Lecture at the *Società Dante Alighieri*, Rome, 16 Nov 2017

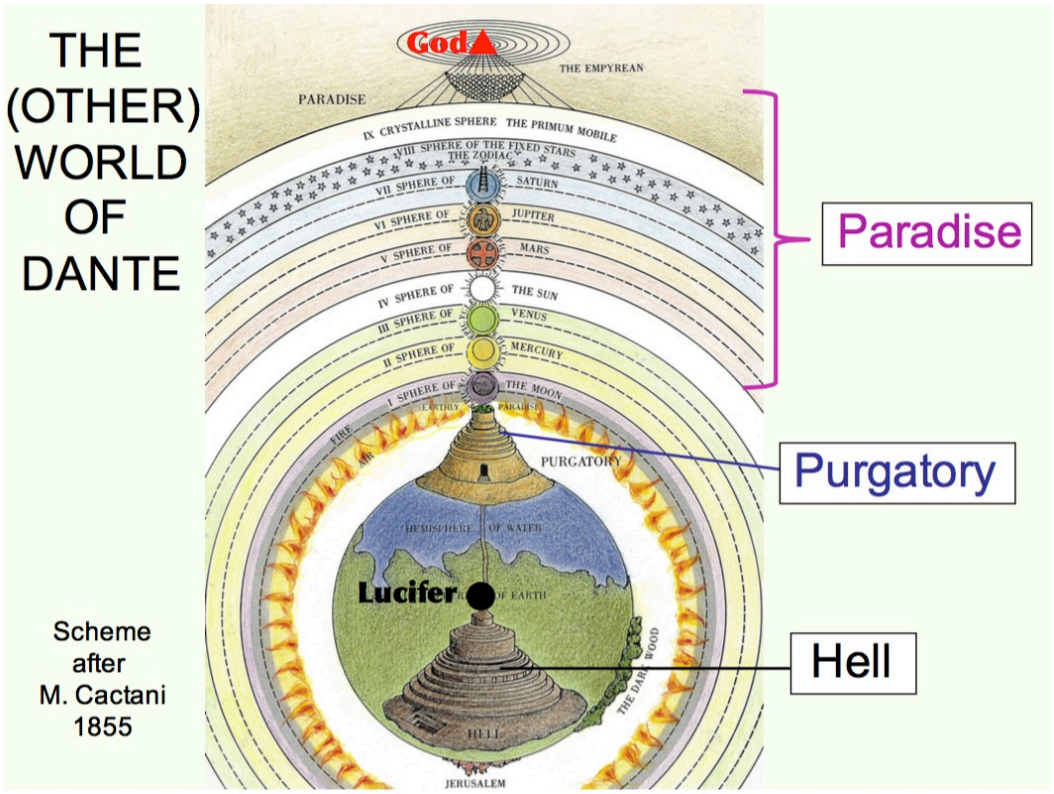
Ladies and gentlemen, it is a great honour and pleasure for me to address you at this wonderful and historic place. I would like to thank Secretary General Alessandro Masi and Anna Ruedeberg of the Berne Committee for their invitation.

Let me start with a small incidental remark. It was also November – in November 1301 – when Dante was last here in Rome. He was on a diplomatic mission to the Vatican to avert the threat of the Black Guelphs taking over Florence. It is well known that this did not succeed, and Dante had to flee his hometown after returning the following year. But why am I telling you this? In the weeks before Dante's trip to Rome, a large comet appeared in the sky. This could only be understood as a bad omen. Dante mentions it briefly in the Convivio, but strangely enough not at all in the Divine Comedy, although Dante always paid close attention to signs of heaven. Today we know that it was the most famous of all comets: the comet Halley. Its appearance in 1301 at least left its mark on a friend of Dante's, Giotto di Bondone, who a few years later painted the star of Bethlehem as a comet in his famous fresco of the Adoration of the Three Magi in the Scovegni chapel at Padova. It is undoubtedly the comet Halley in 1301.

But let us now turn to our subject: the relationship between the world of Dante and today's cosmology. I would like to say in advance that the comparisons between Dante's journey and our current space exploration, which I explain in the following, must not be understood in a scientific sense. The Divine Comedy is still part of our culture today. But on a scientific level, Dante certainly has nothing to do with modern astrophysics. His medieval world is completely different from the modern world in every respect. Nevertheless, it is possible to compare the two worlds in a valid way, namely by means of *analogies.* As presented in detail below, there are astonishing similarities between the cosmos of Dante and the modern universe. – But what exactly is an analogy? Firstly, analogy does not mean equality. An analogy is a similarity – in form, proportion, structure or even function – between different things that have nothing to do with each other causally. Analogous things are on parallel planes, so to speak, it is a *non-causal* relationship. Well, what are these analogies for? Are they just a nice game? There are

people who think so. Of course, I don't have the same opinion. I believe that the analogies between Dante's medieval world and the modern one should be understood as signs of a common symbolism, a psychological symbolism that seem to be inherent in both. This symbolism refers to the spiritual meaning of the Divine Comedy, the Dantists speak of the *anagogical* meaning, the fourth sense of the Divine Comedy, which goes beyond the literal, allegorical and moral sense. Looking at the hierarchical structure of Dante's cosmos, the ethical dimension of the world, from evil at the very bottom to the good and holy at the very top – and Dante's journey takes place along this path, from the bottom to the top, like an ascent – the spiritual or psychological sense, the symbolism of the Divine Comedy, reveals itself without further ado: as a pilgrimage to the deep self, as a return to the divine core and origin of the human soul.

The spiritual sense of contemporary cosmology, on the other hand, if we do not want to deny the existence of such a sense, is less clear and appears more hidden. On the contrary: it is not hidden at all, because there is no sense for itself, independent of us. The meaning of a thing is never found in the outside world, it is always what we ourselves put into it. And it is precisely through these analogies shown here that we have the opportunity to transfer the symbolism, the obvious spiritual meaning of Divine Comedy, at least in part, to modern cosmological research, to today's astrophysics – whatever the true meaning of analogies. In short, in my opinion, we researchers of astrophysics and particle physics also unconsciously make a symbolic journey to the self, to the transcendent origin, and this can (but does not have to) give our task a spiritual meaning. For me this is a satisfying vision, for others less. I just want to make a suggestion, an offer of how we can see and understand our work in a very different way. Conversely, these analogies may offer a new way of understanding, reading and especially appreciating the Divine Comedy.



1

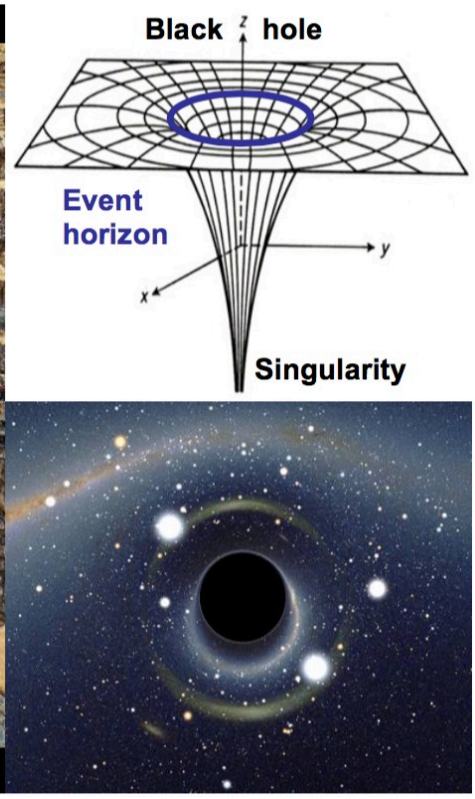
Fortunately, it is not necessary to explain the Divine Comedy to an Italian audience. But a short summary of Dante's world with this standard scheme can be useful (**Figure 1**). His system is geocentric, in accordance with the knowledge of his time, or more precisely, the world of Dante is diavolocentric because Lucifer occupies the center. Around the terrestrial globe, or more precisely around the sublunar space in which the four elements of Aristotle are located (earth, water, air, fire), the spheres or heavens of the celestial bodies extend concentrically. The whole system is a little reminiscent of the structure of an onion. The spherical shells consist of an indestructible substance (the fifth element, the *quintessence*) and rotate uniformly and without interruption. First come the planets (Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn), then the fixed stars and finally the *Primum Mobile*, the first moved object, a pure crystal heaven that sets all other spheres in motion. At this point we reach the boundary of the physical world, the boundary of space and time. Dante designs three realms of the dead – these are zones that cannot or must not be reached before death (except for Dante in his vision!). The three realms correspond to the three parts (*cantiche*) of the Divine Comedy: firstly, we have *Hell* (*inferno*) under the ground, where the lost and damned souls are; secondly, *Purgatory* (*purgatorio*), a mountain on the other side of the earth unknown at that time, with the saved souls still to be cleansed; and thirdly, *Paradise* (*paradiso*), where the cleansed souls are. There are, in fact, three distinct categories of paradise: the terrestrial paradise (Garden of *Eden*) on top of mount purgatory, the heavenly paradise that encompasses all spheres, from the moon to Primum Mobile, and the *Empyrean*, the absolute beyond space and time, seat of God, the Blessed and the angels. The entire system is clearly bipolar. Everything, the whole world – like the human soul – is suspended between the two poles: God in the highest place, Lucifer in the lowest. As already mentioned, this defines an axis, a scale of morality and ethics. The Divine Comedy tells of the poet's journey through the three realms of the dead. Dante is first guided by Virgil through the Hell culminating in the meeting with Lucifer; from there he moves up along this axis (or scale), comes out of Hell and then continues over the terraces of mount purgatory to the terrestrial paradise on its summit, where Beatrice takes command of Dante, ascending with him through the heavens, to God.

In the following I present some analogies between the cosmos of Dante and the modern one. The easiest analogy to discover relates to the structure of Hell. Here is the classic representation of Botticelli (**Fig. 2**). Hell has the shape of a funnel, a huge cone placed on top of the apex, which corresponds to the center of the earth, the center of the entire cosmos – the seat of Lucifer, the archbetrayer who is trapped in the ice. The upper part of Hell resembles an amphitheatre, the lower one a well. One enters Hell through a gate, and above the gate there is an inscription: Dante is reading it:

Through me the way into the suffering city, ... , Abandon every hope, whi enter here.

This is the certainly most famous verse of the Divine Comedy (– unfortunately, I would say. It is known that most readers of Dante do not get beyond reading Hell. Hell is the world of evil, which is widespread in newspapers, on television and the Internet, so it is understood very well. Hell is funny. Purgatory already less so, and Paradise seems so abstract, incomprehensible and boring that it is not read. Too bad!)

2

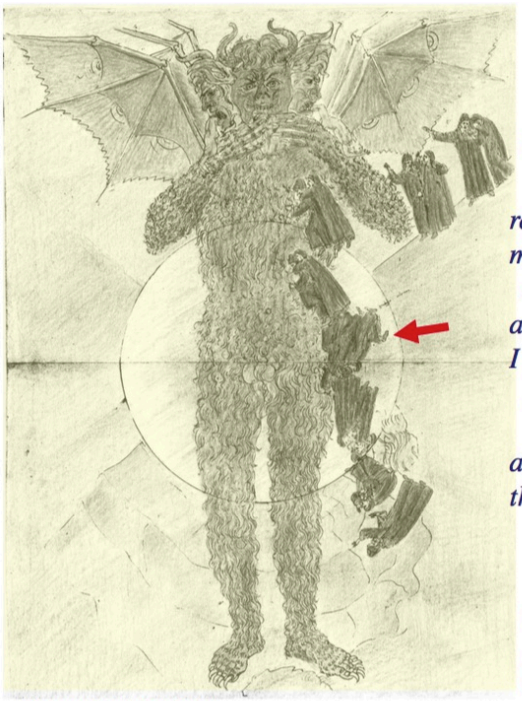


3

But back to the verse *Abandon every hope* ... : it points to the essential characteristic of Hell: once you have entered it, you can no longer escape; Hell is an eternal captivity. Now in astrophysics there is an object of this prison character, a trap, a very famous and popular object: (**Fig. 3**) the *Black Hole*, an object of Einstein's theory of relativity. If a mass is compressed beyond a certain limit, this leads to a total gravitational collapse. There is no longer any matter, but only curved space around a central singularity. In the usual description of this situation, the field of the gravitational effect – reduced to two dimensions (necessarily) – is represented by a curved surface whose steepness indicates the gravitational force. Here's the picture of a well! In addition, the Black Hole also has a gate: there is a critical distance that should not be crossed, otherwise an eternal captivity follows here as well: it is the

so-called *Schwarzschild radius* or the *event horizon*; non even light can escape from the inside of this boundary (therefore the name *Black* Hole).

The symbolism of gravity is very clear. Gravity symbolizes evil or the inclination for evil deeds. In colloquial language, for example, it is said: evil pulls someone down, or an immoral act causes someone to fall down, and so on. The central singularity in Dante's Hell is occupied by Lucifer, who represents, embodies and symbolizes evil in itself. The singularity concerns not only the central position, but also the effect of gravity. Let's take a look at what happens at the moment when Dante and Virgil are about to pass Lucifer, and listen to the following verses (**Fig. 4**):



Ilustration Botticelli

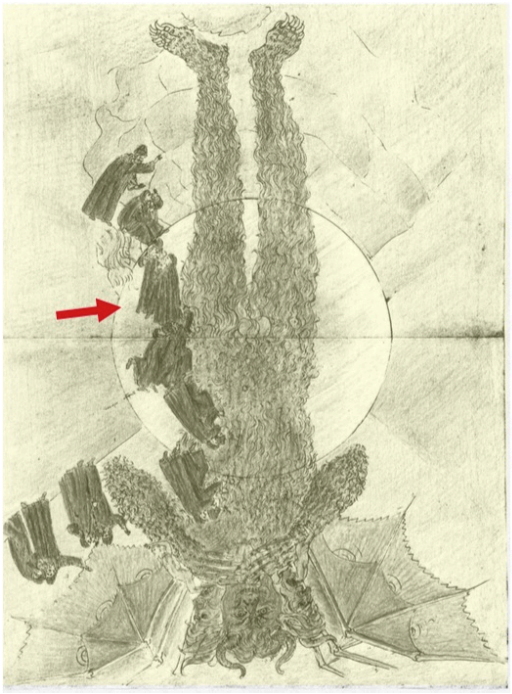
Hell XXXIV 76–84

When we had reached the point at which the
thigh
revolves, just at the swelling of the hip,
my guide, with ***heavy strain*** *and* ***rugged work****,*
reversed his head to where his legs had been
and grappled on the hair, as one who climbs –
I thought that we were going back to Hell.
„Hold tight", my master said – he panted
like
a man exhausted – it is by such stairs
that we must take our leave of so much evil".

Dante and Virgil passing the center of Earth

4

... *heavy strain and rugged work* – This means that the closer you are to the center, the stronger the gravity is there. According to Newton's gravitational law, the opposite is true: The gravitational force decreases to zero when approaching the center of the earth. The situation described by Dante thus resembles Einstein's gravity rather than that of Newton. The singularity is a turning point at which the impression, the feeling of "going down" changes almost instantly (**Fig. 5**) to a feeling of "going up", which astonishes, confuses and irritates Dante. He continues his report:

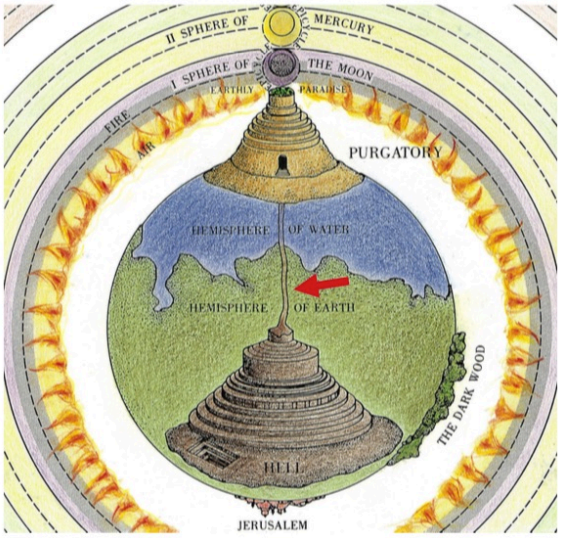


Hell XXXIV 88–93,106–111

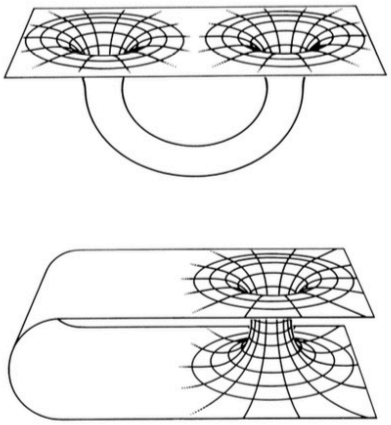
I raised my eyes, believing I should see
the half of Lucifer that I had left;
instead I saw him with his legs turned up;
and if I then became perplexed, do let
the ignorant be judges – those who can
not understand ***what point*** *I had just crossed.*
. . . .
And he to me: "You still believe you are
north of the center, where I grasped the hair
of the damned worm who pierces through
the world.
And you were there as long as I descended;
but when I turned, that's when you passed
the point
to which, from every part, all weights are
drawn."

5

... *the point to which, from every part, all weights are drawn* – that is the singularity.
How do the pilgrim and his guide escape from Hell? (**Fig. 6**) Through a narrow tunnel that leads to light from the other side of the earth. How to escape a Black Hole? In the same way: You can't come return, there is only the escape forward, through the singularity. (**Fig. 7**) An even more exotic object of Einstein's theory than the Black Hole is called a *Wormhole*. The connection of two Black Holes creates a wormhole – and this connection at least theoretically makes such a transit possible through the gravitational singularity.



6



Wormhole

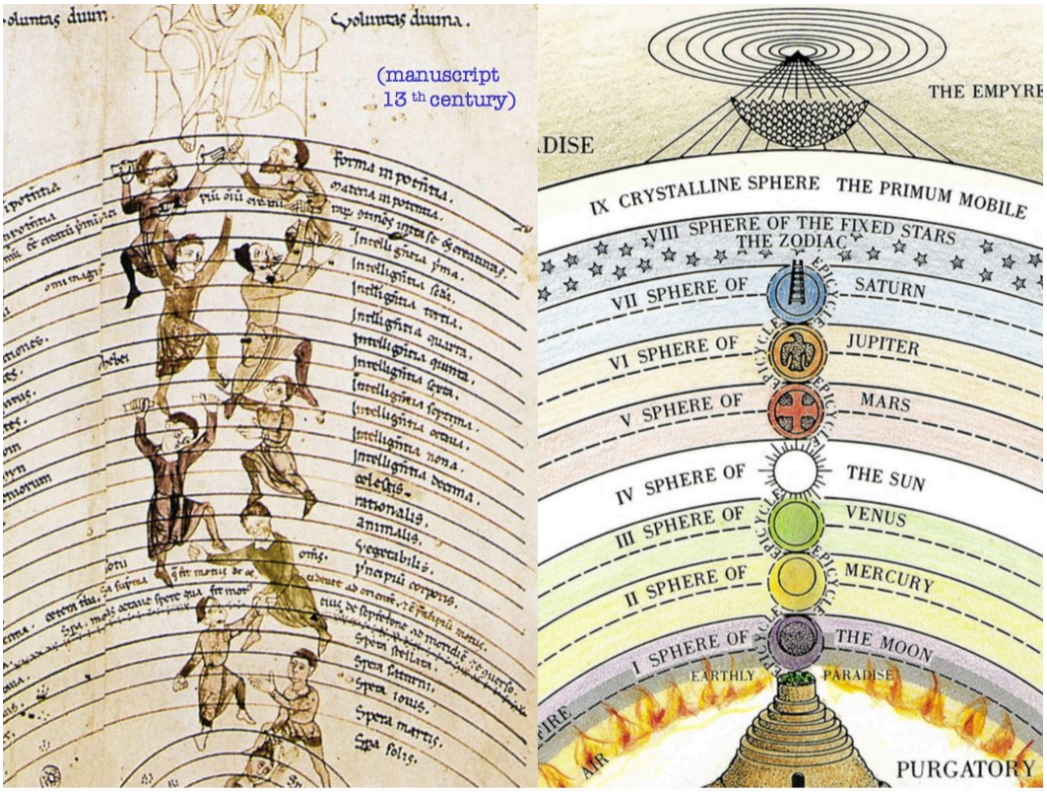
7

8

(**Fig. 8**) ... *we emerged, to see – once more – the stars*. This is how the last verse of the first part of the Divine Comedy sounds. The stars were missing in Hell, and this absence is perhaps the worst thing in Hell.

Then comes the second part, Purgatory. We'll skip it. Here is its last verse: ... *pure and prepared to climb unto the stars.* (**Fig. 9**) Again, the last word is *stars* – and so it will be at the end of the Paradise, at the very end oft the whole poem, as you know. (No wonder an astronomer is interested in Dante! –)

9

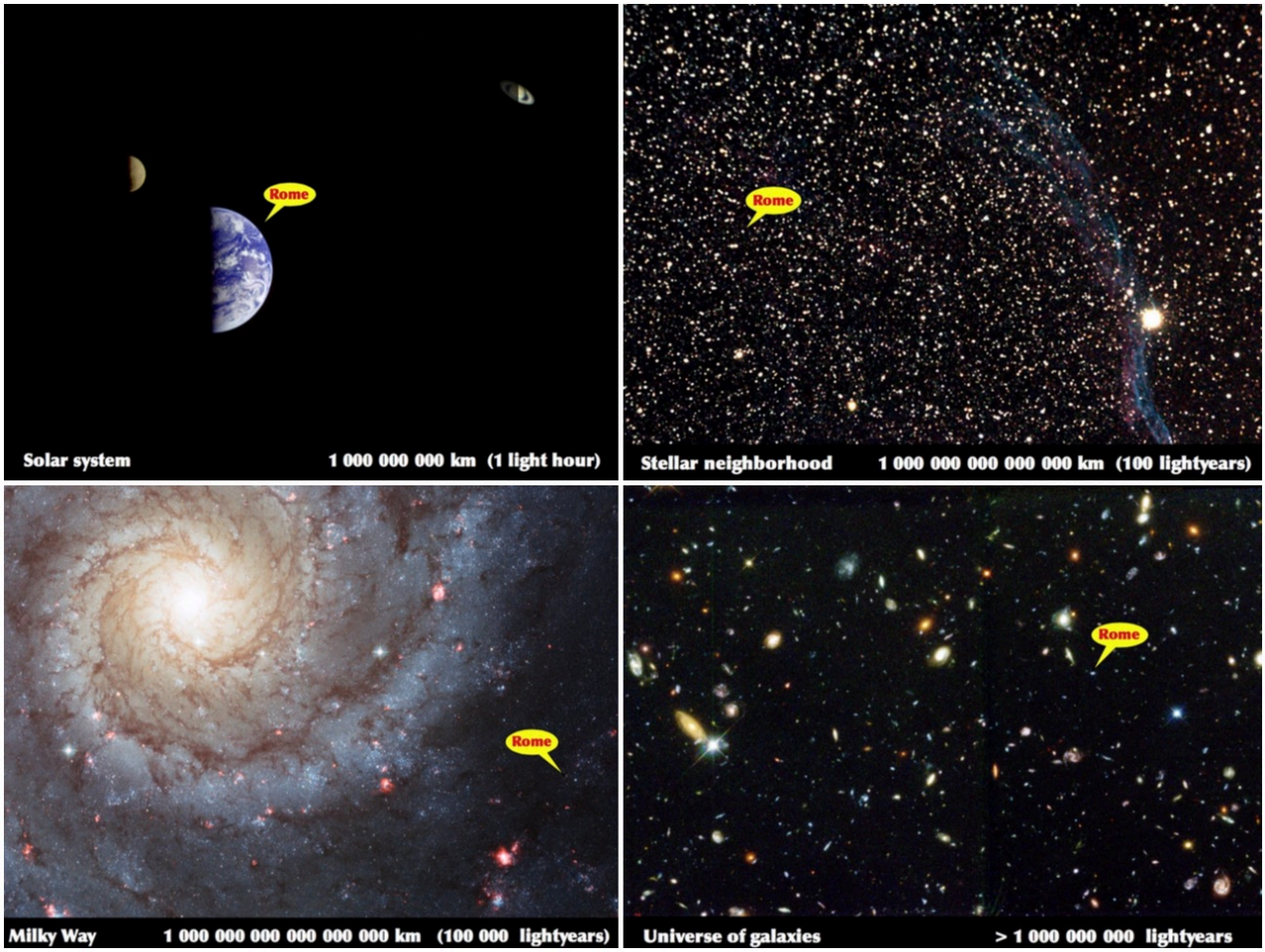


10

But what happened here? After climbing the mountain, Dante and Virgil reach the Garden of Eden, where Beatrice finally appears and Virgil disappears. It follows Dante's confession and penance to Beatrice, and after bathing in the rivers of earthly paradise, Dante is *pure and prepared to climb unto the stars.* Now Dante can not only see the stars, but he can climb up to the stars. Gravity returns again as a symbol of evil, or more precisely the other way around, antigravity as a symbol of goodness. As soon as evil is overcome (by catharsis), the soul rises like a hot-air balloon after the ballast has been thrown down. Thus begins the ascent of Dante and Beatrice (**Fig. 10**). The ascent leads them through all the heavens, i. e. all the spheres where they meet the souls of the saints, up to the Primum Mobile, the highest sphere, and – metaphorically (in his vision) – further into the Empyrean, the realm beyond space and time. On the spiritual level, the ascension signifies the return of souls to the Creator, as shown here on the left in this beautiful contemporary illustration. The whole process is a bit like the one in which an underwater bubble of air rises to the surface and returns to its place of origin. The image of ascension (and of spiritual hierarchy in general) is based on a neoplatonic conception. The unspeakable *One* of the neoplatonists leads to the intellect (*logos*) which in turn leads to the *anima mundi* and the individual souls, and finally to the physical things. It is a sequence of emanations and results in a hierarchy, an ethical scale that leads from top to bottom. And after death, assuming that it has not made only a one-way ticket, the soul goes back from bottom to top, to the One (that is, to God in the Christian sense). But this return to the source can already happen in life – at least on the mental level – through meditation, art, poetry; and such did Dante in his vision!

But what does modern astrophysics have to do with this? For centuries we have known that in cosmic space, in the universe, there are no longer "above" and "below". There are no spheres, there is no hierarchy, there is no preferred direction in space. In fact, our world view and our idea of the world seems to be infinitely different from that of the Middle Ages. Let's have a look where we are. (**Fig. 11**) Earth is a globe, that is true, but it moves around the Sun, like the other planets. And the Sun is just one star among thousands and millions of other stars – huge balls of hot gas, in distances and separations between them, which are already so large that it is better to convert the unit of measurement from

kilometers into light years. Further, the sun and all the stars we see at night are part of a huge system of about hundred billion stars, called the Milky Way, our galaxy; we are located on the edge of this system and ride around the center of the galaxy once in 230 million years. Finally, our galaxy is only one of billions of billions of other galaxies that make up the whole universe. So how can we compare this vast, almost infinite universe with the tiny cosmos of Dante that he travels in a few days? It seems ridiculous!



11

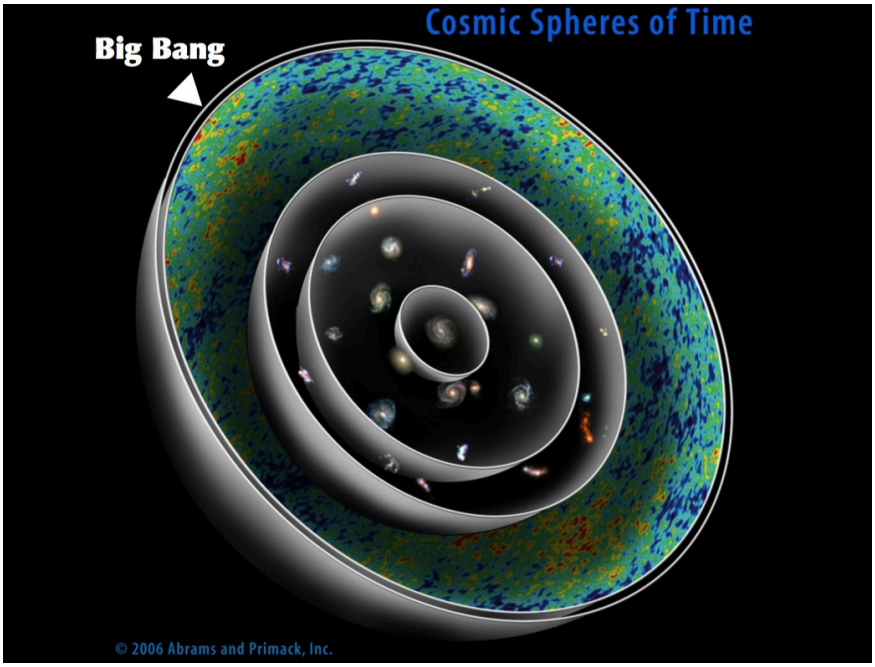
This is where one of the most fundamental observations of modern science must be brought into play: the finiteness of the speed of light! According to Einstein's theory of relativity, nothing can be faster than light which travels a distance of almost 300,000 km per second. The consequences of this fact are not obvious in everyday life, but on the scale of astronomy and cosmology they are very drastic. When we look at the sky above us, we see the celestial bodies not as they are at that moment, but as they were when they radiated the light we see now. Every look into the depths of the sky is actually a glimpse into the past, or more precisely: The further we look into the space, the further we penetrate into the past, that is, the closer to the origin of time.

12

(**Fig. 12**) So we do not see the moon as it is at this moment, but as it was a second ago, in accord with the time it takes for the light to reach the earth. Okay, this is not a serious delay. But the image of the sun comes already 8 minutes too late, because the sun is 8 lightminutes away from us. The stars that are visible at night, at distances from a few light years to thousands of light years, we see as they were so many years or thousands of years ago. Who knows, one or the other star is no longer there (perhaps exploded or extinguished), but the signal has not reached us yet. We have no access to the distant space as it is *at the moment*, this is completely impossible; space and time are always interconnected. A relatively close galaxy, say 10 million (!) lightyears away, is seen as it was 10 million years ago. And so

on – penetrating ever deeper into the depths of space. On deep images of very long exposure times as received by the Hubble Space Telescope, we look at galaxies billions of light years away, so we see them as they were billions of years ago. In fact, very small galaxies on images of this kind must be at extreme distances and been recorded in *statu nascendi*.

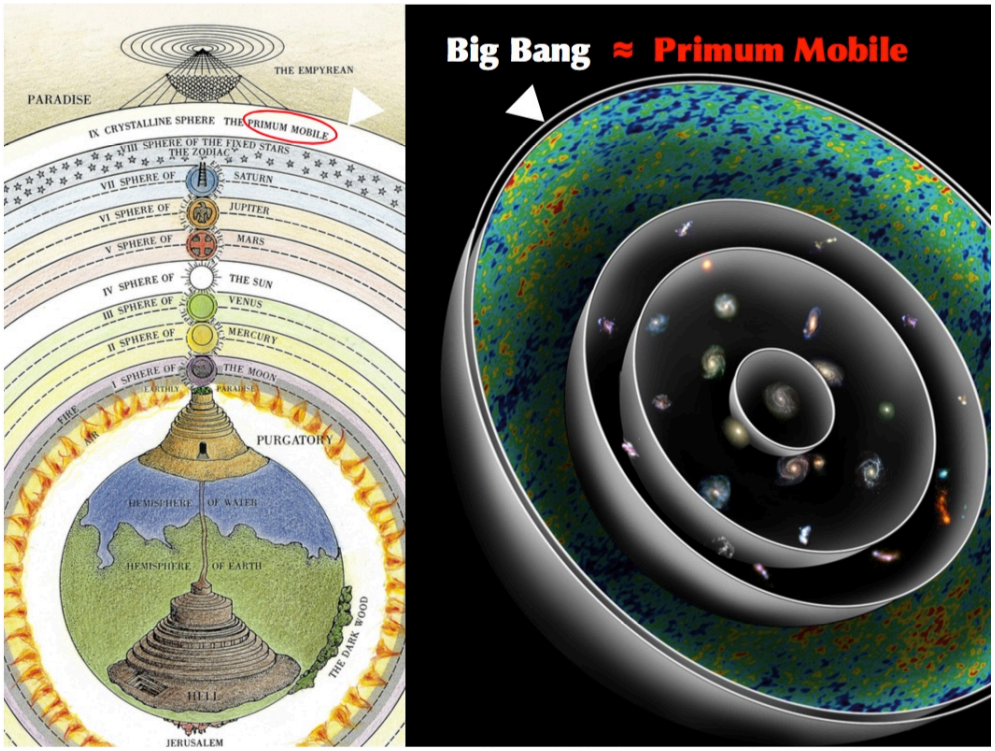
Eventually, going deeper still, we reach an epoch of the past in which neither galaxies nor stars existed because they had not yet been created. For this reason, nothing can be seen, at least nothing in the visible wavelengths. We penetrate the darkness... up to the earliest times, when the universe was still a dense and hot particle soup, about 14 billion years ago. From this epoch we receive a radiation, which was discovered 50 years ago with this radio telescope (small b/w insert, bottom right). It is the so-called *Cosmic Microwave Background*, a fossil radiation, a kind of weak echo of the Big Bang; weak, because the universe has expanded a thousand times since then and therefore cooled down by the same factor. In this way, the wavelength of the radiation was also stretched, such that today we receive microwaves. The image of background radiation, with these tiny irregularities – they constitute the seeds of cosmic structure – is a snapshot of the beginning of our world. What we see in this picture corresponds to a direct view of the most distant regions of the cosmos and at the same time of its temporal beginning. (Note, however: It is not the case that we see the Big Bang itself here; the first four hundred thousand years the universe was intransparent to radiation; therefore the Big Bang, the act of creation itself, remains hidden, an object of theoretical investigation.)



13

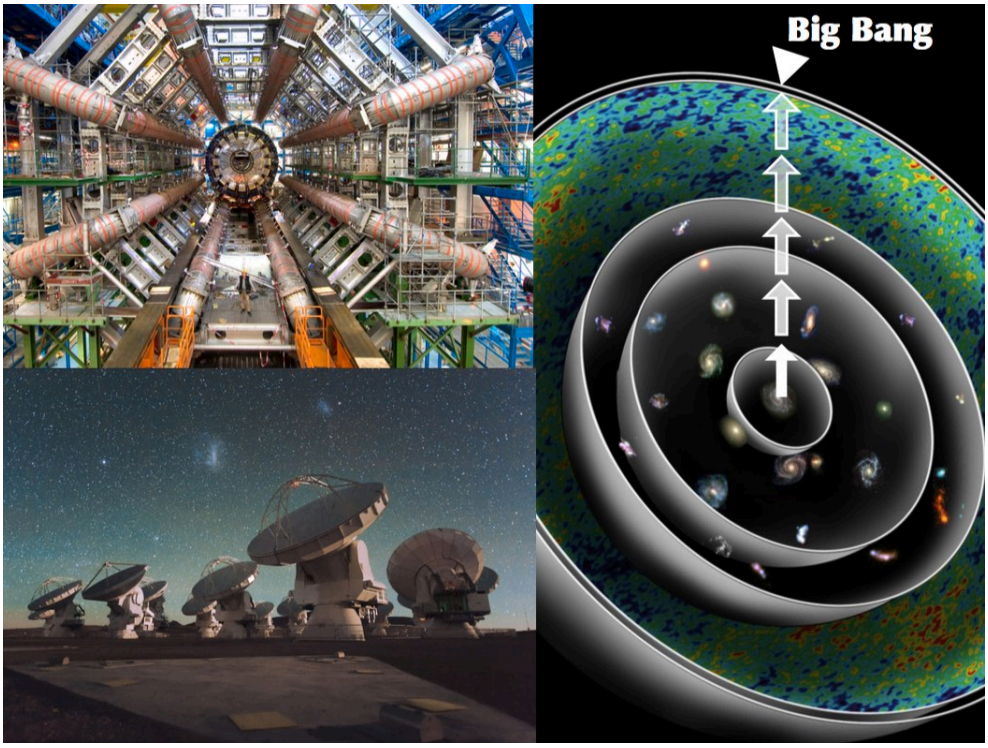
If we now put together all the images of objects that we have seen in the past in a sequence of space and time, we obtain the following cosmic schema (**Fig. 13**). All objects that we observe in the same (arbitrary) past are at the same distance, i.e. the distance corresponding to the past moment in which the light that we now receive has been emitted; so these objects are on the surface of a sphere; a particular cosmic era defines a particular sphere. The result is a sequence of concentric spheres with us viewers in the middle and with the Big Bang, the beginning of time, projected onto the last (largest) sphere. One could speak of' „temporal spheres“. But these spheres are not individually visible: time is a continuous quantity, so the sequence of spheres is also continuous. But it is immediately noticeable that the image of the onion returns as a model or figure of the cosmos! Due to the finiteness of the speed of light, the observed universe – more precisely: the *observable* universe – necessarily takes the

form of a sphere. The schema here does not represent the spatial structure of the universe, which has neither a center nor a boundary; it represents the temporal structure of the cosmos, since time does have a "boundary", a beginning. The entire evolution of the universe, from the Big Bang to the present day, is transformed into a spherical spatio-temporal map. The present epoch is here, at the center, and the Big Bang defines the boundary of the sphere of the observable cosmos.



14

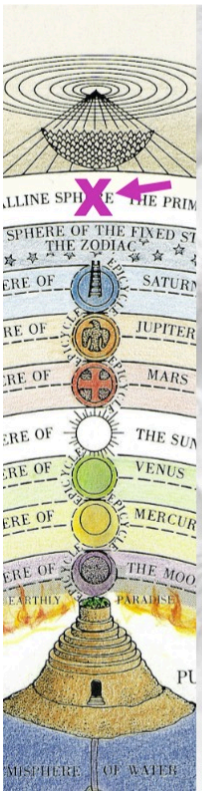
I now come to the central point of my presentation (**Fig. 14**). Let's make a comparison with the system of the medieval world on which the Divine Comedy is based (left). The analogy between the two worlds should catch everyone's eye! The uppermost sphere of Dante's cosmos is the Primum Mobile, the transmission belt of the whole world; in the modern cosmos it is the Big Bang – and it has the same function: everything derives from the Big Bang, it is a Primum Mobile as well! Surely one could argue that this comparison doesn't work, because the modern cosmic onion is almost infinitely much larger than the old one; – that's true, but that's a quantitative argument. The quality of a thing – like form and function – seems to me to be more important than quantity – like size. An analogy is always based on qualitative rather than quantitative properties. Moreover, the cosmos of Dante was as inaccessible to a medieval man as the Big Bang cosmos is to us. In addition, the analogy is not limited to the shape of the sphere and the primum mobile limit. The entire modern cosmos takes over the hierarchical structure that we know from the old cosmos. In the latter, the direction of action was from top to bottom, primarily as a causal chain (after Aristotle), but also as emanation (after the neoplatonists). Both ways – the causal chain and the radiation topdown – are reflected in the modern spherical cosmos quite naturally, because along this direction the temporal flow takes place. The analogy also applies to the reverse direction, from bottom to top. As far as the ancient cosmos is concerned, we have seen that the ascent of Dante through the spheres to the Primum Mobile and beyond, in neoplatonic thinking, means a return to the source, to the Creator. This naturally also describes the direction of our research, if it is presented in this way (**Fig. 15**).



15

With our telescopes we penetrate the depths of the universe to a distance (spatial and temporal) where there are no more objects to observe. This is where the physicists of elementary particles, who carry out experiments and develop theories in order to understand the properties of matter at very high energies, come into contact with the Big Bang in a metaphorical sense. Explaining the physics of the Big Bang, understanding the origin of the material world, is perhaps the noblest goal of physics and astronomy. The Big Bang is the Alpha and Omega, it is our material origin – and our mental goal, the ultimate goal of our research. We researchers, too, make a kind of virtual journey to the source; represented geometrically, it resembles an ascension.

Let us now see what happens to Dante, the pilgrim, on his journey, already close to its end (**Fig. 16**). Entered into the sphere of the Primum Mobile, as always looking in Beatrice's eyes, Dante makes a visual experience described in the verses of *canto* 28 of Paradise:
... just as one who sees a mirrored flame ... , in which Love made the noose that holds me tight.



Paradise XXVIII 4–15

just as one who sees a mirrored flame –
its double candle stands behind his back –
even before he thought of it or gazed
directly at it, and he turns to gauge
if that glass tells the truth to him, and sees
that it accords, like voice and istrument,
so – does my memory recall – I did
after I looked into the lovely eyes
of which Love made the noose that holds
me tight.
And when I turned and my own eyes
were met
by what appears within that sphere
whenever
one looks intently at its revolution,

16

In other words, Dante perceives a certain sparkle in Beatrice's eyes that must originate behind his shoulders and is reflected in Beatrice's eyes. He automatically turns around to see what shines. Here's his report:

And when I turned and my own eyes were met ... , ... one looks intently at ist revolution, –

(**Fig. 17**) *I saw a point that sent forth so acute ... , „On that Point depend the heaven and the whole of nature.“*

Illustration Gustave Doré

Paradise XXVIII 16–18,25–36,40–42

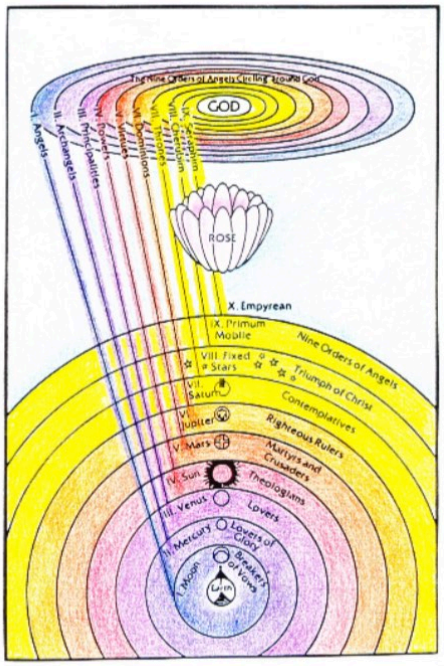
I saw a ***point*** *that sent forth so acute*
a light, that anyone who faced the force
with which it blazed would have to shut
his eyes,
Around that point a ring of fire wheeled
. . . so quickly that it would outstrip
the motion that most swiftly girds the world
That ring was circled by a second ring,
the second by a third, third by a forth,
. . .
The eigth and ninth were wider still;
and each,
even as greater distance lay between
it and the first ring, moved with lesser
speed;
. . .
My lady, who saw my perplexity –
*I was in such suspense – said: „****On that***
Point
depends the heavens and the whole of
nature.“

This point of extreme brightness is a representation of God, and a very appropriate one: the dot shape (i.e. a singularity) and the luminosity, the brightness – in fact, light in general – have a deep spiritual meaning. Nine luminous concentric circles turn around God, corresponding to the nine angelic choirs. The Seraphs closest, then the Cherubs and so on to the archangels and angels at the greatest possible distance. And this spatial order is accompanied by a kinetic order: The closer they approach God, the faster the celestial beings move, so that the Seraphs rotate at maximum speed, the angels at minimum speed. In the geocentric world of the spheres, however, the kinetic order is exactly the opposite: The spheres move faster the more distant from the center (earth) and the closer to God they are, the Primum Mobile rotates at maximum speed and the Moon at the lowest speed. (Note that the spatial and kinetic order of the angels of Dante corresponds exactly to the order of the planets in the *heliocentric* solar system after Copernicus; – it is a bit as if Dante, the poet, had anticipated this order two centuries (!) before Copernicus, but only in the spiritual realm, not in the physical world.)

In any case, Dante, the pilgrim, feels confused by the reversal of order between the spheres and angels. Why this reversal? (**Fig. 18**) As always Beatrice teaches him and explains the reversal as follows:

Paradise XXVIII 64–78

„The size of spheres of matter–large or small–
depends upon the power – more or less –
that spreads thoughout their parts. More
excellence
yields greater blessedness; more blessedness
must comprehend a greater body when
that body's parts are equally complete.
And thus ***this sphere, which sweeps along***
with it
the rest of all universe, must match
the circle that loves most and knows the most,
so that, if you but draw your measure round
the power within – and not the semblance of –
the angels that appear to you as circles,
you will discern a wonderful ***accord***
between each sphere and its Intelligence:
greater accords with more, smaller with less".

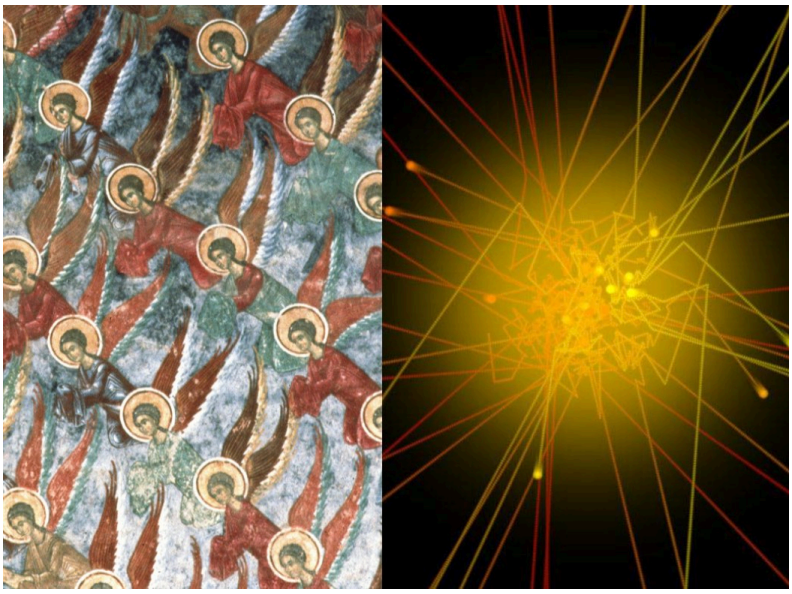


18

This is not exactly a brilliant explanation, but it simply means that it is more noble to be large on the level of space, but more noble to be fast on the level of movement. And because *that* thing (be it a sphere or an angelic choir) that is closer to God is more moved, the reversal between the spheres and choirs of the angels follows strictly logically. The drawing here on the right serves as an imagination of how the movement of angels in the spiritual realm outside of space and time is transferred to the spheres in the physical world; it is an invisible process. This is also how the natural laws of modern science work.

The reverse situation reminds me of another matter of physics. Let us return to the image of the modern spherical cosmos (**Fig. 15**). As already mentioned: Approaching the Big Bang, at a certain point one enters into the primordial particle soup and thus also into the field of elementary particle

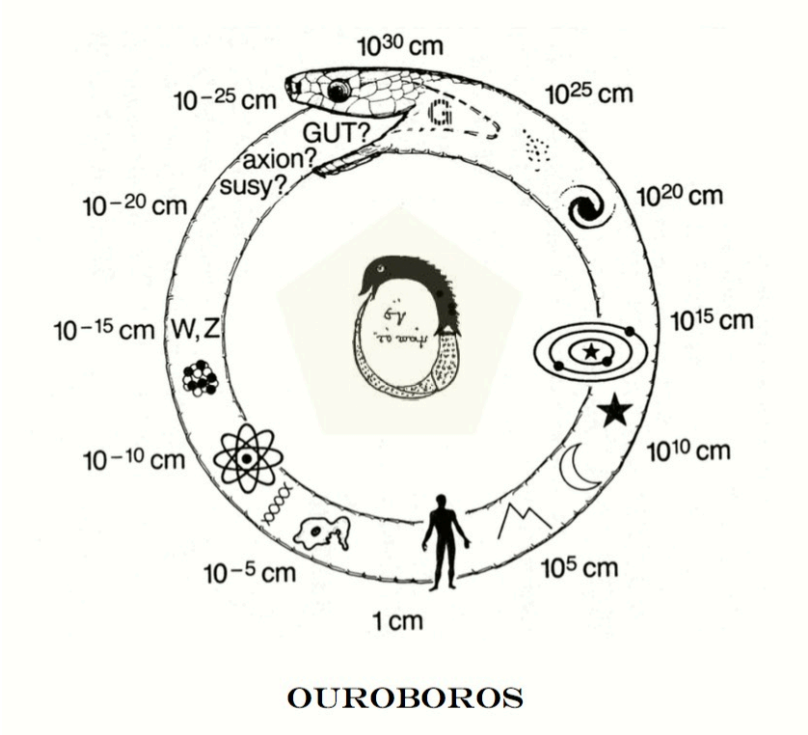
physics. As we virtually march towards the Big Bang (which defines the boundary of this spatio-temporal globe), the temperature of the soup also increases, because we continue to penetrate further into the past (remember that the universe has cooled continuously due to its expansion). Theoretically, the temperature at the Big Bang singularity was infinitely high. Now, in thermodynamics, the temperature of a substrate corresponds to the energy or velocity of the particles in it. With increasing temperature, i.e. with increasing energy or speed, more fundamental particles come into play – smaller particles, in a metaphorical sense. And the speed approaches the speed of light more and more, to the point where the particles become "relativistic" (as the physicists say) and thus (in a certain way) assume the character of radiation (instead of matter). The early universe was dominated by radiation, we call this epoch the „radiation era". (and since radiation is essentially light, this reminds us of the *fiat lux* of the biblical story of creation).



19

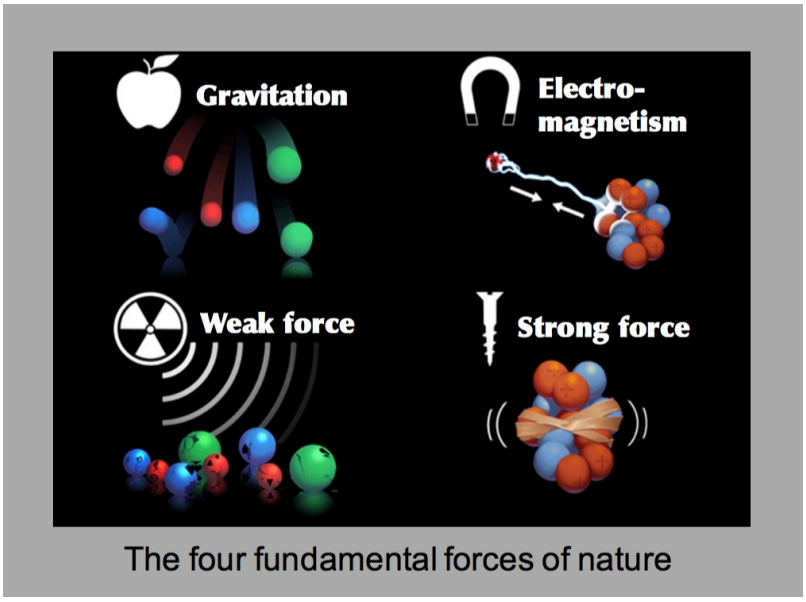
(**Fig. 19**) At this point I would like to mention a (for me) very nice analogy between photons and angels, as they appear in Dante's poem. Both are, in modern terms, light quanta, messenger particles, force carriers, both have no mass, but are pure energy, without number, effective in the world, while „living" outside the world, in the realm of eternity. In addition, the hierarchy of angels endlessly discussed by medieval scholars seems to return in the form of a particle hierarchy, including the photon. There is no time to go into detail; suffice it to express the idea that there is actually a possibility to accomodate the concept of angels also in the modern world – through analogies, and without conflicting with science or twisting scientific facts!

(**Fig. 20**) In any case, it is obvious that the inversion between the order of the spheres and the order of the angels can be analogized with the inversion between microcosm and macrocosm. Near the Big Bang, at the largest distances, we enter the realm of the microcosm. In the Big Bang, the largest and smallest things, the macrocosm and the microcosm, come together, or as it is called in French: *Les extrèmes se touchent*. Shown is a picture of the situation after Sheldon Glashow, Nobel laureate of physics, from the eighties, using a very old hermetic symbol: the *Uroboros*, the snake that bites its own tail.



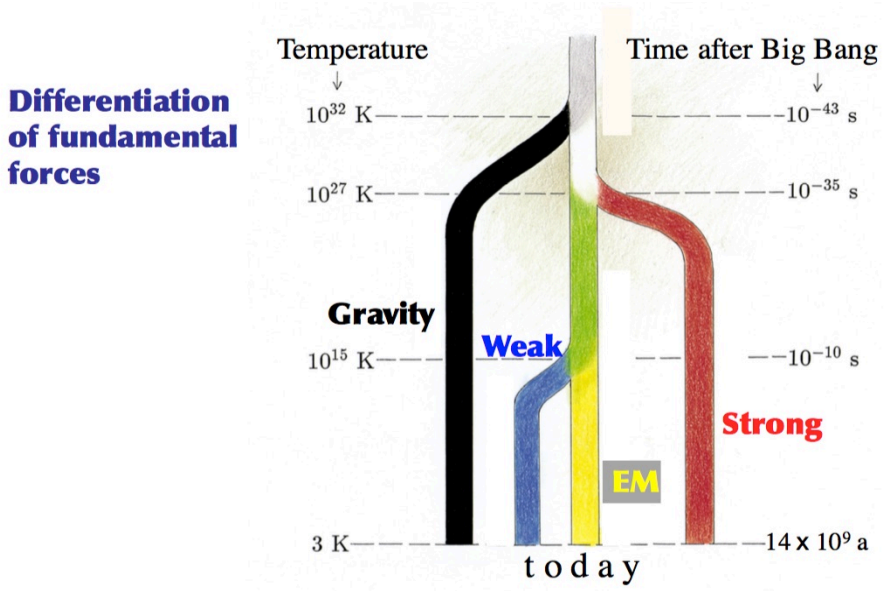
20

I would like to present one last example of an analogy. (**Fig. 21**) It concerns the four fundamental forces, or interactions of nature: gravity, electromagnetism, and, with an extremely small range, the „weak" nuclear force and the „strong" nuclear force. Understanding this diversity, or rather the unity of these forces is perhaps the most fundamental problem of physics, like the problem of understanding the Big Bang mentioned above (but perhaps it is the same problem). The theoretical unification of forces is well advanced: there is a standard theory for the unification of electromagnetism and the weak force. On the other hand, it is not clear how the strong force can be added; there are ideas, but not more. And gravity has so far resisted unification altogether; a quantum theory of gravity is missing to achieve it.

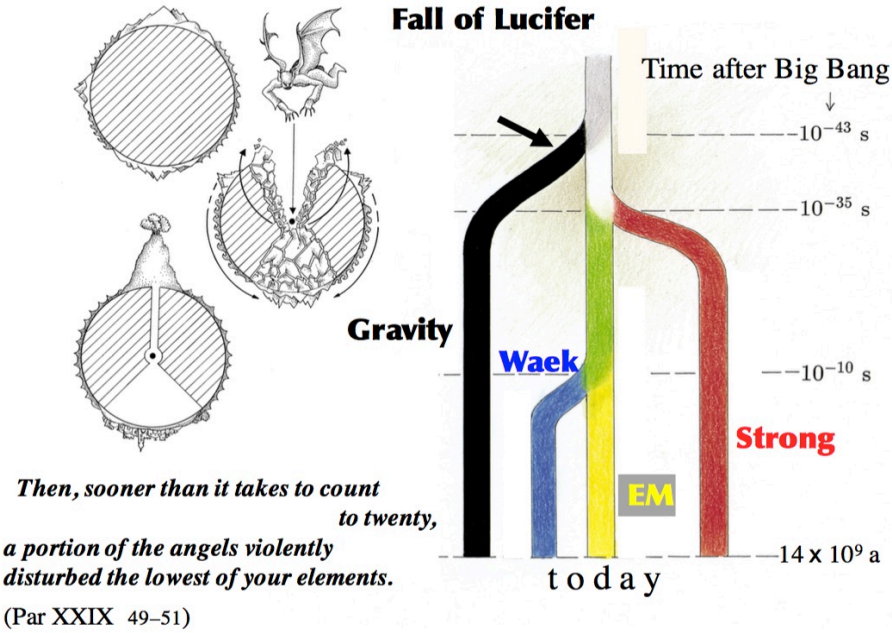


21

(**Fig. 22**) However, the notion or idea in physics is that the forces at very high energies, i.e. at very high temperatures, are indistinguishable and unified in this sense. And in this way the fundamental forces must also have been united in the very early universe, in the almost infinitely hot soup at the Big Bang; there was only one force, so to speak. But already after a very short time, less than one billionth of a second, the forces were differentiated and separated from the original unit, as can be seen in this graphic representation of the process. The first force that theoretically separated from unity was gravity, 10 to minus 43 seconds after the Big Bang – an unimaginably short time span!



22



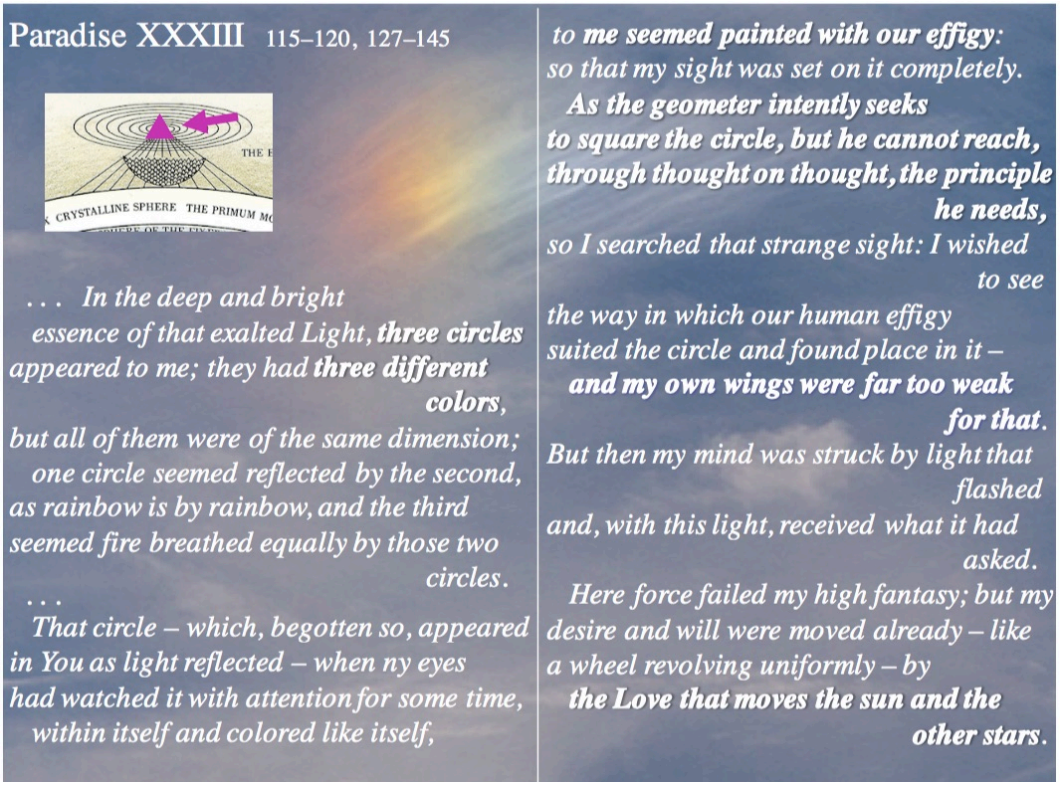
23

At this point I see an analogy with a cosmic catastrophe of mythology, especially as it is described in the Divine Comedy, namely the fall of Lucifer (**Fig. 23**). It should be remembered that evil, personified by Lucifer, is symbolized by gravity. The fall of Lucifer and his companions is mentioned in the Comedy in the following verses:

Then, sooner than it takes to count to twenty, a portion oft he angels violently disturbed the lowest of your elements.
So this is also a very quick process: as soon as the world was created, in less than twenty seconds, Lucifer, initially the Prince of Angels, was expelled from heaven for his pride. The consideration of such a short period of time in the Middle Ages seems remarkable to me. Lucifer fell and *disturbed the lowest of your elements*, as it is said in the text. This means that Lucifer structured the world through his fall (especially Hell and Purgatory, as shown in the diagram on the left). And this can also be found in astrophysics: it is the gravitational force that forms the structure of the universe on a large scale, leading to the formation of galaxies, stars, and planets.

The other three forces that physicists are trying to unify remain – a goal that has not yet been achieved. The theoretical unification of the fundamental forces of nature is a tremendous task, it requires an enormous intellectual effort. Perhaps unification is not possible without the integration of gravity. Perhaps it remains an unsolvable problem if human consciousness is not taken into account in some way.

(**Fig. 24**) Back to the last lines of the Divine Comedy. Dante, the pilgrim, approaches the divine singularity (God) in the Empyrean, where he looks at the Holy Trinity and wants to understand it:



24

As the geometer intently seeks to square the circle, but he cannot reach, through thought on thought, the principle he needs, ...
„Squaring the circle" is an old, mythical image for an insovable problem. Maybe the unification of the forces belongs to this category. In my book I boldly declared this passage of the Divine Comedy a compulsory reading for theoretical physicists! However, Dante solves the problem in a different, holistic and contemplative way:

... so I searched that strange sight ... by the Love that moves the sun and the other stars (**l'amor che move il sole e l'altre stelle**) .

Here is the end of Dante's poem, and also the end of my presentation, thank you for your attention!

★

All Dante quotes from:
Dante Alighieri: *The Divine Comedy*, verse translation by Allan Mandelbaum, 3 vols.,
Bantam Classics, New York 1983

Fig. 13 (und 14, 15) reproduced with permission from:
Nancy Abrams und Joel Primack: *The new universe and the human future* (Terry lectures),
Yale University Pres, New Haven 2011

Literature:

Bruno Binggeli: *Primum Mobile – Dantes Jenseitsreise und die moderne Kosmologie*,
Ammann, Zürich 2006 (only german)

Horia-Roman Patapievici: *Gli occhi di Beatrice – Com'era davvero il mondo di Dante?*
Bruno Mondadori, Milano 2006 (only italian)

Robert Osserman: *Poetry of the Universe.* Bantam Doubleday, New York 1995