# 1

# Black Night

I was nine years old. My father was teaching math and my mother classics, each in different high schools in Tours. Just after the war, they found a pair of jobs in a quiet city, which they actually didn't like very much. So, naturally, they decided to escape it as often as they could, and to look for a house where they could take their four children on vacation. They had no money, but they did discover an old farm in ruins at the foot of a very pretty village in Provence, with fourteen rooms surrounding a courtyard with a well, on five hectares of pebbly terrain where peasants had once tried to grow wheat. At the time, the region didn't have running water, the yield from the land was minimal, and tourism was non-existent. But, to my parents' eyes, the place was perfect. They bought this marvel for a mere 450,000 old francs—barely a few months' worth of their teachers' salaries.

The first winter we spent in the few inhabitable rooms was glacial, but hopeful. And by the following fall, I had decided on my future career: I wanted to work for the department of Eaux et Forêts.[1]

I should mention that the government bureau of Eaux et Forêts was encouraging reforestation. With their help, we planted several thousand cedars, several varieties of cypress, Aleppo and Austrian Black pines, some lindens, acacias and poplars, a hackberry and a catalpa, a rowan, one hundred forty almond trees, thirteen rows of vines including Angevin and Cardinal varieties, a Chasselas, a Muscat, a Gros Vert and a Dattier . . . And I do mean "we," since despite being only ten years old by that time, I had taken up the care of our plantings with my father. Among the pebbles and thistles, I stubbornly tended the attempts of our trees to grow, though drought in both winter and summer decimated a number of them each year. However, with steadfast encouragement, about half of them survived, managed to reach the water table within about ten years, and then suddenly began to grow ten times as fast. The vegetation on the ground was transformed; the thistles disappeared, and the pebbles were quickly covered with moss and a sprinkling of pine needles—favorable conditions for porcini mushrooms in autumn. One day we even found some morels; and we met rabbits, hoopoes (a type of bird), and various kinds of butterflies, which I collected. I made picturesque paths through the new forest we had created and proudly decided that nature was more pleasant when managed than wild.

But then water came to the whole region, thanks to the Durance-Ventoux land management plan: the Renaissance castle in the village started exhibiting ugly geometrical paintings, Madame Francine Coeurdacier sold her food shop to Hediard (an expensive grocery chain), tourists flowed into the region and covered it with swimming pools, and the formerly dark alleys were lit with yellow light . . . Fortunately, our forest acted as a screen to all this excitement, and our nights stayed dark, pure, and perfumed; only the crickets and the toads broke the silence.

Fifteen years later, our parents left the pleasures of this paradise to us. It was then that our friend Jean-Pierre Maury brought us a telescope. Jean-Pierre liked woodlands, astronomy, big Cuban cigars, and popularizing science. From the garbage bins populating the Jussieu campus at the University of Paris, where he taught physics, he gradually extracted a scrap-metal frame, a wide PVC tube 25 centimeters in diameter, an old electric motor, a large aluminum disc, and three wheels. When, to all this bric-a-brac, he added a few planks of light oak and an eyepiece from a microscope, as well as a large parabolic mirror which he had polished himself in his kitchen and had had silver-plated in a workshop in the Marais, Jean-Pierre had successfully put together a very respectable instrument for observing the sky; and he gave it to us as a present.

Thus equipped, we began to pretend that we were all miniature Galileos.

We took the telescope out onto the former wheat field of our farm, well-shaded from neighboring lights by our pines and cedars, turned the axis of rotation to make it parallel to the Earth's, and began endless observations.

My first observations of the night sky were simple: when it was full, the dazzling Moon filled the entire field of vision of our homemade telescope. But I preferred looking at the first quarters of the Moon, when the shadows of the craters would spread out beyond the boundaries of the lit zone, and when we were able to distinguish the neighboring penumbra.

Then I figured out how to find Jupiter. You only had to look south and imagine the place where the sun had passed during the day—a sort of great circular trajectory, which begins in the east, rises to the south, and descends again to the west. The planets follow the same path because all of them, including us and the Sun, are on the same plane. The trajectory of the Sun and the planets in the sky is the intersection of the plane of the ecliptic and the celestial vault. If I found a very bright object in this region of the sky, there was a good chance that it was Jupiter, unless it was Venus instead.

Jupiter was easy to recognize since, like Galileo in 1610, I could clearly see four satellites aligned with it. I learned their names: Io, Europa, Ganymede, and Callisto; then I perceived that these four shining points changed places from one day (or rather, night) to the next. Well, of course: they travel around Jupiter, and I would sometimes see two on one side and two on the other, then three on one and only one on the other, and so on. If the sky was really clear, I could even distinguish the dark bands formed by Jupiter's atmosphere, torn apart by abominable winds. The bands are parallel to the equator and in line with the satellites: the whole thing turns along a single plane! As for Venus, which I found near the Sun—that is, towards the western sky in the early evening or towards the east in the early morning—it was also easy to recognize: a very bright object, but with no satellites. And I discovered that Venus sometimes even had a crescent shape—like the Moon, only smaller.

I was able to tease my friends: that big "star" wasn't a star at all, it was a planet! We could easily tell that it didn't emit its own light, but rather was only reflecting the light it received from the Sun, and that we were obviously looking at a nearby object, since we could clearly see its diameter. I felt small, overcome with vertigo in the midst of this celestial merry-go-round. As I kept adjusting the direction of our telescope, the motor of which never seemed to work very well, I continued to think about Galileo, convicted for having defended science against the Catholic Church. I didn't know at the time that he had actually never added under his breath, "and yet it moves,"[2] as the legend goes—that he didn't have enough strength to do it by the end of his trial; but I did understand that what I was perceiving in my telescope eyepiece was the rotation of the Earth on its own axis, not its revolution around the Sun. That revolution is what makes Jupiter change locations in the sky all throughout the year, unlike the stars. I began to think about the change of seasons, about the inclination of the rotational axis of the Earth in relation to the plane of the ecliptic, about the Ice Ages and the interglacial periods that the Earth has known in its long history . . .

In my daydreams about relative motion, Galileo was my constant companion. In effect, what difference is there between "The Earth revolves around the Sun" and "The Sun revolves around the Earth"? If there were only two objects, the Earth and the Sun, these two scenarios would be strictly equivalent. For example, is it the Moon that circles around the Earth, or the Earth that circles around the Moon? As proof of our general egocentrism, we tend, of course, to say that it's the Moon that revolves around the Earth: "We, the Earth, exert the greater force, which makes the little satellite revolve." But in fact each one revolves around the other, and the Moon isn't really that small compared to the Earth anyway.

In order for it to be the case that no one today says that the Sun revolves around the Earth, I realized then that it had taken generations of astronomers observing not only the relative motions of the Earth and the Sun, but also those of the stars and the other planets. Now, the stars are always in the same position in the sky from one year to the next, which isn't true of the planets—even from one week to the next we see the planets move in relation to the stars. When Copernicus judged that all the planets, including the Earth, moved around the Sun, we finally had a simple model at hand which allowed us to predict the positions of all the objects in the sky. The roles of the Earth and the Sun were no longer symmetrical. In 1915, after a few anomalies in the movements of Uranus and Neptune were observed, it was even predicted that there must be an additional planet influencing those two. In 1930, Pluto was discovered. So it would seem ridiculous today to claim that the Sun revolves around the Earth, which would then be the fixed, immovable center of the Universe. At the end of this series of personal revelations, I felt smaller and smaller, not only within the physical Universe but also in the universe of scientific ideas. I had gained a whole new respect for the history of astronomy and its great men.

Without getting carried away, I went back to conquering the heavens. I perceived another shining point, a little reddish, on what ought to have been the path of the planets. Mars? A glance was enough for me to see that this reddish object also had a visible diameter—that it was indeed another planet. Mars gets its red color from the strong concentration of iron oxides in its grainy soil, and scientists are wondering more and more seriously if it once had life, since subterranean and icy water has been discovered there.

Combining my love of nature with a strong dose of rationalism inherited from my father, I became a physicist. But some days, I'm tempted to buy myself a really nice telescope and go back to Provence, far from the lights of the city and its murky atmosphere, so that I can see for myself that Mars has a white cap which travels from its north to south pole according to the Martian seasons. This ice cap exists, because there is snow made of $CO_2$ there, and carbonic snow is white (like the $H_2O$ snow here on Earth, only a bit colder). And since I know where to find the ephemerides in my newspaper—or better yet, on the Internet—I can know whether

Saturn is visible at a decent hour and in what part of the sky. I remember its iconic rings, which I would try to count as a child, and the inclination of which varied from one year to the next. I also seem to remember that one day, Saturn, sitting inside its rings and seen from one side, looked like an eye—an eye that was looking back at me.

Really, there's only one step from science to dreams, or vice versa.

* * *

Recently, I came across this question, which at first seemed disarmingly naïve:

"Why is it dark at night?"

How could someone ask such a question, you might think? The truth of the matter is that there are few stupid questions, and the most naïve are often actually the most fundamental in nature. That is definitely the case with this question, since it's related to the origins of the Universe, to the theory of the Big Bang, and the current frontiers of cosmology.

Of course, at night, the Sun is shining on the other side of the Earth. But since all of the other stars are just so many other Suns, so why don't they shine enough for us to see at night just as we do during the day?

Obviously, they are far away, and we know very well that the farther we are from a source of light, the less we're lit. We get four times less light from a beacon two kilometers away than from one which is only one kilometer away.

Still, there are a great many stars. If the stars don't shine brightly enough upon us for us to be able to see clearly at night, perhaps it's because there aren't enough stars in the sky? In 1823, this excellent suggestion led Wilhelm Olbers, a German astronomer, to a remarkable conclusion: the observable Universe is not infinite. Now, the problem of the finitude of the universe had been bothering philosophers for millennia, though today, we know the answer to this riddle. Was Olbers right? To find out, we need to go back a few steps.

How many stars are there in the sky? It's not so easy to answer this prefatory question. For simplicity's sake, imagine that the average density of stars in interstellar space is constant.[3] Now imagine counting the number of stars shining at a certain distance from the Earth. Then imagine doing the calculation again for double the distance: the number of stars will be four times as large, but, since they shine from twice as far away, we receive four times less light from each of them. To sum up, the light that comes from twice as far is precisely equal to that coming from twice as close, since the increase in the number of stars is compensated by the decrease in light received as a function of the distance. Next, Olbers calculated the total light we receive from all of the stars in the sky, from the nearby stars out to the faraway ones. If the faraway ones were infinitely far, we should get an infinite quantity of light; but, this isn't the case. Thus we have to conclude that we do not see stars out to infinity—we do not receive light coming from more than a certain distance. This limit must, certainly, be far away, but it can't be infinitely far. Olbers showed, then, that the Universe has a horizon. But how?

Let's keep thinking. As you know, light propagates at 300,000 km/s, which is a lot, but not infinite either. To reach us today from a source infinitely far away, the light would therefore have to have been emitted an infinitely long time ago. Therefore, if we don't receive an infinite quantity of light, perhaps it's because the visible Universe isn't infinitely old! Now that is both more precise and more correct. It is dark at night, because the stars have birthdays; they haven't always been there.

Reaching such a conclusion was truly a revolution. But our conception of the Universe has been greatly enriched since then. In 1923, in effect, a century after Olbers, the American Edwin Hubble discovered that the Andromeda Nebula is actually a galaxy beyond our own.[4] He then discovered other galaxies, succeeded in measuring their distances from us, and then—and this is his greatest discovery—he saw that all of these galaxies were getting farther away from us at a speed proportional to their distance. So he confirmed, in 1929, a hypothesis that was formalized in 1927 by Georges Lemaitre, and that would eventually become famous: the Universe must be expanding as a result of a powerful initial explosion.

Such an impressive phenomenon deserved a nickname, and so it was called the “Big Bang.” But what made Hubble come up with the idea that the Universe had been flying off in all directions since the initial explosion? Progress in this area of study resulted from the fact that we were able to measure the speed of the stars.

When I was little—clearly my childhood had a big impact on me—I had miniature cars with which I held imaginary races. My early passion for fast cars has happily abandoned me, but at the time, I wasn’t content just to push them along roads drawn with chalk: I made the sounds, as well. All that was missing were the lights. Passing in front of me at high speed, the cars went *eeeeeeeeeeeeaaaaaaaaoooooooooo*. Like all my friends, I knew from experience that real cars getting closer to me had a higher sound than when going away, but I didn’t know that this effect had been predicted by the Austrian physicist Johann Doppler in 1843, and was then tested in a rather amusing way, by placing trumpet-players on a train. I also didn’t know that Doppler had predicted that light, being a wave like sound, would show the same effect, nor that the French astronomer Armand Fizeau had deduced from that a way of measuring the speeds of stars in relation to us.

In stars, each sufficiently hot atom emits light which has a particular structure: it is made up of a collection of rays of different colors (called a spectrum), which is a veritable signature of each element in the star. We therefore know how to chart the chemical composition of each star by analyzing the signatures of these atoms in the stellar spectra. Now, these spectra, these colorful signatures, are all more or less shifted towards the lower frequencies, that is, towards red, because of the so-called Doppler-Fizeau effect. So, all the stars are getting farther away from us. By measuring this shift (which is called, appropriately, the “red-shift”), we find how quickly each star is moving away from us. Some are very far and moving away very quickly, and they get very red because of it; others are closer and barely move relative to us, and don’t blush so much. So, imagine we were going back in time: all the stars, and all the galaxies of stars, converge at a point which is the origin of the Universe. Hubble thus imagined that the current Universe resulted from an initial explosion and hadn't stopped expanding since. To date, this is still the central hypothesis of cosmology. The theoretical model has been further developed, and the measurements in support of it have become more precise: we think today that this Big Bang took place 13.7 billion years ago. This is the age of the Universe, three times the age of the Earth and the Solar System, which has also been measured, but by a different method. I'll come back to this; but did you know that the Universe is three times older than the Earth?

Since one unlikely question has taken us as far as the Big Bang, it would be a shame to stop there. So, I'll ask another:

"Is the sky going to fall on our heads?"

I don't know if the history books for primary schools still associate this question with the supposed naïveté of the Gauls, as they once did in France. It is, however, a very real and serious question for modern cosmology, and anything but naïve.

The Sun attracts the Earth, which, as everyone has known since Newton, attracts the falling apple: that's universal gravitation. The stars, therefore, also attract each other. The force of attraction depends on the distance between and the mass of each object, and is the prime mover of the dynamics of the Universe. Imagine, then, a large concentration of masses somewhere, a sort of dense cloud: it will eventually collapse upon itself, and over the course of this implosion, heat up so much that nuclear reactions will be set off. That's how stars, which are nuclear furnaces, are born and shine. One or two are born per year in our galaxy alone, which isn't a comparatively young one.

But what about the Universe itself? If it's very dense, it should collapse upon itself in the same manner, given how much each star attracts every other star. And if this attraction is strong, couldn't the expansion resulting from the initial explosion reverse itself one day? Is it possible that after an expansion phase, the Universe will retract, the velocities of the stars will reverse themselves, and everything will collapse back in upon itself? If that were true, some day someone should witness (someone, not us—it will be a long time coming) another singular event, a sort of Big Bang in reverse which the physicists have given another nickname: the "Big Crunch."

When you throw an apple up into the air, it falls back down. Will the Universe fall back upon itself? Is the sky going to fall on our heads?

Not to worry. Astrophysicists have made a lot of progress in this area and have just discovered that it's the opposite: the Universe is flying away at a faster and faster rate; its expansion is accelerating, and the sky will surely not fall back down on our heads. But how did we manage to establish that fact? It's a long story.

The first thing needed to figure all this out is some idea of the density of matter in the Universe. Visible matter is very diluted: the equivalent of one hydrogen atom per cubic meter. That's not enough to reverse the current expansion. But, by studying the rotation of the galaxies, and then the movements of the clusters of galaxies, we perceived that there must be a lot of matter that we don't see. What could this invisible matter be made of?

First of all, let's consider the planets that revolve around stars. This is matter which doesn't inherently emit visible light; however, we can detect the presence of these dim planets around their stars indirectly. For example, we can observe partial eclipses of stars: their light decreases slightly when one of their planets passes between them and us. We can also observe that the movement of certain stars oscillates as a function of the rotation of their planets; in fact, that's how some planets of our own solar system were discovered. There is also a lot of gas and dust between the stars. However, all this ordinary matter, shining or not, only represents about 20% of the total matter in the Universe.

The candidates for the missing 80% include "neutrinos," elementary particles with which we know the Universe is filled, and the mass of which we have just discovered is not zero. There may also be other unknown particles which also have mass. All this supplementary matter, which is not made of protons, neutrons, and electrons like ordinary matter, is what we call "dark matter," not only because it doesn't shine, but also because we don't really know what it's made of. Why are we convinced that it exists? Because, like planets, we've been able to observe it indirectly. Without it, the angular velocity of some galaxies would be incomprehensible—unless the laws of gravitation were completely revised . . . But I won't go there. What intrigues all the physicists in the world is that this poorly understood dark matter represents the vast majority of the matter present in the Universe. Now, that opens up some big avenues of research—all the more so, since the mysteries to be penetrated run much deeper than even the fundamental nature of dark matter.

The possibility of a Big Crunch depends, in effect, on other surprising aspects of the Universe. In particular, it's possible that the Universe is curved. In his Theory of General Relativity, Einstein represents gravitational attraction as a curvature in space. To understand what that means, physicists are in the habit of comparing space to a mattress, even though one might find the allusion to be a bit simplistic. Lying on a soft mattress, a body distorts the mattress's shape, creating a local curvature—a hollow, if you like—and any neighboring body is attracted towards this hollow. In this analogy, space is two-dimensional; it is a distorted plane. But the space of Einstein's physics is actually four-dimensional: three dimensions for ordinary space, plus the additional dimension of time. Picturing the curvature of four-dimensional space isn't easy, hence the usefulness of the mattress. In any case, we represent gravitational attraction as the result of local deformation of space by the masses located there (stars, galaxies, and so on).

Allow me to make a parenthetical remark. Maybe you believe that the curvature of the Universe by its masses is just an abstract fantasy? A pure speculation on the part of Einstein which has no relation to perceivable reality, or at least no practical utility? Not a bit! By measuring the duration of eclipses of Mercury, and by observing gravitational mirages in the sky (the relativistic equivalent of optical mirages which you may have observed on a hot road reflecting the light of the sun), it has been verified that the deformation of space makes light deviate when it passes near a star. General relativity also predicts that the time shown on a clock depends on its altitude, since even the Earth curves the space in its neighborhood, and that space has a temporal dimension. Of course, this effect is very weak, but for certain applications which require extremely precise measurements of time, like satellite locating systems (the GPS used by navigators or hikers), it's necessary to take into account the fact that clocks on Earth run more slowly than those on board a satellite. So modern physics is bizarre, but also quite useful. Let me also quickly add a few words about black holes, which are often on the covers of scientific journals and which have also become an observed reality. If the concentration of matter is too high, the structure of space gets more than deformed: it collapses, and it forms a sort of hole from which even light can't escape. At the center of our galaxy, such a black hole exists; its mass is about 2.6 billion times that of the Sun and it swallows stars. We now have photographs of this black hole, taken every six months, where we see stars circle around and get swallowed like boats in an immense mythical vortex, like Edgar Allan Poe's maelstrom.

The curvature of space by matter is therefore a reality. One might then wonder whether the entirety of space itself in fact has a global curvature. Placed on a bulging surface, marbles will all go away from each other, whereas if the surface has a trough, they will assemble in the middle. Any curvature of the Universe could thus influence its future, the acceleration of the expansion or its possible deceleration before a retraction phase. In 2001, this curvature was measured by studying what is called the "cosmic microwave background" radiation of the Universe. We'll see what that means later, but I'll give the result right away: the curvature seems to be nil—the Universe is not curved. I don't know whether you will find that information reassuring. But in any case, it's a little less difficult to imagine than the contrary.

So what is this "background radiation?" Right after the Big Bang, the Universe was so concentrated that it was extremely hot, which separated the electrons from the ions, with the consequence that the Universe was a conductor of electricity, like a metal. That made it opaque, again like a metal. Light was only able to propagate freely in the Universe when the temperature dropped enough for the positive ions to capture the electrons and form neutral atoms. That took place 380,000 years after the Big Bang, the day light began in the Universe. In 1946, George Gamow had predicted that as the Universe expanded, the radiation must have been diluted and cooled, but that there must remain a trace of it—background radiation—a sort of cold light that one should be able to observe between the stars. And in 1965, two American astronomers, Arno Penzias and Robert Wilson, discovered it! This was obviously stunning proof of the validity of the Big Bang model, but I won't go on at length about the predictive power of physics. Today, thanks to detectors that are cooled with liquid helium and loaded onto satellites, we've measured the characteristics of this radiation: everything behaves as it would if the temperature of the background of the sky was 2.73 degrees Kelvin (about −270 degrees Celsius). This background radiation resembles the light emitted by a piece of red iron, except that at 1,000 degrees, iron emits light which is very red, whose wavelength is around 0.6 microns; the background of the sky, on the other hand, is very cold and emits very weak microwave radiation (in between infrared and radio waves), about 1 mm in wavelength. The measurement of the curvature of the Universe comes from a close study of this background radiation or, more precisely, its slight inhomogeneities.We know today that this curvature is practically nil. That wasn't at all obvious, however, especially since when linked up with other measurements, this leads one to a new, and no less surprising claim.

Physicists have, in effect, discovered the existence of another force influencing the expansion of the Universe and which comes from what has been called "dark energy," not to be confused with "dark matter." Maybe you have the impression that, despite being a professional physicist, I'm confusing forces and energy. Rest assured, I know that a force is derived from energy, that they are therefore two quantities that are related to one another, though not identical. Regardless of terminology, what is this dark energy? This force, or rather stress, to be more precise, tends to push the stars away from one another, to expand the Universe, like a sort of negative pressure. I will come back to this notion of negative pressure by discussing the height of trees (chapter 8), since I know that this concept disturbs even professional physicists, and as it happens, part of my own research is concerned with it. Let's just think for the moment that if we compress a gas in a cylinder with a piston, we are applying a positive pressure to it, which of course tends to push the atoms or molecules inside closer together. If we imagine a reverse action, pulling on the piston instead of pushing, we are expanding the gas and spreading out the molecules. The problem is that we can't apply negative pressure to an ordinary, classical gas: it's impossible. We can reduce the pressure to less than regular atmospheric pressure (+1 bar), but as the expansion progresses, the gas gets more and more diluted and its pressure and density go to zero. That is the ideal gas law, a consequence of the absence of interactions between the molecules and atoms which constitute the gas. On the other hand, applying negative pressure to a solid or a classical liquid is easy: it means pulling rather hard on it. We will see that the pressure is negative in the sap high up in tall trees. But the Universe is more like a sort of gas composed of stars, rather than a solid or liquid, in which a strong cohesion among the molecules is the rule.

In order for the Universe to be under negative pressure, we need there to be a non-classical cause, a quantum one, in fact. It gets tricky to explain, but that's not astonishing: this is what a number of researchers are now coming up against. We've known since the beginning of the twenty-first century that the existence of dark energy implies a force pulling on the Universe; we know that the effect of this dark energy on the dynamics of the Universe is three times as intense as that of all the matter in it, visible or not; and we know, finally, that as a consequence of dark energy, the expansion of the Universe is accelerating, and has been doing so for 5 billion years, whereas without it the expansion would necessarily slow down. Measurements consistent with this have been done, not only on the background radiation, but also on the explosions of certain stars and on gravitational mirages. So we are certain that this dark energy exists, but we don't know yet where it could have come from. Some invoke what they call "quantum fluctuations of the vacuum," but that would yield a colossal amount of dark energy, bearing no resemblance to observed reality. So it's something else. Is there an unknown symmetry in the Universe? Is it what so-called "supersymmetric" theories, which attempt to unify general relativity and quantum mechanics, are starting to predict?

Here we've arrived at the vanguard of contemporary research, a frontier of knowledge where physicists admit to not knowing, not understanding. We have learned so many things about the Universe in one century that the questions asked today are even more mysterious than the ones being asked before.

One more word about Einstein to end this chapter. It just so happens that it was he who first had the idea of such a mysterious force. He introduced it in 1916 in the form of a constant, called the "cosmological constant," which he added to the equations describing the dynamics of the Universe. This fact is interesting because at the time, the theory of the Big Bang didn't exist yet, and Einstein thought the Universe was stable. However, since the stars attract one another, his model needed a force to prevent the Universe from collapsing on itself. Einstein therefore introduced his constant to represent what we now call "dark energy." Later, he felt that this constant was contrived, that it had no physical justification, and that his introduction of it had been the mistake (the "biggest blunder") of his life. Today, thanks to Einstein (and perhaps in spite of him), the cosmological constant has resurfaced.

When I think about it, I have the impression that we all tend to believe that the Universe, nature, life on Earth—all of it—is stable and benevolent, and unless we destroy this beautiful balance which has been granted us, the future won't be catastrophic. Behind these ideas, there must be the belief that the world must have been created to last. And yet, it must be admitted that this view is false: the Universe isn't stable, and the Sun and life on Earth will necessarily have an end. That's no reason to hasten the end, but life, and especially human life, is only a passing episode in the long history of the Universe.