Life in the Universe: Impact on Philosophical and Theological Questions

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Summer School Alpbach 2011, 19.7.2011

Top three Questions People ask an Astrophysicist

1. Are there Aliens?
2. How did the Universe come into existence?
3. Does God exist?

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Solar system

Astrobiology

Astrobiology has developed in the last centuries from an accumulation of speculations to a serious science. This is due to several new discoveries and findings:

1. **Discovery of extrasolar planets**
2. **Live on Earth under extreme environments**
3. **Technical progress in observations**

There is a good chance that we will discover extraterrestrial life in the next centuries!

Extrasolar planets

- We have already discovered almost 500 extrasolar planets
- Planets similar to our Earth (Second Earths, Super Earths)
- Systems with more planets
- Planets orbiting around two suns or even three suns

Illustration of an extrasolar planet with its sun in the background

Extreme life on Earth

Terrestrial life (extremophiles) can exist under real hostile environments:

- Hot vents in the deep sea ("Smokers")
- In glaciers and ice-covered lakes in Antarctica
- Ice-covered subsurface lakes below glaciers
- Nuclear reactors
- Below Earth's surface ("Dark Life")

Dark Life below the Earth's surface

- More than 50 percent of the biomass on Earth exist as "Dark Life" below the Earth's surface
- Up to a depth of five kilometres in total darkness exist bacteria whose metabolism functions without sunlight
- Some of these bacteria are literally "stone eaters"
- They digest inorganic material like sulphur, iron and manganese compounds or even obtain their energy from radioactivity

Water bears (Tardigrades)

- Biggest water bears reach a body length of 1.5 mm
- Consist of 4 segments with 8 legs
- Can survive temperatures close to absolute zero and as high as 151 °C
- Can withstand the extremely low pressure of a vaccum
- Can live up at least a decade without water

Extreme life on Earth

• The bacterium „Deinococcus radiodurans“ can survive a radioactive dose being 100 times higher then the mortal dosis for humans. This bacterium can be found in alpaca droppings.

Extreme life on Earth

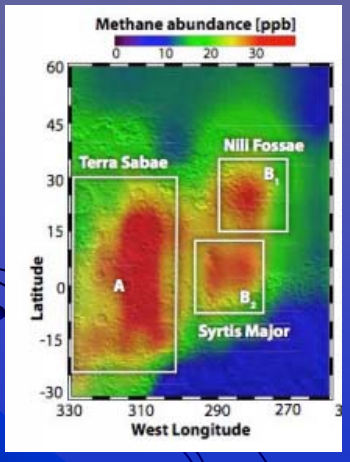
• „Deinococcus radiodurans“ is also nick-named „Conan the Bacterium“, because of the movie „Conan, the Barbarian“ starring the Austrian export to the U.S. Arnold Schwarzenegger.

Space missions with extremophiles

• In May 2011 water bears and Conan, the Bacterium were sent into space along with some other extremophiles on the final flight of the space shuttle Endeavour (Shuttle LIFE)

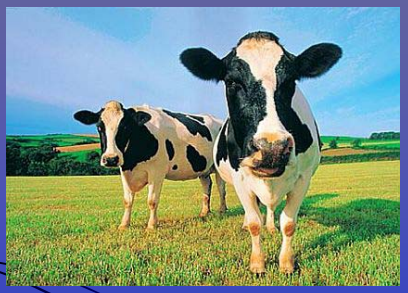
• At the end of 2011 the Phobos Life Mission will start to a three year trip to the Mars moon Phobos and back with the top-10 extremophiles on board (LIFE Phobos)

Life on Mars?



• In the Martian summer there exist regions with large methane emissions
• This methane could be due to bacterial life below the Martian surface
• On Earth a large amount of the methane in the atmosphere comes from agriculture like livestock farming
• On Earth methane is also produced by geo-chemical sources like volcanoes

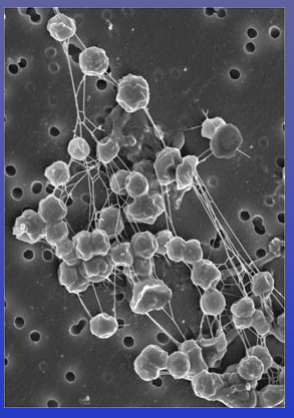
Origin of methane on Earth



Bacteria: Digestion of cattle, rice fields, dung piles, …

Origin of methane on Mars

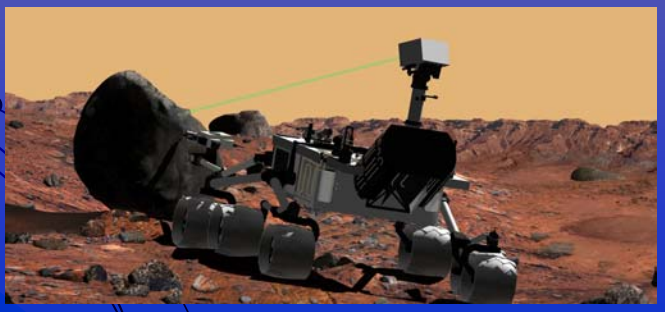
Martians: No



Dark Life: Possible

Origin of methane on Mars

• Mission to Mars "Curiosity" with a mobile Mars lab starts 2011
• One mission objective is to determine if the methane on Mars originates from living organisms using a Tunable Laser Spectrometer
• Consequences if methane originates from living organisms:
- Panspermia: Simple life can overcome large distances between planets
- The universe is abound with (simple) living organisms



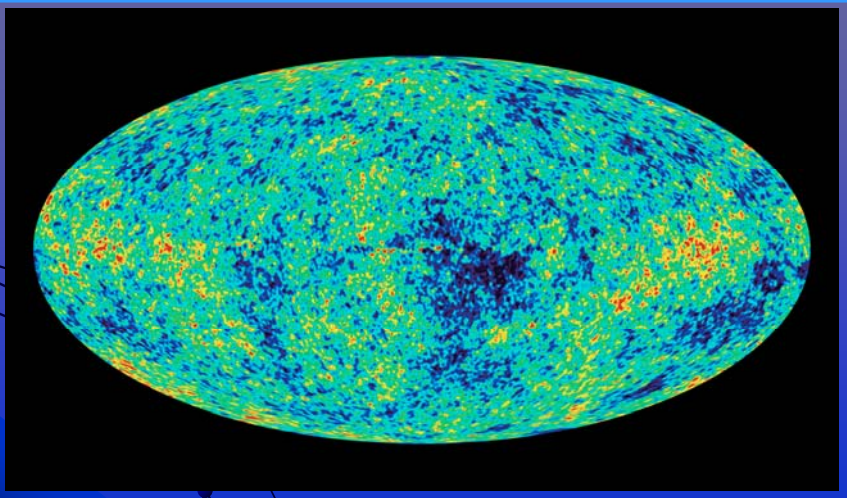
Big Bang

The universe originated 13.7 billion years ago from a state of extreme high density and temperature

What are the observations leading to the Big Bang?
• Recession of galaxies
• Cosmic background radiation
• Creation of light elements: hydrogen, helium, lithium

Cosmic background radiation

Faint background glow of microwave radiation coming from space



Cosmological fine-tuning

- There are observations that our universe has exactly the properties so that life can exist in it
- Fundamental physical parameters (masses of elementary parameters or strengths of basic forces, …) have almost exactly such values that life can exist in our universe

Production of carbon and oxygen

All the chemical elements except the lightest are created by stars („nucleosynthesis“)

Carbon and oxygen, the most important building blocks of life, are created in Red Giants

A tailor-made universe

• The creation of carbon and oxygen in stars depends sensitively in on the nuclear force

• A deviation of more than half a percent in the strength of the nuclear force from the value in our universe would already lead to a strong suppression of the production of carbon or oxygen

• Since carbon and oxygen are essential of life, our universe is also extremely fine-tuned to the existence of life

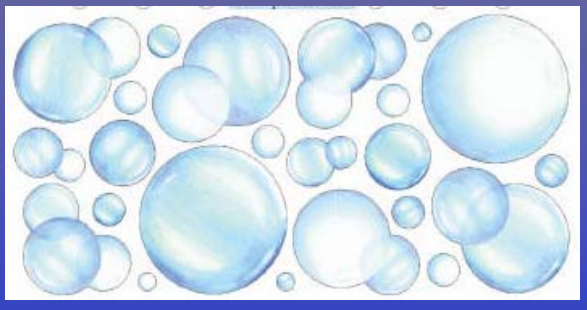
Theory of Everything

• Each theory that wants to explain the properties and structurec of our universe has fundamental physical parameters.

• A final "Theory of Everything" should explain the values of these parameters.

• The tiny range of these parameters for allowed values of life seems an impossible challenge for the mathematical "design" of such a theory.

Multiverse



The creation of the multiverse through chaotic eternal inflation

Our universe corresponds to only one bubble

Inflation

Gigantic expansion of the Universe during the Big Bang

Explanation of many properties of the universe

- Creation of matter and radiation in the Universe
- Properties of the cosmological background radiation
- Expansion of the Universe
- Homogeneity of the Universe
- Inflation of quantum fluctuations to galaxies and clusters
- Creation of order: Clusters, galaxies, stars, planets, life

AND

- Chaotic inflation also predicts a multiverse

String Theory

• String theory is attacking the question what actually happened at the Big Bang.

• Instead of point-like elementary particles the building blocks are strings. The string theory has 11 dimensions, where 7 dimensions are wound up in aver small region.

• String theory leads to a gigantic number of 10^{500} solutions determining the different physical properties of the universe. This also supports the existence of a multiverse.

Meeting in Cambridge: Stephen Hawking

Meeting in Cambridge: Andrei Linde

Possible explanations of fine-tuning

Example: Kidnapper

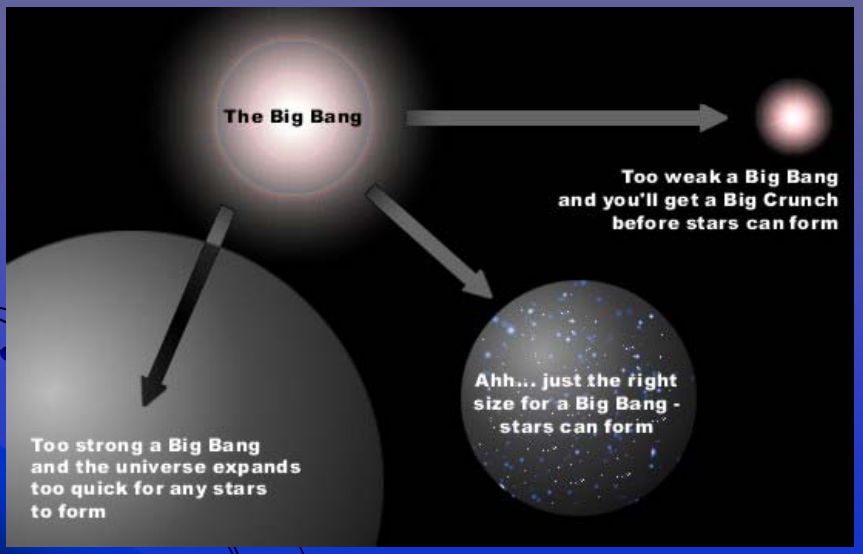
1.Hypothesis of coincidence:
"The universe is just so and need no further explanation."
2. Hypothesis of logical necessity:
"It must have been like this, otherwise we would not be here."
3. Theory of Everything (TOE):
"There exists a final fundamental theory that will explain fine-tuning. We just don't know this theory yet."
4. Multiverse hypothesis:
"There exist an infinite number of different universes. We live in a universe that allows life, whereas many other universes are sterile."
5. „Intelligent Design":
"There exists a creator."

The cosmological constant and fine tuning

• The observed cosmological constant or dark energy density governing the expansion of the universe has a tiny positive value (in Planck units). For life to exist its value must either have either a tiny positive (weak repulsive force) or tiny negative (weak attractive force) value being close to zero.

• If the cosmological constant would not have a tiny positive value the universe would expand so fast that no stars could form. Also if it would have a too large negative value it would end up in the Big Crunch before stars could form. In both cases the elements of life could not be produces in stars.

Matter and Antimatter



Optimal conditions for life

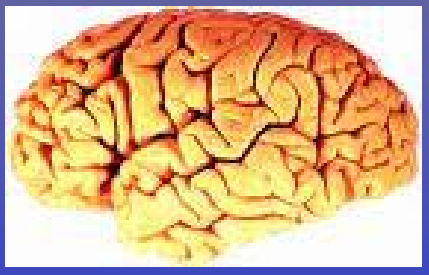
• If the cosmological constant Λ would not have a tiny positive value the universe would expand so fast that no stars could form. Also if Λ would have a large negative value it would end up in the Big Crunch before stars could form. In both cases the elements for life would not be produces in stars.

• The twist is now that the cosmological factor Λ has indeed a value in the life-allowed range for life. However, this is not the optimal value for life, which would be small negative value of Λ maximising the fraction of baryons that form living organisms.

Is God unintelligent or even sloppy?

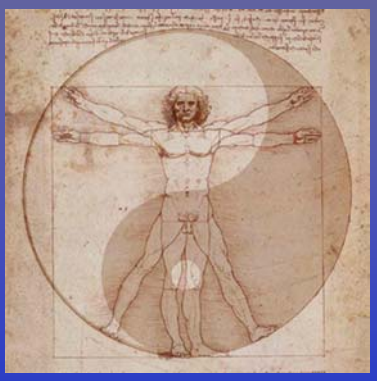
- If the Creator would have designed a single universe why did he not optimise it for life? Was he not intelligent enough? Or die he perform a messy job?
- The only way out for an all knowing almighty creator would be the creation of a multiverse of a huge number of universes with different cosmological values.
- However, leading members of the Intelligent Design movement do not favour such a multiverse. On the contrary they insist on a single universe designed by a creator.

Our brain: The great cheater



The split personality of human beings:
Totally unimportant and nevertheless self-assured

And what about human beings?



Maybe humans are not so totally unimportant, because they can analyse, describe and understand our universe

Thank you for your attention!