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The portraits of Scaliger, Lorentz and Einstein belong to the professorial gallery of Leiden University. They are reproduced here with permission. I thank professor H. J. de Jonge of Leiden University for invaluable information about Scaliger and professor Nancy J. Nersessian of Georgia Institute of Technology for illuminating me in matters concerning the debate between Hendrik A. Lorentz and Albert Einstein.

Two Architects of Time

John A. Michon

Introduction

Tempus fuit. Our clocks tell us so tick by tick, continuously, perpetually, and regularly, without reference to anything external. That, at least, is one image of time, the one that we know as *absolute* time. But there is also a totally different time, one that we encounter in everyday life, for instance when we are waiting, seemingly forever, for a delayed train or when we suddenly become aware of the sobering fact that the end of a romantic evening is there. That other, irregular, form of time clearly depends on the events in which we take part. In this case we speak of *relative* time. But what *is* time?

More than sixteen centuries ago Saint Augustine posed that question and, in a famous writing with the appropriate title *Confessions*, admitted that he did not know what time is. “Or rather,” he added, “As long as nobody asks me I know, but when someone requires an explanation I find myself at a loss.” (Augustine of Hippo, 1963). Since Augustine countless others have attempted to answer this question, apparently without ever reaching a definitive answer. Cynics have come to the conclusion that

> “[o]bviously, trying to ‘define’ time is a fool’s errand. To define a notion is to find for it an equivalent ideational construct made of some other, usually more primitive, notions […] Any attempt to define time, therefore, is bound to be ridiculous, since nothing in this world even remotely resembles time.” (Toda, 1978).

In my opinion this is an interesting, but somewhat grotesque overstatement. The question may not have been answered once and for all, but in the course of time it has been asked with greater and greater precision, and as a result the discussion about the nature of time has reached a much higher and more sophisticated level. In this discussion Leiden University, the most ancient university of the Netherlands has played a prominent role. Two of its most celebrated scholars count among the architects of time: JOSEPHUS JUSTUS SCALIGER (1540-1609), philologist and historian who worked in Leiden from 1593 until his death in 1609 and HENDRIK ANTOON LORENTZ (1853-1928) who served that university between 1878 and 1928 as professor of theoretical physics. At first sight these two intellectual giants may seem to have little in common. Scaliger in his time initiated a chronological revolt that triggered a transition from relative to absolute time. Three centuries later LORENTZ was instrumental in a reverse development, leading to a transition from absolute to relative time. What they have in common, however, is their hesitance to take the decisive, final steps that would have capped their intellectual achievements, but that were instead left to others to take.

Joseph Scaliger (1540-1609)

Josephus Justus Scaliger was born in 1540 in Agen, a provincial town near Bordeaux in France. He was already one of the most famous scholars of his time when, in 1593, he was invited to join Leiden University. Apart from being famous Scaliger was also a prominent protestant, which, at the time, did not contribute to a quiet and peaceful existence in France. It may indeed have influenced his decision to accept the invitation, although it should be added that the offer made by the university was practically irresistible. He was offered the honorary position of *Decus*—literally meaning *Jewel* or P*aragon*—and his salary is known to have matched that of the highest ranking civil servant in the Dutch Republic, the Grand Pensionary, amounting to approximately five times the fee of an ordinary professor. Moreover he was relieved from the obligation to teach undergraduates and auditors.

The significance of Scaliger is acknowledged until the present day—in Leiden there a Scaliger Institute, a Joseph Scaliger Chair and Scaliger's portrait occupies one of the most prominent places in the university's Senate Hall. Scaliger was a highly gifted and comprehensive scholar. Apart from French, his mother tongue, he was in command of Latin, Greek, Italian, German, Arabic, Hebrew, Aramese, Syrian, Persian and Turkish. Moreover his work on the Gothic, Samaritan, and Ethiopian languages was of groundbreaking significance. His international fame was in no small part based on his studies in astronomy, early Latin, Roman and Greek lyric poetry, prosody, and inscriptions. What interested him most, however, and what he is still remembered for is chronology, the science of correctly dating historical events.

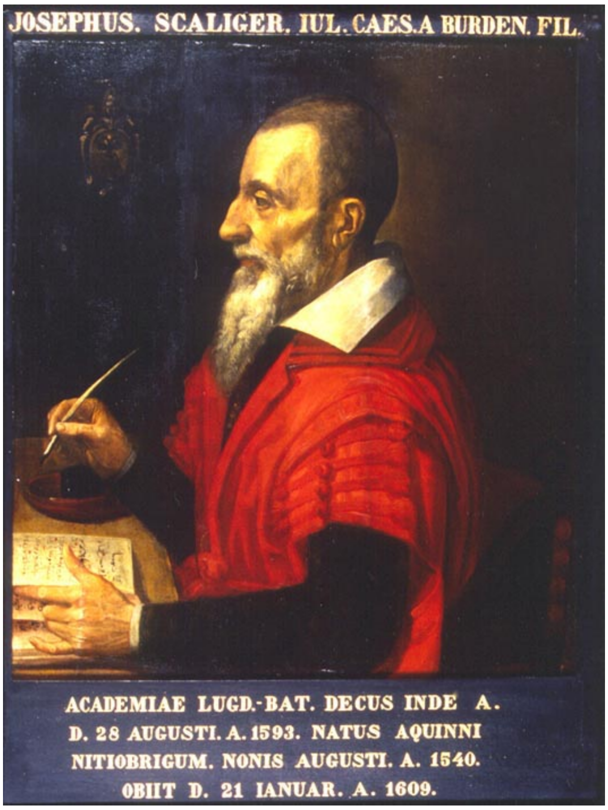

Figure 1 – Josephus Scaliger, son of Julius Caesar of Bordeaux.
Jewel of the Academy of Leiden since 28 August 1593.
Born in Agen on the 9th of August 1540. Deceased on 21 January 1609.

Scaliger's scientific approach

In fact Joseph Scaliger would seem to have a legitimate claim to be remembered as the founder of scientific chronology. He developed a method that makes it possible, at least in principle, to assign an absolute date to arbitrary historical events (Grafton, 1975). In the first place he designed a time scale—known as the Julian Period—that was sufficiently extended to encompass all historical events known at the time. It was based on three calendar cycles that had been in use for centuries and were referred to in most chronicles: the 28-year solar cycle, the 19-year lunar cycle and the 15-year, so-called, *indiction cycle*. The latter had only an administrative basis, but it had served its purpose from early Roman days onward. Since these three cycles share no common factors, Scaliger was able to uniquely define a succession of 28 × 19 × 15 = 7980 years. This enabled him to correlate historical events with celestial events such as solar eclipses, the appearance of comets, as well as with terrestrial disasters of administrative importance such as earthquakes and famines. In the second place Scaliger selected and analysed his sources in an unprecedented, highly critical fashion, which enabled him to evaluate their comparative reliability. Finally he purged his data systematically from all emotional, moral, political and ideological implications, leaving him, so to say with the dry-frozen facts.

Scaliger's dilemma

These tools would have made it possible for him to proceed from the relative, closed chronologies of pre-modern historians—from Herodotus and Thucydides to Guicciardini and Machiavelli—to a universal chronology that assigns each and all historical facts a fixed position on an absolute time scale. But Scaliger never quite took this last step. As usual in those days, the authority of the Bible stood in the way: the devout Scaliger found to his displeasure that there were indubitable historical facts—including, among others, the reign of the early pharaohs of Egypt—that in his chronology would have taken place prior to 4004 B.C., the generally accepted date of the Creation. For Scaliger the dilemma was that he did not choose to contest the received wisdom of the fundamentalist protestant reckoning that prevailed at the time. What stooped Scaliger did, however, not scare the Jesuit priest Dionysius Petavius who, in 1633, some 25 years after Scaliger's death, boldly and convincingly argued that, if the calculated date of Creation was standing in the way of established facts, Creation would have to move. And so modern chronology eventually began with Petavius. Even Scaliger's devoted student and admirer Gerardus Vossius—likewise a Leiden celebrity of the period—admitted that: "[a]nyone who devotes himself without partisanship to write about times will discover that though Scaliger deserves great praise, he will prefer to follow Petavius" (Vossius 1641, quoted by Grafton, 1975).

Hendrik A. Lorentz (1853-1928)

Hendrik Antoon Lorentz was born in Arnhem in the eastern part of The Netherlands. He is recognized as one of the most brilliant and influential physicists of all times. In 1877, at the age of 24 he was appointed full professor of theoretical physics at Leiden University and in 1902 he was awarded the Nobel Prize for physics, sharing it with Pieter Zeeman, his former student, assistant and, from 1900 onward, colleague. Lorentz was a profound and versatile scholar who, although theoretically inclined, didn't shrink away from serious applied issues. As chairman of the expert committee that was responsible for planning the enclosure of the *Zuyder Zee*, he personally made the calculations that proved the feasibility of this colossal undertaking. Eventually completed in 1927, the Enclosure Dam brought the low countries vastly greater protection against the North Sea and the Atlantic Ocean than they had ever experienced before.

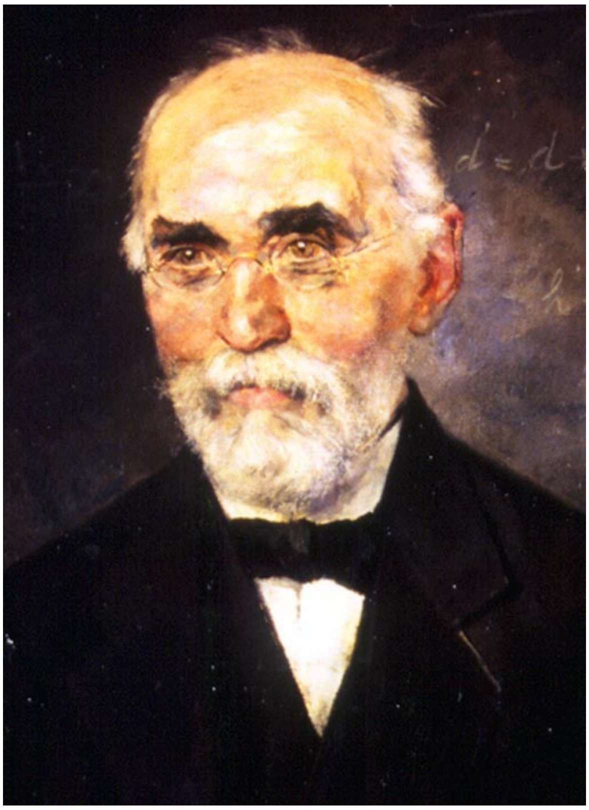

Figure 2 – Hendrik Antoon Lorentz (1853-1928).

Lorentz's scientific approach

Towards the end of the 19th century scientists had come to a point where they had to admit that they had reached the limits of classical physical theory. Their discoveries regarding light, electricity and magnetism just didn't fit the received conception of these phenomena as waves propagated through space. The conventional view was that waves need a medium for travelling, which is why scientists hypothesized that space is uniformly filled with ether, a mysterious, inert, frictionless and weightless, 'substance'.

These properties made it also possible to take the ether as the frame of reference for universal, absolute time. Lorentz was one of the first to realize that this view was seriously flawed. In 1904, following fifteen years of dedicated work, he was able to offer a coherent theoretical explanation of all known electromagnetic phenomena. For this he had to redefine the ether and by doing so he actually turned it into an even more mysterious entity. He came to the conclusion that a body in motion relative to the ether is subject to a contraction in the direction of its movement. The faster it moves, the flatter it becomes and consequently, reaching the speed of light, it will vanish altogether. Necessarily this result also affects the structure of time: in Lorentz's universe time behaves equally strangely. Clocks slow down more and more when they move faster and faster relative to the ether. As a result simultaneity and order of events become relative concepts.

For more than three centuries physical theory had rested on Newton's definition of absolute time as something that "of itself and from its own nature flows equably and without reference to anything external." Lorentz understood that absolute time is not so absolute after all but dependent on the frame of reference of the observer.

Lorentz's dilemma

Blessed with so much insight, why wasn't Lorentz Einstein? This peculiar question asked and admirably answered by Nersessian (1986)—is especially relevant if we realize that that Einstein published his special relativity theory in 1905, barely a year after Lorentz's theory about the dynamics of electrically charged matter had seen the light. Actually it soon became clear that the two theories are formally identical and it is not surprising that the special theory was initially known as the Lorentz-Einstein theory.

Unfortunately, the fundamental assumptions of both theories were different in a way that Lorentz was unable to reconcile and he was unwilling to change his views about the proper way of doing science. For him theory building was essentially a bottom-up constructive activity: scientific research will, step by step, uncover the secrets of Nature and so allow a gradually more and more precise vision of reality. That conviction made it impossible for him to abandon the ether concept and to accept the impossibility of establishing unambiguously the simultaneity and order of events. Einstein, for his part, simply asked what a theory based on the thesis that matter and electromagnetism are equivalent would look like. Taking that shortcut immediately taught him that he could do without the ether altogether.

Lorentz reproached Einstein, arguing that his esteemed young colleague "was quite a bit too eager to present his own private view as a self-evident natural principle" (quoted in Nersessian, 1986, p.230). Einstein replied that, he was not to repent, this assumption simply worked too well and that, with all due respect, it made a lot of sense to him...

This then illustrates why Lorentz wasn't Einstein and Einstein wasn't Lorentz. The two persisted in this debate in a most friendly way for years, Einstein trying politely but unsuccessfully to convince Lorentz that the ether hypothesis is truly redundant. Eventually, however, Lorentz had to admit the indefensibility of his own position. Thus in 1917 he wrote disappointedly:

> It is always risky to close a path of research completely and perhaps it is good, considering everything together, to grant the ether one more chance. Conceivably a time will come when speculations over its structure, from which we now abstain, become fruitful and effective" (quoted in Nersessian, 1984, p. 233).

Figure 3 – Albert Einstein (1879 - 1955).
Portrait by Harm Kamerlingh Onnes (1920).

It is not that Lorentz in his later years found himself unable to keep up with Einstein's leaps of imagination. When Einstein published his general theory in 1915, Lorentz, in less than three weeks time, publicly declared it to be correct. Paul Ehrenfest, Lorentz's successor as professor of theoretical physics in Leiden required several months to reach the same conclusion and confessed to Lorentz that he felt humiliated. "When the two of you communicate," he wrote, "you behave like two freemasons who immediately grasp the meaning of the secret gestures they exchange, a meaning that remains totally obscure to the uninitiated" (F. A. Berends, personal communication).

Interestingly, Lorentz's hope was to be fulfilled in some sense half a century later. One of the implications of quantum mechanics is that there is no such thing as the perfect vacuum. As Paul Davies phrased it: "What may appear at first to be total emptiness is, in fact, a beehive of fluctuating ghosts, appearing and disappearing in an unpredictable frolic" (Davies, 2001, pp. 83-84). It should be added, however, that this new 'ether' hardly resembles what Lorentz had in mind.

Conclusion

There is no doubt that both Joseph Scaliger and Hendrik Lorentz have made a significant contribution to refining and clarifying the age-old question *What then is time?* Each defined a new temporality, as required by their findings. But in the end both failed to accept the ultimate consequence of their own, otherwise undisputed, insights. For me then, both encountered a creative dilemma that they were unable—or perhaps unwilling?—to resolve. Which, in the end, may explain why giants so often need others to stand on their shoulders.

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