

Chapter 8

Conceptions/Misconceptions

Astronomers' views of astronomy in particular and of science in general often differ from the views of the general public. Papers in this chapter discuss this dichotomy. The first paper is a personal view of public misconceptions of topics relevant to astronomy. Next, we see that conflicts between science and the local culture can lead to misunderstandings. The American struggle between "creationists" and scientists about what can be taught in schools is discussed next. Finally, we hear of other conflicts between astronomers' thinking and the understanding of the listeners.

PUBLIC MISCONCEPTIONS ABOUT ASTRONOMY

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*"If I give you a fish
you will eat only one fish
but if I teach you how to fish
you will eat fish all your life..."*

The Chinese proverb quoted above means more or less the same thing that our Rabelais did in the middle of the Renaissance, when his famous Gargantua made the statement: "well built brains are to be preferred to overfed brains."

Indeed, when facing the fallacies that invade our modern life, and when facing the very quickly changing world in which we evolve, it seems that the only weapon we can give is a critical approach to science and life. We feel that anyone can assess at least the likelihood of any alleged fact, or, if he cannot, that he should be able to recognize openly his inability to do so.

Now let us consider the common fallacies of modern times. And you will excuse me if I come back several times to the same motto, from my old Rabelaisian education...

Bye bye Ptolemaeus! bye bye Paracelsus!

A public poll given in France some years ago showed that about one-third of the people still believed that the Sun revolves around the Earth, in the best of the Ptolemaic tradition! About the same percentage — perhaps the same people — give some credit to astrological phenomenology.

This survey shows how important and urgent it is to work at avoiding such a situation. Should I remind you that most of the great dictators on Earth and even *bona fide* statesmen had or still have their astrologers? In a quickly changing world, lucidity and awareness are necessary. The public must be prepared to understand what is going on and to evaluate critically information that is broadcast and that is often turned into sensational events. The public should not be tempted by irrational behaviors that would bring us back to the dark ages.

The aim of teaching is not only to give undigested knowledge to children or students, but also to help them to understand what they are learning, to understand how we have proceeded to our current state of knowledge, and how one may proceed to know more. Of course, we must not be severe. One must excite the young, if one wants them to be willing to understand. And therefore, one must show them beautiful things; fortunately, astronomy is a wonderful field in this respect. And we astronomers are somewhat lucky. But this exceptionally attractive power of celestial objects is also linked with their mystery. We must face the fact that a look at the sky often inspires some metaphysical meditation, and often inspires in contemporaries — as in the shepherds of the past — some strange feelings of fear or hope, some idea of transcendence, and at the same time, the feeling that man is so small in the immensity that he must totally submit himself to the will of the universe, whether it is either God or celestial bodies. Indeed, this idea is often terrifying. Just remember Blaise Pascal: “Le silence éternel des espaces infinis m’effraie. . .” Astrological temptation is thus natural enough.

When faced with the sky, the first move was to pray; the rain dances of early Indians and the sacrifices of the pagan gods were ways to obtain favors from the wild sky. Olympian gods were located quite naturally above the clouds. But in spite of prayers, volcanic catastrophes, floods, or storms still remained the sad rule of our lives. From magic, whose aim was to obtain from the elements whatever was good for man, people turned to the other extreme. Man was no longer in the center of a very small sphere, limited by a tangible Empyrean (the sphere of light or, among Christian poets, the abode of God). The astral universe is eternal and infinite. This Pascalian attitude leads to the fact that, if the machinery of the sky is to determine the destiny of mankind, the lives of men and women are entirely submitted to this strict determinism. In this case, the rules of this determinism are to be established: they are the essence of all astrological thinking.

For a long time, the churches were opposed to astrology, because astrology tended to destroy the idea of human free will. But this opposition was a matter of faith, not a scientific need.

Let us therefore come back to the teaching of science.

The modern development of astronomy, with the fabulous and spectacular conquests of space research, offers young people a world of beauty. And the temptation is great, especially at the elementary or secondary level, for the teacher to show beautiful pictures and to comment on them; he or she often gives the results without explaining how they were obtained. . . .

My own tendency would be to try to explain better the historical evolution and the logic behind astronomical concepts. And, if I limit myself to those concepts the ignorance of which leads people to believe in astrology or in flying saucers, I would probably insert some well known facts in the course of the explanations.

First, let us be observers of the apparent motions of planets and the Sun in the sky. Planetariums are excellent tools for such an approach. One can easily show that there are indeed 13, not 12, zodiacal constellations. One can describe the sky by showing also how the constellations were first described mainly as a guide to show the travels of planets, *i.e.*, only for practical purposes. This motivation explains how subjective the shaping and naming of the constellations was, as demonstrated, for example, by the clear differences between western Assyro-Babylonian cosmography and Chinese sky maps.

It seems sensible to remind students that our ancestors made markers in the sky because they had neither calendars nor compasses; this fact explains the origin of the zodiacal constellations, which indicated the seasons to the farmers, while constellation rings (stars with the same declination) were helpful to sailors. Constellations were memorized by mythological legends; celestial figures were made without reference to the actual arrangements of the stars (*e.g.*, Orion, Andromeda). Thus, when you present a photograph of a part of the sky, say Orion, to some pupils, and ask them to link up the stars in order to form a figure (flower, person, or building), one will obtain almost as many figures as pupils. Doubtless, the brave warrior Orion will not appear among them. This demonstration may show students the total nonsense of allegations like "he's strong and stubborn, because he's born under Taurus."

A look at the motion of the Sun and planets in the different zodiacal constellations shows clearly that they do not stay for an equal time in each of them. The Sun stays 44 days 11 hours in Virgo; it stays only 6 days 8 hours in Scorpius. A planet (such as Venus, for example) does not stay the same time in any given constellation during two consecutive years.

Hipparchus knew about the precession of the equinoxes. The precession can be explained, to the youngest children, as an observed fact, defining the vernal point when you describe the seasons. Then you can distinguish between astrological signs and astronomical constellations.

One can note the loops described by planets in their apparent motion. Though these loops can be explained better in the Copernican system than in the Ptolemaic system, they by no means prove the reality of the former. Still, the demonstration leads to the idea that parallactic ellipses may be a way to determine Sun-planet distances. This idea may be generalized, with modern accuracy, to determine the distances of stars to the Sun.

This determination leads to the fact that stars and the Sun are of the same order of magnitude in absolute brightness. The discovery gives a feeling of the very large distances involved; it also leads to a concept about the unity of the universe.

When speaking about stellar distances, it is easy to show — with animations or by building 3-D models — that the appearance of constellations results from perspective effects. It is easy to show that Vega and Sirius are closer to each other, although in two different directions of the sky, than, say, Sirius and Betelgeuse, which are in almost the same direction in the sky.

But let us come to one essential idea, that of the unity of the Universe. This concept is strictly opposed to Aristotelianism. Let us remember that Aristotle suggested a sublunar world and an astral world in opposition to each other. The sublunar world was subject to violent events, to emotional instability, to the strange and the unexpected; it is essentially made of the basic elements air, earth, water, and fire, whose combinations give diversity. The sublunar world also contains the ephemeral, the putrescent, and the passionate. In contrast, the astral world, all of purity and eternity, is made out of a single element, a fifth one: aether. Between the two worlds, correspondences exist, linking macrocosm and microcosm. Such a link was the basis of medieval medicine, of astrology, and of alchemy.

The Aristotelian construction was based on the regularity of celestial motions, as opposed to terrestrial meteorology and to human weakness.

Aristotelianism was destroyed forever a certain evening of 1572, the 11th of November, to be precise. Tycho Brahe, then a young man 26 years old, was living and working with his uncle, Steen Bille. His uncle was an open-minded person, interested in astrology and alchemy. That very day, Tycho went out of Steen's laboratory, and saw, very near the constellation of Cassiopeia, a very bright star. It was at a place where no star was previously visible. "Nova Stella"! The interesting thing was that all subsequent observations made by Tycho himself, and by many other European astronomers, showed that the star, although weakening in brightness, stayed at the same place in the sky. If one realized that the Moon itself moves by about 13° from night to night, this observation shows that the new star was located much farther than the Moon, in the astral world rather than the sublunar world.

This discovery immediately removed the timelessness of the astral world. An explosive event, the birth of a new star — whatever could be the cause of Tycho's discovery, it implied that the Universe is evolving. The Universe is no longer eternal; it has lost its privileged stature!

The real influence of the Cosmos

Inside the immense spatial structure of the universe, forces and well-known actions "play" with the material bodies.

It is not a matter of obscure and evanescent forces but of well-known actions, particularly the universal gravitation that favors the nearest and heaviest bodies. For example, Venus and Jupiter are able to perturb somewhat the motion of Earth

but only slightly, because the “alignment” (which, in fact, never occurs) of all the planets would produce a deviation in the orbit of the Earth by only a few centimeters.

Let us talk about the “star of the night,” the Moon, to which so many myths and assumed statistics have been attributed (influences on births, deaths, homicides, humors, *etc.*); the tides (which vary as $1/D^3$) clearly explain the large motions of our oceans, but are not at all in touch with the circulation of physiological fluids. It is definitely by chance that the female menstrual cycle coincides approximately with the lunar month; the cycle varies from one woman to another and females of other species than human have totally different cycles!

As to the influences of the faraway Cosmos upon the “destiny of mankind,” one may pragmatically notice that the life of a child born in Greenland, where the daytime is six months long, is different from the life of a Senegalese child, whatever their “sky of birth” might have been.

The Sun acts upon Earth and its inhabitants by its “magnetism.” There is nothing strange in this action; it is only the consequence of the circulation of electrons through a magnetic field. These effects are well known and can be accurately measured with appropriate instruments. One can notice the existence of a variable magnetic field in the Sun, which leads through a complicated process to the formation of flares and gaseous protuberances. In addition, the Sun ejects into space the “solar wind” and other particles, often violently. Their impact here on Earth has very spectacular effects: the aurora borealis, distortion of the magnetosphere, ionospheric perturbations, periodical climatic variations in the terrestrial polar regions, and even the formation of induced currents inside the ground.

Finally, one may note the vast motion of the solar system in the Galaxy (once round in 250 million years at a speed of 900,000 km/hr), where the crossing of spiral arms can probably explain effects that last for long periods (geological eras, glaciations) but certainly not playing any part in the destiny of individuals of the same generation.

Why should we look first for “hidden” forces in the universe, whereas quantifiable influences of the cosmos onto Earth are so numerous, varied, and fascinating to study?

So Long, Mister Spock!

But of course, the above ideas do not prove, again, that the astral universe is of the same nature as the physical universe. This idea came very slowly, through spectrography during the 19th century, and through modern astrophysics. Still, it was convincing enough to lead philosophers of the 16th and 17th centuries to believe in the plurality of inhabited worlds, in spite of Aristotle and in spite of the Church. It was first Giordano Bruno, and later Fontenelle, who spread these ideas at the dawn of the Century of Enlightenment.

The plurality of inhabited worlds, an inductive idea emerging from the progress of knowledge, has led us towards another type of misconception, those ideas concerning extraterrestrial life.

In the earlier works mentioning such ideas, they appear as substrata for philosophical thinking. Kepler's *Somnium*, and later, for example, Cyrano's *Histoire comique des Etats et Empires de la Lune* or *Histoire comique des Etats et Empires du Soleil*, or Swift's *Gulliver's Travels*, or again Voltaire's *Micromegas* are nothing but satirical novels, intended at mocking the author's contemporaries, without enabling the authorities to put the author in jail.

More recently, Jules Verne, Arthur Conan Doyle, and H.G. Wells wrote fantasies that, at the time of their publication, appeared for what they were: science-fiction, philosophical reflections.

Eventually, people started really to ask the right questions. When observing the changes of color in the Martian landscape, it was immediately proposed to associate the green with local spring and the red with local autumn. Later on, it was realized that minerals could also change color, depending upon the state of oxidation; it was also realized that winds could blow up yellow sands all over the planet. But, at least, life could be searched for in planets — not in the form dreamed of by H.G. Wells, but in some very elementary form.

Modern science-fiction, with Lovelace or Bradbury, went further. Even the radio broadcasts, such as the famous Orson Welles show, inspired by H.G. Wells, started to put extraterrestrial beings if not on Earth at least in Earthians' minds. After the Second World War, atomic fear and space conquests gave more credibility to the dreams, and to the fears.

I do not need here to speak more about the development, since that time, of "ufology." The Blue Book of the US Air Force, the Condon report, and many other studies, have clearly led to meaningful statistics. Out of 100 cases, 97 could be assigned to known phenomena: meteors, meteorological balloons, aircraft, or simply bright stars. The remaining 3 cannot be identified, but the description seems almost objective; one is so described that it represents such twisted emotional information as to make it unrecognizable.

No more than making a course on astrology should we consider making a course on ufology! But again, we should give pupils a clear basis to enable them to look with a critical mind at the alleged phenomena.

Of course, astronomy comes first. A discussion can be made of what minimum complexity of molecules is needed for the very existence of life. Therefore, some elements of molecular astronomy — astronomy of cold bodies — could be given; discussion could include planets and comets and also the interstellar medium where cold grains of dust are associated with large molecular clouds — such as in Orion.

The next step is the discussion of the Drake formula, complemented by an introduction of the notion of probability. For other planetary systems, we can have a full discussion dealing with detectability either by the study of radial or proper motions, and the subsequent eventual discovery of invisible companions, or by infrared studies such as the ones performed by IRAS. Detectability, of course, is more likely around close-by stars than in distant objects.

Then comes the question of life on the planets. With what physico-chemical conditions could life, if brought there, survive? This question is almost simple! But

more difficult is the estimation of the probabilities for life to appear given a suitable planet, for life developing into civilization and then into technological civilization, and for alien civilizations to enter into relations with ours.

At least, let us give reasonable estimates, and let us not hide the strong uncertainties; let us remember that science progresses, hence does not have all the answers.

One should also, in cooperation with the psychologists, explain that observations are not always reliable. Astronomers never observe one thing alone; any given observation needs to be checked and rechecked by others before being announced — as did Tycho with his discovery of 1572.

It is easy to say that eyewitnesses may be strongly deceived, be they looking at a crime, or at a celestial and mysterious phenomenon. But can we evaluate the probability of deception? If we believe the Blue Book or the Condon report, we reach a percentage of 3 per cent or so of incorrect testimony! Can we check this on one single object that has been observed by several observers? Without planning it, one of us (J.-C.P., or “I”, in the present paragraph) once did such a thing. On the evening of August 16th, 1966, at Nice Observatory, I received several telephone calls from various people in the area: “What is that bright colored object that we saw falling in the West, behind the town?” As my colleague in Marseilles received similar queries, we decided to publish an appeal to eyewitnesses the following day in all daily newspapers of the French Riviera. More than 400 replies came; about 100 could be assigned to something else, either the time or the direction not being right. But 300 dealt with one single phenomenon. Our opinion was clear: it must have been an explosion, at large altitude, say 80 km, of a large meteorite. An astronomer from Marseilles, Mr. Guigay, made the effort of visiting every one of our 300 witnesses. He went onto their balconies or windows, to measure exactly the apparent direction of the motion. Then he computed by a least-square method the trajectory and the location of the point of explosion. We later found some pieces of the meteorite, a very banal chondrite, in the vicinity of the computed place. It was indeed a well-conducted experiment. Still ten persons (the 3 per cent!) said “Thank you, sir, for having confirmed [!] to us the fact that we have seen a flying saucer.” And three (1 per cent) made drawings similar to the classical images of a flat disk surrounded by regularly spaced circular windows. They indeed saw that! I do not question their honesty. But one can claim that 1 to 3 per cent of witnesses add to an objective phenomenon so much subjectivity that the truth can be completely masked and fully unrecognizable!

What about the anthropic principle? And the Big Bang?

At the opposite of the wild look for alien visitors, in spite of all likelihood, another attitude has spread very quickly within the realm of *bona fide* scientific communities. This attitude is based on the remark that, were the constants of physics only slightly different from what they actually are, life would never have been possible, as evolution would have been much too quick, or much too slow.

In other words, the very existence of life is linked with the precise value of these universal constants: the velocity of light, the gravitational constant, the charge and mass of the electron, Planck's constant. On this basis, one went so far as to claim that it more or less means that the universe is made for mankind. And if one follows that line, one may conclude that man is alone in the universe, in the midst of the lost paradise, of animals, of plants, on Earth. Should we consider this so-called "anthropic principle" as a "misconception?" Possibly not. No doubt, the concept, just like that of a "Big Bang," has very strong metaphysical connotations. If the Big Bang is now, in some modified forms, rather widely accepted, the anthropic principle is not.

I feel that, although I personally have strong reservations about both, the Big Bang and the anthropic principle cannot be either eliminated or accepted as fully established facts.

The expression "Big Bang" is too often open to confusion, wrongly recalling a "creation," a "*fiat lux*." I believe that it is absolutely necessary to fix as clearly as possible the limits of our knowledge on that subject. In this way, the basis of the "Big Bang" model is the expansion of the universe, deduced from the redshift observed for the galaxies. But other interpretations are possible. Indeed, quasars could well be nearby objects, with an intrinsic redshift, and this would be accounted for easily by an absolute brightness otherwise badly understood. Another point: in the "Big Bang" theory the universe expands similarly to a perfect fluid. But at present, the strong anisotropy of the extragalactic universe appears more and more clearly, thanks to more and more impressive observations. Consequently, one cannot assert that the "Big Bang" model is definitively the only one possible.

In any case, even this model of a "primordial explosion" cannot, in fact, be understood as describing the very beginning of the universe. The model imagines a "primordial universe" with extremely large density and temperature, in which the matter could appear only in the form of the most elementary particles. But the description of this universe is thus totally dependent on the state of knowledge in theoretical physics, and is facing the same limits. In this way, the universe at a theoretical instant " $t = 0$ " corresponding to an "infinite" temperature cannot be described, as we ignore the behavior of matter for $T > 10^{32}\text{K}$; the deficiency leads to an interval of 10^{-43} second after the theoretical time zero; the temporal area between $10^{-\infty}$ ($=0$) and 10^{-43} second is indefinite and cannot be comprehended with our present knowledge, neither at a spatial level nor at a temporal level. In particular, we are unable to know if the universe has ever had any "beginning."

This scientific attitude has no correlation with a religious belief. Indeed, as God can be thought of as infinite and inexpressible, the man who believes in God cannot put his religious beliefs in the form of equations except by reducing them considerably; and that would properly be...diabolic!

In any case, the study of the limits of Science, or of the doubts that the scientists are facing, is clearly needed to complete the teaching of scientific results.

But I feel that we cannot speak about these limits in the same way as we do about astrology or ufology, which we know to be fallacious. We must insert, here

and there, into our teaching, the question marks. We must make clear also that an astronomer is also a person with his or her own ideas, philosophy, and religion. This general statement is justified by the study of the history of science and the history of scientists. And when speaking about the evolutions of concepts in astronomy, we should perhaps insist upon the provisional character of the progressing concepts. The last fringe of knowledge will stay somewhat fuzzy. One should realize (and make our pupils and students realize!) that, although science is never “finished,” it is built on firm ground. Even Copernicus broadly used Ptolemaic mechanisms; Kepler worked on Copernicus’ ideas; and Newton justified Kepler’s laws by universal gravitation. Einstein perfected Newton’s work, not replaced it, and his torso will not replace Newton’s on its pedestal. Similarly, we cannot say any longer that the proponents and opponents of modern cosmologies are really in contradistinction with the previous trends of research: they are still searching, piling up arguments, some bad, some good. Which are which, we do not know for sure! But the bad ones will fall, some time or another, in the dumping grounds of scientific history.

Concluding

Dear colleagues,

My talk has ranged amongst concepts as different as astrology, ufology, and modern cosmology. Although there is no ultimate and final truth, there are at least some beliefs that are obviously fallacies, but very popular ones. Some of them may be a danger for mankind, and I feel that the best remedy is an always awakened lucidity.

To bring the students, the school children, to this lucidity, it is not necessary to teach in any systematic way the known misconceptions I have quoted. But one must give the students the elements of a critical look, by showing how the human mind has evolved throughout history. This history of ideas and the history of men and women of science, are, in this respect, illuminating; but one has not only to follow the course of events. One has also to explain the logic of the proofs: the proof of heliocentrism, the proof of the universality of physical laws, the proof of *etc.* . . .

And if I must conclude with one sentence, I should say again and again that teaching astronomy does not mean teaching only the digested facts, but also essentially means teaching the methodology of astronomy, helping people of all ages to understand what they know. Only in this way shall we teach lucidity.

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Discussion

G. Mumford: *Astronomers have established the boundaries of the constellations. Since they do not believe in astrology they added another constellation to the zodiac? Was this done just to confound astrology? (Tongue-in-cheek question.)*

J.-C. Pecker: Who knows?

S.R. Prabhakaran Nayar: *While discussing the movement of the Sun across the background of constellations, it is worth discussing calendars followed in many places where the month (the time spent by the Sun in one constellation) length varies systematically to bring out the ideas of variation in the speed of the Earth on its elliptic orbit.*