

Who was Georges Lemaître?

1. Short biography

LEMAITRE (Georges - Henri - Joseph - Edouard, Mgr), astronomer, cosmologist and professor at the Catholic University of Louvain, was born in Charleroi (Belgium) on the 17 July 1894 and died at Louvain (Leuven) on the 20 June 1966.

He was only 9 when he already felt his double vocation as a priest and as a scientist. After his secondary school at the Jesuits, he entered at 17 the engineering school of the Catholic University of Louvain. In 1914, he interrupted his studies and voluntarily served in the Belgian Army. At the end of the war he was conferred the "Croix de guerre avec palmes" (war cross with palms). He then began to study physics and mathematics and also entered the sacerdotal status. He obtained his doctoral PhD in 1920 with a thesis on "L'approximation des fonctions de plusieurs variables réelles" (Approximation of functions of many real variables) under the direction of Prof. Charles de la Vallée Poussin.

The war tragedy had a deep impact on his life: he entered the Malines seminar and was ordained priest in 1923. But neither the war, his studies, nor his vocation dried up his curiosity: as soon as 1920, he studied the relativity theory and assimilated it well.

In 1923, obtaining a scholarship from the Belgian government as well as a fellowship from the Committee for Relief in Belgium of the Belgian American Educational Foundation, he visited Cambridge University in England. There he met the astronomer - relativist Arthur Stanley Eddington, who initiated him to modern stellar astronomy and to numerical methods. The following year was spent at the Harvard College Observatory of Cambridge (USA) with Harlow Shapley, who was renowned for his work on nebular celestial objects. At MIT, he received a Doctorate in Science. He was CRB fellow during the years 1924-1925.

Returning to Belgium, he was appointed as "chargé de cours" (associate professor) at the University of Louvain in 1925. He started working on the theme that would bring him the international fame. In 1927 he published an article in the "Annales de la Société scientifique de Bruxelles" : "Un Univers homogène de masse constante et de rayon croissant rendant compte de la vitesse radiale des nébuleuses extragalactiques" (A homogenous Universe with constant mass and increasing radius explaining the radial velocity of extragalactic nebulae). There he presented the very new concept of the physical expansion of the Universe. Einstein, although approving the mathematical theory of Lemaître, first refused to accept the idea of an expanding Universe. He conceived it as changeless, but later would recognize this as the major error of his life. Lemaître didn't worry about honors, nor did think it was useful to spread his ideas, and publish his article more widely. In fact, he was already concentrating on a new challenge: to solve the problem of the beginning of the Universe.

This same year (1927), he went back to MIT and presented his doctoral thesis on "The gravitational field in a fluid sphere of uniform invariant density according to the theory of relativity". He was awarded the degree of "Doctor of Philosophy" at MIT and was afterwards nominated Full Professor at the Université catholique de Louvain.

In 1931, his former master Eddington published an English translation of his 1927 article with a long comment. Lemaître was afterwards invited to London to participate in a meeting of the British Association on the relation between the physical Universe and the life of the mind. There he suggested for the first time the idea of a singular beginning of the expanding Universe. This idea was explained in a memorandum published in the Monthly Notices of the Royal Astronomical Society. This proposal produced a strong reaction from the scientific community of the time. Eddington found this a repulsive hypothesis. On 9 May 1931 Lemaître answers Eddington in a letter published in 'Nature' by presenting his ideas which later on led to the concept of the "primeval atom".

As for Einstein, he found this a suspicious idea because according to him, it suggested too much the Christian dogma of creation and was not to be defended from the physical point of view. The debate between cosmology and religion became polemic and lasted for decades. In this debate, Lemaître ceaselessly separated science and faith.

Lemaître met Einstein several times: in 1927 in Brussels during a Physics Congress of "Solvay", in 1931 and 1933 at the Athenaeum of Pasadena (California Institute of Technology), in 1932, in Belgium again during a cycle of conferences in Brussels, and a last time in 1935 in Princeton. In 1933, the year he was working on the theory of the expanding Universe (published in the *Annales de la Société scientifique de Bruxelles*), Lemaître was at the height of his fame. American papers called him "the famous Belgian scientist" and he was considered as the leader of the new cosmological physics.

On 17 March 1934, Lemaître received the Francqui Prize, the highest Belgian scientific distinction, given to him by King Leopold III. Albert Einstein and the academicians Charles de la Vallée Poussin and A. de Hemptinne proposed his name for this famous Prize. The international jury of the Francqui Prize also included Eddington, Langevin, de Donder and Dehalu. Another distinction that the Belgian government reserves for exceptional scientists was given to him in 1950 as the "Prix décennal des sciences appliquées pour la période 1933-1942" (decadal prize for applied sciences for the period 1933-1942).

In 1936, he was elected member of the Pontifical Science Academy in which he played an active role becoming chairman of it from 1960 till his death. He also became a prelate in 1960. In 1946, he published his book on the "Hypothèse de l'Atome Primitif" at the Editions du Griffon in Neuchâtel (Switzerland). This book, prefaced by the philosopher Ferdinand Gonseth, was translated into Spanish the same year and into English in 1950. During this decade, he gradually abandoned teaching which came to an end when he became emeritus in 1964.

Towards the end of his life, he increasingly devoted his time to numerical computation. In fact, he was a remarkable calculator, algebraist and arithmetician. As soon as 1930, he was using the most high-performance calculators of the time such as the Mercedes. In 1958, he introduced a Burroughs E101 at the University as its first electronic computer. Lemaître was deeply interested in the development of computers, and even more in the problems of programming languages and program writing. Getting older, this interest took larger proportions up to the point of absorbing him nearly entirely!

He was sociable, devoted to his students and collaborators, but remained an isolated researcher and one finds only few correspondence or scientific exchange with his foreign peers. If this unmistakable precursor of modern cosmology remains in the shadow of big

names of the XXth century (like Einstein, Eddington, Hubble and Gamov in particular) it is most probably due to the fact he was a priest (Fred Hoyle, who originated the name "Big Bang" never forgave him for this!) and to the ambiguity of the person, at the same time modest and full of himself. Modest because he despised honors and was never seeking fame. But full of himself in his way of asserting, at least in private circles, his capacities of mathematician and the originality of his ideas. This did not prevent him from showing an open, honest, cheerful and optimistic character, always displaying a remarkable flexible mind.

2. A summary of Lemaître's work

Georges Lemaître (1894-1966) is one of the great names of modern cosmology. Being a friend of Einstein, he was the first in 1927 to explain the red shift of the spectrum of galaxies observed by Edwin Hubble as resulting from the expansion of the Universe. Using a spherical model of Universe with an exponential expansion (today, this model is referred to as "Eddington-Lemaître Universe"), he derived a correct expression of the so-called Hubble law (which Hubble published only in 1929) which states that the escape velocity of distant galaxies is proportional to their distances.

Lemaître first studied engineering, but after World War I he turned to physics and mathematics. His "licence report", which he wrote under the direction of Charles de la Vallée-Poussin was dedicated to the approximation of functions of many real variables. During his three years in the seminary (1920-23) he was allowed to continue to study relativity (and especially to study the synthesis of it made by Théophile De Donder, professor at U.L.B, the University of Brussels). He was ordained priest by Cardinal Mercier. In 1924, receiving a scholarship, he went to Cambridge (G.B.) to study astrophysics, becoming there the pupil of Eddington. He went to the MIT (US) and to the Harvard College Observatory. Then returning to the University of Louvain, he was promoted as professor. At that time he had become a general relativity specialist and was lucky to be aware of the recent observation data concerning the galaxies, which led him to write his brilliant 1927 paper.

In the early thirties, he defended an explosive vision of the beginning of the Universe that he later termed his "Primeval Atom Hypothesis". This anticipated the now well tested Big Bang theory. His interest in the question of the beginning of the Universe had nothing to do with any philosophic or theological motivation. In fact, it was a direct reaction to an assertion of his former master Eddington expressing his aversion to the idea of a beginning of the Universe. Lemaître showed that this idea can be treated correctly while using only resources of physics (without the intervention of philosophy or theology), especially thermodynamics and the quantum theory. In this context, the natural beginning of the Universe is a state with minimal entropy where all the matter-energy is concentrated in a unique quantum.

This concept is no more admitted to-day. Physicists no longer explain the constitution of different atomic nuclei by the disintegration of a super atom, but by the progressive condensation of an initial "soup" of elementary particle: quarks and leptons. However, Lemaître's hypothesis allowed him to make a prediction that was verified by observations shortly before he died. This prediction first made by Lemaître is the existence of a fossil radiation giving evidence to the "explosive" character of the beginning of the Universe. Lemaître thought the fossils might be the cosmic rays (charged particles coming from the

primeval atom disintegration). Today we know that it is rather an electromagnetic residual radiation escaped from the Big Bang having a temperature of 3 K (i.e. -270°C).

Lemaître considered the cosmic rays as having a cosmologic importance and this encouraged him to accurately study their trajectories. The problem of calculating these trajectories, called the Störmer problem, requires numerical techniques and a large computing power. With the help of his collaborators and students (among them Manuel Sandoval Vallarta, Odon Godart, Tchang Yong-Li, René de Vogelaere, Lucien Bossy, ...), Lemaître contributed to precisely characterizing the families of orbits followed by the cosmic rays and the Störmer cone in which the cosmic rays hitting the Earth are concentrated. These works contributed to an explanation of the observations of the intensity variation of cosmic rays as a function of the position of the terrestrial observer. For the Louvain cosmologist, the primeval atom hypothesis is associated with a spherical Universe model having three characteristic expansion periods (a decelerated expansion beginning) with the initial singularity, a plateau phase in which the Universe is similar to the static Universe of Einstein and finally a accelerated expansion phase). Such a behavior of the Universe is described by the introduction of a cosmologic constant in the Einstein equations. In opposition to Einstein, Lemaître was much attached to this constant. He thought that the fundamental justification for it could be coming from the quantum theory (to-day we know that it can be interpreted as energy of the quantum void).

He qualified this Universe as "hesitating" and used it to explain his ideas on the formation of such large cosmic structures as the galaxies and clusters of galaxies. For Lemaître, these were formed by the condensation of matter from the disintegrating primeval atom during the quasi-static phase where the Universe looked like the Einstein Universe. The description of this condensation process was elaborated by a model of inhomogeneous Universe (later called Lemaître-Tolman-Bondi model), which Lemaître had already studied for his PhD thesis presented at MIT. Up to the 50ies Lemaître continued to make computations on models of galaxies and clusters.

The conversations between Lemaître and Einstein were very productive. After one of these, the Louvain cosmologist succeeded in showing that an anisotropy of the Universe cannot evacuate singularities appearing in the "Phoenix" models (where initial and final singularities follow each other). So he was the precursor of singularity theorems (Penrose and Hawking) where the irreducibility of these under certain conditions is proved. The passion of Lemaître for numerical computation arose in him an extraordinary mathematical fertility (unfortunately not always reflected in his publications). As noted by his former pupil and collaborator André Deprit, Lemaître was one of the inventors of the modern Fast Fourier Transform technique.

Lemaître was well ahead on his time regarding machine computing. As early as the thirties at MIT, he used the machine perfected by Bush to solve the Störmer problem. It was an analog machine, able to solve numerically and to draw solutions of systems of differential equations. Later in Louvain, Lemaître also used electro-mechanical machines to determine for example the frequencies and vibration modes of the molecule monodeutero-ethylene, during a collaborative project with Marc de Hemptinne and Charles Manneback under the leadership of Hugh S. Taylor, the famous Princeton chemist. In 1958, Lemaître introduced and programmed the first computer of the UCL (a Burroughs E101) and may in a way be considered as one of the first European programmers.

Lemaître also published articles on a generalization of the quaternionic form given by Eddington on the Dirac equation describing the relativistic electron. In fact it is an equation remaining invariant under the action of the bonded spin group associated to the pseudo orthogonal group $SO(3,3)$. This study and the careful reading of Elie Cartan works led him to be interested in the theory of spinners as well from the mathematical as the historical point of view. As a man of great culture, Lemaître distinguished himself by original ideas on Molière's work (he wanted to prove that this work was produced by two authors and he made many conferences with significant titles : "A pair of Molières", "Molière, a double star", ...).

He also introduced a replacement of figures and calculating methods used in the primary schools. The "new figures" of Lemaître (based on a system mixing decimal and binary systems) has been developed in Belgium by Papy, the specialist of teaching with so called "modern mathematics". Lemaître's central idea was to develop calculating methods which decrease the role of short and long term memory. For Lemaître, these methods are nothing else than the ones used in machines! He was a priest strongly attached to his faith and to the Church (he was a member of a sacerdotal fraternity "The Friends of Jesus" where priests took their vows of religious life and were engaged to radically live their vocation). Lemaître always tried to methodically separate the scientific approach from the theological one. To him, there was no way to confuse the initial singularity (the natural beginning) with the creation in the theological sense. When he became President of the Pontifical Academy of Science in 1960, he painstakingly defended the autonomy of the "two ways" as he pleased to call them: the one of science and the one of the Revelation. As soon as 1952, he successfully interceded with Pope Pie XII in order that in his official addresses he would no longer bind the theological notion of the creation with his primeval atom hypothesis.

Lemaître gave the Universe a history and broke the unchanging image that prevailed before him.

3. Some documents on Lemaître

Books over Lemaître

- L'Académie Pontificale des Sciences en mémoire de son second président Georges Lemaître. A l'occasion du cinquième anniversaire de sa mort, 1972, Pontificiae Academia Scientiarum Varia, 292p.
- The Big-Bang and Georges Lemaître, 1984. (A. Berger, éd.), D. Reidel Publ. Company, Dordrecht, Holland, 420 p.
- Cosmology of Lemaître, 1985 (O. Godart et M. Heller, eds), Pachart ed., Tucson, 204 p.
- Georges Lemaître, le Père du Big Bang, 1994 (V. De Rath, éd.), Editions Labor, Bruxelles, ISBN 2-8040-1025-2, 156 p.
- Georges Lemaître et l'Académie Royale de Belgique. Œuvres choisies et notice bibliographique. 1995 (Académie Royale de Belgique), 219 p.
- Mgr. G. Lemaître savant et croyant. Actes du colloque commémoratif du centième anniversaire de sa naissance, Louvain-la-Neuve, le 4 novembre 1994, 1996 (J.-Fr. Stoffel), Reminescence 3, Centre Interfacultaire d'étude en histoire des sciences, univ. catholique de Louvain, 371 p.

- Essais de cosmologie précédés de l'invention du Big Bang, 1997 (J.-P. Luminet et A. Grib, éd.), Editions du Seuil, 337 p.
- Un Atome d'Univers. La vie et l'œuvre de Georges Lemaître. Le père du Big Bang. 2000 (Dominique Lambert), Ed. Racine, 372 pp.
- L'invention du Big Bang, (Jean-Pierre Luminet), Seuil 2004, ISBN 2-02-061148-1, 267 p.
- The Day Without Yesterday - Lemaître, Einstein, and the Birth of Modern Cosmology, (Farrell, John) - Thunder's Mouth Press 2005 - New York, ISBN 1-56025-660-5, 262 p.
- The Day Without Yesterday - Lemaître, Einstein, and the Birth of Modern Cosmology, (Farrell, John) - Japanese translation by Nikkei Business Publications Inc 2006, ISBN 4-8222-8288-0, 285 pp.
- L'itinéraire spirituel de Georges Lemaître. Suivi de " Univers et atome " (inédit de G. Lemaître). 2007 (Dominique Lambert), n°16, Editions Lessius, 222p.
- Charles Darwin et Georges Lemaître, une improbable, mais passionnante rencontre. 2008 (Dominique Lambert et Jacques Reisse), Classe des Sciences, Académie royale de Belgique, ISBN 978-2-8031-0252-5, 288 p.
- Droga Duchowa Georgesa Lemaître'a. Translation in Polish of « L'itinéraire spirituel de Georges Lemaître. Includes a translation in Polish of " Univers et atome " (G. Lemaître, unpublished). 2011 (Dominique Lambert), Biblioteka Religioni et Litteris, 210pp.
- Georges Lemaître : Life, Science and Legacy 2012, (Rodney D. Holder & Simon Mitton, editors), Springer, 201 pp.
- The Atom of the Universe. The Life and Work of Georges Lemaître, 4 juin 2014 (Dominique Lambert), Copernicus Center Press, English version of the biography « Un Atome d'Univers » par D. Lambert.

Film/Vidéo

- Georges Lemaître. Le Maître du Big Bang, réalisation : J.-M. Dehon, scénario : J.-L. Léonard, VHS, duration 57 minutes, To Do Today Productions, R.T.B.F. Charleroi, 1994.