ZAGADNIENIA
NAUKOZNAWSTWA
4 (198), 2013
PL ISSN 0044 – 1619

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Idea of Dynamic Universe – Thought Styles in Cosmology

Abstract. Looking at the roots of modern cosmology we find two important circumstances: the transition from cosmology based on the Newtonian concept of space-time to relativistic cosmology and the acceptance of the idea of dynamical relativistic Universe. We argue that while the former is a scientific revolution in the Kuhn's sense, the latter has no such a character. The reason is that the transition from Einstein's static to Friedmann's dynamic Universe takes place on foundations set up by general relativity theory. The theoretical possibility of dynamic Universe is a natural consequence of general relativity concept of curvature space-time, but it was not recognized from the very beginning, when Einstein was convinced that the Universe is static and did not admit the solutions of expanding Universe. We argue that Fleck's conception of thought style is more adequate to reconstruct the very complicated process of the dynamical relativistic picture of the Universe ('Weltbilt') formation.
Keywords: thought styles, L. Fleck, dynamic universe

Idea dynamicznego Wszechświata – style myślowe w kosmologii

Abstrakt. Patrząc na korzenie współczesnej kosmologii odnajdujemy dwie ważne okoliczności: przejście z kosmologii na podstawie koncepcji czasoprzestrzeni newtonowskiej do kosmologii relatywistycznej i akceptacji idei dynamicznego relatywistycznego wszechświata. Uważamy, że podczas gdy pierwsza jest rewolucją naukową w sensie Kuhna, druga nie ma takiego charakteru. Powodem jest to, że przejście od statycznego Wszechświata Einsteina do Friedmanna dynamicznego Wszechświata odbywa się na fundamentach stworzonych przez ogólną teorię względności. Teoretyczna możliwość dynamicznego wszechświata jest naturalną konsekwencją ogólnej koncepcji względności krzywizny czasoprzestrzeni, ale nie została uznana od samego początku, gdyż Einstein był przekonany, że Wszechświat jest statyczny i nie istnieje rozwiązanie, zgodne z rozszerzającym się wszechświatem. Uważamy, że koncepcja Flecka stylu myślowego jest bardziej adekwatna w rekonstrukcji bardzo skomplikowanego proces tworzenia się dynamicznego relatywistycznego obrazu Wszechświata (*Weltbilt*).
Słowa kluczowe: styl myślowy, L. Fleck, wszechświat dynamiczny

1. Introduction

Looking at the roots of modern cosmology we find two important circumstances: the transition from cosmology based on the Newtonian conception of space-time to the relativistic cosmology and the acceptance of the idea of dynamical relativistic Universe. We argue that while the former is a scientific revolution in Kuhn's sense, the latter has no such character. The reason is that the transition from static Einstein's to Friedmann's dynamic Universe takes place on foundations set up by the general relativity theory. The theoretical possibility of dynamic Universe is a natural consequence of general relativity concept of curvature space-time, but it was not recognized from the very beginning, when Einstein was convinced that the Universe is static and did not admit the solutions of expanding Universe. We argue that Fleck's conception of thought style is more adequate in the reconstruction of a very complicated process of formation of the dynamical relativistic picture of the Universe ('Weltbilt').

Theoretical as well as observational factors play an important role in the constitution of the Standard Model of the Universe (*Lambda cold dark matter model*). We show that the model of the Universe, commonly accepted by cosmologists, plays the role of effective theory of the Universe and at this moment cosmology remains similar to other effective theories like the Standard Model of Particle.

We demonstrate that the key idea is dramatically changing our thinking about space. This idea explores the notion of curvature of the space-time as a whole. If we separate space and time, and imagine the cosmological evolution as an expansion of the flat space in the cosmological time, then such an image gives rise to a misguided intuition inspired by non-relativistic (Newtonian) thinking (Weinberg 1987). Such a point of view does not suffice to distinguish observationally between effect of kinematic expansion of galaxies in the static Universe and expansion of space itself. Therefore our thinking about the expansion of the Universe obviously supersedes the previous Newtonian intuition.

We point out that, while the idea of the dynamic Universe does not require changing of methods (differential geometry, tensor analysis are still preserved as the mathematical language) and notions, the concept of expanding space-time from which time and space cannot be separated is an essential factor of the new relativistic thought style.

Regarding the question of the continuity of the transition from static to dynamic Universe what one can observe is seemingly the discontinuity. If we proceed, consequently, from the Newtonian paradigm towards the relativistic one, then we should think that the space-time is not merely space and time, and the expansion of space is a true physical effect which can be detected through the observation of the curvatures. In the opposite case, this may lead to confusions and paradoxes (Abramowicz 2008; Nikolic 2012). If we agree that the space-time is a physical reality described in terms of general relativity, then it seems natural to expect that it is expanding.

We explore Fleck's ideas with regard to the reconstruction of the transition from the early phase of the Newtonian intuition – changing in view of the general relativity – towards the exploration of a relativistic point of view. It seems that the context of discovery in cosmology is influenced to a large extent not by scientific arguments, but by one's outlook, the philosophical and cultural background. We show that it is related to the cosmological subject of uniqueness in cosmology, which is connected with the problem of initial conditions, which are unknown as contrasted with physics. Therefore, it is necessary to make some assumptions regarding the initial conditions, which are not known from observations or experiments. Methodological assumptions were also important, as they determined the choice of the method for cosmology from the outset: bottom – up instead of top – down. In this context the problem of the initial conditions becomes very dramatic, because only observation should enable one to indicate the initial conditions for the Universe.

With the experience of the relativistic revolution we illustrate assertion that scientific revolution set in motion a laborious process of recognizing the possibilities yielded by the theory, of learning and understanding it, as well as building-up notions and formalisms. We show that the process of understanding of the general relativity ideas is recurrent, taking as an example the discussion on the space expansion, which is a fundamental fact of cosmology.

Our thinking focuses on the Newtonian intuitions, nevertheless they constitute a source of paradoxes and misconceptions. In teaching, cosmology very often incorporates this tendency. And the reason for it is that general relativity is difficult and counter-intuitive. For example, in some introductory courses the relativistic model of a homogenous universe is presented in a Newtonian way, which results in grave errors with regard to explanations, because the correct understanding is possible only within the framework of the general relativity. This tendency observed in didactics and popularization of cosmology is responsible for the fact that the old Newtonian thought style prevails, even though the cosmological concepts have already been elaborated and accomplished.

It is a price to be paid for an elementary level of presentation of the problem, which – because of its relativistic nature – is far from simple. Cosmologists acknowledge the complexity of the relativistic world and also how difficult it is to communicate their discoveries to the wider public. In this context we can recall H. Reichenbach's distinction of the context of discovery and the context of justification. There is a considerable gap between how cosmologists reason in terms of the technical notions and how they communicate their results.

2. Determinants of the acceptance of the idea of static Universe

Thinking of the Universe as being static in a cosmological scale was kind of a common view among cosmologists up to the late 1920s. Albert Einstein, for one, was convinced that there was no alternative solution of the equations and he was consequently opposing every view which tried to undermine this assumption. His negative reaction against Minkowski's lecture in Cologne, elaborating on the concept of 'space-time', is quite a telling example of the situation of the common agreement among scientist about the Euclidean geometry being sufficient for modern physics (Rowe 2009).

It is also interesting that Minkowski himself advocated the substantial interpretation of space-time (Levrini 2002). This view has its origin in Newtonian mechanics, and casts a shadow on the interpretation of general relativity. The concept of absolute space-time, however, when applied to the general relativity, leads to several paradoxes. The wide-spread interpretation of the classical general relativity as well as the loop quantum gravity are closer to the relational interpretation of space and time.

In the paper we try to recast this specific scientific situation in terms of Ludwik Fleck's conceptual framework (Fleck 1935, 1986; Sady 2001).[1]

For our purposes in this paper we focus on two main concepts of the Fleckian philosophy of science: "thought collective" (*Denkkollektiv*) and "thought style" (*Denkstil*). Fleck claimed that a scientist – an individual knower (in the philosophical sense) – experiences some kind of a compulsion of thought, because of being a part of the wider scientific community. The intellectual cognition is, in fact, a social activity. Not only in terms of exchange of scientific results, but also with regard to the specific intellectual constraint of "thought community". It would be claimed – in a philosophical sense – that the result of scientific practice is conditioned by a thought style. It is very important to admit that this social allegiance of knowledge concerns not its content, but the epistemological structure of the scientific cognition.

With regard to cosmology we believe that it is viable to distinguish two separate thought styles in the Fleckian sense: one represented by the followers of the stationary state cosmology and the other another – by the representatives of the Big-Bang cosmology. Kuhnian notions, in particular 'the change of scientific paradigm' and 'the scientific revolution' cannot be applied here, because in the case at hand there is no change in mathematical and conceptual methods (curvature of the space, Riemann curvature, notion of gravitation as the geometrical effect). We believe that 'the thought community' has influenced Einstein's failure in not recognizing and accepting the dynamical nature of the space-time. Smolin (2006) reckoned that the initial acceptance of the static nature of Universe by Einstein was due to the lack of empirical evidence for expansion. He emphasized that, when Einstein has built his general relativity theory, the Universe was understood as consisting of the Milky Way only. The scientific picture of the static Universe was well grounded in this epoch given the then current empirical knowledge coming from astronomy: 'building blocks' of the Universe are stars; well-known nebulae are situated within the borders of our Galaxy. The static Universe paradigm was based on the lack of the visible changes in the structure of the Universe.

Einstein is considered to be the author of the cosmological principle, which is in fact the generalized Copernican principle: the Universe being observed from every

[1] Ludwik Fleck (1896-1961), Polish microbiologist, born in Lviv, studied in Lviv and Vienna. As a scientist he worked in Lublin and Warsaw. Apart from the scientific practice (bacteriology, immunology, hematology), Fleck wrote a book (*Entstehung und Entwicklung einer wissenschaftlichen Tatsache. Einführung in die Lehre vom Denkstil und Denkkollektiv*) and a few papers in philosophy of science. Until 1977 his philosophical works remained largely unknown. It was only after his monograph *Genesis and Development of a Scientific Fact* had been translated into English, Fleck was recognized as an original philosopher more widely.

celestial body and in every direction appears to look the same. Einstein (1917) used the cosmological principle for the first time when he postulated of the spatial homogeneity and isotropy to construct his relativistic model of the Universe. Let us distinguish the main justification explaining the usage of the cosmological principle by Einstein:

1. Simplicity in elaboration of the equations in general relativity: the cosmological principle applied to them allowed to reduce admissible solutions to the subclass of cosmological solutions; namely to the second-order ordinary differential equations.
2. A physical justification: Einstein suggested that in a cosmological scale the Universe can be treated as homogeneous in terms of matter distribution. Moreover, he used the argument that the speed of stars is negligible to the speed of light. We think that when Einstein was speaking of the finite of Universe, he had in mind its spatial closeness. He was fond of the closed Universe model because of his philosophical background knowledge.
3. Einstein in his scientific speculation was constantly rejecting the possibility of galaxies having huge individual speed (of cosmological origin). He did not know much about irregularities in the star distribution.

It is remarkable how important role in building of general relativity was played by philosophical assumptions and views. Kragh (2007) claimed that this feature of correlation between the philosophy (general belief concerning the nature of the Universe) and cosmological methodology is its apparent weakness. He treats in that manner cosmology as scientifically controversial. We have a firm conviction that it is crucial evidence of the scientific practice being conditioned not only by sociologically "tangled" style of thinking but also by philosophical views that is unavoidable background knowledge.

3. The context of the discovery of the dynamic structure of the Universe

A positive correlation between the distance to the galaxies and their redshifts was actually known before Hubble measured these distances. It is very interesting from the methodological point of view, that he treated the problem of correlation in terms of the curve fitting (searching the polynomial representation). Just after he acquainted himself with the first cosmological models and the Robertson-Walker metric, he chose simple linear approximation.

On the other hand, the discovery made by Hubble had an influence on Einstein. He removed the cosmological constant from his equations ("Lambda" was introduced to 'save' the static solution) and called it famously his biggest mistake.

The connection between the acceptance of linear form of correlation and the theory of cosmological model and the Robertson-Walker metric should be emphasized here. According to the Robertson-Walker metric the space-time has the structure of the Cartesian product of real axis representing cosmological time variable and 3-dimentional homogenous and isotropic space. Riemannian spaces as having these features can be mathematically expressed as the spaces of a constant curvature. It can be shown that it is possible to treat the Hubble's relation as a consequence of the acceptance of the cosmological principle.

Some popular books or lectures claim Hubble's law as a confirmation of the general relativity. However, it is recognized that the cosmological principle implies the Hubble law, but not *vice-versa*. E. Hubble's and R. C. Tolman's article states that the Hubble function can be treated as the best interpretation of the observed move of the receding nebulae. Of course, they have not rejected the different interpretation of the effect as being connected with the movement in the local and static system of coordinates. It is so in Milne's model, where the redshift is treated as a kinematic effect (Milne 1934; 1935). Georges Lemaître (1927) was the first who used the term: 'the apparent Doppler effect' in order to clearly distinguish these two kinds of effect. His paper on that was published two years before Hubble's work.

The points below present how profound was the impact of the Newtonian style of thinking on scientific practice.

1. In spite of Einstein's work, namely: constructing the notions of 'space' and 'time' as a non-separable concept, which is often treated as a scientific revolution in the Kuhnian sense, our physical intuition is still far away from such a 'unification'. We still have in mind a background confidence that physical phenomena take place on some kind of a 'stagnant stage' and their dynamics does not depend on the stage in any way.
2. The 'temptation' of seeing the physical world around us in the Newtonian style is so prevailing because our intuition of the physical properties of the objects comes from the empirical experience of the physical reality, which we perceive as being non-relativistic. Abramowicz (2008) suggested that ignoring the fact of physical consistent reality of space-time leads to a serious confusion and paradoxes. In cosmological space-times of non-static nature, expansion of the space is a real physical effect. Affected with the Newtonian conceptual framework we were keen to the idea of expanding Universe as the expanding of the matter/objects in a static (non-expanding) and flat space. It agrees with our non-relativistic intuition, which does not properly take into account the space-time nature of the problem. Abramowicz (2008) writes: "This is reflection of the fact that Newtonian and general-relativistic cosmology of an isotropic and homogeneous Universe are equivalent as long as one does not consider the propagation of light."
3. In other words, the source of this misunderstanding lies in the style of thinking, which gives the concepts of time and space a different meaning.

4. There is a very interesting interpretation of Einstein's general relativity equations presented by Rothman and Ellis (1987) and based on the rule called: 'action-reaction'. In our opinion, it can be treated as intrinsically related to the third Newton's law of motion. It might also shed light on Einstein's doubts about cosmological constant.

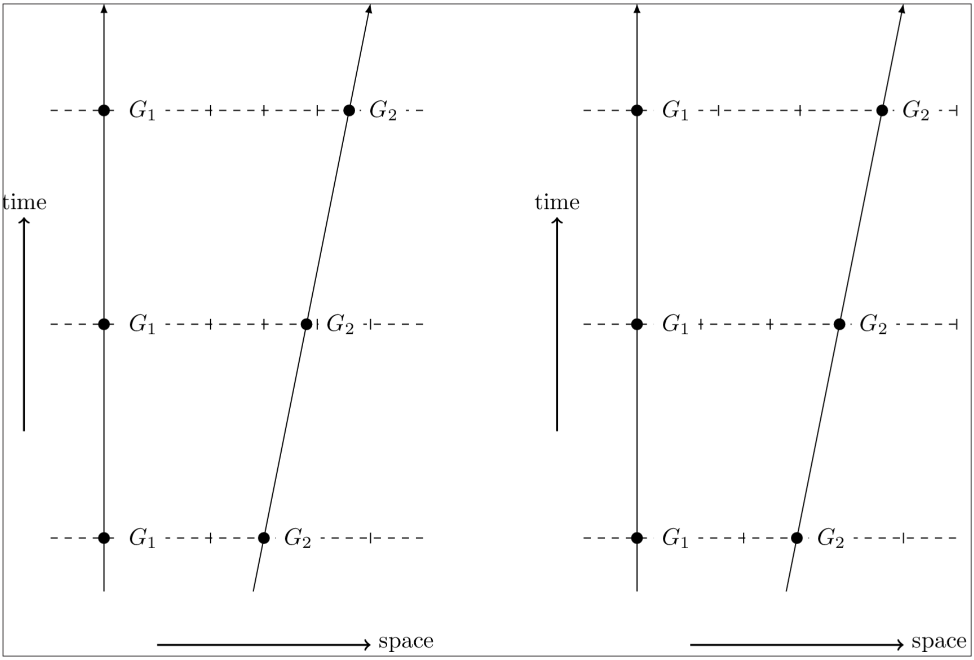

Figure 1. Illustration of apparent equivalence of picture of galaxies moving. Left: Galaxies move relative to each other in static flat space. Right: Galaxies are in fixed point while the flat space expands. Both figures are incorrect because of non-relativistic style of thinking.

The action-reaction rule can be expressed as follows: physical processes are modelling the curvature and vice versa – the curvature has its impact on the dynamics of physical processes. If we look at element Rg_{ab} in Einstein's GR equations, changing R affects the right side of the equation. From the other side, the changes in the value of T_{ab} imply different R. If the cosmological constant – Lambda – is put on the side of Einstein's equations, the picture changes: different values of T_{ab} will not affect the Lambda, but not *vice-versa*. The presence of Λ breaks the action-reaction rule, which was expected by Einstein to comply with the requirements of his interpretation of general relativity theory. Rothman and Ellis's argument seems to be very weak against the cosmological constant because gravitation field unlike the electromagnetic field has energy and momentum therefore it interacts with itself, i.e. gravity generates gravity, in consequence the Einstein's field equations

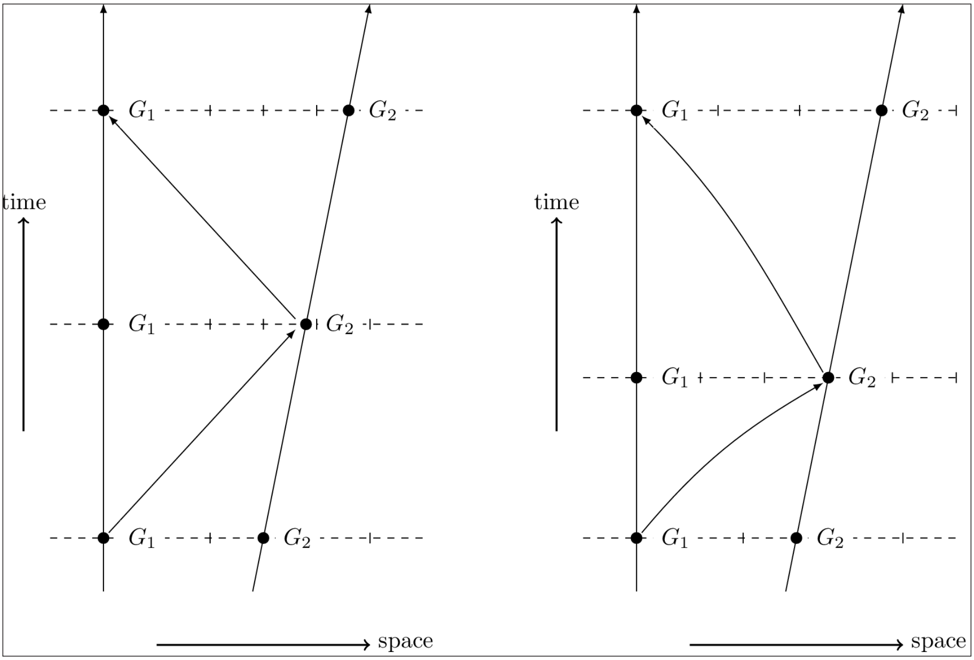

Figure 2. Illustration of the correct picture of galaxies motion in space-time. Left: galaxies moving in non-expanding space. Right: fixed galaxies moving in expanding space.

are nonlinear at very beginning and the simplified scheme of action-reaction is violated.

Another argument against the presence of cosmological constant in the field equations is based on undeterminacy of its role played in the system equation. If it is put on the left hand side of equation it has geometric sense, while moving it on the right hand side it can be interpretated as a some kind of fluid of constant energy density violating strong energy condition (dark energy).

In spite of a quite practical formal analogy, the construction of a cosmological model as based on Newton's theory faces many difficulties and paradoxes. Baryshev (2008) formulated the Friedmann-Holtsmark paradox. For the symmetry reasons, due to the isotropy of the distribution of particles the average force in any given location is equal to zero and one is left with the finite value of fluctuating force, which is determined by the nearest neighbour particles. Hence in an infinite Euclidean space with the homogeneous Poisson distribution and Newtonian gravity force there are no global expansion or contraction, but there are the density and velocity fluctuations caused by local gravity force fluctua-tions.

Another type of paradoxes in standard cosmological models is indicated by Baryshev (2006). He showed that some paradoxes origin from the ill-defined concept of the energy-momentum tensor for the gravitational field, which leads to violation of the energy-momentum conservation for matter and gravity.

In cosmology general relativity determines the geometric structure of the Universe by the metric, which has a local character. The global structure of the Universe is described by its topology (Luminet 2008). The geometrical structure of the Universe cannot be seen directly because it is unembedded in the 3-dimensional Euclidean space. In some way the computer visualization aids our perception of these complex geometrical structures. In perception of non-Euclidean geometry for the universe where space topology may be non-trivial (multiconnected), there are very useful computer programs such as Jeff Weeks‘„Curved Spaces“ (Weeks 2012).

When the fact of expansion of the Universe was firmly established by interpretation of Hubble‘s receding galaxies observation in the framework of general relativity, Lemaitre came to the conclusion that the expanding Universe has the beginning called the Big-Bang. The Universe was no longer eternal. This change in thinking was similar to the change from the static to dynamic Universe.

It was natural to ask whether the expanding but eternal Universe is possible. Bondi, Gold and Hoyle proposed the model of the steady-state universe. The theory of steady-state describes the model of the universe which does not refer to Einstein‘s general theory of gravitation. Its foundation is the ideal cosmological principle. According to it the universe is the same seen from any point, in any direction, and in any time. The last assumption that during its evolution in any point of time the Universe is identical implicates that all parameters of such a universe should be constant, in particular the rate of expansion of the universe described by the Hubble function is constant. If H = da/dt/a = const then the solution is a(t) = a0 exp[H0(t)]. It means that in the steady-state universe the scale factor grows and then the matter density decreases. In a given volume element the amount of matter lessens as the Universe evolves, what contradicts the ideal cosmological principle. That is why the idea of continuous matter creation ex nihilo was introduced to ensure that the density of matter is constant and the Universe is the same in every moment of time. The required amount of matter created to ensure the stationarity of the Universe model is therefore neglegibly small in relation to the amount of matter. It is unmeasurable so it makes this theory unfalsificable in the Popperian sense.

The discovery of cosmic microwave background (CMB) radiation has become the main argument for the Big-Bang cosmology (Penzias and Wilson 1965). The CMB radiation cannot be present in the steady-state cosmology. The recent observations of distant supernovae type Ia indicate that not only our Universe expands, but also the acceleration of its expansion is positive. The discovery that the current Universe is in an accelerating phase of expansion has been done by two scientific groups: the High-Spernova Search Team headed by B. P. Schwartz and A. Riess and the Supernova Cosmology Project led by S. Perlmutter (Riess et al. 1998; Perlmutter et al. 1999). To describe this unexpected fact, Einstein‘s conception of the cosmological constant was resurrected. The cosmological model which makes allowances for these astronomical observations is the standard cosmological model which describes the flat, homogeneous and isotropic universe filled with baryonic matter, dark matter and dark energy. While both baryonic and dark matter are pressureless, dark energy is not. In the model dark energy is represented by the cosmological constant and its nature is still unknown. Both dark energy and dark matter are the prime problems of contemporary cosmology.

From methodological point of view, the standard cosmological model has the status of an effective theory (in particle physics, the standard particle model has similar status). It means that this model offers the description of the Universe with accelerating expansion at the present epoch rather than explanation of what dark energy is. One can distinguish some features of the cosmological model understood in terms of effective theory. First, the main subject of cosmology is the estimation of cosmological parameters from the observational data. Astronomical data, provided by the latest experiments both ground-based and satellite, expand our knowledge about the Universe. The most important sources of information on the evolution of the Universe are observations of supernova type Ia, observations of anisotropy of cosmic microwave background (CMB) radiation, observations of barionic oscillations, and other.

The conception of cosmology in numbers (cosmological parameters) allows us to form the standard cosmological model as the simple six parameter model. From the standard cosmological model one can calculate some observable which open the possibility of falsification of this model through astronomical observations. The standard cosmological model operates in a strictly determined energy scale, that is after the Planck epoch when quantum gravity effects are negligible. In the standard cosmological model we use some parameters describing the matter content whose nature is unknown; we expect that a new cosmological theory resolves what it is. In cosmology we are in search for a more fundamental theory.

While the effective explanation in modern cosmology cannot elucidate the cosmological constant problem (why the cosmological constant is so small?), the scheme of the effective theory for cosmology enables us to extrapolate towards new unobserved parts of the Universe.

4. The significance of the history of cosmology to the understanding of its ideas

Kragh (2011) has recently pointed out the role of modern cosmology in science education. Because cosmology has always excited interest of the public, it should be in great extend used in science education to a great extent. Kragh’s recommendation for science teaching is to use a partly historical approach. As we pointed out in previous section, these early discussions in cosmology were often biased towards Newtonian style of thinking, and cannot give clear picture of modern state of cosmology. Therefore we argue for the model-based view of cosmology. The research practice of modern cosmology confirms that the models, rather than theories, are autonomous instruments for study of the Universe rather than theory. This observation is close to Nancy Cartwright's concept of toolbox (Cartwright 1983). Following Giere (1988), theories are taken to be sets of theoretical models and hypotheses about the relation between the models and the world. Studying cosmology in terms of models for example CDM model and Lambda CDM model we can find some interesting relations between the models and their status with respect to the theory.

Let us examine the rise of idea of the expanding Universe. There is nowadays the debate on "who has discovered the expanding Universe?" (Nussbaumer and Bieri 2009; 2012). According to the popular, historical view Edwin Hubble is thought to be the discoverer. However Hubble has never believed in the expansion of the Universe. Hubble was an empirist. It was important to him that the law should be formulated as an empirical relation and only the increase of data precision would reduce the set of possible interpretations. In the paper published after his death he discussed the law of redshifts (the relation between redshift and apparent magnitude) to be the Doppler effect or the expansion of the spacetime and conclude that "the data now available are not sufficient to furnish a critical test of two interpretations" (Hubble 1953, 666). Following different kind of events leading to scientific discovery as to reconstruct the process in meta-language, researchers, historian and philosophers usually focus on a variety of factors: basic notions, hypotheses stated, experimental data. It is crucial to decide which factor played the most important role in the discovery. The answer to that question depends on the accepted point of view. For a historian of science the most important issues would probably be problems of precedence: date of publication, extensive and lively correspondence between researchers, who discovered an the exact solution of an important equation or successfully performed an experiment, etc. For a philosopher, on the other hand, the most interesting issue is the structure of elaborated theory, its explanatory power, the problem of relation (possibly of reductive character) between known theories, an interpretation of mathematic formalism. We put into that perspective the question of the discovery of expanding Universe.

If not Hubble, then who discovered the expanding Universe? In this ongoing discussion Lemaître is pointed out (Bergh 2011). Obviously, the conceptual framework for the discovery is Einstein's general relativity theory and works by Friedmann, who showed explicitely that Universe is dynamic in itself. Parallel to these theoretical results (and initially independently) runs the observational work of astronomers (more and more precision in measuring cosmic distances, astronomical objects spectrum analyses, etc.).

Albert Einstein, at first, has obtained static solution. As we have shown, it was in accordance with the thought style prevailing in cosmology before the discovery of the Universe expansion. However first Friedmann presented dynamic solutions describing the possibility of expanding or contracting Universe, then Lemaître found new dynamic solution, derived of the formula presenting the radial velocity-distance relationship, drawing on the empirical data by Hubble and Slipher. He estimated the value of Hubble constant (two years before Hubble's papers have been brought to light!). Lemaître published his result in French and in an unknown journal.

There is no doubt that all the credit concerning experimental determination of linear velocity-distance relationship and estimation of galaxies recessional velocity goes to Hubble. Nevertheless, for a cosmologist the most interesting is the nature of our Universe. It is very important in this context to understand that the discovery of the expansion of the Universe has actually happened when the experimental data concerning the galaxies recessional velocity were interpreted in the theoretical context of Friedmann cosmological model. Immanuel Kant used to say: "the experiment without a theory is blind, but theory without experiment appears to be only an intellectual game". There is sometimes a strong temptation to go beyond theory and go in for the so-called 'model/theory independent' astronomy or cosmology.

To put it in more educational perspective, it should be said that modern cosmology is inextricably bound to general theory of relativity. Of course, the studies require quite considerable intellectual effort. Treating Newton's theory as the beginning point and the main conceptual framework in that process, although appearing to be much simpler way, leads to an elusive solution. It is so, because the analogy (or likeness) between specific set of equations does not come with conceptual correspondence. For example, the concept of curvature, which is crucial in general relativity, finds no equivalence in Newton's theory. In our opinion, even if we try to build our knowledge about Universe in Newtonian way, we will not avoid paradoxes unless we use the concept of space-time.

Francis et al. (2007), commenting on the notion of expanding Universe in the framework of receding galaxies (which is very popular approach in teaching cosmology), write: "(…) the concepts of expanding space in explaining the increasing separation of galaxies has recently come under fire as a dangerous idea whose application leads to the development of confusion and the establishment of misconceptions…we develop a notion of expanding space that is completely valid as a framework for the description of the evolution of the universe and whose applications allows an intuitive understanding of the influence of universal expansion (…)".

Why is it so important to us? Francis et al. (2007) looked for the answer on a philosophical question: what is the nature/ the ontology of the 'space expansion' process in standard cosmological model, where the energy conservation law is broken by the expanding space. When we think of it in a physical way, an expanding Universe implies creation of space together with physical vacuum. However, the structure of the real Universe is not homogeneous and isotropic. Bondi (1961) has shown, that in that kind of cosmic structures gravitationally interacting the space is expanding very slowly. ‘Space creation’ is a completely new physical effect, which cannot be tested in the lab. Harrison (2000) claimed emphatically that the cosmological redshift, as the effect caused by the Universe expansion, is quite a new physical phenomenon, not having an equivalent in the lab, where one deals with the classic Doppler effect. During the discussion with Riess and Weinberg (1993), who asked and answered: “how is it possible for space, which is utterly empty, to expand? How can nothing expand? The answer is: space does not expand. Cosmologists sometimes talk about expanding space, but they should know better”, Harrison (2000) replied: “Expansion redshifts are produced by the expansion of space between bodies which are stationary in space“.

In conclusion of the historical and philosophical discussion:

1. It is quite reasonable to reconstruct the historical and philosophical background of the discovery of the expanding Universe. Firstly, it allows clarifying ‘common big-bang misconceptions’ and ‘expanding confusions’, which occur in interpretation of scientific research. Secondly, the question of ontological status of the ‘expanding space-time concept’ is raised as the discussion goes beyond science in the strict sense. It takes place now in more general philosophical ground. Thirdly, the discussion shows, that the standard cosmological model reveals itself a few conceptual problems concerning the notion of energy.
2. The idea of the dynamic Universe is one of the concepts which plays an important role in a current discussion but a historical reconstruction may also help scientist and philosophers of science in better understanding of its theoretical and experimental conceptual framework. Fleckian concepts of ‘thought style’ and ‘thought collective’ can be useful to present the crux of the debate in terms of weak version of social constructivism. The scientific development of the twentieth century’s cosmology appears to be non-susceptible to traditional language of logical analyses (compare to ‘logic of scientific discovery’ by K. R. Popper). We are much more interested in a descriptive than normative methodology.
3. We have also showed in the paper that the case study of the idea of the expanding Universe has considerable educational value. It consists in presentation how the perception of important scientific notions differs and is evolving among scientists and philosophers.

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