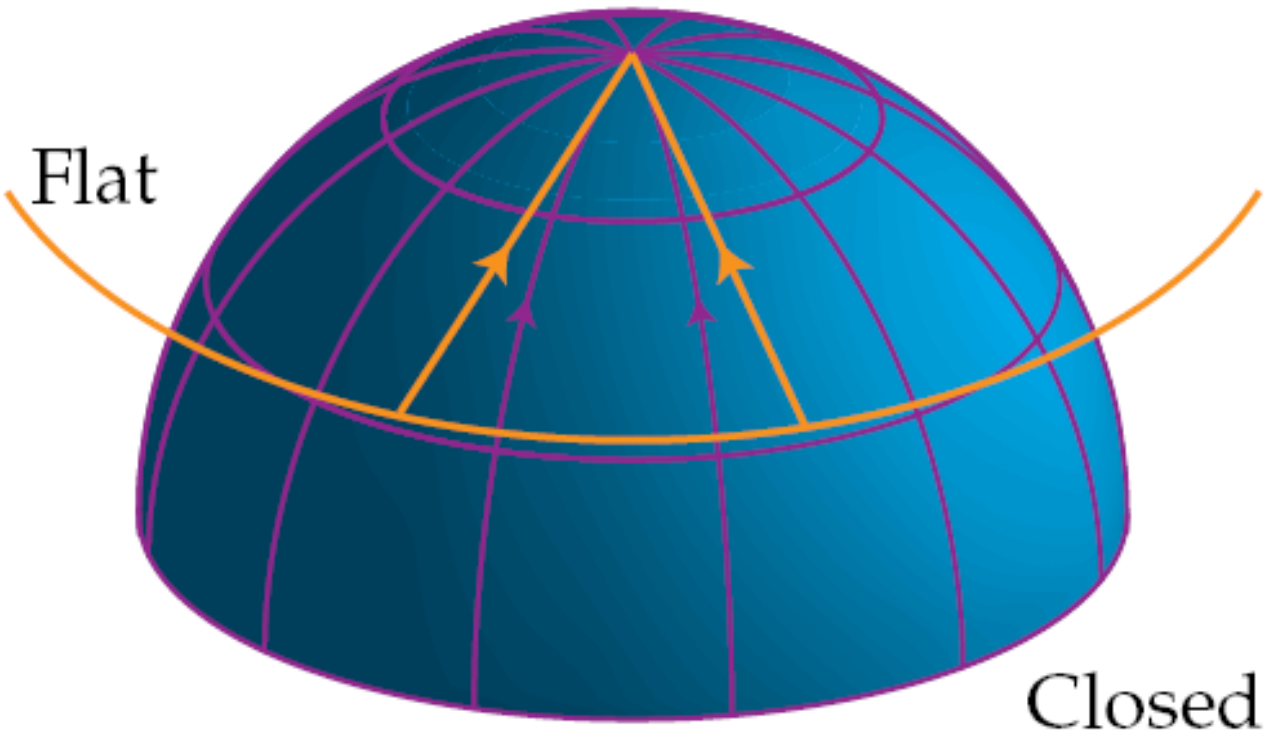

ILC
l=2
l=3
l=4
l=5
l=6
l=7
l=8

In einem flachen Raum

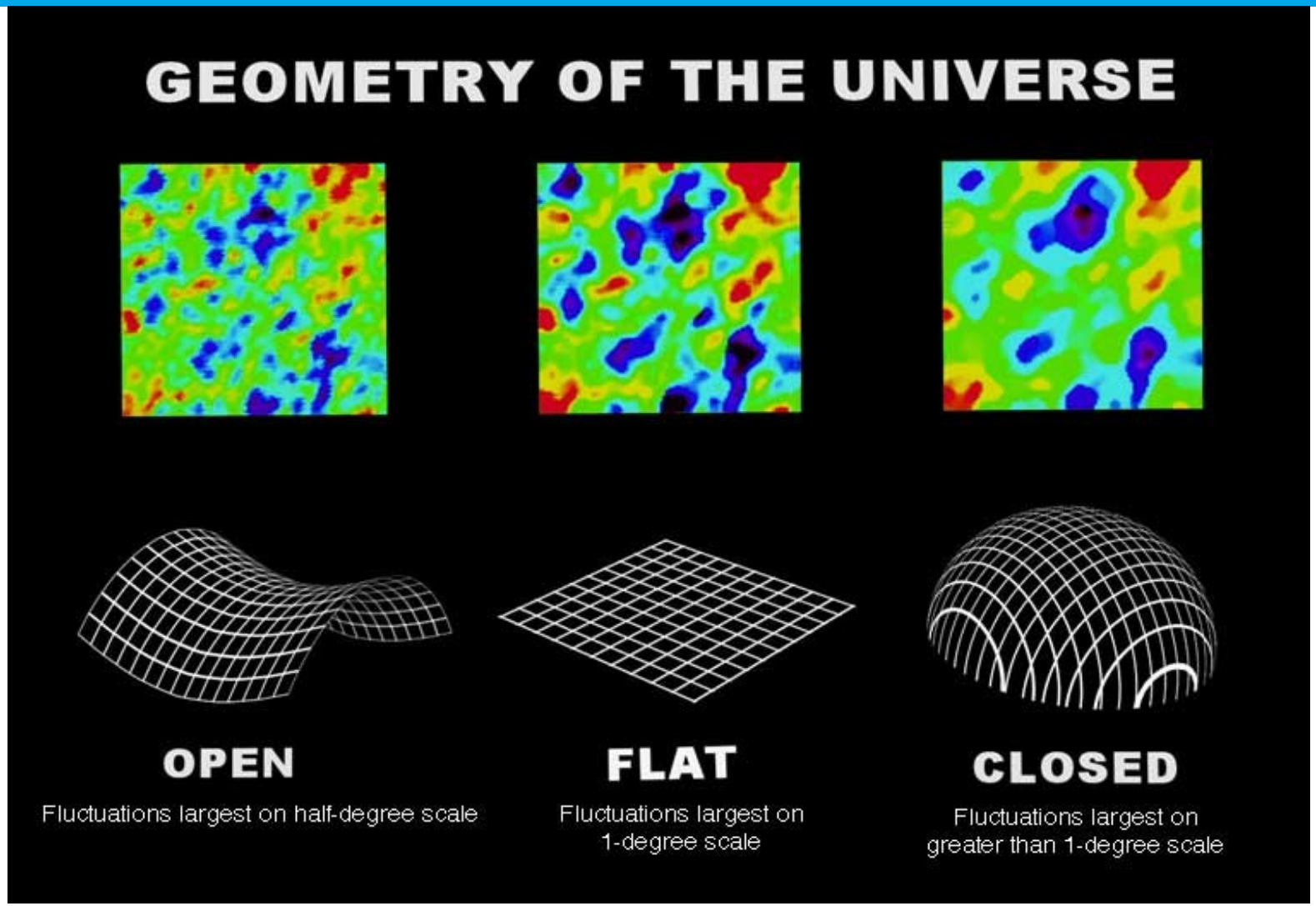


$$\alpha+\beta+\gamma = 180^{o}$$

Raumkrümmung

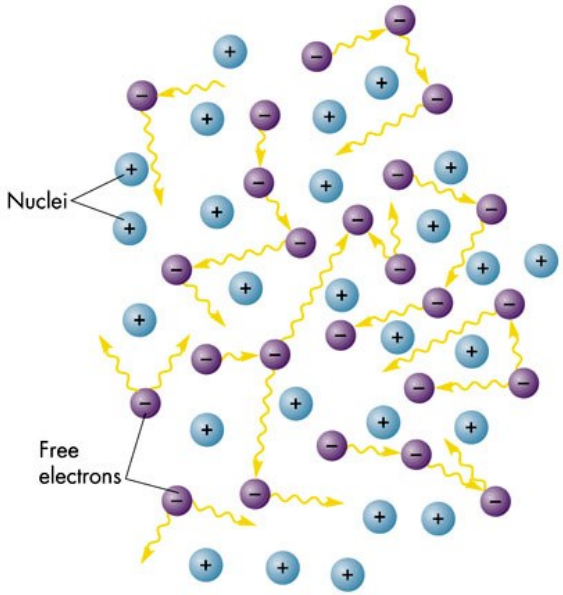


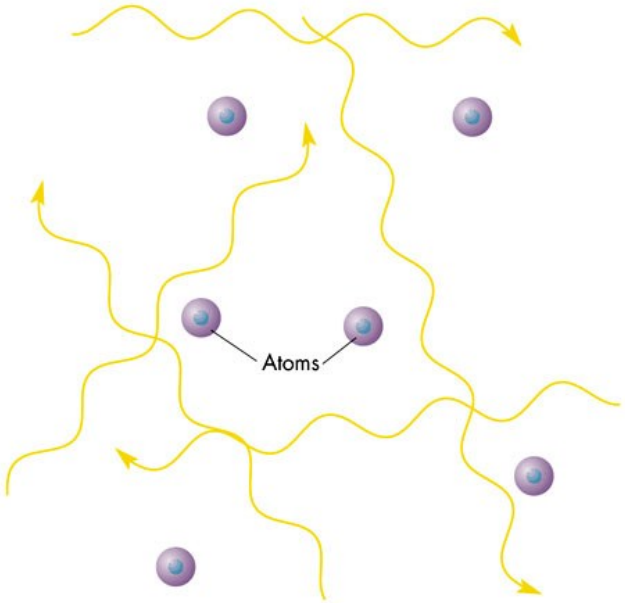
Die Geometrie des Universums



Bildung von Atomen

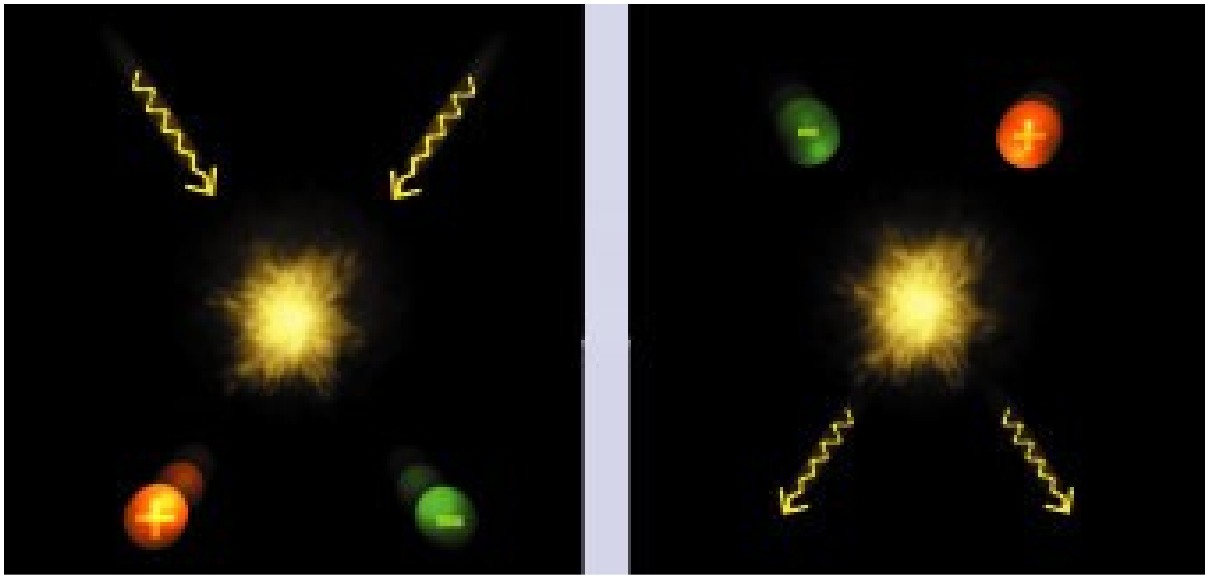
- Alter = 370000 Jahre, T = 3000 Kelvin
  - Erste Atome bilden sich
  - Das Universum wird transparent





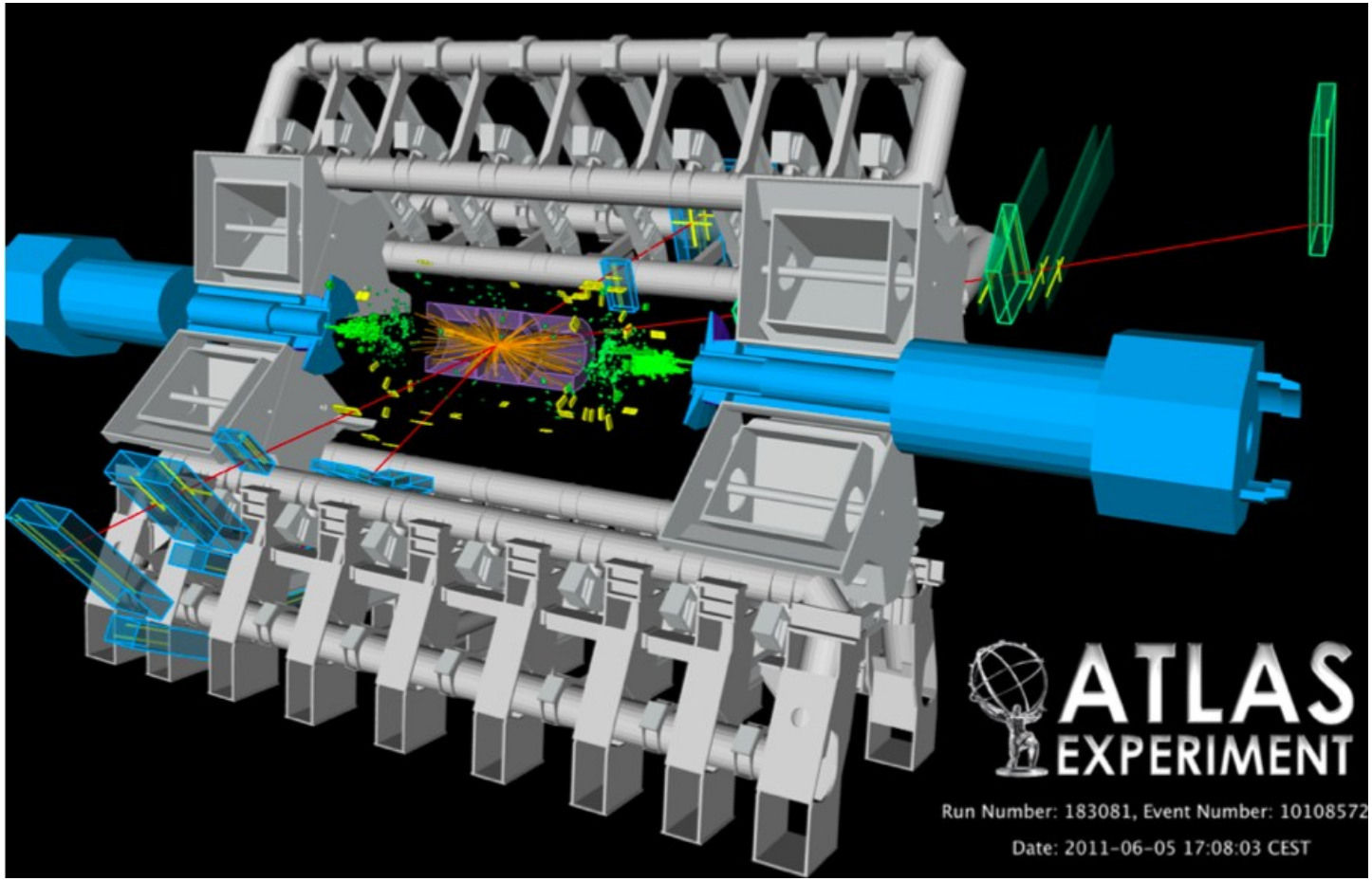
Der Sieg der Materie

- Alter = 10^{-6} s, T = 10^{12} Kelvin
  - Vorher: Materie-Antimaterie-Verhältnis
    100000001 : 10000000
  - Nachher Materie-Photon-Verhältnis
    1 : 200000000

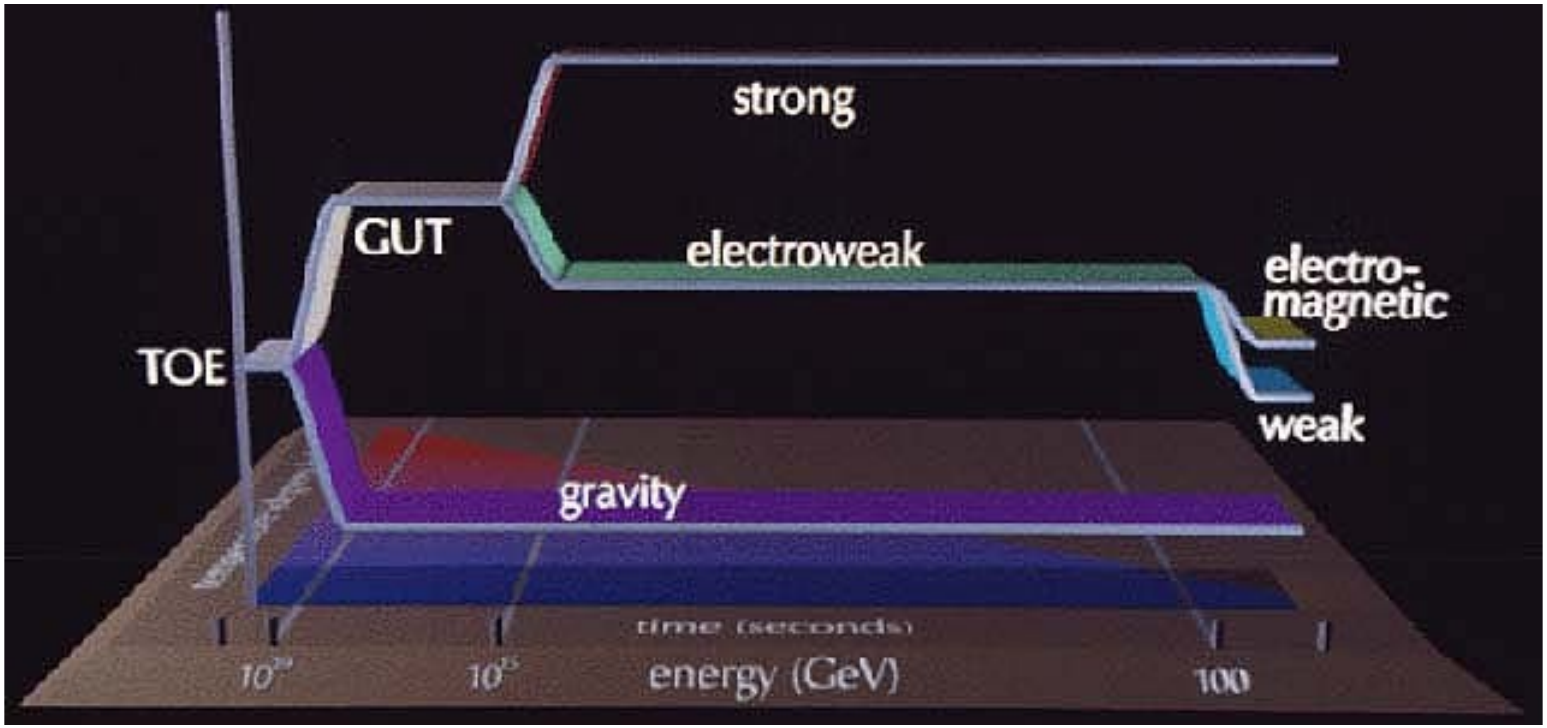


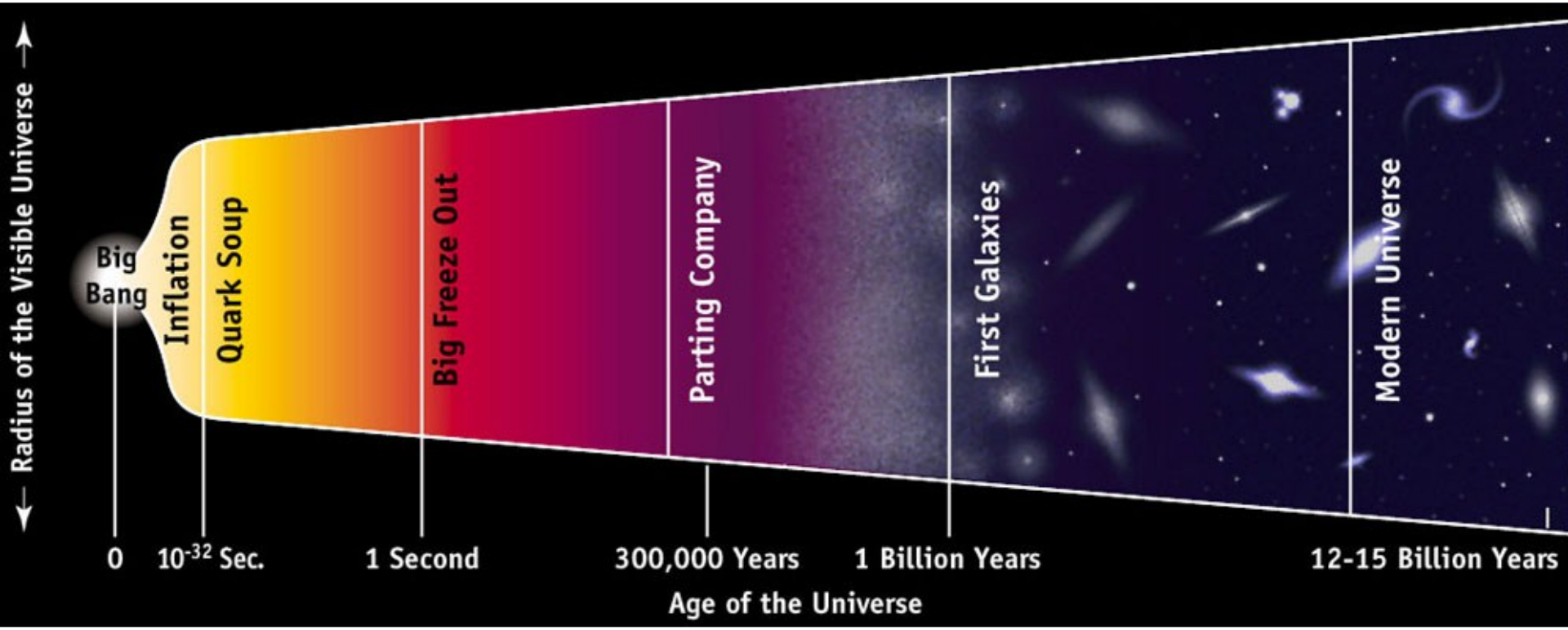
Der LHC auf der Reise zum Urknall

- Alter = 10^{-11} s, T = 10^{16} Kelvin



Die Vereinheitlichung der Kräfte




Radius of the Visible Universe
Big Bang
Inflation
Quark Soup
Big Freeze Out
Parting Company
First Galaxies
Modern Universe
0
10-32 Sec.
1 Second
300,000 Years
1 Billion Years
12-15 Billion Years
Age of the Universe

Die großen Fragen

- Woher kommen wir?
- Wohin gehen wir?

- Elementarteilchenphysik, Kosmologie und Astronomie zusammen sind auf dem Weg zu einer Antwort auf diese Fragen.

Bildnachweise: NASA, WMAP, DESY, COBE, CERN, APOD