

# Bereshit: How the World Started According to the Book of Genesis and According to Modern Physics

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## 1. Outline

- If one takes the Bible literally, it is not exactly up-to-date with physics and biology.
- The world was not created in six days.
- People evolved from the apes, and were not created as they are now.
- This makes sense: the Bible reflects how people saw the world many centuries ago.
- Now we understand better.
- The more we understand, the less we are inclined not to take the Biblical stories literally.
- We view these stories as allegories teaching us ethical issue; for example, the story that we all come from Adam shows:
  - that we are all relatives, that we are all equal,
  - that we should treat each other with proper respect.

## 2. Outline (cont-d)

- But there is one exception to this tendency: the story of how the world came into being.
- In this, as we understood the physics better, we – surprisingly – moved closer to the Biblical story.
- Why is this is somewhat a mystery.
- Why people millennia ago knew what we learned only recently, with very high technology.
- In this talk, we describe the history of how it all happened, and try to explain why it happened this way.

### 3. What the Torah Says About Creation: A Few Physics-Related Points

- [1:1] In the beginning when God created the heavens and the earth,
- [1:2] the earth was a formless void and darkness covered the face of the deep, while a wind from God swept over the face of the waters.
- [1:3] Then God said, “Let there be light”; and there was light.
- [1:4] And God saw that the light was good; and God separated the light from the darkness.
- [1:5] God called the light Day, and the darkness he called Night. And there was evening and there was morning, the first day.

#### 4. What the Torah Says About Creation (cont-d)

- [1:6] And God said, “Let there be a dome in the midst of the waters, and let it separate the waters from the waters.”
- [1:7] So God made the dome and separated the waters that were under the dome from the waters that were above the dome. And it was so.
- [1:8] God called the dome Sky. And there was evening and there was morning, the second day.
- [1:9] And God said, “Let the waters under the sky be gathered together into one place, and let the dry land appear.” And it was so.
- [1:10] God called the dry land Earth, and the waters that were gathered together he called Seas. And God saw that it was good.



Figure 1: G-d creates the world

## 5. Sky Was Believed to Be Solid: Why?

- How did people know what is there in China?
- They saw things coming from China: silk, jade, paper.
- How to people know what is there in the sky?
- We check what comes from the sky.
- First, water comes – as rain.
- This means there is water in the sky.
- (Also, sky is blue – the color of water.)
- Also, once in a while rocks fall from the sky.
- We now call them meteorites.
- This is similar to a stone wall.
- Sometimes – rarely – stones fall from it, this means it needs repairs.

## 6. Sky Is Not Solid

- Similarly, people believed that the sky is a solid dome.
- Once in a while small pieces of the sky fall down.
- Later, people realized that there is no solid dome.
- People continued to report falling rocks, but until early 19 century, such reports were dismissed as nonsense.



## 7. Space and Time Are Infinite: Early Ideas

- Since the sky is not the dome, not the limit, there should be no limit for space.
- In other words, space must be infinite.
- One of the first to promote this idea was Giordano Bruno.
- Since the space is infinite, there are infinitely many planets with intelligent life.
- So, each planet may have its own savior – this is what Mormons teach now.
- In the 16 century, it was a heresy, so he was burnt at stake in Rome in 1600.



Figure 2: Giordano Bruno

## 8. Space and Time Are Infinite: Newtonian Physics

- Isaac Newton made it official: space is infinite, time is infinite.
- There is no limit to space.
- There was no creation, no beginning of time.
- There will be no end, no Judgment Day: the world will never end.
- Newton's equations – based on this idea – accurately predicted positions of planets and eclipses hundreds of years ahead.



Figure 3: Isaac Newton

## 9. Is Non-Euclidean Geometry Even Possible?

- To Newton and to later philosophers like Immanuel Kant, infinite space with Euclidean geometry was the only possibility.
- Our usual – Euclidean – geometry got its name from Euclid.
- Euclid was a scientist from ancient Greece whose Elements described all geometry.
- He based his geometry on five postulates.
- The first four are simple and intuitive.
- Example: Postulate I: if we have any two points:



- Then we can have a straight line going through these points:





Figure 4: Immanuel Kant



Figure 5: Euclid

## 10. Is Non-Euclidean Geometry Even Possible (cont-d)

- Postulate V was not that intuitive:
- If we have, in a plane, a line and a point outside this plane:



- then there is exactly one line parallel to the given line that goes through this point:





## 11. Is Non-Euclidean Geometry Even Possible (cont-d)

- Vth postulate is too complex and non-intuitive.
- Mathematicians tried to derive this statement from other, more intuitive postulates.
- One of the methods was to prove it by contradiction:
  - we assume that this postulate is wrong;
  - we deduce a contradiction from this assumption;
  - this proves that the statement is correct.
- So, to get the desired proof, they analyzed what would happen if this postulate was false.

## 12. Non-Euclidean Geometry

- The above idea was most developed by Omar Khayyam from Persia, most known as a poet.
- His Rubayat were translated into many languages.
- One of his most famous poems sounds truly Biblical:

The Moving Finger writes; and having writ,  
Moves on: nor all your Piety nor Wit  
Shall lure it back to cancel half a Line,  
Nor all your Tears wash out a Word of it.

- Nikolai Lobachevsky: had an idea but could not publish it.
- Solution: brown-nose the Czar.
- Publication (in German), mockery, final success.
- Carl Friedrich Gauss – king of mathematicians.
- He discovered normal (Gaussian) distribution.

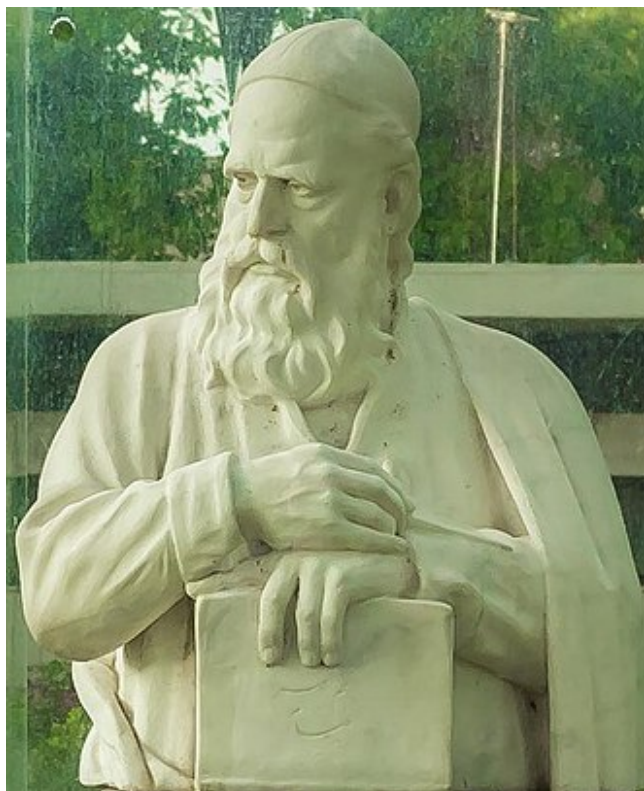


Figure 6: Omar Khayyam



Figure 7: Nikolai Lobachevsky



Figure 8: Nicholas I, Czar of Russia



Figure 9: Carl Friedrich Gauss

### 13. Non-Euclidean Geometry (cont-d)

- It is the well-known bell-shaped curve that describes the distribution of everything: people by weight, students by grade, etc.
- Gauss used the fact that the Vth Postulate is equivalent to the fact that the sum of the angles in a triangle is  $180^\circ$ .
- So, he measured angles in a triangle formed by three mountains.
- The result was different from 180!
- He was thorough, so he decided to measure again.
- He got a different result – also different from 180.
- He repeated measurements many times, plotted them – and got the bell-shaped curve!

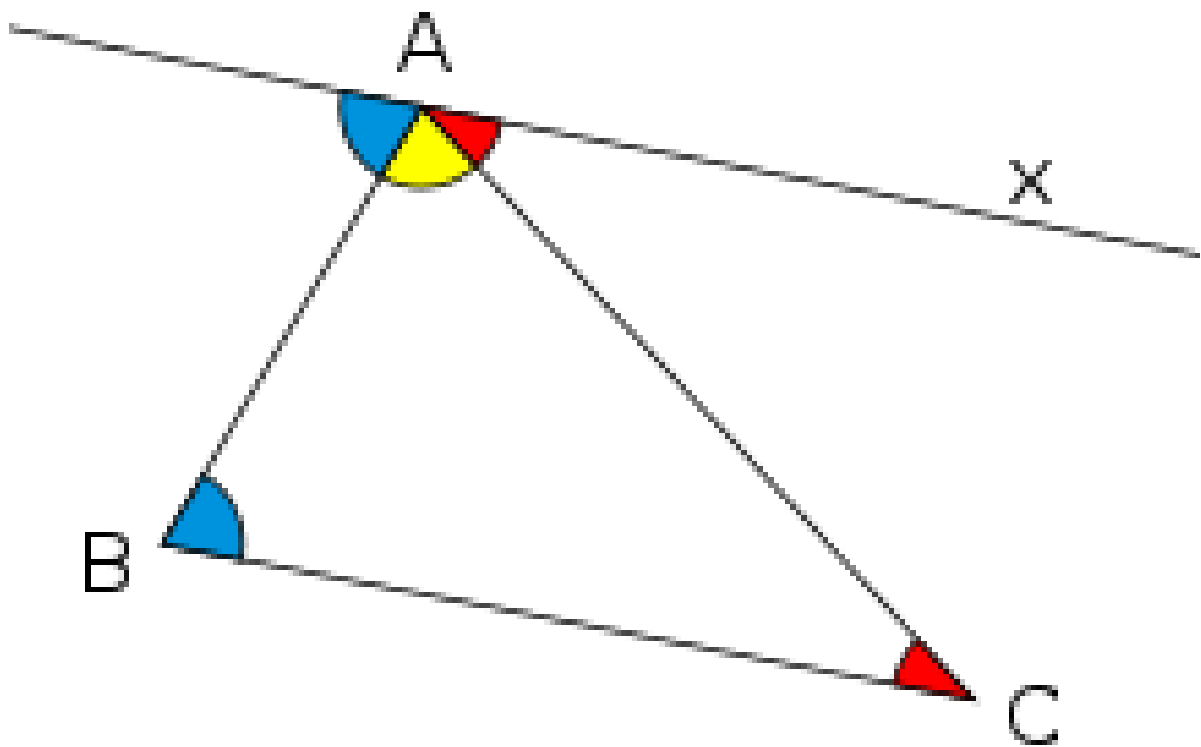


Figure 10: The angles of a triangle add up to  $180^\circ$



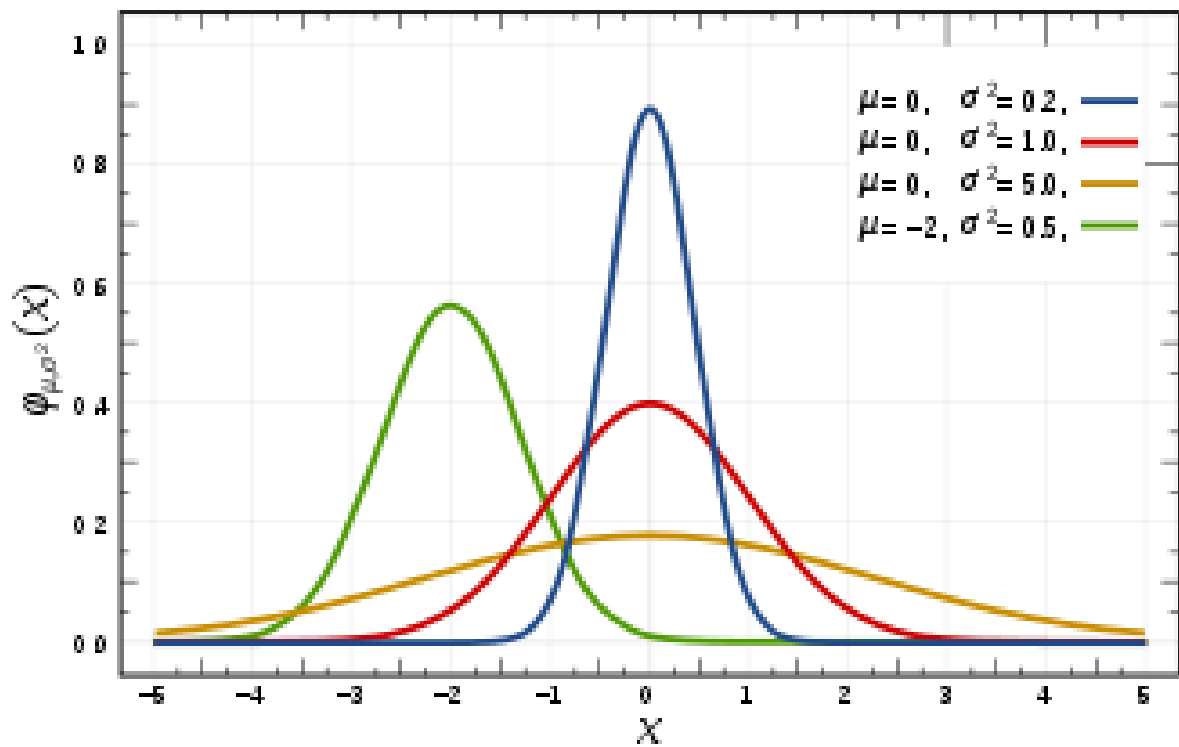


Figure 11: Bell-shaped curve

## 14. Problems with Infinite Space and Infinite Time

- Problem with infinite space:
  - with infinitely many stars,
  - it should be light at night.
- Problem with infinite time:
  - Second Law of Thermodynamics says that eventually, all temperature differences will even out;
  - if the Universe is infinite, it should have reached such a state, but it did not.
- Problem with Newton's physics:
  - Uranus position deviation from predictions;
  - a new planet Neptune was found explaining this deviation;
  - Mercury's position also deviated slightly, but no affecting planet was found.

## 15. Important Comment

- Deviation is  $43''$  per 100 years – only measurable since we have centuries of observations.
- This is why Greenwich and Pulkovo observatories are still active:
  - the presence of big cities make the details unclear.
  - but the ability to compare with what was observed 100 years ago helps.



Figure 12: Greenwich Observatory



Figure 13: Pulkovo Observatory

## 16. Enter General Relativity

- Einstein developed a theory that explained all the deviations.
- A Russian-Jewish physicist Alexander Friedmann showed that this theory, Universe had a starting moment.
- Einstein did not want his theory to support this religious nonsense.
- So, he modified his equations to avoid his conclusion: he added an additional *Lambda term*.
- But then a US astronomer Edwin Hubble saw that the Universe expands: galaxies move away from each other.
- When he divided the distance to the speed, he concluded that the Universe started a few billion year ago.
- So, in this, the Bible was right: the world had a starting moment!

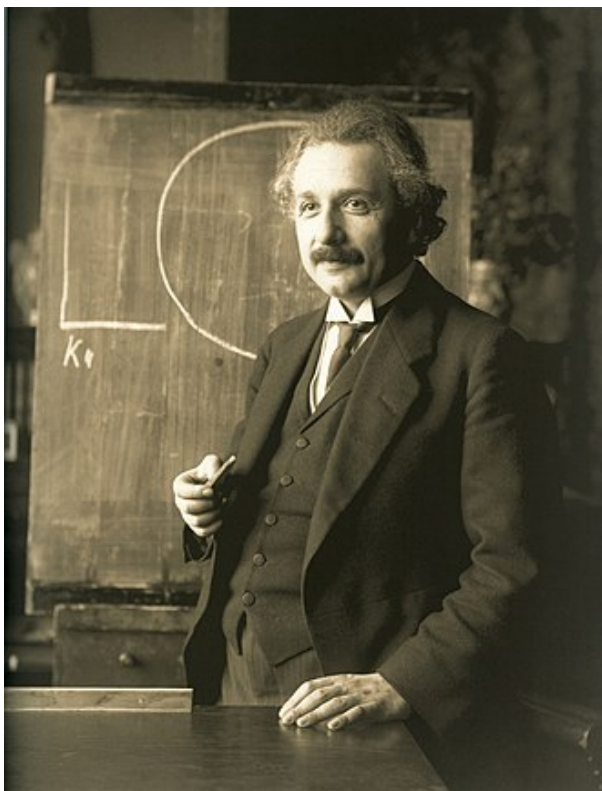


Figure 14: Albert Einstein

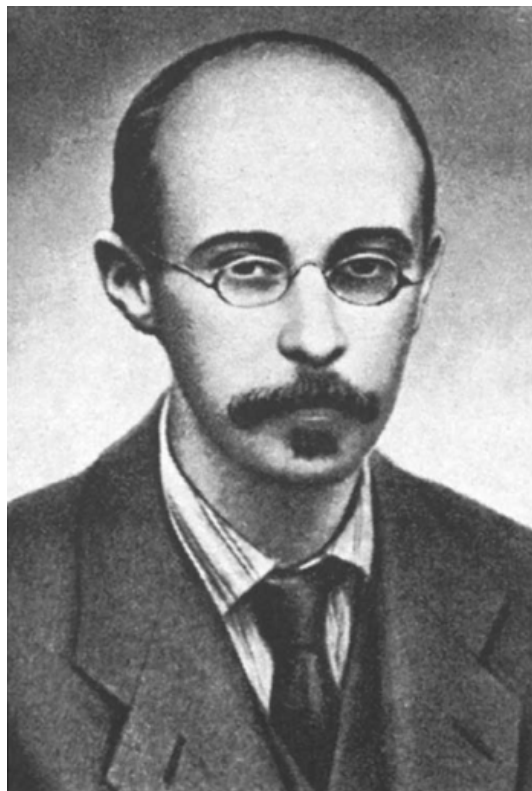


Figure 15: Alexander Friedmann



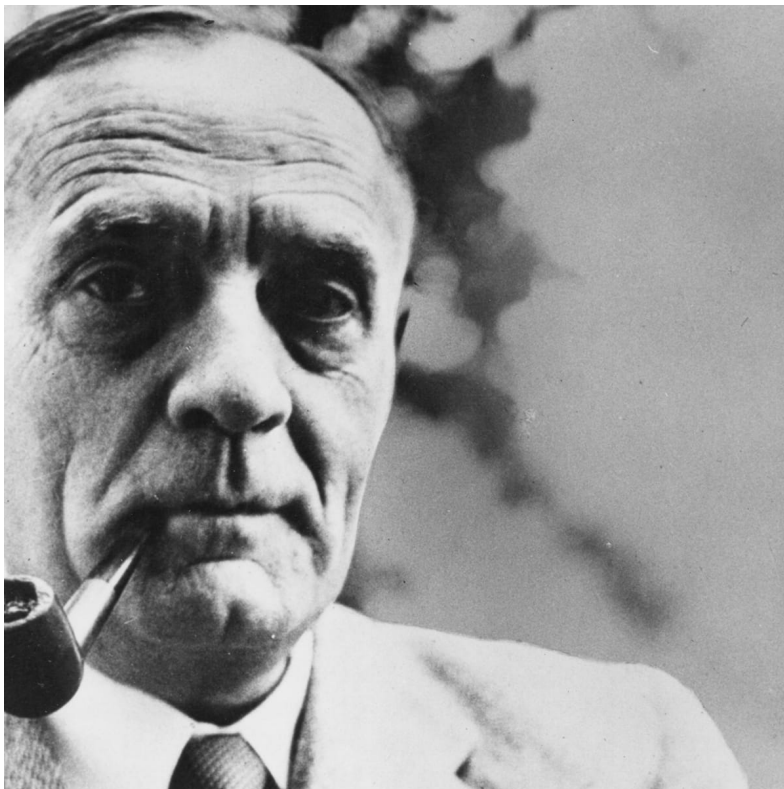


Figure 16: Edwin Hubble

## 17. But Why: A Possible Explanation

- It looks like ancient people knew what science only learned a century ago.
- But they did not have power telescopes, they did not even know Newton's laws.
- How could they know this?
- Maybe G-d himself told them – but then why didn't G-d tell them something more useful, e.g., how antibiotics can save lives?
- Historians of science puzzle over this.
- One possible explanation is that the Universe should be cognizable – otherwise, we would not survive in it.
- We are finite creatures, we can only store and process a finite amount of information.
- Thus, the Universe has to be described by finitely many values.

## 18. But Why: A Possible Explanation (cont-d)

- The Universe has to be described by finitely many values.
- To describe the Universe, we need to describe its state at all possible locations at all moments of time.
- Thus, there is, in effect, finitely many moments of time.
- So, there should be the first of these moments – the moment when the words started.
- But there is more to the Biblical story than this.

## 19. Let There Be Light

- According to General Relativity, at the beginning, the Universe was filled with light.
- However, for a long time, there was no confirmation of this.
- What helped was World War II.
- To detect German planes coming to bomb England as early as possible, engineers designed a radar.
- A radar sends a signal, and detects reflection from a plane.
- To detect this reflection, engineers designed very sensitive antennas.
- After the war, these antennas were used in radio astronomy.
- Signals from faraway galaxies are very weak.
- If you turn a sheet of paper, you used more energy than all radio-telescopes have received.

## 20. Let There Be Light (cont-d)

- To detect weak signals, engineers need to eliminate noise as much as possible.
- They eliminated many noises, but some noise remained.
- In 1965, Arno Penzias and Robert Wilson showed that the remaining noise does not come from any specific source.
- This noise fits perfectly with what was expected as a remainder of the original light.
- So, the Universe did start with light!

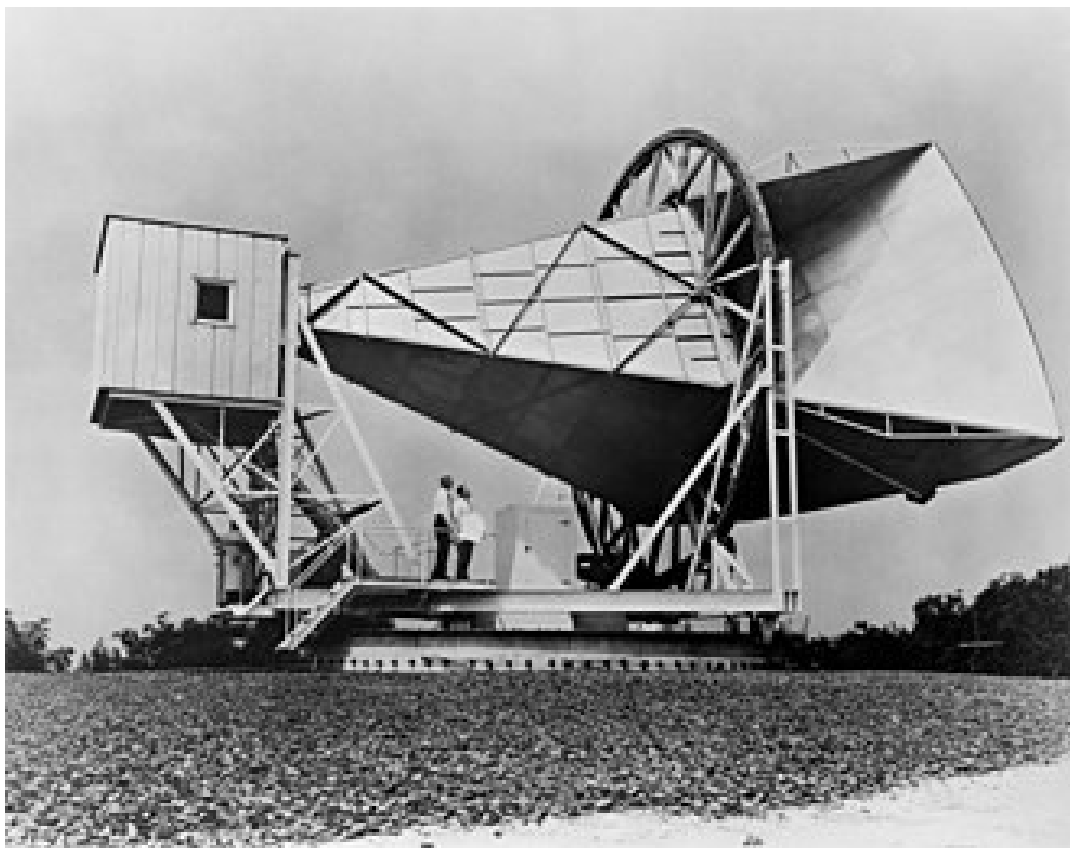


Figure 17: Antenna on which Penzias and Wilson discovered Cosmic Background Radiation

## 21. What Have We Learned?

- Ok, we probably learned a little bit of physics.
- But what we mostly learned is that we should not simply dismiss Biblical stories as naive science.
- Sometimes, it looks like these naive stories contradict modern science – as it was in Newton's times.
- But sometimes – as in this case – later development of science reveals the deeper meaning of these stories.
- Of course, this does not mean that they are literally true.
- The world was not literally created in six days.
- But it is always wise to look for deeper meaning in the sacred texts – even when these texts sound naive.



Figure 18: G-d creates the world