

## Article

# Space and the Papacy

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**Abstract:** There has always been a powerful connection in human consciousness between the beauty and otherworldliness of the night sky, and humanity's religious yearnings toward a reality beyond the mundane. When Pope Leo XIII established an astronomical observatory in 1891, it was as a way of demonstrating the Church's support of science; his choice of astronomy in particular was based primarily on the Holy See's already established good reputation in the field, and specific opportunities for international collaborations. Nonetheless, since its founding, Popes have taken advantage of the natural connection between sky and "heaven" to promote the exploration of space as a way of coming closer, emotionally and intellectually, to the Creator. However, the nature of how this connection is understood has changed significantly over the past 125 years, most recently with the challenges of the Space Age.

**Keywords:** astronomy; history; Holy See; religion; Vatican

## 1. Introduction

A powerful connection has always existed between the beauty of the night sky, which gives visible evidence of an existence different from the world where we live, and humanity's religious yearnings toward a reality beyond the mundane. This can be seen even in the observation that for many languages similar words are used to denote both "sky" (or "heavens" in English) and "heaven." Italian and French, for example, use the same word for both.

One result was that, to the pre-scientific world, celestial activities such as the motions of the stars and planets were regarded as a parallel to the action of supernatural beings. A common feature of most ancient cosmologies was the belief that the physical universe mirrored the spiritual realm, and they often posited a "chain of creation" where different levels or aspects of the physical universe mirrored different levels within heaven. Thus, when the motions of the planets (which included the Sun and Moon) were each attributed to an individual dome over the disk of the Earth or, later, to separate crystalline spheres encasing the sphere of the Earth, each was also assigned to a different mineral or element, to its own god, or to the various ranks of angels; and their individual motions were connected by astrology to events on Earth (Crowe 1990; Danielson 2001; Lewis 1964).

The wordplay of "heaven" and "heavens"—which are the same word in Italian—was the root of the famous pun attributed to Cardinal Caesar Baronius by Galileo in his famous *Letter to The Grand Duchess Christina*: scripture was written to tell us "how to go to Heaven, not how the Heavens go." However, in fact, the implied connection between matters in the sky and theological ideas continued even after the scientific revolution.

For example, Kepler argued for the heliocentric system on the basis of its parallels to the Holy Trinity. As he explained in a letter to his friend Herwart von Hohenburg, among the reasons for adopting his theory for the orbits of the planets in ellipses about the Sun was the mystical significance he read into the structure of the celestial sphere: "The center is the origin and beginning of the sphere. Indeed, the origin has precedence everywhere and is by nature always the first. When we apply this consideration to the most Holy Trinity, the center refers to the image of God the Father. Hence the

center of this material world-sphere should be adorned by the most ornate body, that is the Sun . . . ” (Kozhamthadam 1994). Kepler knew that the original Copernican system still required epicycles, and circular orbits that were not centered exactly on the Sun. Indeed, in that system the Sun still had its own eccentric motion about the presumed center of the system. It would hardly be fitting, reasoned Kepler, for God the Father to make this eccentric little dance around the center of the universe. God the Father had to be the center, in a literal sense. So, Kepler went searching for a better astronomical system; eventually he discovered that elliptical orbits allowed the Sun, and therefore by his model God the Father, to remain fixed at one focus of each planet’s ellipse.

By 1891, when Pope Leo XIII established the Specola Vaticana (Vatican Observatory) as a Papal observatory, such metaphysics had long since been abandoned. However, the Italian confluence of the meanings of *cielo* certainly remained; and along with it, a connection in the popular mind between the two.

Rather than a survey of popular attitudes at that time, however—a topic no doubt fascinating but beyond the scope of this work—the focus to be addressed here is much more limited: not to the general culture, but to the Popes themselves. Since the establishment of their Papal observatory in 1891, how have the Popes understood and used the symbolic role of astronomy? In what way did they expect that scientific research in astronomy could support their role as the leader of a major world religion? A close reading of the statements and documents on this subject by the popes who have maintained the observatory, from Leo XIII to Francis, shows a fascinating development in how they have embraced science and in particular astronomy, and the place they have assigned it within their role as a religious leader. In particular, we will focus on the comments of five popes who significantly advanced this development: Leo XIII, Pius XI, Pius XII, John Paul II, and Francis.

## 2. Leo XIII: Astronomy for Apologetics

Even before 1891, the year when Pope Leo XIII established a scientific institution at the Vatican as a way of demonstrating the Church’s support of science, there were a number of historical precedents of the Holy See support for the natural sciences, and, more often than not, astronomical sciences.

For one example, following the instructions of the Council of Trent, in the 16th century, the Holy See established a papal commission to reform the calendar. Its work included investigating a more accurate way of calculating the length of the year and establishing the dates of the first springtime full Moon, which signaled the date of Easter. Ironically, rather than attempting a formula based on such precise calculations, in the end the commission chose a simpler but more easily understood formula for determining the dates of movable religious feasts (like Easter) that are tied to the original lunisolar Hebrew calendar. Nonetheless, the role of Fr. Christopher Clavius SJ (1538–1612) in this commission led to his own research into astronomy at the Roman College, including his support for Galileo both before and after the latter’s demonstration of the astronomical telescope. Astronomical work at the Papal-supported Roman College and at other Jesuit institutions continued up until the suppression of the Jesuit order in 1773, including such notable Jesuit astronomer-priests as Christoph Scheiner (1573–1650), Niccolò Zucchi (1586–1640), Giovanni Battista Riccioli (1598–1671), Roger Boscovich (1711–1787), and Maximilian Hell (1720–1792).

In addition to the Roman College astronomers, scientific equipment was based at the Vatican itself at several points in its history. These included the meridian line commissioned in 1576, built within the Tower of the Winds above the Vatican Library; a seismological observatory set up following the earthquake of 1703; and a “Specula Vaticana” (note that it includes the Latin word for observatory, *Specula*, which is carried into Italian as *Specola*) including an additional meridian line and telescopes set up in the Tower of the Winds by the Vatican Librarian, Cardinal Francesco Saverio de Zelada (1717–1801), in the late 1700s; notably, a Dollond telescope installed in 1797. Although much of the observational work was soon moved across Rome to the Roman College (Gregorian University), astronomical calculations continued to be made within the Tower of the Winds. This resulted in two Vatican-supported observatories working in parallel well into the 19th century. Following the

revolutionary upheavals of Rome in 1848, these observatories were combined into the Roman College observatory of Fr. Angelo Secchi SJ (1818–1878) (Maffeo 2001).

Undoubtedly, Secchi's international reputation gave astronomy a special status at the Vatican. Secchi—a pioneer in spectroscopy, solar physics, meteorology, and numerous other fields—had won the Grand Prix at the 1867 Universal Exposition in Paris, and Napoleon III had awarded him the French Legion of Honor. At an international meeting in Paris to revise the metric system in 1873, delegates from Italy (whose capital had finally moved to Rome in 1870) objected to Secchi's presence representing the Holy See, which they did not recognize as a nation; but the scientists at the meeting chose to seat Secchi, and the Italians were sent home. Given his international prestige, the Italian government allowed Secchi to keep his observatory at the Roman College even after the college itself had been confiscated in 1870. However, following Secchi's death in 1878, all its instruments were confiscated and moved to an Italian state-supported observatory (Chinnici 2019).

Thus, when, at the suggestion of Secchi's former assistant Fr. Francesco Denza, Pope Leo XIII decided in 1891 to establish some sort of scientific institution, the obvious choice was to set up an astronomical observatory. The tradition of national observatories such as those in Greenwich, Paris, and Washington DC (which performed pure astronomy along with their practical functions in timekeeping and nautical almanacs) meant that such an observatory could be seen as a symbol of nationhood, an important factor since many nations—notably Italy at that time—still did not recognize the Vatican's independence. Furthermore, with Secchi's achievements still fresh in everyone's memory, the Vatican already had a solid reputation in the field. Furthermore, unlike meteorological networks, natural history museums, or botanical gardens (which were being founded in many other national capitals at that time) an astronomical observatory did not require an extensive, expensive, or expansive infrastructure.

In 1879, the year after his election, Pope Leo XIII published a major encyclical, *Aeterni Patris*, on the importance of scholarship. Primarily an endorsement of the theology and philosophy of Thomas Aquinas, it contains a notable statement about the natural sciences:

*Our philosophy can only by the grossest injustice be accused of being opposed to the advance and development of natural science . . . in this very age many illustrious professors of the physical sciences openly testify that between certain and accepted conclusions of modern physics and the philosophic principles of the schools there is no conflict worthy of the name.*

Note that the issue before Pope Leo XIII at that time was the accusation that the Church was opposed to the advance and development of natural science. Here he provided not only a defense of science, but a defense of its advance and development. To him science was not seen as a static set of knowledge. The final edition of Darwin's *The Origin of Species* and his *The Descent of Man* had already been published eight years earlier, in 1871; Kelvin's estimate of the Earth's age had been some 15 years in print. (Kelvin had calculated that the Earth was hundreds of millions of years old, much older than Biblical inferences, though still far younger than modern calculations.) As noted above, Pope Leo had a particular interest in intellectual pursuits and the modern world; he certainly would have been aware of Darwin's work, and possibly Kelvin's. Whether or not he agreed with them, this encyclical argued that that attempting such work is not in and of itself something to be denied, challenged, or feared.

However, what is also telling is the argument behind why advances in science should not be feared: it is because "illustrious professors" have argued that the "certain and accepted conclusions" of modern science do not conflict with classical philosophy. To put it simply, one could conclude that to Pope Leo XIII, philosophy was still more important than the natural sciences, and that any science that did not accord with philosophy could be presumed to be not "certain and accepted." There was no sense that natural science in and of itself might make significant contributions to philosophy.

Twelve years later, when he established the modern Specola Vaticana, his *Motu Proprio* had this explanation:

*In the meantime the Church has not neglected those disciplines which investigate nature and its forces. Schools and museums have been founded so that young scholars might have a better opportunity to deepen those studies. Among the Church's children and ministers there are some illustrious scientists whom the Church has honored and assisted as much as she could, by encouraging them to apply themselves with complete dedication to such studies.*

*Among all of these studies astronomy holds a preeminent position. . . . The Church's pastors were motivated, among other considerations, to see to progress in this science and to support its followers by the possibility that it alone offered to establish with certainty those days on which the principal religious solemnities of the Christian mystery should be celebrated. (These and all subsequent citations of the popes, unless otherwise noted, are as quoted in [Consolmagno 2009](#))*

Again, notice the three particular items that he draws attention to: the preeminent position of astronomy; that its study reflects well on the honor of the Church, showing that it supports science; and that there is utility in astronomy for setting liturgical dates. While the latter issue might seem to have been a settled issue after the Gregorian Calendar reform of 1582, in fact, ever since then various suggestions for improvements have constantly been floated, including a suggestion of a small change (never followed up) in an encyclical by Pope Clement XI in 1703. Such suggestions continue even to the present day ([Casanovas 2009](#)).

Later in the document, he explicitly states that his motive for establishing the Specola is so that “... everyone might see clearly that the Church and her Pastors are not opposed to true and solid science, whether human or divine, but that they embrace it, encourage it, and promote it with the fullest possible devotion.” Thus, he makes clear that, to him, the primary function of the Observatory and by connection the primary utility of astronomy to the Church is confined to the honor that it gives the Church and its scholarship.

### 3. Pius XI and Pius XII: Astronomy as Prayer

The Popes who followed Leo XIII—Pius X and Benedict XV—continued their support of the Specola Vaticana. One can assume that they were motivated by the same issues that had led Leo to establish it: a wish to maintain the sovereignty of the Holy See and a desire to defend the Church against attacks that it was opposed to science. However, by 1930, two events had caused the Papacy to re-examine the state of the Specola.

The first was the recognition of the Vatican City State as a independent nation by the Italian government in 1929. This meant that the Vatican might no longer feel the same need for overt signs of “statehood” such as a national observatory.

The second was the death of its long-time director, Fr. Josef Hagen SJ (1847–1930), on September 5, 1930, at the age of 83. After Hagen's death, Fr. Johan Stein SJ (1871–1951), who had worked with Hagen from 1906–1910, was appointed to succeed him as director.

With the Lateran treaty not only was the Vatican City State established, but also certain traditionally papal properties that had been confiscated by the government, notably the papal summer home in Castel Gandolfo, were restored to the Papacy. Stein proposed that the Specola move from its cramped and now light-polluted location on the walls of the Vatican to the papal villas in Castel Gandolfo. This site had both the dark skies needed for new telescopes, and room for a spectrochemical laboratory. The Pope agreed and thus the Specola was in essence reborn at a new location, with new facilities and a new staff of young scientists.

Two new telescopes on the roof of the Papal Summer Palace were dedicated by Pope Pius XI on 29 September 1935. At that time the Pope delivered an inaugural address that indicated a new way that astronomical research could benefit the mission of the Church. He began with the well-established theme of how support of astronomy gives honor to the Church, including a note of the double-meaning of the word heavens:

*Today we officially inaugurate the Astronomical Observatory and the Astrophysical Institute. The high quality of the scientific instrumentation which has been acquired and the proven expertise of the scientists who will use it will undoubtedly make some important contributions to the progress in research of a science which, as a study of the heavens, can be said to be sovereign among the sciences.*

What goes unsaid, presumably because it did not need to be said, was any reason why “studying the heavens” could be said to be sovereign among the sciences. However, he immediately follows this statement with the comment, “But this is not the only reflection which brings joy to our hearts today,” suggesting that he wishes to indicate a new motivation for this work. He then notes the historical precedents (which had been outlined previously by Fr. Stein):

*What we are doing today, and your presence my beloved sons and daughters makes it all the more beautiful and solemn, adds some lines to the truly golden and most glorious pages which have already been written about the history of the Roman Pontificate. It carries us, like winged Pegasus, through the centuries in an immense and magnificent world of things, of ideas, of happenings.*

*Our dear and most capable Father Stein has given us a simple, but wise and most tasteful, account of that world. His brief history has for a moment thrown light upon and opened our eyes to the unfathomable depths of the heavens. We have been able to capture and enjoy at least a few notes from that immense hymn from on high where the heavens and the heavenly bodies sing the glory and reveal the power and the wisdom and the infinite beauty of the Creator.*

Although linking the glory of the heavens to the glory of the Creator is a theme as old as the Psalms, this is a new note for a Pope to be taking in justification of the Specola Vaticana.

*And one might say that the Creator himself, He who at the end of his work of creation was pleased and proclaimed that all was good, is in a special way pleased with the magnificence of the heavens and the stars.*

At this point, the Pope returns to the apologetic value of the observatory, and how the existence of the observatory can make an important point countering the still-prevalent theme of a conflict between science and faith, again referring to ancient ideas tying together things seen in the sky with the abode of the gods:

*We should not be amazed then if the magnificent matters which astronomy studies and helps us to better understand, and if the ideas which are raised by even the most ordinary but solid view of those matters, become the source of a profound spirituality. I am referring to the relationship between Religion and the Science of the heavenly bodies which has reigned continuously over the centuries from the most remote antiquity to our times. The most recent important Congress of the Orientalist in Rome has also reminded us of this relationship and treated of it in some of the papers. Information from ancient cuneiform and hieroglyphic texts have helped us to understand how observations of the heavens were related to sacrifices and cultic practices. All of this is now well known. It is only yesterday, in comparison with those antiquities, that the reform of the calendar took place.*

Yet, at this point, the Pope signals that he is going in a new direction in the relationship between Church and science. In fact, in 1936, he would re-establish the historical Academy of the Lynxes (established by Pope Pius IX in 1847) and reconstitute it as the Pontifical Academy of Sciences. Here, with regard to this astronomical institution, he notes:

*As you see, what we are doing here is not just to continue and to imitate, within our resources, the patronage of Our illustrious predecessors who have never been sufficiently praised for what they did. It is not just that we are trying to assure for the present and future, as they did for the past with the quiet eloquence of their accomplishments, to assure I repeat that implicit, even explicit, defense of the Faith and of Religion. That defense shines and is more than ever persuasive whenever respect for the faith is joined in a spontaneous way with the development of Science.*

*That which we are doing now is more than all of that. We are taking up once more one of the threads of the history of the Roman Pontificate and it is a beautiful and precious one. That is the thread of its relationship over the centuries with the science of the heavenly bodies, a science one might in all truth say is by its nature religious, just like, as Tertullian so nicely phrased it, the human soul is naturally Christian.*

From this comes the new insight: that studying astronomy is not only a study of creation and thus the Creator, but that because of the history described above the study of astronomy in particular is especially appropriate to the Church:

*From no part of Creation does there arise a more eloquent or stronger invitation to prayer and to adoration . . . It seems to us, dear sons and daughters, in this astronomical, may we call it, inauguration that we are fulfilling in the name of the whole Church, an act of our priestly ministry.*

This is new. The Pope is saying here that to do astronomy is to participate in an act of prayer. Implicit is the understanding that astronomy has a value beyond bringing honor in a general way to the institutional Church. It is of value in and of itself; it is an activity completely in accord with the core function of the Church's religious duties.

He concludes by proposing a motto for the newly founded Observatory. This motto was inscribed on a plaque that remains to this day mounted on the wall of the structure housing the 1935 telescopes, and within the headquarters of the Specola in Castel Gandolfo:

*Fr Stein recalled for us the imposing inscription ordered by Pius IX to be placed on the Pontifical Observatory of the Roman University on the Capitoline, an observatory which he had constructed: Deo Creatori (to God, the Creator). We could do no better than to follow in the wake which Our glorious predecessor so brilliantly left open and to complete his thought by Ourselves declaring and inscribing on the new Specola: Deum Creatorem Venite Adoremus (Come let us adore God the Creator).*

Four years later, in 1939, Pope Pius XII was elected to the papacy in the turbulent months just before the beginning of the Second World War. Among his other qualities, he was personally fascinated by science, especially astronomy, and he had a particularly close relationship to the Specola Vaticana. For example, when the Observatory was looking to upgrade their pre-war telescope equipment in the 1950s, he provided the funding out of his own personal family fortune for a new Schmidt telescope that was constructed in the summer gardens.

In 1939, soon after his election, he delivered an address to the Pontifical Academy of Sciences where he offered a striking image of the role of astronomy as a form of prayer ([Pius XII 1939](#)):

*Man ascends to God by climbing the ladder of the Universe; the astronomer, when reaching the sky, footstool to the throne of God, cannot remain an unbeliever before the voice of the firmament; from beyond the suns and astral nebulae emanates the thought, followed by the love and adoration, which sails toward a sun which illuminates and gives warmth not to the clay of man but to the spirit which animates him.*

This poetic vision obviously builds on the sentiment expressed by his predecessor. Astronomy in particular is called out as having a special value in guiding the participant toward the traditional forms of prayer associated with the Church. However, Pius XII also shared the ideas seen in the writings of Pope Leo XIII that astronomy could also be called into the service of supporting the traditional philosophical underpinnings of theology. In his 1951 address to the Pontifical Academy of Sciences ([Pius XII 1951](#)), "The Proofs for the Existence of God in the Light of Modern Natural Science," he said:

*Contrary to rash statements in the past, the more true science advances, the more it discovers God, almost as though He were standing, vigilant and waiting, behind every door which science opens. Furthermore, we wish to say that not only does the philosophical thinker benefit from this progressive*



*discovery of God, achieved in the increase of knowledge—and how could he do otherwise?—but those also profit who participate in the new discoveries or who make them the object of their considerations. The genuine philosophers especially benefit from it, since, by using the scientific advances as a springboard for their rational speculations, they can achieve greater security in their conclusions, clearer illustrations in possible obscurity, more convincing support in finding ever more satisfactory answers to difficulties and objections...*

*Science, which has encountered the Creator in its path, philosophy, and, much more, revelation, in harmonious collaboration because all three are instruments of truth, like rays of the same sun, contemplate the substance, reveal the outlines, and portray the lineaments of the same Creator. (Pius XII 1951)*

In this document we find two attitudes that would later be rejected, or at least toned down: the sense that astronomy was subservient to the needs of theology and philosophy, and the idea that scientific evidence could be applied to a “proof” of the existence of God. To that end, however, the Pope happily cites scientific evidence such as the billion-year ages of the Earth and the universe, which shows a freedom from more restrictive “literalistic” interpretations of Scripture. However, in his attempt to show that science could be seen as agreeing with a Scripture in the presence, for example, of the necessity of a beginning point, this text came perilously close to *concordatism*, the fallacy that one can and should read scripture and faith as speaking in agreement of the same matters.

Even though the Pope softened his argument toward the end of his presentation by conceding that “the facts verified up to now are not arguments of absolute proof of creation in time . . . ” the concordatism tendency could be found almost immediately afterwards, where he suggested that one should “still wait for further investigation and confirmation, and theories founded upon them have need of new developments and proofs, in order to offer a secure basis to a line of reasoning which is, of itself, outside the sphere of the natural sciences.” Indeed, this appeared to many people to be an endorsement of a particular cosmology theory, popularly known as the “Big Bang.”

The most startling reaction against this speech came from Fr. Georges Lemaître, the Belgian diocesan priest and astrophysicist whose work in the 1920s actually laid the foundation for the Big Bang theory. Lemaître was very leery at reading such an interpretation of his theory.

For one thing, he recognized that his theory was still controversial, and only one of several possible cosmologies given the evidence available at that time. (It would be more than a decade before the discovery of the cosmic microwave background radiation finally convinced most cosmologists that some sort of “big bang” actually did occur.) Worse, in 1951 there was still some suspicion that this priest’s theory might have been invented precisely to find a scientific excuse to support the Genesis description of “fiat lux.” Lemaître wanted his work to be judged purely on its scientific merits. He knew that even the best scientific theory is eventually superseded by later work. Moreover, in any event, while it is good that theologians be aware of the latest advances in science, it is certainly not theology’s role to judge or endorse scientific theories. Nor, for that matter, is it wise to base theology on the latest advances of science, since that is a ground that is forever shifting.

Lemaître spoke personally to the Pope about his concerns. Clearly, he was heard. The following year, the International Astronomical Union (of which the Vatican is a member state) met in General Assembly in Rome, and the Pope was invited to address the assembled astronomers. In his address, of September 8, 1952, the Pope presented an overview of astronomical knowledge prepared with the assistance of the Director of the Vatican Observatory, Fr. Daniel O’Connell SJ.

In this address, the Pope reflected on the deeper implications of the very nature of the astronomical enterprise. However, rather than attempting philosophical or theological arguments, his presentation concluded with a very personal reflection of the nature of love to be found the Universe:

*What a happy and sublime encounter over the contemplation of the cosmos is that of the human spirit with the Spirit of the Creator! . . . The divine Spirit reveals itself from the coldness of space to the scientist open to finding a purpose for the whole of existing reality:*

Spirit moved by a breath of goodness and love penetrating and explaining all which focuses and reveals itself, particularly in the human being made in its image and likeness.

Astronomy was no longer merely an apologetic tool for the Church or only an inspiration to engage in traditional forms of prayer. Instead, it was recognized to be, in itself, a profound act of worship: a route to a deeply personal encounter with the Creator.

The address was presented in French, and not widely distributed afterwards. The English translation from which this was taken was prepared by Fr. Pavol Gabor of the Vatican Observatory in 2009.

#### 4. Pope John Paul II: Astronomy as Partner

In 1987 the Pontifical Academy of Sciences held a study week in honor of the 300th anniversary of Newton's *Principia*. Following that event, Pope John Paul II prepared a letter to Fr. George Coyne S.J., the director of the Vatican Observatory, outlining his thoughts on the relationship between science and religion; the letter was published in the study week proceedings. In it, he took the insights of the previous Popes in a new direction. Not only did he find value in science, in and of itself; he also recognized the scientific enterprise as an activity that was parallel, and equal, to the work of theology.

He began by recognizing how science and the intellectual world interacted (all quotations from [John Paul II 1988](#)):

*The Church and the Academy engage one another as two very different but major institutions within human civilization and world culture ... there has been a definite, though still fragile and provisional, movement towards a new and more nuanced interchange. ... It is crucial that this common search based on critical openness and interchange should not only continue but also grow and deepen in its quality and scope.*

It was important that these enterprises were recognized as independent and equal. Only in that way could a fruitful dialogue, and thus mutual understanding, be promoted. He also refused to pre-judge what fruit that dialogue might produce in the future.

*... we must overcome every regressive tendency to a unilateral reductionism, to fear, and to self-imposed isolation. What is critically important is that each discipline should continue to enrich, nourish and challenge the other to be more fully what it can be and to contribute to our vision of who we are and who we are becoming.*

The key was a sense of the equal value of science and religion; without it, such dialogue was pointless. What resulted was a call to recognition of science at a level that the preceding Popes would never have considered:

*... To be more specific, both religion and science must preserve their autonomy and their distinctiveness. Religion is not founded on science nor is science an extension of religion. Each should possess its own principles, its pattern of procedures, its diversities of interpretation and its own conclusions.*

It was not mere dialogue for dialogue's sake that he was calling for here. Pope John Paul II specifically calls out areas where astronomy and the other sciences can, and ought to, have a profound effect on the way the Church understood itself and its relationship with God.

*... If the cosmologies of the ancient Near Eastern world could be purified and assimilated into the first chapters of Genesis, might not contemporary cosmology have something to offer to our reflections upon creation? ... What, if any, are the eschatological implications of contemporary cosmology, especially in light of the vast future of our universe?*

Yet, he also argued that this dialogue was essential to progress within science itself: not in the sense that religion would favor one scientific result over another, but rather in the role that science



played in the wider human culture. In the following passage he planted the seeds of an understanding of science as a human endeavor, a thread of human culture, which Pope Francis would later develop in *Laudato Si'*.

*... Can science also benefit from this interchange? It would seem that it should. For science develops best when its concepts and conclusions are integrated into the broader human culture and its concerns for ultimate meaning and value. Scientists ... can also come to appreciate for themselves that these discoveries cannot be a genuine substitute for knowledge of the truly ultimate. Science can purify religion from error and superstition; religion can purify science from idolatry and false absolutes. Each can draw the other into a wider world, a world in which both can flourish.*

He also recognized that science inevitably plays a role in the way that human beings, living in a scientific culture, will understand their religion. It is not a question of whether science and religion should interact, but a recognition that inevitably they do interact. The issue then, is to have some sort of awareness of how that interaction is occurring:

*Christians will inevitably assimilate the prevailing ideas about the world, and today these are deeply shaped by science. The only question is whether they will do this critically or unreflectively, with depth and nuance or with a shallowness that debases the Gospel and leaves us ashamed before history. Scientists, like all human beings, will make decisions upon what ultimately gives meaning and value to their lives and to their work. This they will do well or poorly, with the reflective depth that theological wisdom can help them attain, or with an unconsidered absolutizing of their results beyond their reasonable and proper limits.*

If there was one take-away from this lengthy discussion, it can be found in a key sentence from a passage cited above: "Science can purify religion from error and superstition; religion can purify science from idolatry and false absolutes."

## 5. Pope Francis: Astronomy as an Integral Part of the Human Purpose

In the letter from Pope John Paul II cited above, we find the sentence, "science develops best when its concepts and conclusions are integrated into the broader human culture." This integration of science into the fabric of human life was first hinted at by Pope Pius XII, when he noted in his IAU address that "the divine Spirit reveals itself from the coldness of space to the scientist open to finding a purpose for the whole of existing reality." The indivisibility of the human being, who is at the same time living in the physical world that is studied by science and the cultural world beset by questions of purpose, ethics, and desires, is the key insight that forms the basis of Pope Francis's understanding of what science is and why it is important.

A hint of this integration can be found specifically in an address that Francis gave to the Vatican Observatory Summer School students in 2016: "Scientific research... can, and should be, a source of deep joy ... through us this universe can become aware of itself and of its Maker. This is the gift, and the responsibility, given to us as rational creatures in this cosmos." It is not enough that we do science; we also need to reflect on why we do it. He identifies the ultimate motivation as a search for joy, which he identifies as an awareness of the presence of God.

This theme was woven throughout the Pope's most significant work on the role of science in our culture, his encyclical *Laudato Si'* (Francis 2015).

Directly speaking about the relationship of humankind with the physical universe, particularly in the light of global climate change, the theme is set early on in this document: "Climate change is a global problem with grave implications: environmental, social, economic, political and for the distribution of goods." [paragraph 25]. He immediately ties both the physical and social sciences together, recognizing that progress (or errors) in the one can create effects in them all. Within this setting there are three points in this document which touch on the theme of our work.

First, it reemphasizes the nature of the Biblical description of the created word as a theological, not a scientific description. He does this both by examining its historical roots, and by differentiating what he calls “nature,” the physical universe studied by science, and “creation,” which is nature set in the context of a Creator. In this way, his teaching is far removed from any sort of fundamentalist literalism or concordatism. Recognizing that the Genesis account of creation in many ways sets the tone for how the Church deals with the physical world, it begins by examining what is actually said there and noting that its core message is not about nature itself but the relationships between God, nature, and humanity:

*The creation accounts in the book of Genesis contain, in their own symbolic and narrative language, profound teachings about human existence and its historical reality. They suggest that human life is grounded in three fundamental and closely intertwined relationships: with God, with our neighbor and with the earth itself. According to the Bible, these three vital relationships have been broken, both outwardly and within us. This rupture is sin. (Paragraph 40)*

The creation of Genesis and the nature studied by science both are refer to the same material reality, but the Pope notes that “the word ‘creation’ has a broader meaning than ‘nature’ ... Nature is usually seen as a system which can be studied, understood and controlled, whereas creation can only be understood as a gift from the outstretched hand of the Father of all, and as a reality illuminated by the love which calls us together into universal communion.” [76] Religious texts are thus about “creation” as a gift of love, rather than attempts to understand and control the physical universe. Nonetheless, another effect of this description of nature in scripture is that it “... demythologized nature. While continuing to admire its grandeur and immensity, it no longer saw nature as divine.” (Paragraph 78).

Next, with the introduction of “sin” as a rupture of the vital relationships between creation of Creator, science itself as an activity of human beings is thus inexorably tied to the human experience of joy and of sin. Thus, whatever science we do is both motivated and bound by that human experience. Science is seen as an essentially human act which, for that reason, participates in both joy and sin. It is not merely something that might be useful to cite but which is otherwise separate from the religious person; it is more than a tool that a religious person might use to reach God; it is more than an independent route to truth that complements religion. It is one of the essential activities that makes us human.

Finally, it deliberately conflates science with the technology that it enables. We cannot pretend that science is neutral, because to do so denies both its benefits and its dangers. If it had no danger, it would have no value.

Certainly, science itself and its associated technology is to be appreciated—not only for its utility in easing our daily work or improving our health, but also as a medium for all those activities that make us human. It makes new kinds of art possible; and it is, in itself, a new kind of art. However, precisely because it is a great power for good, it must inevitably require a greater need for responsibility:

*It is right to rejoice in these advances and to be excited by the immense possibilities which they continue to open up before ... Technoscience, when well directed, can produce important means of improving the quality of human life ... It can also produce art and enable men and women immersed in the material world to “leap” into the world of beauty ... art and music now make use of new technologies ... Yet it must also be recognized that ... our immense technological development has not been accompanied by a development in human responsibility, values and conscience. Each age tends to have only a meagre awareness of its own limitations ... the scientific and experimental method in itself is already a technique of possession, mastery and transformation... Men and women have constantly intervened in nature, but for a long time this meant being in tune with and respecting the possibilities offered by the things themselves. (Paragraph 102–4)*

Indeed, the problems that can arise from technology are precisely those that confuse the results of technology with those of philosophy.

*It can be said that many problems of today's world stem from the tendency, at times unconscious, to make the method and aims of science and technology an epistemological paradigm which shapes the lives of individuals and the workings of society. The effects of imposing this model on reality as a whole, human and social, are seen in the deterioration of the environment, but this is just one sign of a reductionism which affects every aspect of human and social life. We have to accept that technological products are not neutral, for they create a framework which ends up conditioning lifestyles and shaping social possibilities along the lines dictated by the interests of certain powerful groups. Decisions which may seem purely instrumental are in reality decisions about the kind of society we want to build ... scientific and technological progress cannot be equated with the progress of humanity and history. (Paragraph 113)*

The activity of science and the use of its resulting technology thus must be accompanied with deeper moral questions, those normally thought to be the realm of ethics or philosophy. For the astronomical sciences, which generally have not been thought to be promoters of new technology, this might seem to be irrelevant. However, what is being asked here is more than just worrying if something might be misused; it also demands that we build into our uses an examination of a just distribution of both benefits and costs.

*In any discussion about a proposed venture, a number of questions need to be asked in order to discern whether or not it will contribute to genuine integral development. What will it accomplish? Why? Where? When? How? For whom? What are the risks? What are the costs? Who will pay those costs and how? ... Any technical solution which science claims to offer will be powerless to solve the serious problems of our world if humanity loses its compass, if we lose sight of the great motivations which make it possible for us to live in harmony, to make sacrifices and to treat others well. (Paragraph 200)*

At the very least, astronomy is too often seen as a luxury of privileged societies. If astronomy has an intrinsic value *per se*, then that value is too often not available to everyone. The biennial Vatican Observatory Summer Schools, such as the one addressed by Pope Francis as quoted above, are specifically designed to attract students from the developing world as a way to address this issue.

The third essential point is a recognition that ultimately goodness can come from science and technology, and this goodness is a pointer to God. The document closes with a hymn of praise for the possibilities of science and technology, not in terms of their utility but with rejoicing in the joy of knowledge itself: "At the end, we will find ourselves face to face with the infinite beauty of God (cf. 1 Cor 13:12) and be able to read with admiration and happiness the mystery of the universe, which with us will share in unending plenitude." (Paragraph 243)

## 6. Discussion: Astronomy and the Peaceful Uses of Space

The Church first engaged astronomy in support of making more reliable liturgical calendars, and as a description of the cosmology that formed the basis of its philosophical and theological studies. The Popes' views of astronomy especially after 1891 also recognized that supporting science could be useful for apologetical purposes, to put the Church in a good light.

Yet, early on there was also a realization that astronomy supported a prayerful attitude, that contemplating the night sky provided a reminder that the universe and its Creator are larger than our immediate worries and fears. By the end of the 20th century, astronomy (and science in general) was also recognized as an independent path to truth, with its own necessary freedom and autonomy. By the time of Pope Francis, this grew to a realization that because science was an essentially human activity, it carried with it both the joy and the dangers of a humanity that was both fallen and redeemed.

Meanwhile, an essential change occurred in astronomy and its associated technology during this era. At the end of the 19th century, studying the universe outside of planet Earth was entirely a passive enterprise; unlike chemistry or biology, nothing that astronomy itself taught us could be seen to be actively altering the physical world where humans lived.

With the beginning of the space age, this age of innocence ended. Near-Earth space became a platform from which humans could observe our own planet. These data could be gathered, shared, or sold for purposes that might be peaceful, commercial, or hostile. And by the early 21st century, the Moon and asteroids began to be seen as potential mineral resources to be exploited ... and fought over.

In the early years of the space age, papal pronouncements were generally limited to prayers for the safety of the astronauts, notably Pope Paul VI's message to the Apollo 11 astronauts delivered on live television from the telescope domes of the Vatican Observatory on the occasion of the first lunar landing, 20 July 1969; and his prayers for the astronauts of the crippled Apollo 13 mission on 15 April 1970.

The first specific mention of space exploration at the Pontifical Academy of Sciences was a study week under Pope John Paul II in October, 1984, titled "Impact of Space Exploration on Mankind." The Pope's comments to that gathering emphasized the wish that the benefits of space travel would be made available to the benefit of all:

*These various modes of man's presence in space lead us to ask a question: to whom does space belong? While space was something merely observed and studied by the human eye, though with the aid of powerful astronomical instruments, this question was not yet asked. But now that space is visited by man and his machines, the question is unavoidable: to whom does space belong? I do not hesitate to answer that space belongs to the whole of humanity, that it is something for the benefit of all. Just as the earth is for the benefit of all, and private property must be distributed in such a way that every human being is given a proper share in the goods of the earth, in the same way the occupation of space by satellites and other instruments must be regulated by just agreements and international pacts that will enable the whole human family to enjoy and use it. (John Paul II 1984)*

In 1967, the United Nations promoted an International Treaty on the Peaceful Uses of Space. Fifty years later, the outlines of this treaty were being challenged. Governments with significant space capabilities, such as the United States and China, were reinterpreting or ignoring aspects of that treaty. Small nations such as Luxembourg and the Isle of Man who had not been seen as likely players before, found that their minor status allowed them possible legal loopholes that made them attractive places where corporations could be set up to exploit the resources of space, both tangible and intangible. Such corporations, and multinational consortia such as the European Space Agency, were not envisioned in 1967, much less signatories of the original treaty.

In 2018, the United Nations Office of Outer Space Activities (UNOOSA) celebrated the 50th anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space by hosting an international meeting, UNISPACE+50, in Vienna. Several months before this meeting, the Vatican Observatory hosted a workshop sponsored by the UNOOSA with more than two dozen experts from international organizations, governments and non-governmental organizations, as well as representatives of the private sector and research institutions and leaders from the diplomatic arena. As noted in the official UN report following the workshop, "The Holy See has a strong interest in matters related to the protection of the environment, and Pope Francis has repeatedly called for us to globally address the defining challenges of our time. Thus, [this seminar] provided a suitable framework for an exchange on how space science and technology can directly and indirectly escort the common global efforts to address climate change and the goals set in the Sustainable Development Goals." The meeting ended with a personal greeting to the attendees from Pope Francis at his Wednesday audience.

Following this meeting, the Vatican Secretary of State requested that the director of the Vatican Observatory serve as the head of the Vatican delegation to the UNISPACE+50 meeting, where he presented the official Vatican position on the peaceful uses of outer space (Consolmagno 2019a, 2019b):

*In seeing the Earth from space, we realize that our own borders are insignificant in comparison. The Earth's atmosphere is a global environment that needs to be protected by a global vision of this limited, shared natural resource and must be utilized for the benefit of all humankind ... Space*

*Accessibility should be understood to include accessibility to space-derived data and services for everyone on Earth, not just accessibility to the outer space environment for conducting research.*

Speaking of the work of our seminar, the Vatican statement noted:

*The discussion at the Seminar noted the numerous opportunities for the public's involvement in space science provided by the space community and the need for greater engagement with the public, as well as greater transparency by countries in the sharing of data, policies and motivations for space research . . . We need to reflect on how we can transform the paradigm of the space economy from one of making very expensive space services and products available to a few people, to one that harnesses the abundance of space-derived data and services for the good of all.*

And finally, it concluded:

*All nations share a common border with outer space, so all nations would be equally near such an area of conflict. Conflict in space would inevitably escalate tensions on Earth, and the effects of armed conflict in space would affect all present in outer space, whether they are combatants or not. The Holy See therefore, implores all States to maintain the peaceful uses of outer space—for the good of all and our one common home.*

At the same time that Popes were recognizing how astronomy was deeply entwined with the human person, whose joys and desires color the way we study the universe, we have become all the more aware of how the possible exploitation of space made possible by astronomy carry with them ethical and social dimensions (Consolmagno 2019a, 2019b).

In an age of in-situ space exploration, the famous linguistic quip of Cardinal Baronius takes on a new meaning. Our religion tells us not only how to go to Heaven; it reminds us of how we ought to behave when we go into the Heavens.

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