Georges Lemaître and the Hubble–Lemaître law

Frank J Tipler

salutes the overdue recognition of an important figure in 20th-century cosmology.

This October, the International Astronomical Union (IAU) voted to change the name of Hubble's law, which describes the expansion of the universe. Henceforward, the law will be known as the Hubble–Lemaître law. At last, Georges Lemaître has received the recognition he has long deserved.

Albert Einstein (1917) created modern cosmology, but he assumed that the universe is static and has existed forever. The Russian mathematician Alexander Friedmann (1922, 1924) showed that Einstein's equations of general relativity had solutions that corresponded to expanding and contracting universes, but his work was merely mathematical; Friedmann made no attempt to connect his solutions to astronomical observations. Georges Lemaître (1927) independently discovered Friedmann's dynamical solutions to the Einstein field equations, but he went further: Lemaître pointed out that an expanding universe would mean that the further galaxies were from us, the faster they would appear to move away from us. That is, Lemaître showed that if D is the distance a galaxy is from us, and v is its measured velocity away from us, then $v = CD$, where C is a universal constant.

"Lemaître originally published his analysis in an obscure journal written in French"

We now write this simple linear law as $v = HD$ because Edwin Hubble (1929), who independently discovered the law, has received the entire credit for the discovery. But Lemaître discovered the law first, published it first, and realized that the law was a consequence of an expanding universe governed by general relativity. Hubble merely noticed the linear relation between the velocity of galaxies away from us and the distance of the galaxies – Hubble did not connect this law to general relativity.

Obscure journal

So why is Hubble's name on the law rather than Lemaître's? Because Lemaître (1927) originally published his analysis in an obscure journal written in the French language. So not only was Lemaître's work generally unknown, but so was Friedmann's (see Tipler *et al.* 1980 for a history of these events). The great English astrophysicist Arthur Stanley Eddington gave a talk in January 1930 at a Royal Astronomical Society meeting in which he wondered why no non-static cosmological solutions to Einstein's equations were known. Eddington's talk was published in *The Observatory* (Eddington 1930), where Lemaître read it.

Lemaître, a former student of Eddington, immediately wrote to Eddington, telling him about his 1927 paper. Eddington was impressed by Lemaître's paper and arranged for it to be published in English translation in *Monthly Notices of the Royal Astronomical Society* (Lemaître 1931a). In the English translation, Lemaître himself (Livio 2011) deleted the paragraphs deriving the linear law, because he felt that Hubble had since obtained better data to support it. Thus it happened that, although he published first, Lemaître got no credit for his remarkable discovery.

Lemaître was a modest man and was not bothered at all by the fact that Hubble received all the credit for the linear law. For Lemaître, it was the advance of science that counted, not the assignment of credit (Livio 2011). But we astronomers like to see justice done and the IAU has now seen that it has been done.

In the same year (1931) that the English translation of his earlier paper appeared in *Monthly Notices*, Lemaître (1931b) published a paper in *Nature* arguing that the universe began in a single unique quantum state. This proposal is as important as the Lemaître–Hubble law, but equally ignored, even though Lemaître later tried to get publicity for his proposal by publishing it as a book, *The Primeval Atom* (1931c, 1946 in English translation).

Quantum theory

I have shown (Tipler 2005, Tipler *et al.* 2007) that modern quantum field theory supports Lemaître's proposal; indeed, quantum theory as developed in the 1980s *requires* the universe to have begun in a single unique quantum state! I have further shown (Tipler 2005) that Lemaître's proposal solves the horizon, isotropy and homogeneity problems of cosmology, which have led to the idea of inflation at an early stage in the origin of the universe.

Part of the reason why Lemaître's primeval atom has been ignored is that, until recently, no-one has been able to compute any observational consequences. With the establishment of the Standard Model of particle physics – confirmed in 2012 with the discovery of the Higgs boson – this has now changed. I showed (Tipler 2005) that the Standard Model, when combined with Lemaître's primeval atom, implied that the Sunyaev–Zel'dovich effect (the temperature of the cosmic background radiation [CBR] is reduced slightly as the CBR passes through clusters of galaxies) would be observed to be too low by a factor of two. The Planck collaboration (2014) showed exactly this.

The IAU has given Lemaître the recognition he has long deserved. But his true greatness has yet to be fully appreciated. ●

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FURTHER READING

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