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Georges Lemaître:

Visionary architect of modern physical cosmology

FEATURED ARTICLE

Monsignor Georges Lemaître: Life and Work of a Visionary Belgian Physicist

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Georges Henri Joseph Edouard Lemaître was born in Charleroi (Belgium) on 17 July 1894 into a devout Catholic family. He and his brother, Jacques, served during World War I in the volunteer corps. In the trenches, between battles, Georges kept fellow soldiers' spirits up by telling them about science, while furthering on his own his study of physics and philosophy. After the war he was distinguished with a rare medal, the Croix de Guerre, for conspicuous bravery in the face of the enemy (Fig. 1). He then also resumed for a year his studies at the University of Louvain, but changed fields from engineering, which he had begun before the war on the advice of his father, to mathematics and physics. He obtained a doctorate in mathematics under the famous mathematician Charles-Jean de la Vallée Poussin, jointly with a degree in Thomist philosophy. With special permission from the Archbishop, he combined his further formation in philosophy and theology at the Saint Rombaut House in Malines, with studies in exact sciences. His scientific interests focused in particular on special and general relativity theory, which he mastered mostly on his own. For Lemaître science and religion were two complementary representations and approaches aiming towards an understanding of the Universe and our existence within it [1]. He never saw them as contradictions, nor in competition with each other, but rather as "Two Paths to Truth". In 1923 he was ordained to the priesthood. For his attitude towards science and religion, he received in 1934 the Mendel Medal of the Villanova University (Pennsylvania, USA), established and awarded to outstanding scientists who, by their painstaking work to advance the cause of science, and by their lives and their standing before the world as scientists, have demonstrated that between true science and true religion there is no intrinsic conflict.

In 1922, encouraged among others by his professor in Louvain, Maurice Alliaume, Lemaître wrote an extended summary on relativity theory, entitled "La Physique d'Einstein" [2], as part of an application for a travel grant from the Belgian government. The historically edited original text in French (Fig. 2) and an English translation have recently been published together as a Springer book [3], "Learning the Physics of Einstein with Georges Lemaître" (Fig. 3). Lemaître's essay is an excellent introduction to special and general relativity, highly recommended to gain insight into Lemaître's own views and conceptions of the methods and rigour of fundamental physics. Lemaître won the competition. The prize money allowed him to study for a year with Arthur Eddington at St Edmund's College in Cambridge (UK). From there he travelled for another year to the US, where Edwin Hubble and Vesto Slipher

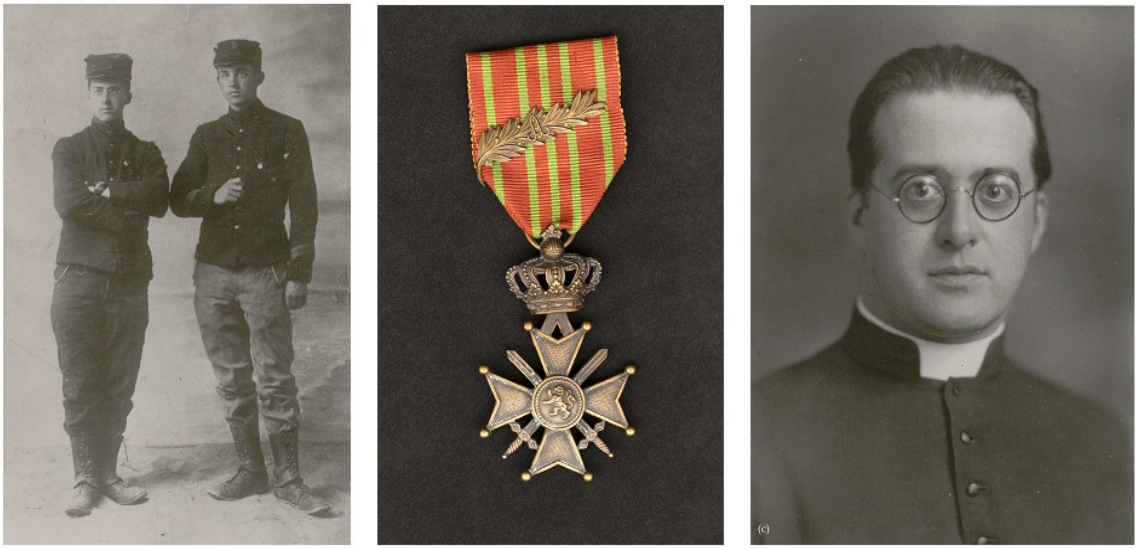


Figure 1: *Georges and Jacques Lemaître in military outfit during World War I (a). The Croix de Guerre (b). Georges (aka Abbé) Lemaître in April 1936 (c).*

Figure 2: *Introduction of the original article entitled "La Physique d'Einstein" (left). Georges Lemaître in October 1920 (right).*

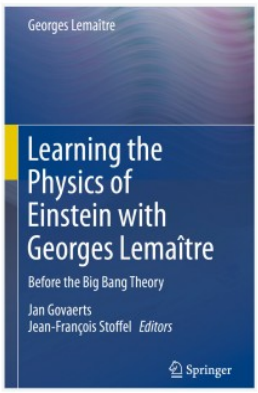


Figure 3: *Cover of the Springer book with Lemaître's summary on the relativity theory.*

were working on measuring distances of nebulae and their velocities.

Lemaître was appointed as Lecturer at the University of Louvain in 1925 and was awarded a PhD by MIT in 1927. In the same year he presented and published his first famous paper on the theory of an expanding Universe, which includes the prediction of a law for the recession velocity of galaxies [4]. The theory was first published in the Belgian Journal, Les Annales de la Société Scientifique de Bruxelles, but did only get modest attention. In 1931 it received more international recognition thanks to a republication and translation, stimulated by Eddington, in the Monthly Notices of the Royal Astronomical Society in Britain [5]. The paper was followed in 1931 by a brief, but dense and visionary, note in Nature, entitled "The Beginning of the World from the Point of View of Quantum Theory" [6]. In this short article he rebutted a statement by Eddington, published in that same journal, by proposing the idea that time and thereby space could have emerged from a single quantum, which would as well have been at the origin of all matter in the Universe. In this most remarkable article of a mere 460 words, Lemaître's genius defined the beginning of the Universe and brought together, for the first time, insights from thermodynamics and

quantum mechanics in a cosmological context ...! The initial singularity was termed as the "Primeval Atom" by Lemaître, now commonly known as "Big Bang".

Lemaître, Einstein and the cosmological constant

The historical scientific context for the 1927 article is interesting (see further Jean-Marc Gérard's contribution to [2]). Not long after having introduced the physics community to his theory of general relativity, Albert Einstein set out to apply it to a model Universe with a homogeneous and isotropic matter distribution ('the cosmological principle'). He thereby discovered that his equations imply a non-static Universe, a possibility running counter to his philosophical convictions. To counteract the effects of attractive gravity, Einstein then introduced the so-called cosmological constant term, a form of energy density that does not scale with the space-time geometrical scale factor. The positive value of the term is akin to an outward pressure contribution that counterbalances the action of gravity, thereby allowing the existence of a static Universe. Soon thereafter Willem de Sitter considered another model for the Universe, this time empty of any matter, but with a cosmological constant, leading to an apparently expanding space-time (given a choice of coordinate system). In his 1927 article Lemaître wanted to combine the virtues of both models: a matter filled Universe in expansion. By pointing out with de Sitter that in fact Einstein's static model is unstable against fluctuations, and by choosing a value for the cosmological constant slightly larger than that required by Einstein's static model, Lemaître proposes his first model for a matter filled expanding Universe. In the coming years Lemaître calculated different solutions for the evolution of the Universe depending on the value of the cosmological constant (Fig. 4). He became convinced that there must have been a beginning to space and time.

It is interesting to note that after having received a letter from Lemaître, in which he reported his paper of 1927 (Fig. 5), the famous British astronomer Arthur Eddington, gave full credit to Lemaître for the development of a realistic model of the evolution of the universe in his letter, dated 19 March 1930, to the Dutch scientist Willem de Sitter (Fig. 6). Eddington showed also his human side in the letter by stating that "it was a blow to us to find it [the problem of the evolution of the universe] done much more completely by Lemaître", but adds "a blow softened, as far as I am concerned, by the fact that Lemaître was a student of mine". In his obituary on Lemaître [7], George C.McVitie (the 'student' mentioned in the letter of Eddington to de Sitter, see Fig. 6), recalls "I well remember the day when Eddington, rather shamefacedly, showed me a letter from Lemaître which reminded Eddington of the solution to the problem which Lemaître had already given. Eddington confessed that, though he had seen Lemaître's paper in 1927, he had completely forgotten about it until that moment". Eddington was quick to remedy the oversight in his letter to Nature of 7 June 1930, in which he underlined the importance of the brilliant work of Lemaître of three years earlier [8], and again in his published version of his presidential address to the Mathematical Association of 5 January 1931 in the Nature issue of 21 March 1931 [9] entitled "The end of the world from the standpoint of Mathematical Physics".

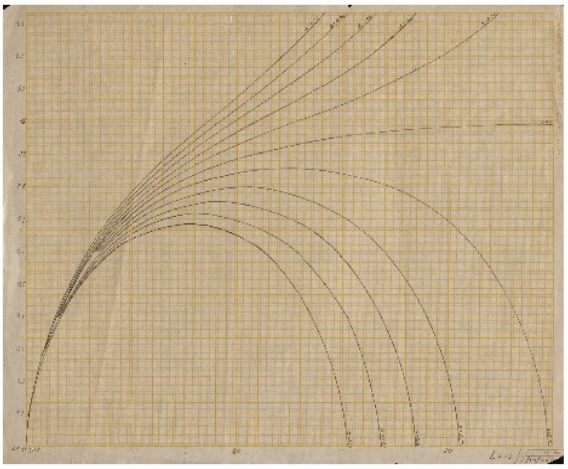


Figure 4: *Time dependencies of the scale factor of the Universe as function of the cosmological constant for a space of positive curvature, by Georges Lemaître, circa 1927-1930.*

From a Newtonian perspective, the situation is best understood in terms of the effective total gravitational potential for radial motion, which is comprised of two additive contributions, namely the usual attractive Newton potential in $(-1/r)$, and the inverted harmonic potential in $(-r^2)$ proportional

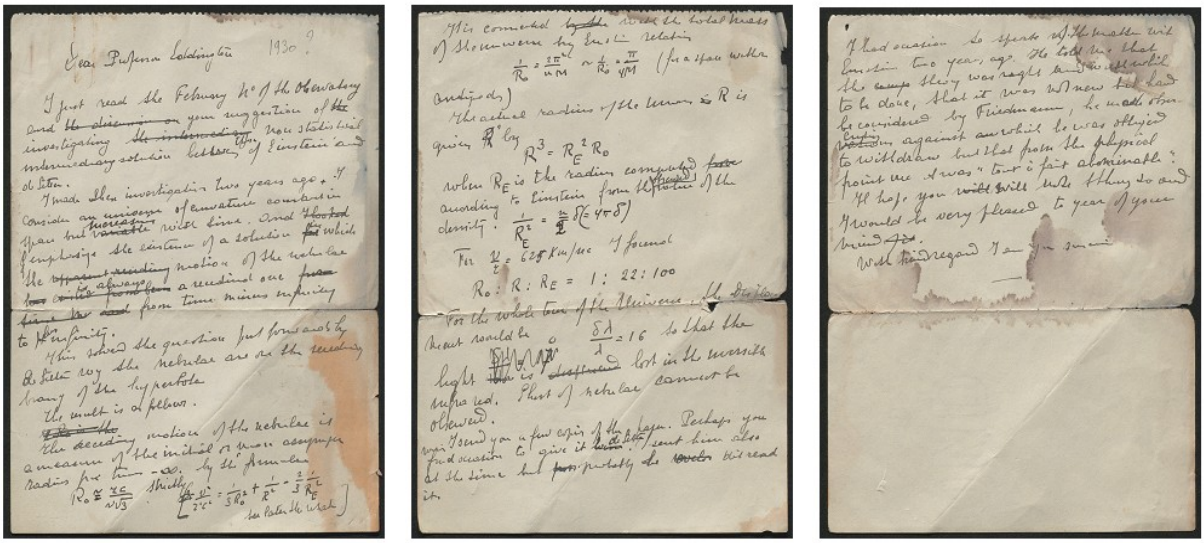
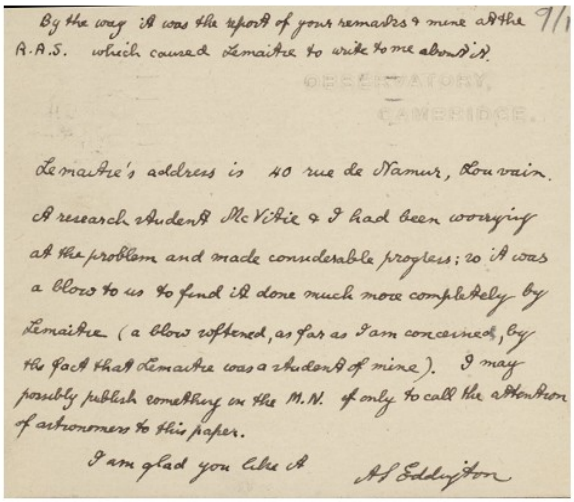


Figure 5: *Letter from Lemaître (beginning of 1930) to Eddington announcing his paper of 1927.*



By the way it was the report of your remarks + mine at the A.A.S. which caused Lemaître to write to me about it.

Lemaître's address is 40 rue de Namur, Louvain.

A research student McVittie + I had been worrying at the problem and made considerable progress; so it was a blow to us to find it done much more completely by Lemaître (a blow softened, as far as I am concerned, by the fact that Lemaître was a student of mine). I may possibly publish something in the M.N. if only to call the attention of astronomers to this paper.

I am glad you like it A.S. Eddington

Figure 6: *Letter from Eddington to the Sitter about Lemaître's discovery, dated 19 March 1930.*

to the (positive) cosmological constant. The total potential thus presents a unique local maximum corresponding to Einstein's unstable static Universe. Away from the maximum the scale factor of the non-static solution is time dependent. At large values the scale factor increases, with matter thus becoming more and more diluted, thereby approaching a behaviour predicted by de Sitter for a Universe empty of any matter.

On their first personal encounter in 1927 at the occasion of the fifth Solvay Conference in Brussels, Lemaître learns from Einstein, who had read the 1927 paper, that Friedmann had published a similar solution for an expanding Universe. The story is mentioned by Lemaître in his 1930 letter to Eddington, where he mentions in the draft version (sic): "I had occasion to speak in the matter with Einstein two years ago. He told me that the theory was right and ... which to be done, that it was not new but had been considered by Friedmann, he made critic against which he was obliged to withdraw but that from the physical point of vue it was "tout à fait abominable". Lemaître however, as a genuine physicist and astronomer, goes much beyond the mere mathematical analysis. From his model he establishes as a prediction the law now known as the Hubble-Lemaître Law for the expansion of the Universe [10]. While using data on galaxy velocities known at the time, he also provides a first estimate of the Hubble-Lemaître constant, which measures the expansion rate of the Universe.

After Hubble had published his famous compilation of the recession velocity of galaxies in 1929, which established the Hubble-Lemaître Law, Einstein no longer saw any reason to retain a cosmological constant in the general relativity equations for cosmology [11]. In 1932 he and de Sitter designed a space-time expanding cosmology based on a vanishing cosmological constant, which became the standard paradigmatic theoretical cosmological model well into the 1990s,

with the prediction of a decelerating expansion rate.

Yet all his life Lemaître remained convinced that a non vanishing cosmological constant is a necessity, to provide for what he called a 'waiting period' in the Universe's expansion to allow time for sufficient structure formation. This is clearly borne out by the diagrams he himself drew to that effect. Lemaître and Einstein had several exchanges on this complex matter. Lemaître praises Einstein for the introduction of the cosmological constant. He also contributes (in the company of the most famous physicists of that time) to the volume of the Library of living Philosophers compiled to honour Einstein, with a dedicated paper entitled "The Cosmological Constant". Einstein however, remained averse to the addition of the cosmological constant. He still called it an 'ugly thing' in a personal letter to Lemaître in September 1947 (Fig. 7). The letters exchanged between Lemaître and Einstein on the subject are part of the Georges Lemaître Archives at UCLouvain. However, against all expectations, an accelerating expansion of the Universe was discovered observationally in 1998.

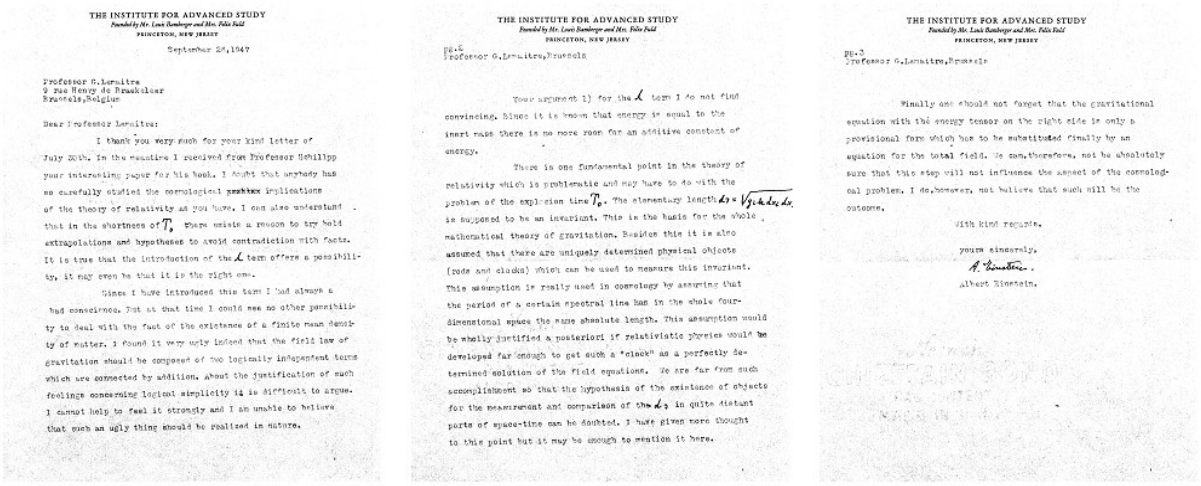
With the discovery of the accelerated expansion of the Universe Lemaître was vindicated in that conviction, based both on scientific fact and observation (to the extent that it remains to be established that the cause for this acceleration is indeed a cosmological constant, rather than some other dynamical mechanism to account for that 'dark energy'). Lemaître's vision in 1927 for a relativistic cosmology thus extends well into the XXIst century, with the necessity remaining still today to develop a complete quantum theory for gravity, which he also foresaw.

Praise, scepticism and experimental evidence

With his famous concept of the 'primeval atom', Lemaître gives for the first time a description of how the initial state of the universe may be conceived purely in terms of the laws of physics, using a thermodynamic argument based on entropy as well as notions of quantum mechanics. Lemaitre was also the first physicist to call for a genuine quantum theory of gravity and cosmology. Later he referred to the beginning of space and time as "Cet instant unique, qui n'avait pas d'hier" ("That unique moment, that had no yesterday"), see also Fig. 17(a).

This founding and major contribution to modern physical cosmology was recognised already in 1934 by the Francqui Prize (see Fig. 8), the most prestigious Belgian scientific distinction. One of the nominators for the prize was Einstein himself. While at that time Einstein was not convinced by the idea of a non-static Universe, the two men would remain friends and interact with each other over the years on any possible occasion. At the end of 1932 Lemaître was invited by Nobel Laureate Robert Millikan to Caltech in Pasadena, California (Fig. 9). The seminar on the primeval atom cosmology attracted great public attention, including Einstein's, who in the meantime had accepted the idea of an expanding Universe. In 1933, the year when he resumed and further developed the theory of the expansion of the Universe, Lemaître would experience his greatest fame. American newspapers called him the 'famous Belgian scientist' and he would be described as the leader of new cosmological physics. Newspapers block lettered with titles as "Lemaître follows two paths to truth", and even "Einstein 'Goes to School' To Study Le Maitre Theory"... (The New York Times 19 Feb 1933 and the Christian Science Monitor of 11 Jan 1933). He spent part of 1935 as visiting professor to the famous Institute for Advanced Study in Princeton, New Jersey, where Einstein then lived and worked and he received during his stay at this institute a letter from President Roosevelt (dated 24 September 1935).

However, praise and criticism go hand in hand. Fred Hoyle, an English astrophysicist, always promoted the idea that the Universe did not result from a hypothetical explosion. In 1949, during a radio broadcast on the BBC, he mockingly called Lemaître's theory the 'Big Bang' theory, and thereby coined the metaphoric expression that now refers to the beginning of time and space. Nonetheless Georges Lemaître, Fred Hoyle and his wife have always kept a cordial and amicable relationship (Fig. 10). They even travelled together to Italy, as witnessed by pictures taken by Lemaître himself, as he was indeed a keen amateur photographer. This joint excursion has



THE INSTITUTE FOR ADVANCED STUDY
Founded by Mr. Louis Bamberger and Mrs. Félix Fuld
PRINCETON, NEW JERSEY

September 26,1947

Professor G.Lemaitre
9 rue Henry de Braekeleer
Brussels,Belgium

Dear Professor Lemaitre:

I thank you very much for your kind letter of July 30th. In the meantime I received from Professor Uehilpp your interesting paper for his book. I doubt that anybody has so carefully studied the cosmological xxxxxx implications of the theory of relativity as you have. I can also understand that in the shortness of T_0 there exists a reason to try bold extrapolations and hypotheses to avoid contradiction with facts. It is true that the introduction of the λ term offers a possibility, it may even be that it is the right one.

Since I have introduced this term I had always a bad conscience. Just at that time I could see no other possibility to deal with the fact of the existence of a finite mean density of matter. I found it very ugly indeed that the field law of gravitation should be composed of two logically independent terms which are connected by addition. About the justification of such feelings concerning logical simplicity it is difficult to argue. I cannot help to feel it strongly and I am unable to believe that such an ugly thing should be realized in nature.

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Pd:c
Professor G.Lemaitre,Brussels

Your argument 1) for the λ term I do not find convincing. Since it is known that energy is equal to the inert mass there is no more room for an additive constant of energy.

There is one fundamental point in the theory of relativity which is problematic and may have to do with the problem of the explosion time T_0. The elementary length $ds = \sqrt{g_{ik}\,dx_i\,dx_k}$ is supposed to be an invariant. This is the basis for the whole mathematical theory of gravitation. Besides this it is also assumed that there are uniquely determined physical objects (rods and clocks) which can be used to measure this invariant. This assumption is really used in cosmology by assuming that the period of a certain spectral line has in the whole four-dimensional space the same absolute length. This assumption would be wholly justified a posteriori if relativistic physics would be developed far enough to get such a "clock" as a perfectly determined solution of the field equations. We are far from such accomplishment so that the hypothesis of the existence of objects for the measurement and comparison of the ds in quite distant parts of space-time can be doubted. I have given more thought to this point but it may be enough to mention it here.

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Pd:3
Professor G.Lemaitre,Brussels

Finally one should not forget that the gravitational equation with the energy tensor on the right side is only a provisional form which has to be substituted finally by an equation for the total field. We can,therefore, not be absolutely sure that this step will not influence the aspect of the cosmological problem. I do,however, not believe that such will be the outcome.

With kind regards.

yours sincerely,

A. Einstein.

Albert Einstein.

Figure 7: *Letter from Einstein to Lemaître, dated 26 september 1947, in which he refers to the cosmological constant as 'an ugly thing'. The German version handwritten by Albert Einstein is available at the Albert Einstein Archives in Jerusalem.*

also been the inspiration for a theatre play by Jean-François Viot, entitled, "Sur la route de Montalcino".

Lemaître always suspected that cosmic radiation must bear traces of the initial events. After the detection of fossil radiation from the Big Bang in 1965, Lemaître's reputation as a great scientist was indeed established. The story of the experimental discovery of this cosmic background radiation is remarkable in itself. In the 1960s at Princeton University three astrophysicists, Robert Dicke, James (Jim) Peebles and David Wilkinson, were advancing the theory of the early Universe. They reasoned that the Big Bang must have released a tremendous blast of radiation. This radiation should be detectable as microwaves, because of a large cosmological redshift factor, and they were designing a radiometer for an experimental confirmation. Unbeknown to them however, at the same time Arno Penzias and Robert Wilson were calibrating a supersensitive horn antenna at Bell Labs in New Jersey, with which they wanted to detect faint radio waves bounced off echo balloon satellites[1]. To obtain the required extremely high sensitivity, it was essential to eliminate all recognisable interference from the receiver. Whatever they tried, a low, steady, mysterious noise persisted. It was 100 times more intense than they had expected. It was evenly spread over the sky and was present day and night. They were certain that the radiation was coming from outside our own galaxy, although they were not aware of any radio source that would account for it. A friend, Bernard Burke, a professor of physics at MIT, told Penzias about a preprint paper he had seen by Jim Peebles on the possibility of finding radiation left over from an explosion that filled the Universe at the beginning of its existence. That knowledge made Penzias and Wilson realise the significance of what they had discovered. To avoid potential conflict, the teams of Princeton University and Bell Labs decided to publish their results jointly as two Notes in Astrophysical Journal [12, 13]. The Notes reached Louvain in 1966 and attracted Odon Godart's attention, the assistant to Lemaître. On learning of the news Lemaître was very pleased and must have said: "Je suis content, maintenant, au moins, on en a la preuve" ("I am happy, now, at least, the proof is there"). He was already very ill at that time and passed away a few days later, on 20 June 1966.

During his life his fantastic work was recognised by several international prizes. In 1935, he received the Jules-Janssen Prize for astronomy from the Astronomical Society of France (SAF). In 1953 he was awarded the Eddington Medal by the Royal Astronomical Society for investigations of outstanding merit in theoretical astrophysics. He received various distinctions from the Belgian

[1] https://www.nasa.gov/centers/langley/about/project-echo.html

Le Conseil d'Administration de la
Fondation Francqui
siégeant à Bruxelles le 14 mars 1934,

ENTENDU LE JURY CHARGÉ DE LUI FAIRE RAPPORT;
CONSIDÉRANT QUE,

par l'originalité de son esprit créateur,

par la valeur propre de ses recherches sur les systèmes des galaxies dans l'univers et des théories cosmogoniques,

ainsi que par l'influence profonde que ses découvertes ont exercée sur les recherches d'astrophysique et de physique poursuivies dans divers pays au cours de ces dernières années,

Monsieur le Professeur GEORGES LEMAITRE a apporté récemment à la science une contribution importante dont la valeur a augmenté le prestige international de la Belgique,

décide de conférer le
PRIX FRANCQUI
à Monsieur le Professeur Georges Lemaître

Figure 8: *Prix Francqui awarded to Lemaître in 1934.*

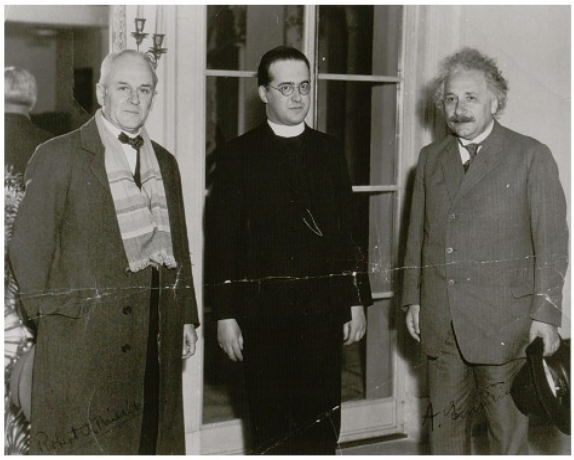

Figure 9: *Millikan, Lemaître, and Einstein in Pasadena.*

Figure 10: *Georges Lemaître in discussion with Fred Hoyle.*

government, among them the prestigious Grand Officer of the Order of the Crown in 1956 and Grand Officer of the Order Leopold II in 1962 [14].

Abbé Lemaître was elected member of the Pontifical Academy of Sciences in 1936 and was the second president of this Academy from March 1960 until his death. In his honour Paul Dirac pronounced Lemaître's obituary and presented a summary of his scientific work during a plenary session of the Pontifical Academy in the Vatican in 1968 (Fig. 11).

Legacy and worldwide recognition

Following his passing, Lemaître was buried in the family vault in Marcinelle, close to Charleroi in Belgium. The family specifically bequeathed all of his archives (many scientific and personal paper documents, correspondence with great scientists of the day, as well as material items) to the Université catholique de Louvain (UCLouvain) in Louvain-la-Neuve. In 2018 these Georges Lemaître Archives were granted the status of "a treasure and intangible heritage of the Wallonia-Brussels Federation" and are placed under the care of UCLouvain for their preservation. The document collections of the Lemaître Archives are now being made accessible world-wide via the internet[2].

Ever since the late 1970s, through the 1980s, further on and still to this day, Lemaître's legacy has been celebrated through publications, exhibitions, workshops and conferences dedicated to his science, his life and his many interests, some of which taking place abroad, but mostly organised in those days by colleagues at UCLouvain (see "Further Reading" for more details). Noteworthy among

[2] https://archives.uclouvain.be/

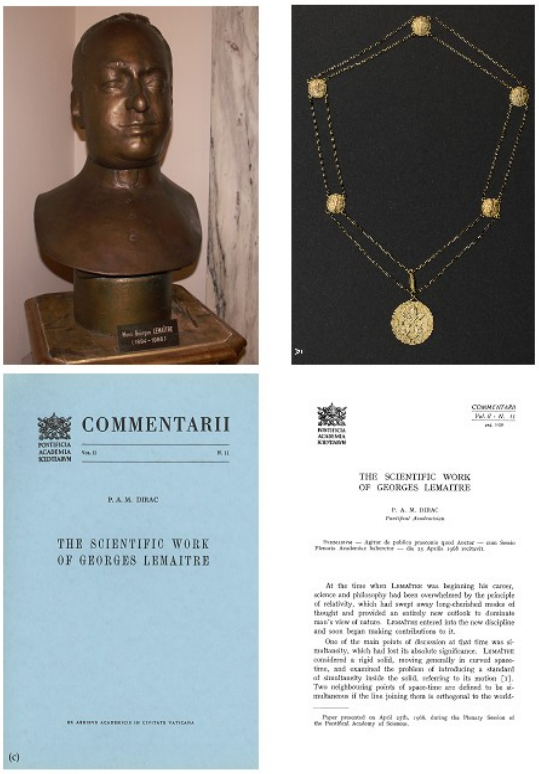

Figure 11: *Lemaître's bust at the Pontifical Academy of Sciences (a), his pontifical necklace (b), publication of Dirac's talk at the Pontifical Academy in honour of Lemaître after his death (c and d).*

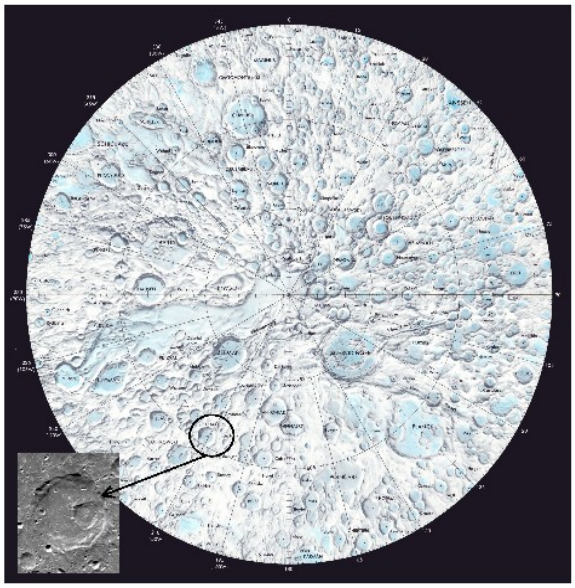

Figure 12: *Polar Stereographic projection of the southern hemisphere of the moon (polar areas 45N to 90N). The upper half of this chart is the side of the moon that is visible from the earth.*

these, for instance, is the year 1994 celebrating the centenary of his birth. That year saw a Colloquium in Louvain-la-Neuve dedicated to "Mgr. Georges Lemaître savant et croyant. La Physique d'Einstein" which not only brought together many of his former colleagues and collaborators, who provided precious recollections, but which also foreshadowed the opening by UCLouvain of "La Maison Georges Lemaître" in Charleroi, as well as the establishment of the Georges Lemaître International Prize, which is awarded every second year. Of note, in the context of the present contribution, is the first recipient of the Prize, in 1995, namely Jim Peebles (Physics Nobel Prize 2019), as well as the last two recipients, in 2016 Kip Thorne (Physics Nobel Prize 2017), and in 2019 George Ellis (University of Cape Town), a famous and long-time collaborator of Stephen Hawking.

Lemaître was the first cosmologist to estimate the expansion rate of the Universe, later known as the Hubble constant. Lemaître remained a humble man and was not resentful that Hubble's name became attached to the theory. Over the years however, his due scientific legacy has been recognised and in October 2018 the International Astronomical Union renamed the Hubble Law as the Hubble-Lemaître Law in acknowledgement of his foundational contributions. Today, Lemaître is also remembered at St Edmund's in Cambridge with a prize in his name and a commemorative plaque in the Chapel. Furthermore, asteroid 1565, discovered by the Belgian astronomer Sylvain Arend in 1948 at the Royal Observatory in Ukkel (Municipality of Brussels)[3], and a lunar impact crater are named after him[4] (Fig. 12). In 1994, on the centenary of his birth a postal stamp with his picture was issued in Belgium (Fig. 13(a)). On 17 June 2018, Google celebrated Lemaître's 124th birthday with an animated Doodle depicting Abbé Lemaître

[3]https://www.minorplanetcenter.net/db_search/show_object?object_id=1565

[4]Located close to the Lemaître crater is the Minnaert crater, dedicated to the Belgian-Dutch astronomer and professor Marcel Minnaert, famous for his very interesting three volume edition "De natuurkunde van 't vrije veld", describing surprising physical phenomena in everyday life. An English translation of the first volume is available as the Springer Edition "Light and Color in the Outdoors".

Figure 13: *Various ways to honour the great scientist: (a) a postal stamp, (b) an animated Doodle on Google.*

immersed in the constantly expanding Universe, surrounded by galaxies expanding outwards[5] (Fig. 17(b)).

Lemaître even travelled to space! In July 2014 a photo of him was taken aboard the International Space Station (ISS) by the uncrewed cargo spacecraft ATV-5 (Automated Transfer Vehicle), the last of its type to be launched to the ISS by the European Space Agency, which was baptised as the Georges Lemaître ATV. You may catch Lemaître sitting in one of the ISS' window bays, pondering the fate of the Universe (Fig. 14). On that occasion a joint UCLouvain-KU Leuven international symposium promoted by BELSPO (the Belgian Science Policy Office) took place in Leuven in May

[5]https://www.google.com/doodles/georges-lemaitres-124th-birthday

Figure 14: *A picture of Lemaître aboard the International Space Station.*

2014 to celebrate Lemaître's legacy. A first plaque was unveiled in honour of the Father of the Big Bang Theory on the walls of the Premonstratensian College in the City of Leuven (Naamsestraat 61), the then Physics Institute of the University, where he worked and lectured from the second half of the 1930s onwards (see Fig. 15). While his lectures were considered to be difficult and challenging by students, Lemaître was known to be rather understanding and generous in final assessments, with a number of cherished anecdotes bearing witness to the fact that Lemaître was considerate of his students (see Fig. 16). An audio recording of Lemaître during one of his lessons explaining the study material for the upcoming examination, clearly illustrates the affectionate and easygoing interaction with his students (available at the Archives Lemaître in Louvain-la-Neuve).

To commemorate the 50 years since his passing, the year 2016-2017 saw a whole series of diverse events organised by UCLouvain, under the auspices of the Royal Palace, which concluded in May 2017 with the joint inauguration by UCLouvain and KU Leuven of two statues of Lemaître in the two cities of Ottignies-Louvain-la-Neuve and Leuven, these two cities then signing a twinning agreement as well on that occasion. In Louvain-la-Neuve a sculpture by Gigi Warny (Fig. 17(a)) was installed at the UCLouvain Faculty of Science on the Place

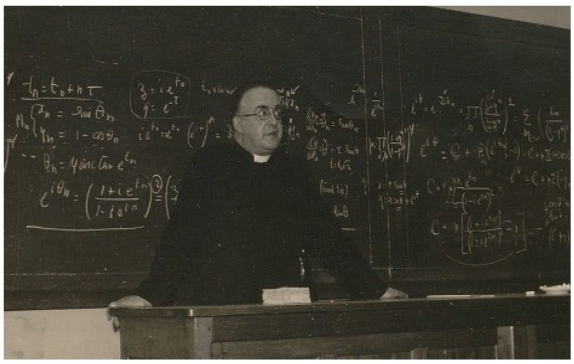

Figure 15: *Lemaître teaching at the University in Louvain*

Figure 16: *Caricature of Georges Lemaître drawn by an unknown engineering student.*

des Sciences, which represents Lemaître lecturing in front of Friedmann-Lemaître curves drawn by Lemaître himself, illustrating different possible evolutions of the Universe depending on the value of the cosmological constant. In Leuven a bust by Fred Bellefroid was unveiled in the courtyard of the Premonstratensian College (Fig. 17(b)).

In May 2019 the European Physical Society (EPS), upon nomination by the Belgian Physical Society, recognised Lemaître's earlier residence in Leuven, the College of the Holy Spirit (Heilige Geestcollege), located at Naamsestraat 40, as an

Figure 17: *Statues erected in honour of Lemaître in the Place des Sciences in Louvain-la-Neuve (a) and in the Premonstratensian College, Naamsestraat 61, Leuven (b).*

EPS Historic Site[6], (see Fig 18). Lemaître lived and worked at the College of the Holy Spirit from 1927 to 1933, where he laid the foundations of his theory of the expanding Universe and the primeval atom. A documentary of this festive day in Leuven is available on the website of the Belgian Physical Society[7]). On that same occasion a 75 km long round touristic cycle route was inaugurated between Leuven and Louvain-la-Neuve, joining the two sculptures, the two universities, the two cities and the two Provinces of Brabant. Along this 'Big Bang Route'[8] cyclists are invited to follow on their smartphones the history and evolution of our Universe, from the Big Bang up to today with the appearance of life on Earth, and towards tomorrow with a glimpse of what may be Earth's future with its present-day climate challenges as well as what lies in store for our Universe's future.

In the meantime, knowledge of the early Universe continues to advance, both theoretically and experimentally. No less than four Nobel Prizes in Physics have already been awarded in the field since Lemaître's death. The first one in 1978 to Arno Penzias and Robert Wilson "for their discovery of cosmic microwave background radiation". The second one in 2006 to John Mather and George Smoot "for their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation". The third one in 2011 to Saul Perlmutter, Brian P. Schmidt and Adam G. Riess "for the discovery of the accelerating expansion of the Universe

[6]https://www.eps.org/distinction_sites
[7]https://www.belgianphysicalsociety.be/page/34
[8]https://www.bigbangroute.be/pages/en_GB/start

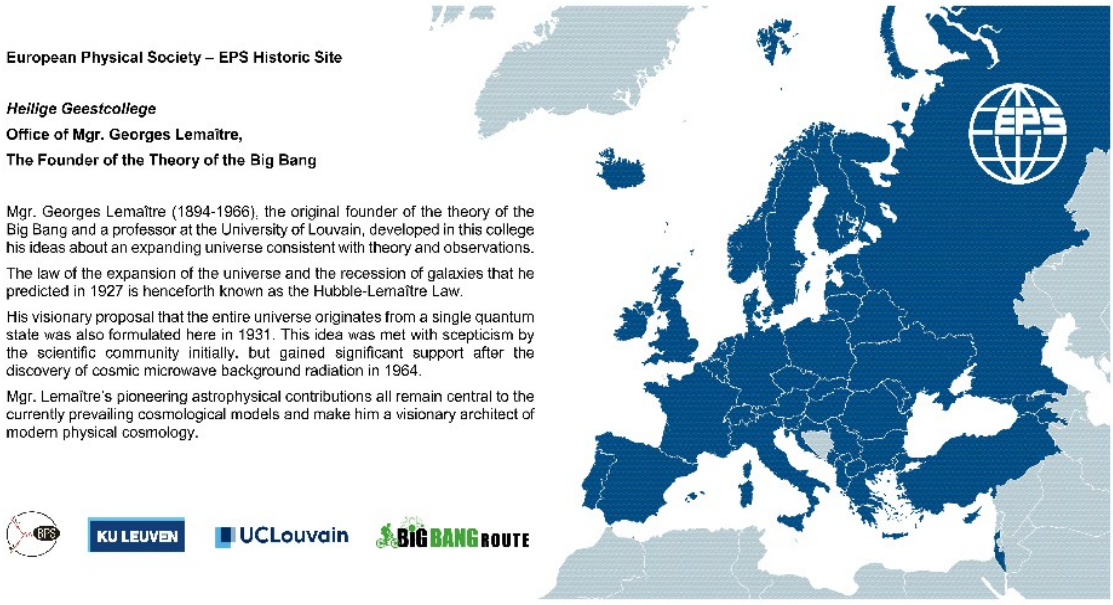

Figure 18: *Plaque at the College of the Holy Spirit in Leuven, recognised as EPS Historic Site in 2019.*

through observations of distant supernovae". The fourth one in 2019 in part to James Peebles "for theoretical discoveries in physical cosmology". All these works are related to the early findings of Georges Lemaître, who can rightly be called a revolutionary and visionary Belgian and European physicist of the XXth century.

Appendix: Belgian Royal distinctions awarded to Georges Lemaître [14]

- "Knight of the Order Leopold II" by Royal Decree of 7/04/1934
- "Officer of the Order of the Crown" by Royal Decree of 15/11/1938
- "Officer of the Order Leopold II" by Royal Decree of 10/03/1946 with retroactivity to 15/11/1944
- "Commander of the Order Leopold II" by Royal Decree of 1/08/1946
- "Commander of the Order of the Crown" by Royal Decree of 19/03/1951 with retroactivity to 15/11/1950
- "Grand Officer of the Order of the Crown" by Royal Decree of 23/05/1957 with retroactivity to 8/04/1956
- "Grand Officer of the Order Leopold II" by Royal Decree of 10/07/1962 with retroactivity to 8/04/1962.

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Figure 1c: (right) Georges Lemaître, Avril 1936, Archives de l'Université catholique de Louvain | Archives Georges Lemaître, BE A4006 FG LEM 1750.

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Figure 10: The Master and Fellows of St John's College, Cambridge; Special Collections.

Figure 11: (b) Collier de membre de l'Académie pontificale des sciences, Archives de l'Université catholique de Louvain | Archives Georges Lemaître, BE A4006 FG LEM 1695.

Figure 12: from NASA Lunar Chart LPC-1, 2nd edition, Februari 1979; https://www.hq.nasa.gov/alsj/LPC-1.html

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