Can there be a Catholic approach to the teaching of Physics to students in Catholic universities? Some ideas for teachers and students to discuss

Elisabetta Canetta*: St. Mary's University, Twickenham, London, UK

Email elisabetta.canetta@stmarys.ac.uk

Can there be a Catholic approach to the teaching of Physics to students in Catholic universities? Some ideas for teachers and students to discuss

We currently live in a high-tech society where portable supercomputers, artificial intelligence, genetic enhancement, etc., are becoming part of our daily life. It can be argued that this steady flow of complex technology is vigorously pushing aside religion and faith in God. Nowadays if a student decides to study physics he/she cannot possibly think of, nor have an interest in philosophy, let alone theology. This limited attitude towards physics is stripping it of its real meaning and purpose. This paper argues that physics is a study that God has put in the hands of humanity to be used in conjunction with philosophy and theology, in order not only to be able to ask *big questions* about nature and the universe, but also to actively contribute to finding some answers to them. Ideas about a scientific-philosophical-theological approach to teaching physics at the undergraduate level within a Catholic institution are presented and discussed.

Keywords: physics; philosophy; theology; Renaissance; cosmic knowledge; inner meaning; creativity; curiosity; big questions

Introduction

"*Vanity of vanities; all is vanity*" is what we read in the opening of the *Book of Ecclesiastes* (Ecclesiastes, 1:2)[1]. Vanity can be interpreted as empty or meaningless (Sacks 2011) and, therefore, the passage can be read as "*Emptiness, emptiness, all is empty*". This gloomy and doom laden sentence neatly summarises what science in general, and physics and engineering specifically, are becoming: Vehicles leading to technological advance but not to acquiring Wisdom through which knowledge of the universal Truth can be obtained.

The physicists of the 21st century appear to be more interested in feeding and expanding their "I", their vanity, than exploring the cosmos (i.e. the complexity and order of the universe), and empowering humankind in its quest for meaning, for answers to the ultimate questions about the origins of the Cosmos. This attitude is typical of humanity as a whole, a humanity which does not perceive itself as part of a greater cosmic reality but as a superior being who is not only outside of nature but also dominates it as if it were its own property (White

2015). Such a way of thinking has negative repercussions on how new generations interpret and perceive learning. The majority of students who pursue their university studies in physics are not interested in asking and eventually answering *big questions* about the ultimate meaning of life, the world, the universe. They simply wish to get a degree which will allow them to get a good job, earn a lot of money and, why not, become famous and acclaimed in their area of research and beyond.

How can we widen their vision? The first step is to educate physics students to ask not only *How* nature, the universe, and the forces keeping the world together work, but also *Why* physical entities function, occur and evolve the way they do. Being able to ask "Why" means to be capable to rediscover the *Fanciullino* (little child) within each of us, of which the Italian poet Giovanni Pascoli (1855 – 1912) spoke about in his writings[2]. The ability to ask "Why" corresponds to rediscovering that "Why period" each child goes through when with their eyes wide open they look with awe at the world around them, when they are still able to feel a boundless joy in observing nature with all her strengths and weaknesses. The "Why period" is when we discover the thrill and delight of *Curiosity*. As the great theoretical physicist Albert Einstein (1879 – 1955) famously said "*I do not have any special talent, I am only passionately curious*" (Letter to Carl Seelig (11 March 1952), Einstein Archives 39-013). Hence, educating physics students to ask "Why" along with "How" means to help them become the little children Jesus referred to in his teachings. Transforming students into little children full of curiosity and asking endless "Why's" means to help them attain the true knowledge of what life and the universe are all about: "*Let the little children come to me [Jesus]; do not stop them; for it is to such as these that the kingdom of God belongs. Truly I tell you, whoever does not receive the kingdom of God as a little child will never enter it*" (Mark 10: 14-15).

In the *Book of Wisdom* we are warned of the dangers of believing that the end of our quest for truth is merely to understand how natural phenomena occur and work: "*If [people] had the power to know so much that they could investigate the world, how did they fail to find sooner the Lord of these things?*" (Wisdom 13: 9). As the famous theoretical physicist, who later became an Anglican priest, John Polkinghorne FRS flawlessly demonstrated in his article on the limitations of

science (Polkinghorne 2011), physics deals with *how* events occur and evolve, whereas theology deals with *why* events happen. This means that while physics is concerned with the *process* of life and nature, theology addresses their *meaning* and *purpose*. It is thus the perfect synergy of these two disciplines, as many physicists-theologians, of the calibre of M. Heller (Heller 1996), W.R. Stoeger (Stoeger 2010), J. Polkinghorne (Polkinghorne 2011), and G. Consolmagno (Consolmagno 2012), have clearly shown.[3]

How can physics and theology work together? The answer lies in seeking Wisdom since "*to fix one's thoughts on [Wisdom] is perfect understanding*" (Wisdom 6:15). The next question is how can we attain Wisdom? "*The beginning of wisdom is the most sincere desire for instruction, and concern for instruction is love of her, and love of her is the keeping of her laws, and giving heed to her laws is assurance of immortality, and immortality brings one near to God*" (Wisdom 6:17-20). Attaining Wisdom means to encounter God, i.e. to reach the limits of the universe, of that ever-expanding territory whose only boundary is God. This journey can be made only by reminding humanity of what it really means to teach and study physics, space-time, and the intricacies and complexities of the universe: "*for it is [God] who gave me the unerring knowledge of what exists […]; I learned both what is secret and what is manifest, for wisdom, the fashioner of all things, taught me*." (Wisdom 7: 17-22).

The Renaissance approach to physics and mathematics: the humanist approach to study

Before exploring what a Catholic approach to the teaching and learning of physics at the university level could look like, we need to look back at the origins of modern physics. The modern approach to physics was born during the glorious period of rediscovery of 'true knowledge', the Renaissance (i.e. 14th to 17th centuries)[4]. The main driving force of the Renaissance movement was the rediscovery and application of fundamental values of Greek philosophy, notably Platonic and Pythagorean concepts, which led to the so-called *Humanism* (Kristeller 1977) whose primary goal was to make knowledge available to as many people as possible (in contrast to the elitist and "scholastic" approach to knowledge typical of the Middle Ages). This humanist approach to study produced the *seven liberal arts*: grammar, rhetoric, logic (*Trivium*), arithmetic,

geometry, astronomy, music (*Quadrivium*). They were called "liberal" because their scope was not to train students to earn a livelihood (which was the goal of the so-called "illiberal"[5] arts) but to teach students how to transform into *free men* capable of pursuing the sciences, i.e. to combine philosophy (including natural sciences) with theology, in order to gain true knowledge, to find answers to the ultimate questions about life, the world and their inner (esoteric) meaning. The approach to study in which the student's mind and heart are kept unencumbered (free) from the limitations of materialism (e.g. getting a university degree to find a job and earn money) follows Jesus' way of teaching and instructing his disciples: Becoming Jesus' true disciples (i.e. "free men") is the first step towards the ultimate goal of the human quest (encountering God) because as Jesus teaches us "*you will know the truth and the truth will make you free*" (John 8:32).

A very important aspect of Renaissance Humanism was its close relationship with Christianity in general and Christian theology in particular. The branches of Christian theology which played a pivotal role in the development of modern physics were the theology of Creation and of Incarnation. The theology of Incarnation brings immediately to mind John 1:14, "*and the Logos became flesh and lived among us, and we have seen his glory, the glory of the father's only son, full of grace and truth*". In its turn, the descent of the Logos (Word) into the flesh calls to mind Plato's *Theory of Ideas* according to which *true* reality is made up of substantial (non-physical) *Ideas* (also called *Forms*). These Forms constitute the essence of the material objects that we can know using our five senses. The essence is unchangeable and represents the true reality, whereas the material object in which this essence is present is a mere appearance, and since it is changeable it is not truly real. This concept was clearly explained by Plato in Book VII, 514a to 517a of his treatise the *Republic* (ca. 380BC) by means of the *Allegory of the cave*, a dialogue between Socrates and Glaucon in which Socrates describes "*a situation which you [Glaucon] can use as analogy for the human condition – for our education or lack of it*". Here, Plato also explained how education should "free" the student from the shackles of the material/physical reality we are accustomed to, in order to know the 'Truth'.

Geometry and the transcendental nature of mathematics

Another Platonic concept which was dear to Renaissance scientists was *Geometry* which, for Plato, was the philosophical language in which the metaphysical (real) realm was described and made known to humanity living in the physical (unreal, a pure reflection of the real/metaphysical plane) world. Plato himself in the *Republic*, Book VII, 510d-e, says "*and do you not know that [the geometers] make use of the visible forms and talk about them, though they are not of them but of those things of which they are a likeness, pursuing their inquiry for the sake of the square as such and the diagonal as such, and not for the sake of the image of it which they draw? And so in all cases […] what they really seek is to get sight of those realities which can be seen only by the mind*".

A philosophical concept which is closely related to the Christian theology of creation is the Pythagorean theory of the *transcendental*[6] *nature of mathematics*[7]: Geometry and mathematics do not passively describe what is observed in the world around us, but they are an active exploratory agency for understanding the inner/real nature of what we observe in the universe, i.e. they allow us to understand and know the Form, the essence of the physical world. In the words of the second century AD Greek mathematician Theon of Smyrna, "*numbers are the sources of form and energy in the world. They are dynamic and active even among themselves […] almost human in their capacity for mutual influence*" (Theon 1980, p. 13). That is also how scientists of the calibre of Johannes Kepler (1571 – 1630) and Isaac Newton (1643 – 1727)[8] interpreted and used the relationship between mathematics (including geometry), physics and astronomy.

Johannes Kepler

Kepler was a deeply devout Christian whose greatest desire was to glorify God. He achieved such a goal through astronomy as he explained to his teacher and mentor Michael Mästlin[9] in a letter dated 3rd October 1595: "*I wanted to become a theologian. For a long time I was restless. Now, however, behold how through my effort God is being celebrated in astronomy.*"(Kepler 1937, p. 40). At heart Kepler was a geometer who perceived geometry as the model used by God to shape and create the world. Hence, he was convinced that God manifested Himself both in the Scriptures and in the wonders, beauties and complexities of the universe. Kepler thought that God made

Himself known to humanity through His creation in order to be comprehensible to the human mind. Similarly, when grown-ups talk to little children, they do not convey to them complex ideas using highly specialised jargon but through a simple and visual language which matches the child's cognitive development. Keplerian's theological-philosophical investigation and study of physical and astronomical phenomena, which led to the formulation of his famous three laws of planetary motion, was explained in details in Kepler's masterpieces: *Mysterium Cosmographicum* (The mystery of the cosmos) (1596), where the first two laws were stated, and *Harmonice Mundi* (The harmony of the world) (1619), where the third law was proposed. To achieve such an outstanding astronomical and mathematical result, Kepler used the philosophical-geometrical concept of the five Platonic solids (tetrahedron – four faces, cube – six faces, octahedron – eight faces, dodecahedron – twelve faces, and icosahedron – twenty faces) and inscribed them into orbs in order to describe the movement of the six planets known at that time (Mercury, Venus, Mars, Jupiter and Saturn).

Isaac Newton

Newton can be considered a Deist because he saw God as a non-intervening Deity who was responsible for the creation and existence of the Universe. In other words, Newton conceived God as the benevolent Deity whose actions allowed the planets' orbits to be stable despite the inability of his mathematical explanation of planetary motion to account for such stability (Force 1990). A clear example of Newton's deistic approach to physics can be found in *Query 31*, the last of the *Queries* which compose Book III of *Optiks* (1704), his famous treatise on optics and the physical properties of light: "*All these things being consider'd, it seems probable to me, that God in the Beginning form'd Matter in solid, massy, hard, impenetrable Particles, of such Sizes and Figures, and with such other Properties, and in such Proportion to Space, as most conduced to the End for which he form'd them; and that these primitive Particles being Solids, are incomparably harder than any porous Bodies compounded of them; […] no ordinary Power being able to divide what God himself made one in the first Creation. […] Now by the help of these Principles, all material Things seem to have been composed of the hard and solid Particles above-mention'd, variously associated in the first Creation by the Counsel of an intelligent Agent. For it became him who created them to set them in order. And if he did so, it's unphilosophical to seek for any other Origin of the World, or*

to pretend that it might arise out of a Chaos by the mere Laws of Nature; though being once form'd, it may continue by those Laws for many Ages." (Newton 2016, Lines 1-57)

Cosmic knowledge: Holy Scriptures and Apocrypha as one of the best "textbooks" on science and scientific education

We have talked extensively about knowledge and its relationship with Wisdom; however, we should ask ourselves: "Do I really know what knowledge is, what "knowing" means?" In his thought-provoking book *Jesus of Nazareth* Pope Emeritus Benedict talks about the "*oneness of 'knowing' through the communion in the truth*" (Ratzinger 2007, p.282). He explains that "*it is only in God that we rightly know man. Any 'self-knowledge' that restricts man to the empirical and the tangible fails to engage with man's true depth. Man knows himself only when he learns to understand himself in light of God, and he knows others only when he sees the mystery of God in them*" (Ratzinger 2007, p.283). We see, therefore, that we can *know* ourselves, the world surrounding us, the cosmos only through the *eyes of God*, only by using the *spectacles* (i.e. the intellectual means) that God has provided us with; "*you have been anointed by the Holy One, and all of you have knowledge*" (1 John 2:20).

Interestingly, one of the best accounts of creation can be found in the *Book of Job*. In Job 38: 1-38, we find the most astounding and comprehensive description of our world. God tells Job how He formed the earth, divided it into ordered sections, bounded the seas to keep them separated from the earth, created the planets, the stars, the galaxies, and kept the weather under control. God also tells Job that the creation of the physical world which we sense and live in is a feat that only God could achieve. No man could create anything similar (see Job 39: 1-30). This clearly shows us that a combination of theological, philosophical and scientific arguments, ideas, concepts and approaches leads us to a *cosmic knowledge*, a knowledge which goes beyond the physical reality that we can sense and experience, and ushers us into the breath-taking and mind-blowing realm of "*real*" reality, i.e. the Kingdom of God. Cosmic knowledge grants us *freedom* from pre- and mis-conceptions about the meaning of knowledge, the open-mindedness and communion between different disciplines which permit us to embrace the cosmos with just one single look and thereby finally begin to grasp the Universal Truth which lies with God. How can we achieve such cosmic knowledge?

This is not a knowledge that can be gained simply by going to university and pursuing an academic career (although this is an important step); such harmonious, cosmic knowledge is the end of a long and difficult journey. As we can see in the highest heaven we find Wisdom, that supreme guidance which begins with "*fear of the LORD*" (Proverbs 9:10, see also Ecclesiasticus 1:14). Only Wisdom can guide us on our journey towards universal and harmonious knowledge of the Truth. And so, what better *teacher* can we hope for to learn about the Truth, to learn how to use the practical (physics), intellectual (metaphysics), and spiritual (religion) approaches we have at our disposal to gain *cosmic knowledge*? After all, that is the path we are to follow if we are really serious about unravelling the mysteries and unlocking the secrets of the universe:

Physics is excellent at explaining and dealing with space; however, physicists have yet to understand what time is, let alone to explain its meaning (Rovelli 2017). However, a detailed explanation of what time is was given by St Augustine in his masterpiece the *City of God* Book XI, Chapters 5-7. This is an excellent example of how a complex and elusive concept as time can be tackled using philosophical and theological arguments.

The esoteric approach to the study of nature that we find in the Holy Scriptures and the Apocrypha can also be found in Ancient Greek philosophy and physics. For example, Heraclitus (ca. 535 – 475BC) reminds us that "*a hidden connection is stronger than an apparent one"* (Fragment 14) and that "*Nature prefers to hide*" (Fragment 15), where this time Nature (with capital N) indicates the essence, the Form, the real/inner aspect of the natural reality that we can experience with our five senses. At the centre of Heraclitus' investigation of nature there is the Logos which he sees as the ultimate goal of human understanding and knowledge (Geldard 2000).

Our review of the Ancient Greek, Christian, and Renaissance learning and teaching methods has demonstrated that the real scope of studying and investigating the physical world (from the very small – the domain of quantum physics – to the very large – the realm of astrophysics) is to share knowledge with God, to know what He knows, and i.e. to "*become participants of the divine nature*" (2 Peter 1:4). It becomes, therefore, evident that from a Christian perspective the only two guides that any serious student of nature can have are Wisdom and Jesus Christ; Wisdom because she was there at the beginning and assisted God in creating the physical world and so has first-hand knowledge of the Truth, and Jesus because He is the Son of God and as such knows

what His Father knows: "*I am the way, and the truth, and the life. No one comes to the Father except through me. If you know me, you will know my Father also. From now on you do know him and have seen him*" (John 14:6-7).

Teaching physics in the classroom using a scientific-philosophical-theological approach: Utopia or reality?

How can we translate this scientific-philosophical-theological paradigm into a workable model which could be used in a modern Catholic university to teach physics? I believe that a good starting point would be Plato's *Timaeus*, that masterpiece of scientific, philosophical and theological account of creation and the physical world that Plato wrote in ca. 360BC. I am not suggesting that the *Timaeus* should become a core textbook appearing in the reading list of every undergraduate and postgraduate physics degree (although such an insightful and mind-blowing reading would not do any harm to any serious physics student!) but simply that Plato's approach to the teaching of creation, physical sciences, physiology, anatomy, structure of matter, mathematics, geometry, psychology, and medicine using scientific, philosophical and theological concepts and tools is unique. More importantly, since the *Timaeus* is, first of all, a religious and teleological[10] account of the origin of the physical world we live in, it can be considered as an example to follow when using a Catholic approach to the teaching of physics.

It is clear that the first step is to look at things differently, to approach the study and learning of physics not simply from a scientific and mathematical point of view, but also from a philosophical and theological perspective. In the light of what was said earlier about Wisdom and Jesus Christ being the best teachers to instruct us in the truth underlying the mysteries, wonders, and complexities of the cosmos, it is obvious that a physics student who is serious about learning about nature and its laws needs to have a robust knowledge of philosophy (whose literal meaning is "love of wisdom") and of theology (which means "love of God"). Philosophy will allow the physics student to become a follower of Wisdom, whereas theology will help the student to become a true disciple of Jesus.

The philosopher physicist

A philosophical approach to physics is not something which belongs only to the Academy of Plato and Ancient Greek teaching, or the Renaissance approach to learning; it is not a relic of the past. On the contrary, it is an approach to science that was quite common up to the end of the 19th century and the beginning of the 20th century. A typical example is Albert Einstein, whose "*philosophical habit of mind, cultivated by undergraduate training and lifelong dialogue, had a profound effect on the way he did physics*" (Howard 2005, p. 34). As Prof. Don Howard from the University of Notre Dame (Indiana, USA) points out "*nowadays, explicit engagement with the philosophy of science plays almost no role in the training of physicists or in physics research. […] Careful reflection on philosophical ideas is rare. Even rarer is systematic instruction*." (Howard 2005, p. 34).

However, things were not always like that. When Einstein was an undergraduate student at the Swiss Federal Polytechnic Institute in Zürich, every physics student was obliged to take a course in philosophy of science. The majority of the physicists of the time were also philosophers, one example being Ernst Mach (1838 – 1916) whose main contributions to physics were in optics, mechanics and wave theory, and who is considered the founder of philosophy of science. Einstein was convinced that "*when experience forces us to seek a newer and more solid foundation, the physicist cannot simply surrender to the philosopher the critical contemplation of theoretical foundations; for he himself knows best and feels more surely where the shoe pinches. In looking for a new foundation, he must try to make clear in his own mind just how far the concepts which he uses are justified and are necessities*" (Einstein 1936). So, a well-rounded physicist is also a philosopher. Why? Because this combination will lead to *independence of judgment*, i.e. the ability to critically and unbiasedly discuss and ponder received ideas. It is obvious that only intellectually ambitious physics students can embark on such a learning challenge. Thus, since a well-grounded physicist is also a serious philosopher, we can conclude that a robust undergraduate physics degree should engage students in physics and in philosophy.

The well-rounded physicist: A philosophical-theological approach to teaching physics

It is now time to add another layer of knowledge to the physics-philosophy approach in order to give to physics students a holistic and complete education, and ultimately equip them with the scientific, intellectual, academic, spiritual, philosophical and theological

knowledge they will need to be able to ask *big questions*, and give their active contribution to answer them. This additional perspective is the theological dimension.

Every university can provide a scientific-philosophical education to physics students; however, a Catholic university would be better equipped to add the theological component. This is also the view of the Catholic Church as clearly explained in the Declaration of Pope Paul VI "*Gravissimum educationis*": "*The Church is concerned also with […]universities. In those schools dependent on her she intends that by their very constitution individual subjects be pursued according to their own principles, method, and liberty of scientific inquiry, in such a way that an ever deeper understanding in these fields may be obtained and that, as questions that are new and current are raised and investigations carefully made according to the example of the doctors of the Church and especially of St. Thomas Aquinas, there may be a deeper realization of the harmony of faith and science. Thus, there is accomplished a public, enduring and pervasive influence of the Christian mind in the furtherance of culture and the students of these institutions are moulded into men truly outstanding in their training, ready to undertake weighty responsibilities in society and witness to the faith in the world*". (Second Vatican Council 1965, Declaration on Christian Education "Gravissimum Educationis", section 10).

What would a philosophical-theological approach to teaching physics look like from a practical point of view? Would it be necessary to change drastically the curriculum of a standard undergraduate physics degree? Not at all, for by its very nature physics has already a philosophical and theological dimension and the only thing that a physics teacher has to do is to make it emerge in the classroom and beyond. Theoretical physics and mathematical physics constitute the esoteric and spiritual side of physics, whereas experimental and applied physics are its practical aspect. The current syllabus followed in all universities is mainly focused on the practical aspects of physics and even theoretical physics modules teach students about its abstract and mathematical side ignoring completely its esoteric, spiritual and philosophical components. The typical example is quantum physics, one of the most spiritual and philosophical branches of physics. Due to its *weirdness* quantum physics is either rejected or embraced by physicists. Why? Because what makes quantum mechanics phenomena *weird*, and sometime inexplicable, is that to explain them we must enter the realm of philosophy and more specifically of metaphysics. Taking such a step requires an open-minded

attitude; a willingness to step into the unknown domain of what can be seen and understood only by using the eyes of the mind. This philosophical and spiritual approach to the teaching and learning of physics can help explain and understand concepts as diverse as human consciousness and the behaviour of black holes.

Following the path which leads us from physics (physical observation of nature as we see and experience it) to metaphysics (intellectual exploration of the nature and existence of the physical world) keeps us on the right track and prepares us for the last stage of our *cosmic journey*. Theological concepts and perspectives ought to be used to understand the true meaning of and answer the ultimate questions about the world, life, the universe, and the cosmos; and in the end from a Christian perspective, to encounter God (the scope and purpose of every authentic and sincere human quest for knowledge).

We can, therefore, say that a holistic and well-rounded undergraduate physics programme should educate students in the two aspects of physics since we human beings need both: The practical/applied component (it is important to make technology advance for the wellbeing and benefit of humanity) and the abstract/spiritual one (humanity must continue its quest for the ultimate knowledge, for the Truth). This is not something new or unheard of. For example, Fra Luca Pacioli (1447 – 1517) provides a good example of how important the abstract and applied aspects of mathematics are. Fra Pacioli was an Italian Franciscan friar and mathematician. He taught pure mathematics and geometry to Leonardo da Vinci and used his knowledge of applied mathematics to develop an accounting system which is still used today. In his treatise "*De divina proportione*" (Divine proportion) published in 1509, Fra Pacioli tells us that "*As God confers being to the celestial virtue, called by the other name 'fifth essence', and through that one to the other four simple bodies, that is, to the four earthly elements […] and so through these to every other thing in nature. Thus this our proportion is the formal being of (according to Timaeus) heaven, attributing to it the figure of the solid called Dodecahedron, otherwise known as the solid of twelve pentagons*".

In his turn Leonardo da Vinci used pure mathematics and physics to paint his masterpieces; for example the famous fresco "*L'ultima cena*" (The last supper) was composed using the golden ratio[11]. However, Leonardo used applied mathematics and physics to design and build "*flour−mills, fulling−mills, and engines, which might be driven by the force of water*" as Giorgio Vasari (1511 – 1574) tells us in his famous "*Le Vite de' più eccellenti pittori, scultori, e architettori*" (The Lives of the Most Excellent

Painters, Sculptors, and Architects) (1550). According to Vasari, Leonardo "*was continually making models and designs to show men how to remove mountains with ease, and how to bore them in order to pass from one level to another; and by means of levers, windlasses, and screws, he showed the way to raise and draw great weights, together with methods for emptying harbours, and pumps for removing water from low places*".

Conclusion

The multidisciplinary approach to teaching and learning physics described in this paper could be summarised in two words: *Creativity* and *Curiosity*. An essential ingredient when presenting to students the different aspects of physics (scientific, philosophical and theological) is to allow them to be creative, to let their imagination wander freely in the cosmos. Students have to be encouraged to not stop at the surface of the physical world (i.e. simply observing and understanding how physical phenomena happen and using mathematical formulae as mere instruments to solve practical problems) but to use philosophical arguments and perspectives to ask why the world is as it is, why physical phenomena follow certain laws and not others, and to test and understand whether a physics theory/idea/thought is true, is logical. Students have to be taught to be curious, to not be afraid to ask *big questions* but above all not to be afraid to contribute to an attempt to answer them.

Curiosity is that fire within us which is not quenched by the mere knowledge of the world as we observe it and experience it. That fire is sacred and is the beacon which guides our steps on the long, perilous and uncertain journey which leads to God (see Exodus 13:21). It is that sacred fire burning inside our Temple (see 1 Corinthians 6:19) which gives meaning to our lives, which makes us "*the salt of the earth […]. The light of the world*" (Matthews 5:13, 14).

Notes

[1] Scriptures texts are from The New Revised Standard Version.

[2] In 1897, Giovanni Pascoli wrote a short treatise entitled "*Il Fanciullino*" (The little child) in which he explained that "*There is within us a little child who not only has chills, as Cebes of Thebes – the first to discover his presence – thought, but tears and his own moments of joy*". This inner little child stays with us from birth until we die and it is its innocence and naivety which permits us, as adults, to discover those mysteries and novelties of the world around us that escape "*our senses and our reason*". It is like a new Adam who "*names everything he sees and hears*", which means that he is capable of understanding and knowing the real meaning of the reality which surrounds us and, through him, we can achieve the same level of deep and inner knowledge.

[3] "Science and religion complement each other in the search for truth" (Polkinghorne 2011, p. 136); "Both science and theology can claim that they are exploring the nature of reality, but clearly they do so at different levels. The object of study for the natural sciences is the physical world and the living beings that inhabit it. These sciences treat their subject matter objectively, in an impersonal mode of encounter that employs the investigative tool of experimental interrogation. […] Theology's concern is with the quest for truth about the nature of God, a sacred reality that is not available to be put to the experimental test. As with all forms of personal engagement, encounter with the transpersonal reality of the divine has to be based on trusting and its character is intrinsically individual and unique" ((Polkinghorne 2011, p. 137);

"The 'god' that Laplace and Hawking have overthrown is a god who is merely one force alongside all the other forces in nature. Rather than being supernatural, present at the beginning, outside space and time, this kind of god is a pagan nature deity, responsible if not for thunder and the growth of crops, then at least primordial Big Bang and the growth of the universe. This is most certainly not the personal God of scripture." (Consolmagno 2012, p. 117); "Only a supernatural God can give our life meaning. Only a supernatural God, existent outside of the mechanism of Newton's universe, can account for our experience of beauty, freedom, and love. And only a supernatural God is worthy of our adoration. The God who set off the Big Bang, even if there were such an entity, is not by that mere act any more worthy to be worshipped than one would worship the force of gravity. Hawking knows that; otherwise, by identifying the start of the universe with the fluctuations that he identifies with gravity, he logically would have to conclude that gravity was the god one ought to worship. And he sees, rightly, that such a worship would be absurd." (Consolmagno 2012, p. 118).

[4] Renaissance was a period in European culture that started at the end of the Middle Ages (ca. 1400) and ended in ca. 1600. Renaissance is the French word for *rebirth* as this period saw a renewal in interest in classical scholarship in philosophy, science (in particular, physics, mathematics and

astronomy), architecture, literature, theology, and the arts. During the 16th and 17th centuries the so-*called Scientific Revolution* occurred, which paved the way to modern science as we know it.

[5] Illiberal arts utilise "a trade or craft that involves the use of hands". Aristotle distinguishes between liberal and illiberal arts in its Politics, Book VIII: "There can be no doubt that children should be taught those useful things which are really necessary, but not useful things; for occupations are divided into liberal and illiberal; and to young children should be imparted only such kinds of knowledge as will be useful to them without vulgarising them. And any occupation, art, or science, which makes the body or soul or mind of the freeman less fit for the practice ir exercise of virtue, is vulgar; wherefore we call those arts vulgar which tend to deform the body, and likewise all paid employments, for they absorb and degrade the mind" (Politics, Book VIII, p. 181).

[6] What goes beyond the purely physical.

[7] Pythagoras thought that "not all things were to be spoken to all people" (Diogenes Laertius, VIII. 15). What Pythagoras meant was that there are realities that cannot be openly disclosed to everybody. As Aristoxenus (360 – 300BC) tells us "Pythagoras most of all seems to have honoured and advanced the study concerned with numbers, having taken it away from the use of merchants and likening all things to numbers" (Fr. 23, Wehrli). Pythagoras elevated numbers to a higher level of knowledge, i.e. he saw numbers as a link between the natural realm and the spiritual domain. Again in the words of Aristoxenus: "most of all valued the pursuit (*pragmateia*) of number and brought it forward, taking it away from the use of traders, by likening all things to numbers" (Fr. 23)".

[8] Johannes Kepler (1571 – 1630) was a German mathematician and astronomer. His most notable work is the development of the three laws of planetary motion: *First Kepler's law*: All planets move about the Sun in elliptical orbits, having the Sun as one of the foci. *Second Kepler's law*: A radius vector (mathematical entity that has a direction and a magnitude) joining any planet to the Sun sweeps out equal areas in equal lengths of time. *Third Kepler's law*: The squares of the sidereal periods (of revolution) of the planets are directly proportional to the cubes of their mean distances from the Sun. Isaac Newton (1643 – 1727) was an English physicist, mathematician and theologian. He is best known for his work on the law of gravity, theory of colours, and the infinitesimal calculus. Newton wrote extensively on theological subjects but only recently his theological works have re-emerged and have been studied.

[9] Michael Mästlin (1550 - 1630) was a German mathematician and astronomer. He was Johannes Kepler's mentor and an assiduous supporter of the Copernican heliocentric theory according to which the Sun is at the centre of our solar system and the other planets (including Earth) rotate around it. Mästlin passed this strong belief in the correctness of the Copernican system onto his pupil Kepler who developed it further until he formulated his three laws of planetary motion.

[10] Teleology is a philosophical system whose purpose is to explain something as a function of its scope, its final goal, its purpose.

[11] The *sectio aurea* (Latin for golden ratio) is $\Phi = \frac{1+\sqrt{5}}{2} = 1.618$. It was used in Renaissance art as a method to aid composition.

References

Aristotle. 1999. *Politics*; translated by B. Jowett, Batoche Books.

Consolmagno, G. 2012. "The new physics and the old metaphysics: an essay for the use of Christian teachers". *International Studies in Catholic Education* 4(2): 111-121.

Einstein A. 1936. "Physics and reality". *Journal of the Franklin Institute* 221: 349-382.

Force, J.E., Popkin, R.H. 1990. *Essays on the Context, Nature, and Influence of Isaac Newton's Theology*. Dordrecht: Kluwer Academic Publisher.

Geldard, R. 2000. *Remembering Heraclitus*. Lindisfarne Books.

Heller, M. 1996. *The new physics and the new theology*. Vatican: Vatican Observatory Publications.

Howard D. 2005. "Albert Einstein as a philosopher of science." *Physics Today* - December: 34-40.

Kristeller, P.O. 1961. *Renaissance Thought: The Classic, Scholastic and Humanist Strains*. First Harper Torchbooks Edition. New York, Harper & Row.

Kepler, J. 1937. *Johannes Kepler Gesammelte Werke* (1937-), Vol. 13, letter 23, l. 256-7.

Newton, I. 2016. *Optiks*. CreateSpace Independent Publishing Platform.

Polkinghorne, J. 2011. "The incompleteness of science: Reflections for Christian teachers and for other interested in science-religion relationship." *International Studies in Catholic Education* 3(2): 136-144.

Polkinghorne, J. 2011. *Reason and reality: The relationship between science and*

theology. London: SPCK Publishing.

Ratzinger, J. 2007. *Jesus of Nazareth*. London: Bloomsbury.

Rovelli, C. 2017. *The order of time*. Allan Lane.

Sacks, J. 2011. *The great partnership: Science, religion and the search for meaning*. New York: Schocken.

Second Vatican Council, *Gravissimum educationis* [Declaration on Christian education], Vatican Website, 28th October, 1965, sec. 10, accessed 26th July, 2018, http://www.vatican.va/archive/hist_councils/ii_vatican_council/documents/vat-ii_decl_19651028_gravissimum-educationis_en.html.

Stoeger, W.R. 2010. "The Big Bang, quantum cosmology and *creatio ex nihilo*." In D. Burrell, C. Cogliati, J. Soskice, and W. Stoeger (Eds.), *Creation and the God of Abraham* (pp. 152-175). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511778063.012.

Theon of Smyrna 1980, *Mathematics useful for understanding Plato*, translated by R. Lawlor and D. Lawlor, Wizards Bookshelf,U.S

White, D. 2015. *The Lost Knowledge of Christ: Contemporary Spiritualities, Christian Cosmology and the Arts*. Collegeville, MN: Liturgical Press.

Notes on Contributor

Dr Elisabetta Canetta is Senior Lecturer in Physics at St Mary's University, Twickenham, London. She is a nanobiophysicist whose research interests encompass the investigation of nanomechanical biomarker of human living cells for diagnostic purposes. She has also a keen research interest in the synergy between physics and theology, the theological aspect of the mathematical order of the cosmos, and the religious side of the Enlightenment.

Disclosure statement

No potential conflict of interest was reported by the author.