Wonder and Knowledge of the Universe and the Role of Wonder in Scientific Discovery
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Crossroads Cultural Center inaugurated a new season of inquiry by delving straight into one of the deepest mysteries of existence—that of existence itself. Why is there something rather than nothing, and where did it all come from?

On the stage to address these questions were philosopher, cosmologist, and Catholic priest Michał Kazimierz Heller and astronomer and astrophysicist Marco Bersanelli. Neither began their presentations by giving answers. Rather, they each first addressed what must come before the answers to the questions: the capacity to ask the questions. The origin of this capacity, they both argued, is wonder in front of reality.

Science, they asserted, requires men and women who face reality with wonder, because it is wonder that provokes not only questions, but also the inner drive and burning curiosity to answer those questions. Moreover, true wonder is what enables a scientist to go beyond the preconceptions of the time to advance our common body of knowledge about reality. It is because of this essential foundation of wonder, they argued, that science must always be viewed as a deeply human activity, not as something separate from human experience.

In his opening remarks, Prof. Robert Pollack, director of the Center for the Study of Science and Religion at Columbia University, affirmed that wonder is at the heart of the scientific enterprise. Addressing specifically the field of evolutionary biology, Prof. Pollack noted how easy it has become to reduce humanity to the seemingly meaningless natural selection of one set of DNA over another. Wonder, for Prof. Pollack, arises from the fact that, despite what science tells us about natural selection, we are still able to choose to act against our own individual interest, even though such action might not be favored in terms of evolution (that is, in terms of the number of copies of our DNA that we pass onto future generations).

Fr. Heller next took the stage to discuss the origin of the universe in science and philosophy. Appropriately, he began his slide presentation with a stunning picture of a radio telescopic array pointed at the sky, waiting for answers from the infinite. To this picture he likened some of the greatest scientists and philosophers of all time—gazing in wonder at the sky, and begging for answers in front of its seeming incomprehensibility.

For example, Sir Isaac Newton wondered why all the matter in the universe, even though all its particles are unevenly spaced, doesn't collapse under the force of gravity into a central point. Fr. Heller acknowledged, that even though this does not occur, there are in fact signs of great destructive instability in the universe: namely, black holes. In contrast to the destructive instability of the universe represented by these black holes, Fr. Heller directed the audience's attention to the "initial singularity" or "white hole," more commonly known as the big bang. The universe is, he said, still essentially emerging from this "white hole", from which, instead of light and matter being drawn in and seemingly destroyed, light and matter are generated, radiating out through time and space.

Moving on from Newton, Fr. Heller took us—in extremely broad strokes—through the basic premise of Albert Einstein's general theory of relativity. Among other things, the theory postulates that gravity is a bending of space-time. To help us understand this concept, Prof. Heller offered an elementary metaphor: imagine that space-time were a band of rubber, and a planet were a heavy ball placed in the middle of that band of rubber. The band of rubber would bend, and any smaller objects within the bend of the rubber would roll toward the heavy object—appearing as if they were attracted. The larger the central object, the larger the curvature would be, and thus, the stronger the observed gravitational pull. In real life, this can be seen by the "gravitational lens" phenomenon, in which light from distant galaxies bends around other galaxies between themselves and us. Taking the metaphor another step, if one were to

place an object on the band of rubber (space-time) that was heavy enough to break it, everything else on the band of rubber would fall into the break. This, Fr. Heller said, is a black hole, where space-time loses its known characteristics.

After bringing us to this limit of current scientific understanding regarding black holes, Fr. Heller returned to the philosophical origins of science. He began by proposing the assumption that the laws of physics are valid. But this assumption begets a question: where did these laws—and the universe that operates according to them—come from? Or, as the question is otherwise commonly posed, why is there something rather than nothing?

The ancient Greeks had no definitive answer to this question. Instead, there were three divergent standpoints about creation: the Atomists believed that the universe had no distinct beginning, and instead, there had always been a motion of atoms, and out of the collision of some atoms, the universe was formed. Aristotle likewise believed that the universe had no beginning, but, in contrast to the Atomists, he believed that the universe had a *telos*—that is, an ultimate goal. Plato believed that the universe emerged from chaos, which the ancient Greeks understood as similar to nothingness.

For a more definite concept of creation, we have to turn to the Book of Genesis, which says that God "created." Interestingly, Genesis does not explain what "creation" means. The first explanation of the word is found in the Book of Maccabees (7:28) where God is said to have made everything out of nothing. Later Christian thinkers grappled further with the question of creation. To the question of what did God "do" before creation, St. Augustine responded that time only exists where there is a change. Before the creation of the world, there was no change, and thus there was no time. And if there was no time, there was no "before" of which to speak. St. Thomas Aquinas asserted that "creation is a relationship between the creature and the creator consisting of the continual dependence of the creature on the creator." In other words, God gives existence to the universe at every moment—creation was not a singular act. A more modern thinker, Gottfried Wilhelm Leibniz, echoed Aquinas and Augustine in his notion that space and time are a relationship between material events; if there are no material events, there is no space or time. In other words, time was created with the universe; outside of creation, time does not exist.

Following Fr. Heller's lead, Prof. Bersanelli took the microphone and spoke of some of the greatest names in science, and more particularly, these scientists' personal experience of "doing" science. Such is the topic of his recent book, "From Galileo to Gell-Mann." The impetus for this book was Bersanelli's observation that modern science increasingly marginalizes the person. As a result, the scientist is seen as irrelevant to doing science. Once the scientist is taken out of science, all progress in science then appears to be the result of well-established, pre-defined procedures, and the results of scientific experiment are perceived as disconnected from other aspects of human knowledge. This, Prof. Bersanelli said, was very different from his own and many other scientists' experiences.

Prof. Bersanelli instead asserted that awe in front of the mystery of reality, represented by the vastness of the sky, is deeply engrained in human culture. Every culture, from its very origins, has stood in awe before the sky. In harmony with this fact is Max Planck's observation that "those who have reached the stage of no longer being able to marvel at anything simply show that they have lost the art of reasoning and reflection." Thus, according to Bersanelli, "the first step in our relationship with reality in science, not only to start our research, but to continue the motivation of research, is wonder."

The greatest scientists in many situations have expressed their understanding of what this wonder is and how it operates in a scientist's life. American physicist Richard Feynman once said that "[t]he same thrill, the same awe and mystery, come again and again when we look at any problem deeply enough," and "[w]ith more knowledge comes deeper, more wonderful mystery, luring one on to penetrate deeper still." Albert Einstein has stated his agreement, remarking further that "[t]he eternal mystery of the world is its comprehensibility." In other words, no matter how deeply we penetrate, reality makes sense. It is rational. As an illustration of this, scientists have observed that modern data gathered about the evolution of the universe fits what the theory of general relativity has predicted.

What exactly happens to the scientist who is attracted by reality, like Feynman or Einstein? Wonder leads to observation, which leads to experiment. Experiment, in turn, generates better observations of reality, which provoke greater wonder, and thus the self-renewing process continues. But something more is required to truly advance knowledge: to be open-minded in front of what is being observed, instead of thinking that we already know what we are looking at. In other words, poverty of spirit, or simplicity, is required.

To illustrate this point, Prof. Bersanelli described the discovery of the cosmic microwave background radiation of our universe—also known as the "first light" of the universe. This first light was discovered in 1964 at Bell Telephone Labs in New Jersey, and is hypothesized to be left over from the big bang. What made the discovery so remarkable was that the cosmic microwave background had been previously observed by many scientists who paid it no attention. It wasn't until two particular scientists—Arno Penzias and Robert Wilson—paid attention to what they were observing, and were curious enough and open enough in front of what they were observing, that this fact about reality that others had brushed aside was first grasped and understood.

In the course of describing all the work that scientists have done since that time to learn more about this first light, Bersanelli took us through the development and launch of the PLANCK Satellite, on which he and an international team have worked for 17 years. This satellite is designed to get a clear picture of the first light of the universe, which, they hope, will help them to understand better the nature of the completely unknown dark energy and dark matter that comprises 95% of the universe. But, asked Bersanelli, is there a greater purpose in doing this? Considering that our presence in the universe is rooted in 14 billion years of cosmic history, then yes, answered Bersanelli, there is a purpose to the scientific enterprise. It is to answer the question of whether all this history is a sign of something greater, or if it is all just meaningless. Until that ultimate question is answered, we are left in the words of Max Planck: "[t]he greatest joy of a thinking man is to have explored the explorable, and just to admire the unexplorable."