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History of Sciences and Ideas

The providential timing of scientific discovery: André-Marie Ampère in 1820

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Abstract. The 2025 commemoration of the 250th anniversary of André-Marie Ampère's birth in 1775 was inspired in large part by the legacy he left through his creation of the new branch of physics he called electrodynamics. Primarily accomplished between 1820 and 1826, Ampère's achievement was precipitated by Hans Christian Oersted's 1820 discovery of an unexpected interaction between a magnetic needle and an electric current. While many factors contributed to Ampère's successful response to Oersted's discovery, there was some serendipity to its timing that is best appreciated by locating it within the biographical context of Ampère's academic career, his tumultuous personal life, his extensive philosophical investigations, and his tenuous religious faith. It is noteworthy that Oersted's discovery came at a point in time when Ampère's status on all these fronts was relatively stable. The fortuitous state of equipoise he enjoyed in 1820 facilitated his engagement with electrodynamics to an extent that would have been extremely difficult to achieve during the previous decade. From Ampère's religious perspective, the perspicacious timing of Oersted's discovery could readily be attributed to divine providence. The timely balance between the romantic and analytic components of Ampère's mentality in 1820 is aptly symbolized by the first of the four equilibrium apparatuses he invented to ground his derivation of the force law at the heart of his electrodynamics.

Keywords. Equilibrium experiments, Electrodynamics, Serendipity, Romanticism.

Note. This article follows a presentation by the author at the conference "250 Years of Ampère: An Electric World Tomorrow?", held on December 11–12, 2025, in Lyon.

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1. Introduction: Ampère's complex mentality

While historians of science understandably emphasize André-Marie Ampère's scientific accomplishments, his complex personality has always been an additional source of interest. For example, although his devout Catholicism sometimes wavered, Ampère always remained convinced that divine providence played a crucial role in his life. He was often dismayed when his ambitions and desires were thwarted by what he considered to be a supernatural intervention, and he was plagued by anxiety over how his conduct might have merited these setbacks. Ampère's response to providential events was conditioned by his mercurial personality, torn between romantic inclinations to emotional exuberance on the one hand and the competing demands of intellectual rigor on the other. This essential tension in his character is a large part of what makes Ampère a fascinating historical figure [1–3]. Another way to express this duality is to say that he was a unique product of both early nineteenth-century French romanticism and the scientific milieu of mathematical physics we associate with more single-minded personalities such as Cauchy, Laplace, Poisson, or Biot.

With this context in mind, it is noteworthy that the impetus for Ampère's most creative scientific work, the experimental exploration and mathematical formalization of a new branch of physics he called electrodynamics, came at a most propitious time, a point in his life when his romantic and analytic inclinations were in a rare state of harmony. This turning point came in 1820 when Ampère was informed of Hans Christian Oersted's discovery that a suspended magnet changes its orientation in proximity to an electric current. He immediately began his own research and soon demonstrated that electric current bearing wires either attract or repel each other depending upon the direction of the currents. Had Oersted's revolutionary discovery come at a different time than it did, Ampère might very well not have been in a position to take up this research and carry it out so brilliantly.

Let us first consider in more detail the two facets of Ampère's mentality. On the one hand, in addition to his highly volatile personality, Ampère had many other characteristics usually associated with a romantic temperament. In keeping with Rousseau's skepticism about materialism and technological progress, nineteenth-century romantics reacted against the artistic conventions of neo-classical art and musical classicism, the imperialism of Napoleon, and the dehumanizing aspects of the industrial revolution. Perhaps most importantly, Romanticism represented a reaction against Enlightenment ideals of objectivity, predictive power, quantitative analysis, and mechanical cause and effect determinism. With an acute awareness of the limits of reason, Romantics called attention to emotion, freedom, subjectivity, spirituality, unpredictable individualism, and nostalgia for an idealized past. Ampère was drawn to many of these attitudes. He maintained a preference for bucolic rural environments rather than urban modernity. He shared with his philosopher friend Maine de Biran an introspective disposition for metaphysics and moody psychological analysis. Although periodically tempted by the deism typical of Enlightenment figures such as Voltaire, Ampère was resolute in his rejection of materialism in favor of a tenuous but devout commitment to Catholicism and some receptivity to the intervention of supernatural providence. While heaven is sometimes thought of as a peaceful state of resolution, for Romantic Catholics such as Ampère, striving for an unattainable sanctity typically resulted in a life of anxiety plagued by doubt and guilt. The image he often presented to public scrutiny was that of a bemused eccentric, largely indifferent to social norms and the practical concerns of daily life. The traumatic loss of his father to the guillotine in 1793 and the early death of his beloved wife Julie Carron in 1803 are well-known episodes in the early life of Ampère, and they left permanent emotional scars. His innate sensitivity later made him ill at ease in the competitive social and scientific environment of Paris. All these characteristics make Ampère an obvious candidate for the "romantic" label.

But this designation must be tempered by recognition of another facet of Ampère's personality, his atypical aptitude and passion for mathematics and mathematical physics and his ability to compartmentalize these interests and pursue them with minimal input from his romantic inclinations. As a childhood prodigy, especially in mathematics, he was immediately recognized as a remarkably brilliant intellect. For those who have experienced a formal institutional education, it is difficult to imagine the intellectual freedom of Ampère's childhood. His literally "encyclopedic" reading in his father's library may have been partly responsible for his lifelong fascination with classification schemes and his inclination to abruptly shift the focus of his investigations in response to his eclectic interests rather than more pragmatic obligations.

2. Ampère in 1814

In addition to his own state of mind, Ampère's reaction to scientific opportunity was of course also affected by circumstances beyond his control. The pivotal moment of his scientific career came at a particularly opportune time in 1820. It was at that point, in response to Oersted's discovery of the mutual interaction between an electric current and a magnet, that Ampère began investigations into what he would call the science of electrodynamics. It has been a persistent puzzle among historians to account for his amazing creativity in so rapidly laying the foundations for this new branch of physics. His metaphysical presuppositions, his outsider status with respect to the predominant Laplacian paradigm for French physics, and his enthusiastic investigation of what historian Friedrich Steinle has called "exploratory experiments" have all been appropriately documented as contributing factors [4–7]. However, there was a providential timing to Oersted's discovery that was also highly significant. As an historical exercise, consider how difficult Ampère's response would have been if this discovery had come just six years earlier in 1814. The detrimental factors he would have had to overcome fall into several categories.

1814 was of course the year prior to Napoleon's final defeat. Ampère followed the events leading to the fall of the Empire very closely and his dread of the future of France and the human condition in general kept him in an even more heightened state of anxiety than usual. On a more personal level, his domestic life had degenerated due to his rash 1806 marriage to Jeanne Potot, a woman Joseph Janin once described as a "pimbêche prétentieuse" [8, p. 15]. The marriage was an unmitigated disaster and promptly dissolved into prolonged legal proceedings over their daughter Albine, born on 6 July 1807 and initially treated with shameless indifference by her mother. But 1814 also included the painful ending of another romantic relationship with a woman Ampère referred to in correspondence only as *la constante amitié*. Ampère seems to have adopted this term due to his fascination with an engraving by that name based upon a painting by Jean-Baptiste Mallet [9, vol. 1, p. 373]. Ampère's angst concerning the complicated nature of his breakup with this woman may have driven him to thoughts of suicide. In a letter to his Lyon friend, Claude-Julien Bredin, on 14 March 1814 he referred to "ce jour affreux" and reassured Bredin that "Je te reverrai, j'en suis sûr à présent. Ne crains rien pour ma vie !" [9, vol. 2, p. 465]. Although Ampère's penchant for dramatic language may have given the impression that he was closer to suicide than he actually was, he was clearly burdened by a severe and debilitating sense of guilt over how this affair ended. He found some consolation in believing that "aucune volonté humaine n'a prévu ni ordonné de cet événement; mais il est une volonté toute puissante qui a appesanti sur moi les coups de sa vengeance. Ah ! sans doute je méritais ce qui m'est arrivé, puisqu'elle l'a permis" [9, vol. 2, p. 465].

In addition to his personal turmoil, Ampère's efforts to make a significant contribution to philosophy had reached a turning point by 1814. Throughout the previous decade he had participated in vigorous discussions of Kant's *Critique of Pure Reason*, the new German epistemology that was under scrutiny in France. Although Ampère agreed with the consensus among French philosophers that innate ideas should not be posited and that knowledge originates through sensation, he was driven by an obsessive need to justify knowledge that is not limited to subjective phenomena. In his lengthy correspondence with Maine de Biran, he persistently argued that the discovery of relations (*rapports*) among phenomena, especially when mathematically expressed, can serve as a bridge from the subjectivity of sensations to an objective reality he referred to as the world of *noumena*, adopting a term from Kant. He found it very difficult to find a convincing justification for this "structural realism", as it has been termed [10]. His efforts included analysis of faculty psychology together with dubious speculations that the spatial aspect of sensation suggests a physiologically based alternative to Kant's analysis of space and time [10, pp. 247–248]. In response to criticisms from Maine de Biran and an enthusiastic disciple of Kant, Sébastien Falquet de Planta [11], Ampère was forced to retreat to a contingent hypothetical assertion of the desired analogy between phenomenal and noumenal relations. By 1814 his argument amounted to the claim that only some form of realism could adequately explain the empirical success of science. This meant that the justification of one of his strongest philosophical convictions was contingent upon confirmation by the development of successful scientific theories. Consumed as he was by these metaphysical issues, Ampère was severely distracted from concentrating on the scientific research he needed to justify his own epistemology.

During the first half of 1814 it appeared that chemistry might be the domain in which this support would come, and Ampère threw himself into the debates of the day with his customary passion. Unfortunately, his outsider status with respect to the highly centralized and competitive community of chemists in Paris ensured that his insights into the discovery of new elements were marginalized. Furthermore, during the waning days of the Empire, his interactions with the British chemist Humphrey Davy were frowned upon and further isolated him. Once again, Ampère saw the workings of providential retribution as he explained in another letter to Bredin in February 1814 [9, vol. 2, pp. 458–459].

> La malédiction du ciel semble attachée sur moi ; mais c'est toujours par ma faute, que je me suis précipité dans le malheur. Toujours je ne sais quelle providence me mettait dans une situation qui m'éclairait, qui me donnait le temps de réfléchir, et ensuite un événement subit me venait entrainer dans le moment où je semblais n'avoir plus rien à craindre.

He did manage to publish one 1814 paper on molecular structure and atomism in the *Annales de Chimie*. Because of the geometric foundation of his approach, he had high hopes that it was destined to advance his metaphysical program. Ampère posited a "representative form" for each particle of a chemical element or compound, a polyhedron with atoms ("molecules" in Ampère's 1814 terminology) located at each vertex. For the simplest of these forms, Ampère drew upon the "primitive forms" Haüy had discovered in his study of crystallography. As a purely mathematical set of relations, this model was ideally suited to illustrate Ampère's belief in a scientific bridge between the phenomenal and noumenal worlds. By studying how his geometrical particles could be superimposed and combined to agree with empirical data such as Gay-Lusaac's law of combining volumes for gases, Ampère essentially tried to reduce chemistry to a branch of geometry. Unfortunately, although he did manage to construct appropriate geometrical models for some relatively simple chemical reactions, his approach was of little value for more complicated cases, and it generated little interest.

Ampère partially overcame this disappointment by turning to mathematics during the second half of 1814. Despite his innate mathematical ability, he rarely pursued pure mathematics except for pragmatic purposes of career advancement. This was certainly the case in 1814. In desperate need of publications to support his candidacy for an opening in the mathematics section of the First Class of the *Institut National*, Ampère wrote three significant mathematics papers and submitted them on 11 July, 12 September, and 17 October 1814. After several months of trepidation, he was elected as a member of the mathematics section on 28 November. His papers involved highly technical analysis and classification of partial differential equations, a branch of mathematics Ampère had not published previously. They required some intense concentration on his part, and he complained that the time and energy they consumed would have been more productively spent on philosophy and chemistry.

One more important facet of Ampère's state of mind in 1814 concerned his religious faith. Ampère's son, Jean-Jacques, recalled that his father often insisted that the celebration of his first communion was one of the three most influential events of his childhood [12, p. 67]. Nevertheless, his faith was intermittent after that point. Raised in a devout home, he had a crisis of faith just prior to his first marriage but was reconciled during his last years in Lyon. This was the period in which he participated in the *Société chrétienne* and wrote some of his most quoted expressions of personal piety. In one famous example, probably written in 1805 shortly after his move from Lyon to Paris, Ampère pleaded with himself to reach a state of harmony in which his spiritual and intellectual impulses would be in equilibrium [9, vol. 2, p. 541].

> Étudie les choses de ce monde, c'est le devoir de ton état ; mais ne les regarde que d'un œil ; que ton autre œil soit constamment fixé sur la lumière éternelle !

Ampère did not always achieve this goal of balance and moderation, but he did acknowledge it as an ideal to be sought. Although he would return to Catholicism by 1817, in 1814 he was spiritually adrift. This state did not sit well with him, and he agonized that it was in some way responsible for his personal and professional setbacks.

So, let us return to our hypothetical question: would Ampère have been able to successfully devote himself to electrodynamics if Oersted's discovery had come in 1814, just six years earlier than it did? The evidence indicates that he would have been in no position to do so. Untethered from the religious mooring of his youth, entangled in romantic and domestic drama, embroiled in complex disputes with chemists and philosophers who denied his relevance, and compelled to publish detailed memoirs on partial differential equations in pursuit of election to the *Institut*, Ampère was too overwhelmed to do justice to an additional agenda in 1814, especially in a competitive environment in which every such opportunity was seized upon by experienced researchers intent upon their own career advancement.

3. Ampère in 1820

By 1820 Ampère's life had taken on a new stability that contributed to his more optimistic frame of mind. In 1818 he reluctantly sold his property in Poleymieux and purchased a home at 19 rue Fossés-Saint Victor near the École Polytechnique. With his legal disputes with Jenny Potot resolved and no longer interested in additional romantic entanglements, Ampère enjoyed a temporary period of domestic tranquility. His unmarried sister Joséphine took care of his household and helped nurture his daughter Albine and his son Jean-Jacques. Both children would cause him considerable consternation in the future, but these developments were unforeseen in 1820. He also periodically rented out a room to academic boarders who provided the scientific and philosophical conversation he craved.

With his election to the mathematics section of the Institut secured in 1814, Ampère was no longer burdened by publishing demands in a field he found uninspiring. He did write some short mathematical analyses when a topic sparked his interest. In 1816 he also wrote an idiosyncratic chemistry memoir in which he set out to provide a "natural" classification of the 48 recognized elements into fifteen *genres*. Due in part to his lack of attention to the issue of atomic weights, this memoir generated even less interest than his 1814 paper. Ampère's frustrated efforts to revolutionize chemistry came to an end at this point and he admitted in a letter to Bredin "dans les sciences je ne puis prendre un vif intérêt qu'aux travaux qui se présentent comme pouvant en changer la face à quelques égards" [9, vol. 3, p. 887].

Ampère's return to his Catholic faith was particularly fortifying during this period. In one of several devotional passages written during 1817 and 1818, he pledged to remain faithful [9, vol. 2, p. 533].

> Dieu m'a révélé aujourd'hui 5 octobre, 19^{e} dimanche après la Pentecôte, à quoi tenait mon salut éternel [...] Grand Saint Joseph, à l'intercession duquel je dois surtout cette grâce, Sainte Marie, mère de Dieu dont j'ai reçu le nom à mon baptême et à qui j'ai aussi ce don inexprimable [sic], intercédez toujours auprès de Dieu pour qu'il me le conserve et pour que je m'en rende digne !

As Charles Braverman has pointed out, Ampère's renewed faith also helped him to reconcile himself to the inconclusive status of his philosophical efforts [10, p. 195]. His failure to provide a convincing argument for his structural realism was set aside in favor of a more pragmatic acceptance of it as a *de facto* methodology supported by both scientific progress and a belief in divine providence. Rather than continue to try to establish his realism metaphysically, Ampère subsumed it into the four "points of view" through which he eventually structured his classification

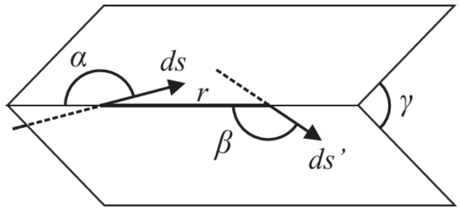

Figure 1. The geometry of the mutual orientation of two current elements.

of the sciences in his 1834 *Essai sur la Philosophie des sciences*. This project was just beginning in 1820, and it would benefit from Ampère's experience creating electrodynamics during the 1820s.

Ampère certainly never lost the emotional intensity that was one of his innate characteristics. In 1826 when he was 51 years old, Ampère burst into tears when an experiment he had designed to support his theory of magnetism did not give the result he had predicted. Shortly thereafter, when Jean-Daniel Colladon paid a midnight visit to inform him that a revised version of the experiment had succeeded, Ampère insisted upon immediately marching to the Collège de France demonstration room to witness the result in person [13, p. 119]. But this enthusiasm was simply an expression of the exuberance Ampère brought to scientific investigation and life in general; beneath this superficial turbulence he was closer to an overall state of equipoise than he had been for many years.

Immediately following Oersted's discovery and his own investigation of forces between current carrying wires, Ampère launched into an ambitious effort to reduce all electrodynamic phenomena to their most basic constituents. A crucial stage in that project was his determination of an expression for the electrodynamic force between infinitesimal electric circuit elements. Ampère eventually formulated the strength of this force as:

$$r^{-2}(\sin\alpha\sin\beta\cos\gamma - \tfrac{1}{2}\cos\alpha\cos\beta)\,\mathrm{i}\,\mathrm{d}s\,\mathrm{i}'\,\mathrm{d}s'$$

As shown in Figure 1, $\mathrm{d}s$ and $\mathrm{d}s'$ are two tiny circuit elements of currents with strength i and i' separated by a distance r; α, β and γ are angles that depend upon the mutual orientation of $\mathrm{d}s$ and $\mathrm{d}s'$ [14, Figure 2.15a, p. 45].

Applications of this electrodynamic force law to complicated arrays of circuits and magnets was the crux of Ampère's research program. In his most comprehensive electrodynamics publication, his 1826 *Théorie des phénomènes électro-dynamiques, uniquement déduite de l'expérience*, Ampère would base his derivation of the force law on four experimental demonstrations, each of which displayed a static state of equilibrium in which all the acting electrodynamic forces cancel each other out and leave a potentially mobile part of the apparatus stationary. These equilibrium demonstrations were unusual in that they did not involve the recording of any quantitative data. Instead, a potential state of equilibrium is designed, and when it is observed experimentally, mathematical consequences are drawn from an analysis of the balanced forces in play.

Ampère designed the first of these equilibrium demonstrations in December 1820. In the final version of the equipment, as shown in Figure 2, a potentially mobile rectangular circuitry **GCDHG** is suspended and is free to rotate around a vertical axis through **FI**, and the segment **GH** is exposed to two electrodynamic forces, one due to a current in a straight vertical wire **QP**, and the other due to another vertical current **SR** in a wire twisted into a series of small "sinuosities". These two vertical wires are located at equal distances from the vertical portion **GH** of the suspended circuitry **GCDHG** and repel it in opposite directions [15, Planche 6, Figure 16].

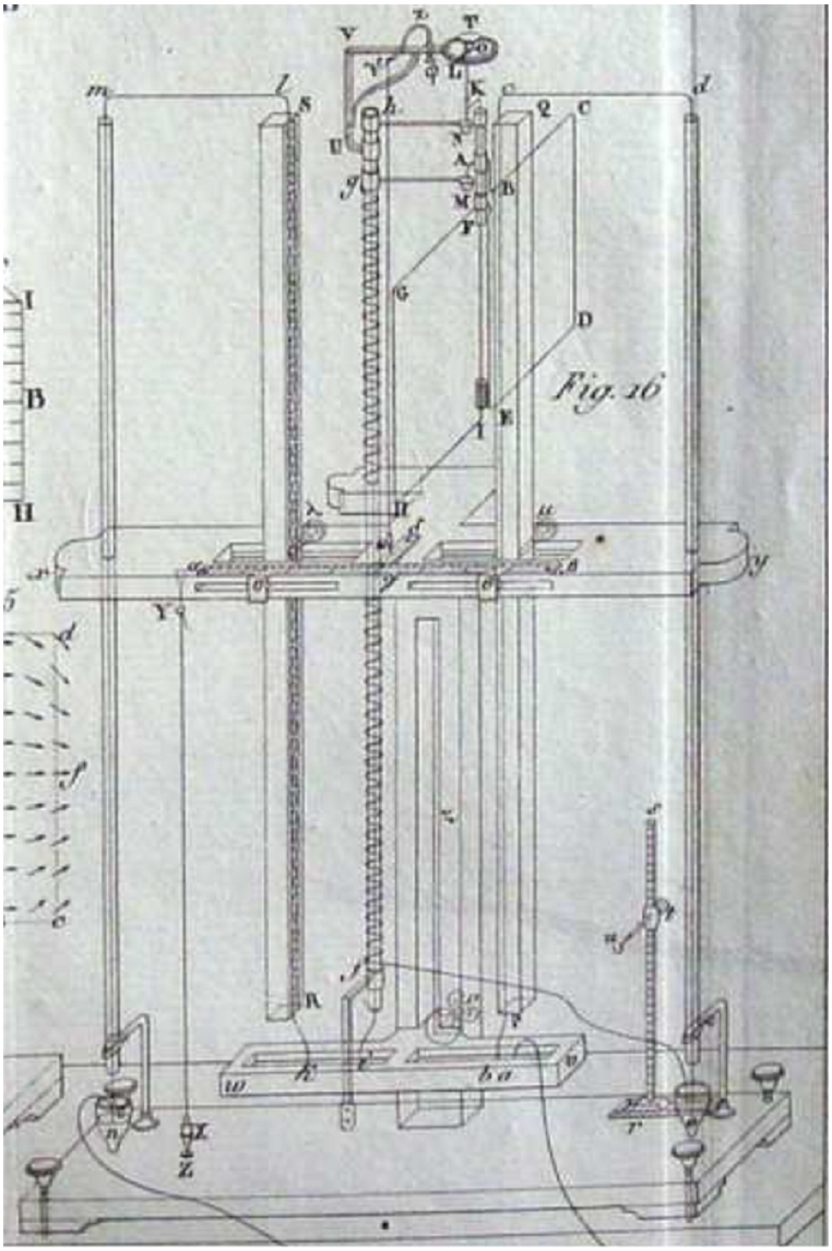

Figure 2. The final design of Ampère's first equilibrium apparatus.

If the two oppositely directed forces acting on **GH** are of equal magnitudes, the rectangular suspended circuitry **GCDHG** will remain in equilibrium and will not rotate. Following his successful demonstration of this phenomenon, Ampère could incorporate a mathematical expression of the observed state of equilibrium into a derivation of his electrodynamic force law between current elements [16, pp. 77–82]. Although Ampère did not immediately make equilibrium demonstrations his preferred mode of argumentation, he continued to design and revise them until they eventually became the foundation of his 1826 *Théorie des phénomènes électrodynamiques.*

4. Conclusion

The conceptualization and successful operation of the apparatus shown in Figure 2 were important accomplishments during an early phase of Ampère's most creative period of research. However, in addition to the scientific import it had during the 1820s, the equilibrium demonstration can be given symbolic significance as well. From our perspective 250 years after Ampère's birth, his first equilibrium demonstration is symbolic of an elusive state of emotional stability that Ampère rarely achieved. Just as his electrodynamic apparatus maintained equilibrium only if the forces in action were balanced, so too Ampère occasionally found himself in a healthy state of equipoise when his romantic and rational impulses were synchronized and his religious, philosophical and scientific impulses were in harmony. Fortunately, this was the case in 1820, and Ampère was ideally positioned to focus his energy on electrodynamics, driven by what his son Jean-Jacques called his characteristic "soif de certitude" [12, p. 12]. He may never have recovered the happiness he experienced during brief periods of his youth in Poleymieux, but he did accomplish a remarkably innovative contribution to scientific inquiry, facilitated by the fact that Oersted's suggestive discovery came at the providential time that it did.

Declaration of interests

The author does not work for, advise, own shares in, or receive funds from any organization that could benefit from this article, and has declared no affiliations other than their research organization.

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