

Introduction

By GIANFRANCO BASTI* AND FRANCESCO M. FERRARI**

1. An overview of this volume

All the papers collected in this Volume are written versions of the contributions presented by the respective Authors at two International Conferences, organized by the *International Area on the Foundations of the Sciences* (IRAFS) of the Lateran University, for celebrating significant dates in the history of modern cosmology. By visiting the *Events* page of the IRAFS web portal, (www.irafs.org), it is possible to look at the *Programs* of these two events.

The Papers 4., 8., 10., 11., 12., 13., 17., 18., 19., 20. are updated versions of speeches delivered by their Authors at the *Lateran '09 International Conference '1609-2009. "From Galilei's Telescope to Evolutionary Cosmology"*, November 29th – December 2nd, 2009. This Conference was organized in collaboration with the Pontifical Academy of Sciences, because the Conference was the concluding event of the celebrations by the Holy See of the “International Year of Astronomy, 2009”.

The Papers 2., 3., 5., 6., 7. 9., 14., 15., 16. are updated versions of speeches delivered by their Authors to the *International Conference "One Century in the Space-Time. Physics, Philosophy, and Theology in a Time of New Questions"*, November 24-25, 2016. This Conference was organized in collaboration with the State University of Urbino, for celebrating the hundred years of the Theory of General Relativity (1915-2015).

The Authors are all specialists in their respective fields and the present volume combines four different sorts of works, according to four distinct fields of inquiry: Physics, Ontology, Epistemology, and, finally, Theology. The volume is therefore articulated into four main Sections.

* Faculty of Philosophy, Pontifical Lateran University, Italy; basti@pul.va

** Associate Researcher, University of Campinas, Brazil; ferrarifram@gmail.com

1. The SECTION I, titled *Scientific Cosmology and Quantum Physics* consists of papers (1-5) presenting the state for art of the scientific – theoretical and observational – cosmology, according to the two main sources of the actual cosmological research. The Theory of General Relativity, and the Quantum Physics, not yet reconciled in one only coherent theoretical framework.
2. The SECTION II, titled *Ontology, and Metaphysics of Nature* (papers 6-10) consists of papers concerning the ontological and metaphysical interpretations of cosmological theories, with several related issues.
3. The SECTION III, titled *Epistemology and History of Science* (papers 11-14), where several themes, from the birth of Modern Cosmology and Physics (the Galilean one) to the epistemic paradoxes of Relativity theory are developed and discussed.
4. The SECTION IV, titled *Theology and Science* (papers 15-20) includes theological studies addressed to sketch the harmony between natural sciences and God’s Existence and Creation. The last contribution, in this Section (the paper 20.) by Card. Gianfranco Ravasi is a sort of *Afterword* to the entire volume because it includes a fresh and inspiring synthesis of the Biblical Cosmology.

Finally, we want to emphasize the *Foreword* to the First Section of this volume (the paper 1.), written by Gianfranco Basti. It is titled *A Chronology of the Universe Evolution*. Effectively, it works as a sort of “extended index” of the main topics discussed in the First Section, for helping the reader not acquainted with physics to have an overview of the state of art of the cosmological research presented in these papers.

As usual for any *Aquinas* issue, this volume finishes with the three columns of

- Aquinas Newsletter
- Book Reviews
- Received Books

To conclude this Introduction, we present the *Outlines* of all the papers collected in this volume, according to their progressive numbering, within the four main Sections of the volume, to introduce their contents and to show some their connections.

2. Paper outlines

2.1. Section I: Relativistic Cosmology and Quantum Physics

1. GIANFRANCO BASTI – *Foreword: a chronology of the universe evolution*. This Foreword is intended as a sort of “extended index” of the main topics discussed in the papers of the First Section of the volume, for helping the reader not acquainted with physics to have an overview of the state of art of the cosmological research presented in these papers. At the same time, it offers a chronology of the universe evolution, from the first instants after the big-bang, till the actual epoch, depending on the progressive expansion and cooling of the universe itself, at the beginning very dense and hot. After a short presentation of the two main sources of the actual scientific cosmology: a) the Cosmological Standard Model, based on the General Theory of Relativity (see Paper 2.); and b) the Standard Model of the Elementary Particles (see Paper 3.), based on the Quantum Field Theory, the paper offers a short synthesis of the main stages of the universe evolution, from its “very early stages”, starting with the hypothetical “Planck age” about 10^{-43} sec. after the big-bang, till the actual structure of the universe, about 13.8 billion years after the big-bang, in which we live.

2. SILVIO BERGIA – *Celebration for 100 years of the General Theory of Relativity*. This paper, as mentioned in the title, is intended to celebrate the hundred years from the publication of Einstein’s *Grundlagen der allgemeinen Relativitätstheorie* (1915). The Author follows and comments a sequence of steps characterising the development of the Relativity theory. After illustrating its creation, the content of the paper is devoted to discuss different phases in the development of the theory. (i) The first basic successes; (ii) The “third effect”; (iii) A period of “low water” that lasted something like forty years and, finally; (iv) The revival: in the last decades of the twentieth century the theory achieved a series of great successes, including a “fourth effect”. Finally, the Author gives a brief account of the further developments of the theory characterizing the XXI century: the existence of the “gravitational waves” only recently observed (Abbot, LIGO Collaboration, & VIRGO Collaboration, 2016; Abbott & al., 2017; Abbot, LIGO Collaboration, & VIRGO Collaboration, 2017) and the open issue of the “dark matter”.

3. CESARE BINI – *Open problems in Fundamental Physics*. Along several centuries of experience, physicists have been generally driven by the idea that the description of all the natural phenomena was based on a bunch of fundamental laws or *Principles of Nature*. Fundamental Physics starts from this expectation, corroborated by many results along the centuries. According to the Author, the ambitious program of Fundamental Physics has proceeded essentially along to two main directions: one, towards the infinitely small – under the label of Elementary Particles Physics – and the other towards the infinitely large – that we call Scientific Cosmology. The former is based on the leading idea according to which matter is made up of few elementary bricks and few forces acting among them. It is essentially the *atomistic* idea from Democritus, underlying also quantum mechanics (QM) and the so-called Standard Model (SM) of elementary particles. The latter is, on the other hand, based on the *holistic* idea of the Universe as a whole: a large-scale structure, from its origin to its fate. This contribution emphasizes that this latter direction is actually something that has been always present in (m)any culture(s) but only during the XX century evolved from mere speculation, to precise mathematical hypotheses because of the “General Theory of Relativity”, object of the 2. Paper of this collection, till becoming a fully “Galilean Science”. That is, based on mathematical hypotheses confirmed by observations and precise measurements. I.e., the so-called “observation cosmology”, object of the 4. Paper of this collection. In the present paper, the Author particularly emphasizes that the SM is based on the Quantum Field Theory (QFT), embodying Special Relativity and QM, and making of the dynamic continuum of “fields” – the “material” fields, whose quanta are “fermions” (quarks and leptons), and the “interaction fields” of the three quantum forces, whose quanta are “bosons” – and not of “isolated particles” like in the former mechanistic view, the proper objects of the Fundamental Physics. Nevertheless, the paper emphasizes that the SM is from many points of view “unsatisfactory”. Therefore, the Author concludes his work with the following statement: “the impression is that the ‘end of the story’ is far from being reached: any step forward opens new frontiers, the comprehension of physics being like a ‘bottomless pit’”.

4. MARCO BERSANELLI – *Observational cosmology*. Galileo’s groundbreaking observations in 1609 inaugurated an extraordinary development in astronomy (as well as in science at large) leading in the following centuries to a *new scientific understanding* of the physical universe. As remarked in the Paper 1., a more recent contribution to this view of the universe, was Einstein’s theory of “General Relativity”. The present paper starts from the

further cosmological hypothesis of the universe expansion, better known as the “big-bang hypothesis”, by Lemaitre and Hubble. However, the observation of the universe using telescopes at different wavelengths of the electromagnetic radiation (X-rays, ultraviolet, optical, infrared, radio-waves...) was originally limited to the “light” emitted by galaxies. Of course, because of Relativity Theory the finite velocity of light implies that farther we observe galaxies in space, farther we are going back in time toward the universe origins, dated about 13.8 billion years ago. The observational confirmation of our quantum-relativistic hypothesis of the universe evolution required, however, the observation and the measurement of the universe light radiation before galaxies’ formation. This radiation is the so-called *cosmic-microwave-background* (CMB) radiation, discovered by Penzias and Wilson in 1965, in the form of a diffuse, highly uniform “luminosity” of the sky with an average temperature of less than 3K, demonstrating that the “dark sky” circumventing galaxies is not completely lightless. The photons constituting this (invisible for the naked eye) radiation were released by the early universe, smaller and then denser than the actual, when it cooled at a temperature about 3000K, so to allow the formation of the first light atoms from the preceding “plasma” of electrons and nuclei. This happened when the universe was 380,000 years old, while the observation of light emitted by the farthest galaxies, we are able today to observe allows us to arrive till about 0.8 billion years of the universe age. By the missions of the COBE (1989-1996) and the WMAP (2001-2003) satellites launched by NASA, and finally of the PLANCK (2009-2013) satellite launched by ESA, we became able to perform measurements of growing precision of the CMB radiation, confirming the theoretical previsions, and inaugurating the so-called “precision cosmology”. These measurements, indeed, confirmed the presence of inhomogeneities (anisotropies) in the CMB radiation temperature, mainly determined by the gravitational field fluctuations acting over the uniform distribution of the matter density in the early universe, which is what we expected for justifying the formation of galaxies and of the other large structures of the actual universe. This paper, written by one of the chief experimental scientists of the PLANCK mission, explains us the astonishing results derived by this “observational cosmology”, making of the scientific cosmology a real “Galilean science”. That is, based on mathematical models, and confirmed by experimental measurements of ever-growing precision.

5. ANTONIO CAPOLUPO, GAETANO LAMBIASE, AND GIUSEPPE VITIELLO
 – *Cosmic microwave radiation, neutrino masses and fractal-like self-similar*

structure of the thermal vacuum. A distinctive difference between Quantum Field Theory (QFT) and Quantum Mechanics (QM) in particle physics is that in QFT there are infinitely many *unitarily inequivalent* representations of the canonical commutation relations (for bosons) and anti-commutation relations, (for fermions), each one represented as a different Hilbert space of the underlying quantum field dynamics (Heisenberg equations). In the framework of the “thermal” interpretation of the Quantum Vacuum – i.e., of the quantum fields ground state (minimum of energy) at a temperature higher than zero – we have indeed the possibility of *infinitely many unitarily inequivalent vacuum condensates*, with an evident cosmological relevance. Indeed, this means that thermal QFT, differently from QM, is adequate for describing different “phases” of the oscillating fields, in which the system may live depending on physical boundary conditions and parameters, such as, for example, the temperature. In all these cases, the minimal energy of the field ground state corresponds to a *balanced state* (i.e., a “zero-energy summation” state for different energy (temperature) values) between the system and its thermal bath, persistently in far-from-equilibrium conditions. That is, passing through different phases coexisting in the same ground state for the same overall temperature value. The paper thus exploits such a richness of the thermal QFT formalism for describing the *cosmic microwave background* (CMB) and the *cosmic neutrino background* (CNB) of the Universe. CMB is a significant observational proof of the quantum-relativistic cosmology as illustrated in the 4. Paper of this collection. CNB is one of the more suitable candidates for starting “to unravel the skein” of the “dark matter” issue in cosmology (see Paper 2.) and that the SM of elementary particles cannot justify (see Paper 3.). Particularly, the paper reports recent results showing that the thermal vacuum condensate of the CMB and of the CNB is a coherent state displaying fractal self-similarity properties. This may result in a general feature in cosmological studies, supporting the unifying view by which coherent field dynamics is at the basis of most natural phenomena, all showing *scale-free* self-similar behavior, and then a fractal-like structure.

2.2. Section II: Ontology and Metaphysics of Nature

6. GIANFRANCO BASTI AND FRANCESCO M. FERRARI – *The dual paradigm in quantum physics and its ontology. I Part: mathematics and physics.* This contribution concerns the foundation of a Philosophy of Nature conceived as a *formal ontology* of the natural sciences, as far as based on the

fundamental notion of *duality* and the role that it plays, on the one hand, in QFT, as Fundamental Physics, and on the other hand in the logic of Category Theory, as the proper metalanguage, both of quantum physics and of formal philosophy. The notion of “duality” must be intended in two distinct, but related senses. On the one hand, in the *ontological* sense. Namely, each system in nature, at whichever level of its complex physical constitution, is constituted by *matter* and *form*. That is, by *energy* and *information* (according to the famous Wheeler’s motto “it from bit”), intended as two distinct even though related *physical magnitudes*, against any *dualistic* or *monistic* ontology of natural systems. On the other hand, “duality” must be intended in the *mathematical and logical sense*. In this sense “duality” is a notion passing through the whole history of logic and mathematics. For instance, in logic are dual the “and” and the “or” logical connectives according to the De Morgan laws, and consequently are dual the “universal” and the “existential” quantifiers, or the “necessity” and “possibility” operators in modal logic, etc.. In mathematics, are dual the highest common factor, and the lowest common multiple, or are dual a function and its inverse, or a function and its Fourier transform, etc. Therefore, the ubiquitous phenomenon of “duality” is one of the main inquiry objects of the Category Theory, studied in the framework of the algebraic calculus of relations. The illustration of some elementary features of Category Theory and of its “arrow-theoretic” way of thinking is the core of the paper.

7. GIANFRANCO BASTI AND FRANCESCO M. FERRARI – *The dual paradigm in quantum physics and its ontology. II Part: logic and ontology*. Particularly relevant for the natural sciences and the natural philosophy is the CT notion of the *functorial dual equivalence* between opposed categories of algebraic structures (e.g., algebras (products) and coalgebras (coproducts)), made *isomorphic* by the double and reversed application of a *homomorphism* (structure-preserving mapping) between them. In the I Part of the contribution, the fruitfulness of this notion was discussed in the “operator algebra” formalism of QM, of QFT, and overall, of the “thermal QFT” with its non-commutative coalgebraic formalism, in which the two senses of “duality” – ontological and mathematical – become strictly connected, because of the relationship among the mathematical notions of “non-commutativity”, “ordering”, and “information”. In the II Part, consequently, the fruitfulness of the categorical notion of dual equivalence is discussed in the formal ontology of the “natural realism” (NR), based on the dually reversible *homomorphism* or *dual isomorphism* between, the *ontic* (causal) *co-algebraic* structures in the physical reality according to QFT, and the *logical* (Boolean) *algebraic* structures of a

language truthfully referring to them – the language of a formalized Philosophy of Nature –, where the former (coalgebra) constitute the semantics of the latter (algebra) in the Category Theory logic. The conclusion of this paper concerns the interpretation of the NR formal ontology, not only as a formal ontology of Fundamental Physics, but also as a formalization of the Aristotelian and then Aquinas’ “arrow-theoretic” ontology and metaphysics. Differently from the Platonic ontology, it is indeed based on the notion of “causal relations” as foundation not only of the existence, but also of the different natures (essences) of the physical things. This metaphysics is object of several papers in the rest of this volume, so that the present paper wants to constitute the “hinge” between the scientific and the philosophical-theological contents of this volume.

8. WILLIAM E. CARROLL – *Time and Creation: Thomas Aquinas and contemporary cosmology*. The Big-Bang described by modern cosmologists does not coincide with creation. Nor the scientific accounts which claim to eliminate an absolute “singularity” at the origins of the universe do away with creation. Natural science cannot itself provide an ultimate account for the *existence* of all things. As the Author wants to expound in his contribution, from this it does not follow, however, that reason remains silent about the origin of the universe. Reason embraces more than the categories of the natural sciences. By the reading of this contribution, we will see then that, although Aquinas did not think that reason alone can conclude that the universe has a temporal beginning, he already thought that reason alone can demonstrate that the universe is *created*. Such a demonstration is strictly metaphysical: namely, always remembering that just as metaphysics ought not to deny the truths about the world discovered in the natural sciences, so too the natural sciences ought not to reject the truths discovered in metaphysics. According to the Author we must remember that it is one thing to attend to the processes which occur in nature; it is another one to examine what does it mean for things to exist at all. The conclusion that the present work draws is then that even if we rejected Aquinas’ claim that reason can demonstrate that there is a Creator, we should be able to accept his arguments for the *distinction between creation and change* and that, on the question of the ultimate foundation of the existence of the matter from which the *cosmos* evolves, the scientific cosmology that necessarily must suppose as a primitive the matter existence at least in the form of the energy in a close universe, must remain silent.

9. MARIO PANGALLO – *Formless matter and creation from nothing – Materia informe e creazione dal nulla*. [For express desire of the Author, we also publish the Italian, original version of his contribution]. In this contribution, the Author proposes a philosophical reflection about two aspects of the creative act by God: 1) what does it mean the statement that creation (in its active sense) is making something existing “from nothing”; 2) what does it mean that, by creation, a formless matter is produced. As to the first issue, the Author emphasizes the difference between the notion of “creation from nothing” as to the Neo-Platonic notion of creation, according to which “creation” means that God inserts forms into a pre-existing formless, disordered matter from the outside, because they “emanated” by his immaterial divine nature. In this way, this notion of creation as “emanation”, want to justify, on the one hand, the existence of different beings in an ordered cosmos, and, on the other hand, their necessary “return” into the divine nature. The Author emphasizes how this notion of creation as emanation, in its double component of “exit-return” from-to God is re-proposed in the Modern Age in a purely immanent way in the “dialetheism” of the Hegelian philosophy. In it, the “nothing” is conceived as the necessary negative moment of the dialectical triadic development of the Absolute. The Author compares this Hegelian notion of “creation from nothing” with Aquinas’ notion, in which, on the contrary, it is expression of the divine transcendence (*versus* immanence) and freedom (*versus* necessity). As to the second issue, the Author emphasizes that the “creation from nothing” means that “nothing apart from God” is supposed to his creative act, so that also the formless matter depends causally on God’s creative act (“First Cause”). The “formless matter” has therefore to be intended in an Aristotelian way, as a dynamic substrate from which the universe develops by ordering itself progressively and then temporally, through the action of physical causes (“second causes”).

10. MARCELLO SANCHEZ SORONDO – *Common esse and subsistent esse: the degrees of created causality*. This work is devoted to recall and remark the distinction between *esse* (being) as “Pure Act” (“Subsistent Being”), and the “common *esse*” of thing *existence*. In this framework, “creation” consists in the unique act of “participation of the ‘act of being’ (*actus essendi*)” outside time to the different “essences” or “natures”, as far as they are made available in the universe evolution. These essences are *limiting* this participation, so to produce in space and time the different existent things constituting the *cosmos*. Following Aquinas, the Author emphasizes, with precision, how the very effect of Creation is therefore the common *esse* (existence) of things, and not

the subsistent *esse*. The latter, namely, the *esse per essentiam* is God Himself, who is unique like the Absolute has to be, and then absolutely different from (transcendent as to) the multiplicity of different beings constituting the cosmos, characterized by different essences depending on the universe evolution. Following the Author, it emerges that this hermeneutics is proper of the Aristotelian principle of the *essence* of any physical being, as a *physical* composition (*synolon*) of *potency* (matter) and *form* (act), depending exclusively on physical (material and efficient) causes. To this (Aristotelian) composition, Aquinas adds a further composition potency-act. That is, the *metaphysical* composition between the *essence* and the *act of being* participated by the Pure Act (Subsistent Being), from which the existence of the universe, or of the totality of the physical beings, with their differences, and their spatial-temporal becoming, ultimately depends.

2.3. Section III: Epistemology and History of Science

11. OWEN GINGERICH – *Galileo, the impact of the telescope, and the birth of Modern Astronomy*. One of the leading misconceptions was the idea that Galileo's brilliant telescopic observations *proved* the motion of the earth. Allied with this myth is the parallel notion that the Catholic Church stubbornly clung to the past, refusing to accede to the obvious march of the astronomical science. With his paper, the Author argues that even if it is *true*, of course, that the Inquisition *forced* Galileo under the threat of *torture* to recant his belief in Copernicus's heliocentric system, on the other hand, the *efficacy* of the Copernican system actually played a *very small role* in Galilei's trial. Finally, what clearly emerges from this contribution is that certainly Galileo would have dearly loved to explain to his examiners how his observations made the belief in the Copernican system more intellectually respectable. Nevertheless, because he is aware of not having any irrefutable proof of the earth's motion, this was an opportunity he never got.

12. ENRICO BERTI – *From physical to metaphysical cosmology: the Aristotelian path*. The aim of this contribution is to show that in recent times there is less danger of a relentless conflict between physics and metaphysics, than it was at the beginning of the Modern Age. Namely, in some way, it is today reestablished, *mutatis mutandis*, that harmony between the two disciplines, which existed in Aristotle's times. Aristotle, indeed, did not attribute to physical cosmology, and to physics in general, the same kind of exactness that he

attributed to mathematical demonstrations, because he refused to use the mathematical method in physics. This character of flexibility and approximation that Aristotle attributed to physics, was not always sufficiently considered at the beginning of the Modern Age when Galilei re-established the Archimedean method of using mathematics in physics. This implied that Aristotle's distinction between physics and mathematics about the exactness of their respective demonstrations, was ignored both both by those who appealed to Aristotle, such as, for example, the famous logician of the sixteenth century Jacopo Zabarella, and by those who disagreed with his physics, but not with his logic, such as the same Galileo Galilei. In fact, Galileo also believed that physics, in particular astronomy, was structured like mathematics, according to Zabarella's approach. Namely, that it must proceed first with the "resolutive" method (from consequences to premises), and then with the "compositive" method (from premises to consequences), and in that way it was able to provide "necessary demonstrations", that is demonstrations endowed with necessity (logical reversibility), not only from causes to effects, but also from effects to causes. The Author reconstructs by an attentive analysis of the texts, how in this way both the supporters and the adversaries of the Copernican theory at Galilean time – both forgetting Aristotle's lesson – were wrong in pretending an empirical proof for demonstrating the necessary truth of the Copernican premises. The Author concludes, "only in recent times, after the so-called second scientific revolution, (...) did we understand the character, not necessary but approximate, that is, statistically probable, of science in general and therefore of the same physical cosmology". Therefore, it becomes today possible recovering the harmony between physics and metaphysics that existed in Aristotle's times.

13. MARCELLO PERA – *Science, religion, and the doctrine of the two Books*. In the first part of this paper the Author presents the doctrine of the two Books, that of *Nature* or *Science* and that of *Faith* or *Religion*. The second part is devoted to focus the weakness of this doctrine. In the third part, the Author investigates one side of the relations between the two distinct domains, arguing that Science is not irrelevant to Faith. Finally, in the fourth part, it is suggested a different approach – starting from the discussed "Regensburg Lecture" of Pope Benedict XVI in 2006 – based on the need for "broadening our concept of reason". The Author believes the Pope challenge should be met, if only because there is a lot at stake: moral responsibility in our laboratories, mutual understanding among peoples and among States, ordered progress in our civilization.

14. VINCENZO FANO AND GIOVANNI MACCHIA – *Epistemology of the cosmological principle*. The “Cosmological Principle”, that is, the hypothesis that the universe is homogeneous and isotropic when observed on large scales, was implicitly introduced by Einstein in 1917, in the paper that founded the modern relativistic cosmology. Today, this principle is still one of the fundamental bricks of the entire theoretical building of cosmology, despite its epistemological status has often been misunderstood by several scientists. In this contribution, the Authors analyze some of the reflections that eminent scientists have devoted to this principle since the third decade of last century, emphasizing several misunderstandings in approaching it. According to the Authors, a similar fate concerned another principle, tied to the cosmological one and equally crucial for cosmology: the “Copernican Principle”, according to which we do not occupy a privileged position in the cosmos. The Authors, briefly discuss its epistemological status, concluding that the proper way in which both principles should be understood is that of the hypothetical-deductive method of the empirical sciences.

2.4. Section IV: Theology and Science

15. INNOCENZO CARDELLINI – *The tales of creation (Gn 1-3). A teaching in life for mankind*. The exegete, even in a remote age, was aware that some parts of the Biblical narration had to be interpreted in an *allegorical* or didactic way, without any pretension of being historically accurate. For historians and philologists, the text of *Gen 1-3* must be read and interpreted based on myth as its proper literary genre. Scholars know that what is important is *the message* rather than the sequence of descriptions. It is useless to compare the tales of Creation (*Gen 1-3*) to modern scientific data: the quarrels between Creationism (Creation as described in *Gen 1-3*) and Evolutionism, between Monogenism and Polygenism are simply pointless. These misunderstandings have been (and still are) possible because these texts, in their role as conveyors of the Divine revelation for the believers, have been confused with unquestionable historical truths. The purpose of this contribution is, then, to show how humans have tried to give word to the Divine revelation, telling and imagining the way in which the Divine creative act gave origins to our ordered and intelligible “cosmos”, starting from a disordered and unintelligible “chaos”.

16. LUBOMIR ŽAK – *The reception of General Relativity in Pavel A. Florenskij*. Pavel Florenskij (1882-1937) was a distinguished Russian

mathematician and theologian, who worked in Russia at the very beginning of the XX cent. and was imprisoned and killed by Stalin's regime. This contribution will not focus on the theoretical aspects of Florenskij's understanding of the theory of Special and General Relativity. The Author examines the reception of the Relativity Theory by Florenskij in the context of his philosophical and theological reflections. Since a brief and yet speculatively interesting booklet of 1922 – titled *Imaginary Points in Geometry. The Expansion of the Domain of Two-Dimensional Images in Geometry* – Florenskij not only revealed a deep and informed interest and understanding of this topic but also suggested an unusual approach to it, which sparked the interest of many contemporary Russian intellectuals: mathematicians and physicists, before all. At the same time, it caused a strong criticism by the scientists more involved in the ideology of Stalin's regime. This booklet is the starting point of Author's contribution that – profiting by his knowledge of the Russian language and then accessing many Florenskij's works not yet translated – shows how the deep mathematical reflections of Florenskij about a reversal of the time-arrow, as far as written on a space-time defined on imaginary numbers, was inspired in this booklet from his deep commentary (incredible!) to a passage of Dante's *Inferno* chant of his *Divina Commedia*. What is amazing for us, from the scientific standpoint, is that Florenskij links explicitly such reflections to Special Relativity and to Riemann's idea inspiring Einstein and that is at the basis of the Relativity Theory, according to which the space-time geometry depends in physics on the force fields acting on it. In this way, Florenskij, speaking about an "inner" physical imaginary space-time dual as to the "outer" space-time defined on the real numbers, and characterized by the reversal of the time arrow, was anticipating effectively many notions of the relativistic QFT that are today part of the standard formalism used by physicists. This is a testimony of the unbelievable mathematical thoroughness of Florenskij's mind, who used these reflections for philosophical and theological applications discussed in this contribution.

17. CHARLES MOREROD – *From Physical Cosmology to Theological Cosmology: the Analogy Path*. This contribution talks about physical cosmology, although in a fundamental way: by *physical cosmology* the Author means the knowledge we can have of the World, the Cosmos, the whole Universe. Undoubtedly, there are several contemporary physical theories on what the World is. Nonetheless, the fundamental question tackled in this contribution, as mentioned in its title – *From Physical Cosmology to Theological Cosmology* – is: how can we pass from knowing the world to knowing God as its

Author? Can we elude this question? When we look at the World, we do not see God and God is not, even indirectly, evident, the Author argues. A further intriguing question is, therefore, posed: should we give up thinking about this issue? “Maybe yes” one may answer. But if we do – this is Author’s honest conclusion – we are ignoring a fundamental human need. The issue of understanding things by understanding their “proximate” and “ultimate” causes, and by collecting and organising these partial understandings together in a rational vision that, even though always necessarily incomplete and perfectible, never must renounce to its aspiration to be total. Because we are human beings, we cannot destroy our innate desire to know the truth in its physical and metaphysical foundation, and to act accordingly, for acting responsibly. Nonetheless, we cannot act responsibly as if we were not human beings that are part of the *cosmos* we are investigating: our knowledge, indeed, also in its unavoidable metaphysical components, originates always from the material, physical world.

18. RINO FISICHELLA – *Science, Philosophy, and Theology in Dialogue on Cosmology: is a Synthesis Possible?* In the past centuries *geocentrism* was replaced by the centrality of man who observes the dynamic movement of the universe – *anthropocentrism*. Humans discovered that the cosmos evolves and progresses, following the laws that determine its evolution. Following the Author, this vision appears to undergo further transformations when humans place themselves at the center, giving rise to a *micro-cosmos* that is conditioning not only his own existence, but also that of the surrounding cosmos. Unavoidable questions are raised about what before big-bang. The Author’s intent here is not to delve into the interpretative meanderings of the cosmological theories developed on this regard. Rather, his intent is to outline the theoretical space for formulating and trying to answer specific and fundamental questions: is there a mutual determination between cosmology and anthropology? Is humans’ self-understanding inevitably also involving the cosmos? And, reciprocally, is it possible that what is produced by the cosmos in its evolution determines humans’ self-understanding? These issues have no easy and overall conclusive answers, and overall, they cannot be addressed within one only disciplinary realm, either scientific or philosophical. Therefore, as the Author suggests we need a strong interdisciplinary effort that thrives on different types of expertise, for developing a global approach able to offer meaningful responses, because (not despite!) they are incomplete and always perfectible.

19. GEORGES COTTIER – “*Causa Prima*” and “*Causae Secundae*”. The issue of the distinction between the *First cause* and the *second causes* belongs to the field of metaphysics, more precisely of that “first philosophy”, which Aristotle called *theology*, the science of the divine. Christian thought, while recognizing its legitimacy, calls it *natural theology* for distinguish it from that theology that has the task of scrutinizing the revealed mystery. Natural theology is presupposed to it. Once, philosophy will have given, on purely rational basis, a metaphysical account of what the believers name “creation”, the distinction will be manifest and clear to all in its full extent. Nonetheless, this contribution shows how this doctrine has always been disputed, especially in the tradition of nominalism. The problem, according to the Author, has become more acute with the emergence of Galilean science and its opposition to the “old” Aristotelian physics. Notwithstanding this opposition, the distinction between natural sciences and the philosophy of nature was never clearly perceived, having both the *ens mobile* as their object of investigation. Consequently, the Galilean science was often presented in the Modern Age as a new philosophy. But such a confusion, remarks the Author, affected its results and not only: the two have two distinct methods and two different ways of conceiving the rational knowledge and its object. This poses epistemological issues that also today are far from having found a satisfiable solution.

20. GIANFRANCO RAVASI – *Afterword: A Synthesis of the Biblical Cosmology*. This contribution offers a fresh and readable synthesis of the Biblical Cosmology, as it is expressed in the Chapters 1-2 of the *Book of Genesis* that is common to the Traditions of the three “biblical religions”, Judaic, Christian, and Islamic, with their different confessions. The Author offers a triadic analysis – phenomenological, philosophical, and theological – of the biblical text, with the systematic effort of connecting the biblical language with our Western and even scientific language. At the same time, he defines in a synthetic but effective way the limits and the possibilities of such an operation that is anyway unavoidable, because our comprehension depends necessarily on the linguistic community to which we belong. In this sense, this contribution can work as an effective “afterword” of the Section IV and then of this entire volume.