Priestly Contributions to Modern Science: The Case of Monsignor Georges Lemaître – page 16

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JOSEPH R. LARACY

In a timely piece for the Year of the Priest, Joseph Laracy shows that Monsignor Georges Lemaître is a recent and significant example of the importance to the rise of science of Catholic priests. Mr. Laracy is a seminarian for the Archdiocese of Newark, New Jersey, USA, in formation at the Pontifical North American College in Rome. Previous to that he was a research assistant at the Massachusetts Institute of Technology.

One of the significant obstacles to Christian evangelization in the twenty-first century is the widely held notion in the West, both by fundamentalist[1] Christians and by non-Christians, that there is an inherent conflict between science and religion. Such people are comfortable with such a position because they see reason and faith to be at odds as well. Religion and theology is viewed simply as a blind leap of faith, rather than *fides quaerens intellectum*. St. Augustine has strong words for those who take up the mantle of Christ and further this divide.

> It is a disgraceful and dangerous thing for an infidel to hear a Christian, presumably giving the meaning of Holy Scripture, talking nonsense on these topics [of cosmology]…If [non-Christians] find a Christian mistaken in a field which they themselves know well and hear him maintaining his foolish opinions about our books, how are they going to believe those books in matters concerning the resurrection of the dead, the hope of eternal life, and the kingdom of heaven, when they think their pages are full of falsehoods on facts which they themselves have learnt from experience and the light of reason? Reckless and incompetent expounders of Holy Scripture bring untold trouble and sorrow on their wiser brethren when they are caught in one of their mischievous false opinions and are taken to task by those who are not bound by the authority of our sacred books.[2]

Clearly, it is essential to provide a credible witness of serious Christians committed to the advancement of science and what better witness could there be than the clergy themselves? Physicist Stephen Barr and others provide an impressive list of Churchmen throughout history that have made lasting contributions to modern science:[3]

- Pope Sylvester II (ca. 946-1003), Pope who reintroduced Arabic numerals and the abacus to Europe.[4]
- Bishop Robert Grosseteste (ca. 1168-1253), Bishop of Lincoln and founder of the “Oxford School” known for developing the tradition of experimental science.
- Archbishop Thomas Bradwardine (1290-1349), Archbishop of Canterbury who was one of the first people to write down an equation for a physical process.
- Bishop Nicholas of Oresme (1323-1382), Bishop of Lisieux who as a mathematician discovered how to combine exponents and developed graphs of mathematical functions and as a physicist

explained the motion of the Sun by the rotation of the Earth and developed a more rigorous understanding of acceleration and inertia.

- Cardinal Nicolas of Cusa (1401-1464), Bishop of Brixon as well as mathematician and astronomer who postulated non-circular planetary orbits, developed a mathematical theory of relative motion, and even used concave lenses to correct near-sightedness.
- Canon Nicolaus Copernicus (1473-1543), Cleric who formulated a heliocentric model of the Solar System.[5]
- Fr. Francesco Cavalieri, SJ (1598-1647), Priest who played a pivotal role in the development of calculus and made contributions in geometry, optics, and mechanics.
- Fr. Marin Mersenne (1588-1648), Priest who made contributions to number theory, the mathematics of music, afocal forms of the two-mirror telescope, and other areas of physics and astronomy.
- Fr. Christoph Scheiner, SJ (1573-1650), Priest who discovered sunspots and the rotation of the sun.
- Fr. Francesco Grimaldi, SJ (1630-1653), Priest who made fundamental contributions to lunar cartography as well as optics (refraction, diffraction, destructive interference of radiation).
- Fr. Giovanni Riccioli, SJ (1598-1671), Priest who discovered the first binary star.
- Fr. Francesco Lana de Terzi, SJ (1631-1687), Priest who was a pioneer in the field of aeronautics.
- Fr. Girolamo Saccheri, SJ (1677-1733), Priest who developed the theorems of hyperbolic (non-Euclidian) geometry.[6]
- Fr. Lazzaro Spallanzani (1729-1799), Priest who conducted research in biology, vulcanology, and meteorology. He explained the process of human digestion through gastric acids, as well as fertilization, respiration, and regeneration in animals. He also empirically disproved the widely held hypothesis of spontaneous generation.
- Fr. Giuseppe Piazzi, CR (1746-1826), Priest who first discovered an asteroid, Ceres.
- Fr. Bernhard Bolzano (1781-1848), Priest who contributed to the theory of functions of one real variable, the theory of differentiation, the concept of infinity, and the binomial theorem.[7]
- Fr. Pietro Secchi, SJ (1818-1878), Priest who developed a spectral classification of stars, invented the meteorograph, and correctly understood nebulae to be gaseous.
- Fr. Gregor Mendel, OSA (1822-1884), Priest who described the laws of heredity and recognized as the "father of genetics." – page 17
- Fr. Julius Nieuwland, CSC (1878-1936), Priest that co-developed the first synthetic rubber, neoprene.
- Fr. Henri Breuil (1877-1961), Priest whose work as a paleontologist and geologist has earned him the title of "father of pre-history."
- Msgr. Georges Lemaître (1894-1966), Priest who formulated the Big Bang hypothesis of the universe as well as made significant contributions to celestial mechanics and our understanding of galactic structure.

The last figure mentioned here, Monsignor Georges Lemaître, is one of the most important astrophysicists of the twentieth century. His accomplishments merit further elaboration as the dissemination of his life[8] and Christian witness can perhaps make him the "apostle to the scientists" of the 21st century.

Modern Cosmology

According to Godart and Heller, cosmology is one of the youngest sciences yet has the longest history[9] for probably since the beginning, man has contemplated the Heavens. In Monsignor Lemaître's time, both philosophy and science were being very affected by the concept of relativity. Einstein's theories were challenging strongly held scientific positions and were also being misapplied in the humanities and social sciences. According to Paul Dirac, Pontifical Academician, relativity "provided an entirely new outlook to dominate man's view of nature."[10]

Lemaître's principal area of study was relativistic cosmology. After completing his first doctorate in mathematics and studying relativity on his own as a seminarian, he had the tools to join Sir Arthur Eddington and Harlow Shapley in their investigation of the astronomical implications of relativity and earned a second doctorate in Physics at the Massachusetts Institute of Technology. As a result of this investigation, Monsignor Lemaître developed an understanding of the relationship between galaxy red shift and the expansion of the universe. This led him to reject Einstein's model of a static universe. Einstein's solution of the general relativity equation for a homogeneous universe was intrinsically unstable. Lemaître proposed a dynamical model which was not only mathematically pleasing, but consistent with astronomical observation and physics.[11] This approach took cosmology from the hands of mathematicians and put it in the hands of physicists.[12]

According to Rev. Hubert Vecchierello, O.F.M., Ph.D, "The theory [Lemaître's model] is a daring one, sweeping aside old astronomical ideas and presenting a picture which is not only one of great splendor but also has the added beauty of seeking to reconcile several conflicting notions held by preeminent scientists." In Lemaître's own words, "Most of the work I have done with the theory of the expanding universe…is to reconcile it with the evidence of astronomers." See the next two pages for an overview of Lemaître's ingenious insights.

Monsignor Lemaître's interest in cosmology also led him to investigate the study of the structure of the universe. The formation of galaxies and clusters of galaxies fascinated him. On June 9, 1958, Lemaître presented his theory on the structure of the universe in Brussels to about forty physicists and astronomers. The attendees included such men as Robert Oppenheimer and Wolfgang Pauli.[13]

Lemaître's Witness

When not exercising his God given scientific intellect, Lemaître lived like any other Christian man. He enjoyed walking either alone so he could ponder new ideas or with friends to enjoy conversation. Many walks ended at a pastry shop on the first floor of his apartment building. Georges Lemaître loved to play the piano although his neighbors at the College du Saint-Esprit didn't share his appreciation and even encouraged him to move! Lemaître's friends and colleagues unanimously agreed that Lemaître was very sociable, cheerful, and optimistic. "He liked the good things God had put at our disposal. He did not scorn a good cake, a good bottle, a tasty dinner; everything within the limits of reason."[14]

At the end of his life, in 1965, Professor Godart and his research assistants would function as Lemaître's interface to the university computer. During these visits, they would enjoy a whisky on the rocks and good conversation. In this context, Lemaître encouraged Godart to create the Institute of Astronomy and Geophysics. He also predicted that the space era would speed up the information revolution and the interest of engineers in computers.[15]

In conclusion, Godart and Heller described Lemaître in this way:

> The great involvement in science and scientific work did not temper Lemaître's religious impulse that had led him to the Priesthood… He was a very good Priest, very

comprehensive, considering Christianity on a much deeper level than its exterior formalisms. He practiced the Christian essence. This means, first of all, the effective love of neighbor.[16]

Monsignor Lemaître would no doubt share the view of Saint Athanasius who said:

> For if the movement of the universe was irrational, and the world rolled on in random (i.e. indeterminate) fashion, one would be justified in disbelieving what we say. But if the world is founded on reason, wisdom and science, and is filled with orderly beauty, then it must owe its origin and order to none other than the Word of God.[17]

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An Overview of Lemaître's Significant Theoretical Advances – page 18

Lemaître describes the basis for his theory in this way:

> We must have a fireworks theory of evolution. The fireworks are over and just the smoke is left. Cosmology must try to picture the splendor of the fireworks. If the Earth were a hundred billion years old, or if the universe were that old, all the nebulae would be out of range of our telescopes and all the radium would be exhausted…The universe is a great number of energy packets that continuously divided themselves. Go back to it all and energy must have existed in one packet…We know that the volume of space is increasing. We know a type of evolution that gives a zero radius…But we must go even beyond that. That takes us to inter-nebular space, where we should expect to find the story of the primeval fireworks that preceded the formation of the expanding universe. In that library of inter-nebular space, we find the story, the characters of which are the writings of cosmic rays…Cosmic rays are the birth cries of the universe still lingering with us.[18]

Lemaître's original model included an initial singularity followed by an expansion damped using Einstein's constant followed by another expansion. As a result of new problems emerging from this research, he was probably one of the first scientists to realize that a synthesis of quantum mechanics and general relativity is necessary to adequately explain the origin of the universe. Despite the fact that the mathematical tools at his disposal were significantly less advanced than are available today, many of his comments on the origin of space-time could easily be found in a contemporary physics paper.[19]

According to Turek, "The significance of Lemaître's work for cosmology lies not in his particular solutions to Einstein's field equations, but rather in the new approach he provided to fundamental questions in cosmology."[20] For this approach, Lemaître is widely regarded as the founder of physical cosmology and the "Father of the Big Bang Theory." However, the singularity itself had many infinite quantities such as curvature and density, which made it difficult for many scientists to accept.[21]Today, through the use of modern mathematical methodologies, most astrophysicists believe that the singularity can be eliminated by a robust theory of quantum gravity. Lemaître's application of quantum effects did not remove a singularity from his model but did provide "geometric support" for a primordial quantum of energy.[22] Utilizing his own theory of expansion and fundamental thermodynamics, Lemaître did in fact conclude that in the initial stages, quantum laws were the dominant player.[23]

A Significant Step Forward

It is helpful to see the diversity of scientific thought in the 1920's and 30's. Albert Einstein's model of the universe included a cosmological constant which permitted a static, finite universe, closed, but not bounded. However, the astronomer Edwin Hubble observed spiral nebulae were retreating from the Earth at velocities proportional to their distance, thereby suggesting an expanding universe. The mathematician Willem de Sitter developed a mathematically interesting model that includes expansion but did not match Hubble's observations. It was also physically impossible because it implied that the universe has zero density for matter everywhere! Independently of Georges Lemaître, the Soviet mathematician and meteorologist, Alexander Friedman, developed a model by taking particular solutions to Einstein's equations which defined a spatially homogeneous, isotropic universe with a finite radius varying with time.[24]

Monsignor Lemaître investigated models with a positive cosmological constant, $\Lambda > 0$,[25] so that initial conditions permit a universe expanding from a large density followed by a quasi-static stage when gravity nearly cancels Λ followed by growth similar to de Sitter's limiting case. Lemaître was one of the first to identify Olbers' paradox, the fact that in Einstein's static universe, stars would have shone forever and the starlight would aggregate toward infinity. According to Jim Peebles of Princeton University, Lemaître's framework for cosmology is still relevant today because it "consider[s] scenarios for the evolution of structure that start at high redshift with initial conditions that do not seem unduly conjured, evolve according to accepted laws of physics, and end up looking more or less like the universe we observe."[26]

In a letter to Sir Arthur Eddington, Lemaître wrote:

> Now, in atomic processes, the notion of space and time are no more than statistical notions: they fade out when applied to individual phenomena involving but a small number of quanta. If the world has begun with a single quantum, the notions of space and time would altogether fail to have any meaning at the beginning…[27]

Given this and the lack of contemporary mathematics, cosmology was an area of investigation that required great imagination. However, Lemaître's ideas have an even more challenging implication: an evolutionary universe may permit laws of nature that also evolve. Scientific models which assume certain parameters to be constants may actually be variable with their time derivatives too small to observe. If the constant of gravitation is not a constant, but has a time derivative, then models which assume no change must be modified or perhaps discarded.[28]

Celestial Mechanics and Galactic Structure – page 19

By 1950, Monsignor Lemaître's research had primarily shifted out of cosmology. He then pursued celestial mechanics, numerical analysis, and the history of science. The latter interest originally developed during his younger years, studying under the direction of a famous historian of science, Father Henri Bosman, S.J.[29]

Lemaître's work in computational science was motivated not only by a search for mathematical tools to support his other research, but also to further develop the discipline itself. In 1955 he published a series of papers on topics such as the integration of systems of differential equations, harmonic analysis, and rational iteration.[30]

In his pursuit of the elusive cosmic radiation which would support the Big Bang, Lemaître made contributions to the fields of numeral analysis and analytical mechanics. His theoretical framework involved characterizing the structure of dynamical systems, computing singular periodic orbits, and their asymptotic behavior under constraints.[31] Also, Lemaître's prediction that cosmic rays would include α and β particles in addition to photons is now confirmed by observation.

Despite Lemaître choosing not to pursue the career in mechanical engineering for which he had originally studied, his interest in mechanics lasted his entire career as a physicist. Lemaître's contributions to the classical three body problem greatly advanced our knowledge of the motion of bodies in the universe.[32] Lemaître showed that by taking the masses of the bodies to be small and their radial distance to be large, one could develop a solution for relativistic celestial mechanics.

As early as 1920, after hearing Elie Cartan's lectures on integral invariants, Lemaître began to apply Cartan's geometric approach in an ingenious manner to develop systems of equations for some previously intractable problems. This type of work enabled the "big bang" of scientific computing.[33]
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Notes

[1] By fundamentalism, I refer to a rigid literalism that wrenches a text from the context of a passage in Sacred Scripture and the living Tradition of the Church. As a type of ideology, it is a comprehensive world-view that is resistant to evidence and inquiry. Ideology always implies an unreasoned, blind assent to a set of ideas that bears not the mark of faith, which is *light*. This view is inimical to the approach of *Fides et Ratio*.

[2] Saint Augustine, *The Literal Meaning of Genesis*, trans. John Hammond Taylor, SJ (New York: Paulist Press, 1982), 42-43.

[3] Stephen M. Barr, *Modern Physics and Ancient Faith* (Notre Dame: University of Notre Dame Press, 2003), 9-10.

[4] J.P Kirsch, "Sylvester II," *The Catholic Encyclopedia*, ed. Kevin Knight, (New York: Robert Appleton Company, 1912).

[5] J. Hagen, "Nicolaus Copernicus," *The Catholic Encyclopedia*, ed. Kevin Knight, (New York: Robert Appleton Company, 1908).

[6] B. Wilhelm, "Francesco Lana," *The Catholic Encyclopedia*, ed. Kevin Knight, (New York: Robert Appleton Company, 1910).

[7] Matthias Leimkuhler, "Bernhard Bolzano," *The Catholic Encyclopedia*, ed. Kevin Knight, (New York: Robert Appleton Company, 1907).

[8] For further reading on the life of Lemaître, see Joseph R. Laracy, "The Faith and Reason of Father George Lemaître," *Homiletic and Pastoral Review*, February 2009.

[9] Godart and Heller, *Cosmology of Lemaitre*, (Tuscon: Pachart, 1985), 13.

[10] Paul A.M. Dirac, *The Scientific Work of Georges Lemaitre*, Vol. 36, (Vatican: Pontifical Academy of Science), 67.

[11] A.L. Berger ed., *The Big Bang and Georges Lemaitre,* (Boston: D. Reidel Publishing, 1984), 394.

[12] Frederick Lamb, Personal Interview, February 28, 2005
[13] Berger, *The Big Bang and Georges Lemaitre*, 299.
[14] Godart and Heller, *Cosmology of Lemaitre*, 186.
[15] Ibid.
[16] Ibid.
[17] St. Athanasius, *Discourse Against the Pagans*, in *The Liturgy of the Hours,* vol. 3 (New York, Catholic Book Publishing Co., 1974), 67.
[18] Hubert Vecchierello, *Einstein and Relativity; Lemaitre and the Expanding Universe* (Paterson: St. Anthony Guild Press, 1934), 19-22.
[19] A.G. Pacholczyk, *Lemaitre, Big Bang, and the Quantum Universe* (Tuscon: Paschart Publishing, 1996), 14.
[20] Jósef Turek, *Georges Lemaitre and the Pontifical Academy of Sciences*, (Vatican City: Vatican Observatory Publications, 1989), 2.
[21] Pacholczyk, *Lemaitre, Big Bang, and the Quantum Universe*, 15.
22 It is now known that strong curvature singularities lead to catastrophic effects which Lemaître could not have foreseen. At that time, scientists did not have modern field theories, gauge methods, unifying schemes, and canonical quantization of space-time.
[23] Quantum mechanics dictated that the universe be described as a collection of potentials states. Equal occupation of all possible states is probabilistically most likely and therefore would represent the *final* distribution. This distribution maximizes entropy so minimum entropy would be found in a system with all energy contained in a few quanta; hence, the Primeval Atom hypothesis. See Pacholczyk, *Lemaitre, Big Bang, and the Quantum Universe*, 31.
[24] Dirac, *The Scientific Work of Georges Lemaitre*, 6.
[25] Lemaître's famous differential equation for cosmic expansion is: $\dot{R}^2 = \frac{C}{R} + \frac{1}{3}\Lambda R^2 - k$
where R is the scale factor for cosmic expansion which is proportional to the radius of the universe when that radius has meaning; C>0 and proportional to the average present-day density of non-relativistic matter in the universe; cosmological constant, $-\infty<\Lambda<\infty$, which serves to create a cosmic repulsion that keeps galaxies from being drawn together by gravity when it is positive and adds to the attractive force of gravity when it is negative; and spatial curvature, k = -1, 0, +1. Lemaître solved the equation for k = +1 and $\Lambda > \Lambda_C$ for a big bang model. The significance of these assumptions is that Λ is greater than the critical value of the cosmological constant, Λ_C, so the universe expands forever. Also, k = + 1 implies a spherical geometry and a closed, finite universe (k = 0 is a flat, unbounded, and infinite universe while k = -1 is a saddle shaped, open, unbounded, and infinite universe). Modern observation indicates that the curvature is very near zero. However, the intrinsically inaccurate nature of measurement means that we may never know if the universe is actually flat, spherical, or saddle shaped. For more information see: Ray D'Inverno, *Introducing Einstein's Relativity* (Oxford: Clarendon Press, 1992), 331-341.
[26] Berger, *The Big Bang and Georges Lemaitre*, 24.
[27] Pacholczyk, *Lemaitre, Big Bang, and the Quantum Universe*, 33.
[28] Dirac, *The Scientific Work of Georges Lemaitre*, 16.
[29] Godart and Heller, *Cosmology of Lemaitre*, 181.
[30] Berger, *The Big Bang and Georges Lemaitre,* 394.
[31] Berger, *The Big Bang and Georges Lemaitre*, 396.
[32] Berger, *The Big Bang and Georges Lemaitre*, 182.
[33] Berger, *The Big Bang and Georges Lemaitre*, 152.