Typescript of the round table

“Rethinking 20th century cosmology”

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<u>Chair: Agustí Nieto</u>

I would like to thank the organizers for asking me to chair this round table. It is a pleasure to be here with you all today. You are kindly asked to talk from 5 to 7 minutes to share your reflections and comments on the presented papers and then we can open the general discussion with the public before closing the workshop.

<u>Helge Kragh</u>:

I would like to mention three things very briefly. First of all, I am very pleased that you (Manuel García Doncel) mentioned this crucial distinction between the temporal and non-temporal meaning of creation of the universe. The concept of creatio continuans that goes back to Thomas Aquinas was accepted in Thomistic philosophy or neo-Thomism and so there is a question arising. Why did the Pope in 1951 or other people identify the creation with the creation in the past? The Pope must have known that even without big bang, one could argue that there was a creation of the universe. Therefore, it was accepted within the Catholic Church that cosmic creation does not depend on a first event, on a big bang, but that sounds strange to me.

Second, Creation cosmology is not the same as big bang relativistic cosmology and especially at the time of the Pope’s speech creation cosmology for many people meant Edward Milne’s cosmology, which was totally different from the relativistic idea.

On a different note, I want to mention a third thing. One should be careful “not to read the present in to the past” and to believe that scientific cosmology started with Einstein’s relativity theory. In fact, classical Newtonian cosmology was well alive at least for ten years and most astronomers up to the late 1920s either didn’t care about cosmology or they conceived of the universe and its evolution as dominated by Newton’s laws and not by Einstein’s theory. Indeed astronomers’ knowledge of general relativity was very scarce. The large majority either did not accept or didn’t know about general relativity.

<u>Xavier Roqué</u>:

I have a brief question: in this regard, would you say that for a classical astronomer relativistic cosmology would make little sense as far as his observations were concerned? Would you say that his way of practicing science was not concerned with relativistic cosmology?

<u>Helge Kragh:</u>

Yes, but of course there were a couple of notable exceptions, such as Eddington and De Sitter. In 1926 we have a very important paper by Hubble on the size of the universe in which he cites relativistic cosmology at the end of the paper, but he was one of the few observational astronomers to mention it. And even if Eddington talked about relativistic cosmology, he was a theorist and not an observational astronomer.

<u>Erhard Scholz:</u>

Thank you very much for the opportunity to participate in this workshop. I am very interested in the discussion about the social and historical background in which cosmology grew up to the stage we are witnessing now. What I realized is that many of the talks considered Cold War as a political ideological effect, whereas Silvia De Bianchi went down to the material history of the military interests and the space race and the result was that she explained the experimental tests on general relativity, but she had to skip the analysis on cosmology and I would like to ask her to talk a little bit more about it, because this might be connected to an open point in Helge Kragh's talk when he briefly mentioned the work done by the first generation of physicists after Stalin's death. What I realized is that in the 1960s and 1970s, in both US and USSR were the nuclear physicists who drove the development of cosmology substituting Lemaitre's theory with a new field heavily informed by military research and nuclear physics research. Now we are living in the next generation of elementary particle physicists' era who are the driving force for the development of cosmology and probably this is an interesting aspect to be explored from both the philosophical and historical perspective. I leave it as an open question.

Matteo Realdi:

Let me draw just a few general comments. A first issue which has been faced in this workshop is the question of how to define modern cosmology in the sense of relativistic cosmology. For example, Erhard Scholz mentioned the field of nuclear physics, that was something almost outside the early discussions on cosmology, compared to the theoretical aspects of the first relativistic models of the universe and their connection with astronomical observations. In a sense, in the 1950s and 1960s the field of cosmology is open to the facilities of nuclear physics and radioastronomy as well, and this certainly was a crucial element informing the development of modern cosmology as we conceive of it today. A different issue is the way in which new aspects of cosmology were circulated and debated. Take for instance the famous case of Lemaitre, namely the fact that his model of the expanding universe (1927) was initially published in an almost unknown Belgian journal. The different approach of the Jesuit scientists that I have described in my talk, generated on the contrary relevant discussions (1930s-1950s), but mostly in Southern Europe. Finally, an aspect which deserves consideration is the use of a common language to communicate at the international level. For instance, at the time of the Korean War, the president of the International Astronomical Union raised the issue of a proper way to present and debate scientific contributions at IAU meetings, for some speeches of Soviet scientists were supposed to be only in Russian. In this sense, more studies are needed on the way in which astronomers, astrophysicists and (astro)chemists interacted during the Cold War around the science of the universe, so I would suggest to enlarge the study of the circulation of knowledge and communication in the field of relativistic cosmology during those crucial years.

Antoni Roca:

As I mentioned in my talk, the visit of Weyl in 1922 shows us some aspects of the Spanish attempt at constituting a real scientific community in a very difficult environment (difficult from various perspectives, e.g. political, economical and so forth), and if Xavier Roqué allows me to enter in his talk, apparently Franco's regime had the function to consolidate modern capitalism in Spain by means of authority and discipline, and perhaps in this context science had a new function, because in modern capitalism you need human capital, engineering resources and all that was accumulated in 1920s was later used during Francoism.

Xavier Roqué:

What has mostly impressed me is the discussion around models that Erhard Scholz and Helge Kragh discussed yesterday and today. This is an evocative and important element in the history of science and, of course, it is very important because of its metaphysical and social implications. I also found very interesting what Silvia De Bianchi said about the material culture of general relativity theory testing during the Cold

War. How all this comes together in 20^{th} century cosmology is a very nice story that takes into account very different aspects.

Silvia De Bianchi:

I would start with the general remark that cosmology is a very interesting subject: in it we find an intersection of fundamental physics and philosophy and, as Erhard Scholz underlined, there is a very important philosophical question implied in works such as Weyl's. The reflection on general relativity and cosmology led us to realize that there is a world made of models and of possibilities that not always become physical reality. In cosmology we find today various hypotheses or attempts at finding a "theory of everything" (as it happens in string theory, for instance), but from a philosophical perspective it should be noticed that the very idea of a theory of everything has been embodied by cosmology itself, given that it deals with the idea of "totality" or the "whole". Very interestingly, there is a talk Weyl gave in 1955, a few months before dying, entitled "Why is the world four-dimensional?". In it Weyl dealt with the debate on the dimensionality of spacetime and he made two philosophical points. The first one concerns the fact that the four-dimensionality of spacetime in this universe is a contingent (metaphysical) necessity, it possesses a hybrid character, and therefore the question of the dimensionality of the world can be used from both the theological and the scientific perspective, as well as from a philosophical one. The second point Weyl raised is that if we investigate the topology of causation of spacetime, we notice that the Lorentz group is a fundamental building block of our universe and in mathematics we have to promote the study of the reason why the dimensionality of the world depends on this building block. To answer to your (Erhard Scholz's) question: it is very interesting to see how the research on cosmology in the Soviet Union heavily relies on nuclear physics and particle physics research, especially from the 1960s on. I have in mind for instance Shakarov's works. Furthermore, in the Soviet Union there was an impact exerted by Zwicky and his idea of dark matter. This impact is due to the work on the possible test for the CMB. There were Soviet scientist in the 1960s that were able to use the technology of radioastronomy, but they were still trying to catching-up the know-how that American scientists had in the field of cosmology. There was a delay in this sense with respect to the research done in the United States. This aspect is taken into account in various articles collected in "A Brief History of Radio Astronomy in the USSR" published in 2012.

Public: In your (Erhard Scholz's) talk, you mentioned the difficulties that Weyl had in matching his model in cosmology to physical reality. How would you qualify the later development of mathematics in quantum mechanics, in which the mathematics was considered only as a formal approach without physical basis? I think there is a second step in which mathematics gets far away from reality.

Erhard Scholz:

I guess for Weyl there was not such a jump between the relationship of mathematics and physics from general relativity to quantum mechanics, of course the structure changes, but you will find in his book "Philosophy of mathematics and natural science", written in 1926 (so it was at the time of the transition from general relativity as a main reference theory to quantum mechanics, and to a quantum mechanical approach toward matter), and therefore it was written in a very important phase for physics and for Weyl's work as well. If you read the book you find interesting discussions concerning his old views of mathematics that were shaped by intuitionism and constructivist approaches. In the book Weyl discusses exactly the point according to which Hilbert's programme in the foundations of mathematics developed also in the mid-1920s. On the one hand, Weyl criticized Hilbert for making a formal game out of mathematics. On the other hand, he accepted that Hilbert can save a broader realm of mathematics than the constructive mathematics would do. And therefore to answer to your point, Weyl discusses the role of mathematics in the symbolic construction of the understanding of the world and mathematics acquires relevance to explain the world by means of physics. The understanding of mathematics as symbolic construction is quite important. He was well aware of what was going on in quantum mechanics and he had discussions with

Born and Jordan, so there was no big break, because he believed that mathematics played a fundamental role in the symbolic construction of the world and was therefore linked to it.

Helge Kragh:

With regard to the Russian contribution in the 1960s to the standard model of cosmology and CMB you probably know the book edited by Jim Peebles edited in 2012 called "Finding the big bang". In it there are several contributions by Russians and by those contributing to the research in the 1960s and 1970s and it is a very valuable source. I think that in the 1964 article by Doroshkevich and Novikov it is mentioned not only the possibility of detecting and measuring CMB, but also that this should have been done by means of an artificial satellite, in a very similar way as much later was done by the COBE experiment.

Silvia De Bianchi:

Thank you very much for pointing this out. As I mentioned before, in the 1960s, the Soviets were making an effort in order to catch-up the Americans in terms of know-how. As you recalled, the discovery of the radiation is accidental, but the capacity to "read" the results in connection with the prediction of the theory made the difference in the case of CMB.

Silvia De Bianchi and Xavier Roqué:

Thank you all for participating in this workshop and thank you Agustí for chairing the round table.