Editor's Introduction: I. Writing Modern Art and Science – An Overview; II. Cubism, Futurism, and Ether Physics in the Early Twentieth Century

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the X-ray), the Surrealists and quantum phenomena, and the Italian artists in the 1950s who committed themselves to atomic and nuclear art.

II. Cubism, Futurism, and Ether Physics in the Early Twentieth Century

Returning to the question of Cubism and science leads us to another key moment in the history of modernism's engagement with the invisible and imperceptible, which forms a leitmotif within this issue of *Science in Context*. In order to determine the parameters of "what it was possible to imagine" (Harrison 1993) for an artist like Picasso in the pre-World War I era, we need to investigate the visual evidence of his Cubist works (e.g., the *Portrait of Kahnweiler* of 1910 [fig. 2]) within the cultural field of avant-garde art writing, popular scientific literature, and even occult sources in this period. Unfortunately, Picasso himself remains an elusive subject, a painter's painter who wrote no statements of his artistic ideas in this period – in contrast to the Salon Cubists Albert Gleizes and Jean Metzinger, Duchamp, or the Italian Futurists, such as Umberto Boccioni (see his 1913 drawing *Muscular Dynamism* on the cover of this issue).[49] Like Duchamp, whose extensive notes for the *Large Glass* provide a useful guide to science as popularly known in prewar Paris, Boccioni was actively engaged with contemporary science. As he queried in a diary entry of 1907, "How, where, when can I study all that chemistry and physics?" (Coen 1988, 257).[50] Thus, chronicling Boccioni's visual and verbal responses to contemporary science serves as a useful counterpoint to an examination of Picasso's Cubism, given the considerable artistic and literary exchange between Paris and Milan.[51]

For Picasso the case will necessarily be more circumstantial. Yet an artist hardly needed to have had the specific interest in science of Boccioni or Duchamp, since the exhilarating new ideas issuing from contemporary science were readily available in popular journals, newspapers, and books as well as responses to these phenomena in avant-garde literature.[52] In addition, the presence of the erudite poet Guillaume Apollinaire in Picasso's circle and the record of his library provide important clues to ideas that may have been present within Picasso's milieu, which also included the poet Max Jacob, the poet and critic André Salmon, and the salon of Gertrude Stein.

[49] On the interests of the Salon or "Puteaux" Cubists, see, e.g., Henderson 1983, Antliff and Leighten 2001. Metzinger, initially a member of Picasso's circle, formed a bridge between the two groups. On Duchamp's relation to the Salon Cubists, see Henderson 1998. For Boccioni, see, e.g. Coen 1988.

[50] For Duchamp's interest in science, see again n. 43 and the related text above.

[51] On the interconnections, see, e.g., Martin 1969, in which Futurism's founder F. T. Marinetti is described as "practically commut[ing]" between Milan and Paris. Boccioni's fellow Futurist Gino Severini lived in Paris from 1906 onward and married the daughter of French poet Paul Fort, around whom the avant-garde gathered. See Antliff and Leighten 2001, 20–22. Boccioni and his fellow painters visited Paris in October 1911 and met both Picasso and the Salon Cubist circle.

[52] For the literary response to new developments in science and technology, see, e.g., Henderson 1998, 98–100.

Fig. 2. Pablo Picasso, *Portrait of Daniel-Henry Kahnweiler*, 1910, oil on canvas. Art Institute of Chicago, Gift of Mrs. Gilbert W. Chapman in memory of Charles B. Goodspeed. © 2004 Estate of Pablo Picasso/Artists Rights Society (ARS), New York. Photo: Art Institute of Chicago.

Before investigating Picasso, we need to de-familiarize his Analytical Cubist works such as the *Portrait of Kahnweiler*, which have come to look so natural to us in the last fifty years, hanging on the walls of collections of modern art. Since mid-century we have tended to see Cubist painting through the formalist art historical explanations of its evolution as a logical, internal stylistic development, resulting from the lessons Picasso and his collaborator Georges Braque learned from the art of Paul Cézanne and African art.[53] Hence, from Cézanne came the initial geometrical orientation and denial of one-point perspective and from African art, the powerfully simplified forms and, ultimately, the conceptual sign language that enabled Picasso to communicate information about a sitter in the same way a caricaturist distills a subject's key characteristics. Yet, while the stylistic explanation is convincing for early Cubist painting, by later 1909 or 1910, such radical changes occur that artistic sources alone are no longer adequate. More recent scholarship has gone a considerable way toward recovering Cubism's larger cultural context, including the fourth dimension, the philosophy of Henri Bergson, and contemporary politics, but there are still basic questions posed by paintings such as the *Portrait of Kahnweiler*. *Why* would Picasso and Braque so stubbornly deny the solidity and boundaries of forms, causing their sitters to dissolve into the surrounding space? The two painters always considered themselves realist painters, with Picasso explaining later, "I paint objects as I think them, not as I see them" (Gómez de la Serna 1929, 100). *What* can Picasso have been thinking or imagining about the nature of reality?

Over two decades before the public in France first heard of Einstein and Relativity Theory, the decade of the 1890s witnessed a series of scientific discoveries that successively challenged conventional notions of matter and space. These widely discussed developments included Wilhelm Conrad Röntgen's discovery of the X-ray in 1895, Henri Becquerel's discovery of radioactivity in 1896 (extended by the subsequent work of Marie and Pierre Curie as well as Ernest Rutherford), J. J. Thomson's identification of the electron in 1897, and the subsequent establishment of wireless telegraphy based on the electromagnetic waves Heinrich Hertz had identified in 1888.[54] The existence of invisible realms just beyond the reach of the human eye was no longer a matter of mystical or philosophical speculation; it had been established empirically by science. Madame Curie asserted in regard to radioactivity in 1904, "Once more we are forced to recognize how limited is our direct perception of the world around us" (Curie 1904, 461).

Röntgen's discovery of the X-ray caused the greatest popular scientific sensation before the explosion of the atomic bomb in 1945 (Badash 1979, 9). Rendering matter transparent, X-rays made previously invisible forms visible. Even more importantly,

[53] For that narrative, which was promulgated in Museum of Modern Art publications by Alfred Barr and William Rubin, see, e.g., Fry 1966. For a thorough, step-by-step tracking of the evolution of Picasso's Cubist style, see, e.g., Karmel 2003.

[54] For these developments, see, e.g., Keller 1983, Kragh 1999; for their popularization, see Henderson 1998.

however, the X-ray definitively demonstrated the inadequacy of the human eye, which detects only a small fraction (i.e., visible light) of the much larger spectrum of vibrating electromagnetic waves then being defined.[55] As the astronomer Flammarion argued of X-rays in his 1900 book *L'Inconnu*, "[I]t is unscientific to assert that realities are stopped by the limits of our knowledge and observation" (Flammarion 1901, 14). On a practical level, X-rays were quickly adopted in medical practice, and photography journals touted X-ray photography as the natural extension of the amateur photographer's activity. And the massive amount of popular literature on the subject – including articles, books, songs, cartoons, poems, and cinema – kept X-rays and their subsequent development in the news well into the first decade of the new century (see Glasser 1934, chap. 6; Knight 1986; Henderson 1988).

X-rays offered a radically new way of seeing, breaking down the barrier that the skin had always represented between outer and inner. That same transparency and fluidity are evident in Picasso's portrait of his dealer Daniel-Henry Kahnweiler, a shift the sitter himself described around 1915 as "pierc[ing] the closed form" or "skin" (Kahnweiler 1949, 10). Here was a new kind of light that allowed a painter to go beyond the preoccupation of earlier artists with surface appearances. Kahnweiler also noted that Picasso considered traditional modeling with visible light and shade to be a dishonest "illusion" (Kahnweiler 1949, 11; Karmel 2003, 12). Beyond the ubiquity of the X-ray in popular culture, Picasso was an amateur photographer and would have encountered the advocacy of the new X-rays as "photography of the invisible" in photography journals. Further, as John Richardson has documented, Picasso's companion, Fernande Olivier, was X-rayed in a hospital in January 1910. And in 1917 Picasso queried in one of his sketchbooks, "Has anyone put a prism in front of X-ray light?" (Richardson 1996, 158). All of this is not to suggest that Picasso's images derive from X-ray photographs, but rather that Cubist painting employs the general model of penetrating vision as well as the characteristics of transparency and fluidity suggested in X-ray images.[56]

Although, in contrast to Picasso's static sitter, Boccioni's *Muscular Dynamism* depicts a figure in motion, the Futurist's drawings and paintings of this period exhibit a similar fluid relationship of figure and space. It was Boccioni who had made the first published mention of X-rays in relation to avant-garde painting, declaring in the 1910 "Technical Manifesto of Futurist Painting": "Who can still believe in the opacity of bodies . . . ? Why should we forget in our creations the doubled power of our sight, capable of giving results analogous to the X-rays?" (Boccioni 1973, 28). Subsequently, he asserted in 1911, "What needs to be painted is not the visible but what has heretofore been

[55] Although Röntgen and others suspected that the new rays were electromagnetic waves akin to visible light and Hertzian waves, the wave-nature of X-rays would be confirmed experimentally only in 1912. Popularizations of X-rays often included tables or diagrams charting the ranges of known and unknown invisible radiations surrounding the narrow band of visible light perceptible to the human eye (e.g., Snyder 1903, 119).

[56] For theorists of Cubism such as Gleizes and Metzinger, who had been close to Picasso in 1909–10, such profound, expanded seeing was a central feature of the new style (see, e.g., Henderson 1988, 335–36).

held to be invisible, that is, what the clairvoyant painter sees" (Coen 1988, 239). Given the Futurists' connections to activities in Paris, Boccioni's comments testify to the international currency of the new focus on the invisible as well as occultism, in which Boccioni was deeply interested.[57]

The interpenetration of matter and space in the works of both Picasso and Boccioni would have been encouraged equally in this period by popular fascination with radioactivity. With the Curies' isolation of two new radioactive elements, polonium and radium, in l898 and Ernest Rutherford's subsequent formulation of the theory of radioactive decay in 1902–3, radioactivity captured the attention of the general public (Badash 1979). Radioactive substances produced yet another kind of invisible emissions – alpha, beta, and gamma "rays" (actually particles in the case of the alpha and beta emissions) – and, in the process, actually changed their chemical composition, releasing energy. In contrast to the traditional image of matter as stable and constant, the continuous emission of particles by radioactive substances suggested a vibrating realm of atomic matter in the process of transformation. In his best-selling books, such as *L'Evolution de la matière* (1905), scientific popularizer Gustave Le Bon argued that *all* substances were radioactive and that matter was only "a stable form of intra-atomic energy" in the gradual process of decaying back into the ether of space around it (Le Bon 1905, 9; see also Le Bon 1906).[58] Le Bon was a friend of the philosopher Henri Bergson, whose import for the Cubists and Boccioni has been well established. Also, certain of Bergson's views stand as counterparts to Le Bon's popularization of universal radioactivity (see, e.g., Antliff 1993; Antliff and Leighten 2001, 80–93; Petrie 1974). In books such as *Matter and Memory* of 1896 and *Creative Evolution* of 1907, Bergson argued that the essence of reality was flux and that "all division of matter into independent bodies with absolutely determined outlines is an artificial division" (Bergson 1988, 196).

Anyone could observe the phenomena of radioactivity at home in the popular parlor toy, the spinthariscope, invented by Sir William Crookes in 1903. Holding this tiny cylindrical instrument fitted with a magnifying lens to the eye, a viewer could see the flashes of light produced when alpha particles from a speck of radium struck the zinc-sulphide screen within. In Picasso's *Portrait of Kahnweiler* figure and ground are unified by a shimmering, vibratory texture of brick-like Neo-Impressionist brushstrokes that likewise suggests atoms of matter disassociating into the surrounding space, itself already filled with such particulate emissions. Such images likewise deny the "independent bodies" Bergson had rejected in favor of reality as continuity and flux.

[57] On the Futurists' interest in the occult, particularly spirit photography, see Celant 1981.

[58] Lodge and Rutherford also mentioned the possibility of universal radioactivity in their popular writings (Lodge 1904, 386; Rutherford 1904, 284). On Le Bon, see Nye 1974. In a prescient article (Mitchell 1977), Timothy Mitchell pointed to Le Bon's possible significance for Cubism; however, without reconstructing the larger popular scientific context for Le Bon himself, this essay had little impact on Cubist scholarship at the time.

Boccioni's paintings of this period, such as his depiction of his mother entitled *Matter* of 1912 (Giovanni Mattioli Collection, Milan), are likewise executed in a tapestry of discrete brushstrokes with which he deliberately sought to convey the dematerialization of matter.[59] In his writings Boccioni spoke of "the electric theory of matter, according to which matter is only energy," a contemporary theory closely associated with the ether of space, which was also central to Boccioni's aesthetic (Boccioni 1975, 105).

Picasso need not have read Le Bon's best-selling books himself. His close compatriot Apollinaire owned a 1908 imprint of Le Bon's *L'Evolution de la matière* as well as Commandant Darget's book on how to photograph "fluido-magnetic" bodily emanations, such as the "Rayons V (Vitaux)," one of the numerous varieties of emissions and rays thought to have been discovered in the wake of X-rays.[60] In the context of contemporary views of photography as a revealer of the invisible, Picasso seems to have been fascinated by the intrusion into his own photographs of "noise" suggestive of invisible phenomena.[61] Like Boccioni, Apollinaire was deeply interested in occultism, and he owned a number of books dedicated personally to him by occultist Gaston Danville, including the latter's 1908 *Magnétisme et spiritisme* (Boudar and Décaudin 1983, 52). In fact, occult sources served in this period as an important means for the popularization of the new physics, with texts on the practice of Magnetism or on other sort of emissions often drawing on the latest developments in the physics of electromagnetism.[62] Given the Curies' prominence as French cultural luminaries and with Apollinaire close at hand, Picasso could hardly have been unaware of radioactivity's fundamental reorientation of basic conceptions of matter as well as its occult interpretations.

Along with radioactivity and Le Bon's talk of matter dematerializing into the ether, the recently discovered Hertzian waves of wireless telegraphy (as well as X-rays) focused popular attention on the invisible, impalpable ether of space. Space was not thought of as empty in this period, and the terms *space* and *ether of space* are often synonymous in the written record. The longstanding concept of a world-filling "aether" had returned to physics in the 1820s with Augustin Jean Fresnel's positing of a "luminiferous ether" as the necessary medium for the propagation of light waves. By the 1860s James Clerk Maxwell and William Thomson (Lord Kelvin) had concluded that a material ether must also be the source of and vehicle for electromagnetic fields.[63] Early conceptions of the imponderable ether ranged from a thin elastic jelly to a swirling fluid, and Kelvin

[59] For Boccioni's *Matter* in scientific and occult context, see Henderson 2002.

[60] On the rage for various new rays, see, e.g., Kragh 1999, 34–37. For Apollinaire's library holdings, see Boudar and Décaudin 1983. On Apollinaire and the occult, see Hicken 2002.

[61] See Baldassari 1997, 87, figs. 83, 84, 109. See also, e.g., Mareschal 1897, and Geimer 2000.

[62] For example, Albert de Rochas added fifteen appendices to his 1895 *L'Extériorisation de la sensibilité*, including recent writings by Lodge and Edwin Houston (for Rochas' book, see Houston [1895] 1909 in the list of References); see also Henderson 1998, 101–2; or Henderson 2002, 140–42).

[63] On the ether, see, e.g., Cantor and Hodge 1981, Harman 1982, Hunt 2002. For an excellent discussion of the ether as a fictional construct rooted in the commitment of nineteenth-century physicists to a model of

suggested that atoms might well be whirling vortices in the ether, akin to smoke rings. In the later nineteenth and early twentieth century, additional new functions were proposed for the ether, including its possible role as the source of all matter, as in the "electric theory of matter" propounded by Joseph Larmor and Sir Oliver Lodge and embraced in the writings of Boccioni and in Wassily Kandinsky's 1911 *Über das Geistige in der Kunst* (see, e.g., Lodge 1904; Kandinsky 1973, 40).

In order to transmit vibrating electromagnetic waves, including light, the mysterious ether required the rigidity of an elastic solid; at the same time, it must allow the free motion of bodies through it and be rarefied enough to flow through the interstices of even the densest matter. Le Bon noted the difficulty of discussing this "phenomena without analogy" (Le Bon 1905, 88); not surprisingly, the writing on the ether by both scientists and popularizers is filled with metaphor. The passage of the immaterial ether through matter was compared to water flowing through a sieve (Houston 1892, 489; Houston 1909, 232); yet the ether as the very source of matter made this relationship more complex. As science writer Robert Kennedy Duncan declared of this "vast circumambient medium" in 1905: "Not only through interstellar spaces, but through the world also, in all its manifold complexity, through our own bodies; all lie not only encompassed in it but soaking in it as a sponge lies soaked in water." Raising a basic question repeatedly encountered in popular literature in this period, Duncan declared, "How much we ourselves are matter and how much ether is, in these days, a very moot question" (Duncan 1905, 5; see also, e.g., De Launay 1908). The same year Le Bon in *L'Evolution de la matière* emphasized the ether's elemental role in nature:

> The greater part of physical phenomena – light, heat, radiant electricity, etc., are considered to have their seat in the ether. . . . All the theoretical researches formulated on the constitution of atoms lead to the supposition that it forms the material from which they are made. Although the inmost nature of the ether is hardly suspected, its existence has forced itself upon us long since, and appears to be more assured than that of matter itself. . . . Its role has become of capital importance, and has not ceased to increase with the progress of physics. The majority of phenomena would be inexplicable without it. (Le Bon 1905, 88–89)[64]

Historians of culture regularly treat Einstein's 1905 Special Theory of Relativity (if not the 1887 Michelson-Morley experiment's failure to detect an "ether wind" resulting from the earth's motion) as the death knell of the ether. However, not only did the general public not hear of Einstein's theories until 1919, the question of the existence of the ether was hotly debated among scientists skeptical of Einstein's theories during the 1910s and 1920s, with passionate defenses of the ether being made in scientific and

continuity in nature, see Benson 1984. The ether was discussed in a variety of French popular sources in addition to Le Bon's writings; see, e.g., De Launay 1908.

[64] Le Bon's book was still popular in 1911, when a translation was published in London and New York; see Le Bon 1911, 87–88.

popular literature, including in France.[65] Reflecting the mood of the ether's adherents, Sir J. J. Thomson declared in his Presidential Address before the British Association for the Advancement of Science in 1909, "The ether is not a fantastic creation of the speculative philosopher; it is as essential to us as the air we breathe. . . . The study of this all-pervading substance is perhaps the most fascinating duty of the physicist" (Thomson 1910, 15). Lodge certainly took that position, and his own BAAS Presidential Address, published as *Continuity* in 1913, along with his 1909 *The Ether of Space* and countless popular articles, kept the ether in the spotlight in England and the United States, as well as in France. In Einstein's Germany the ether also continued to be championed in the 1910s by scientists such as Gustav Mie, for whose electromagnetic theory of matter it was central.[66] Even with the ultimate scientific triumph of Relativity Theory sans ether, the concept possessed such a powerful grip on the cultural imagination that it lasted well into the 1920s and beyond.[67]

In the late nineteenth and early twentieth century the ether was the ultimate sign of continuity and signified a realm of continuous cohesion and diffusion, materialization and dematerialization, coursed through by forces and vibrating waves. Two later statements by Picassso are remarkably suggestive of this insubstantial realm. Speaking of his paintings of the period 1910–1912 he told curator William Rubin, "It's not a reality you can take in your hand. It's more like perfume – in front of you, behind you, to the sides. The scent is everywhere, but you don't quite know where it comes from" (Rubin 1972, 72). Some years earlier he had described his portrait of Kahnweiler to Françoise Gilot in similar terms: "In its original form it looked to me as though it were about to go up in smoke. But when I paint smoke, I want you to be able to drive a nail into it. So I added the attributes – a suggestion of the eyes, the wave in the hair, an ear lobe, the clasped hands – and now you can" (Gilot and Lake 1964, 73). Did Picasso resort to such language because the ether was no longer in common parlance as it had been? Significantly, the association of the ether with smells such as perfume appears in a contemporary text, Emile Durkheim's *The Elementary Forms of*

[65] In addition to Lodge, the ether's most stalwart defender (e.g., Lodge 1920), see, e.g., Magie 1912, 290–91; and Marshall 1914, 446. Although Paul Langevin championed Einstein in France, advocacy of the ether there continued into the 1920s; see, e.g., Glick 1987, 136–44.

[66] Lodge's publications were followed in France (see, e.g., De Launay 1908, 392). On Mie, see Kragh 1999, 117–19; and Corry 1999. Einstein himself found it necessary to define a "new ether" in his 1920 lecture "Ether and the Theory of Relativity." There he posited a "gravitational ether" without mechanical properties that "determine[d] the metrical relations in the space-time continuum" and could be identified with space itself. Einstein concluded with a statement subsequently quoted gleefully by the ether's proponents: "We may say that according to the general theory of relativity space is endowed with physical qualities; in this sense, therefore, there exists an ether. According to the general theory of relativity space without ether is unthinkable" (Einstein 1922, 20, 22–23).

[67] On literary responses to the ether, including that of D. H. Lawrence, see Clarke 2001, chap. 7. Leon Theremin christened his electronic musical instrument, premiered in 1920 and later termed a theremin, an "etherphone." On the numerous ether references that surrounded Theremin and his "ether wave music" – as well as radio, see Glinsky 2000.

the Religious Life of 1912. In discussing the powers of collective representations to take on "properties that do not exist in them," Durkheim concedes that sensations of smell, taste, and sight "do express the properties of particular material or movements of the ether that really do have their origin in the bodies we perceive as being fragrant, tasty, or colorful" (Durkheim 1995, 229).

The ether is probably the major lacuna in scholars' understanding of the early twentieth century worldview – both scientific and occult – and, hence, its importance for modernism in general. We need to be alert to its presence in writing of the period, although as in the Durkheim example, it may simply appear as a commonplace reference. Seen as both an ancient and a modern concept, the ether figured prominently in occultism, and there achieved another kind of ubiquity. Apollinaire himself responded to Theosophist Madame Blavatsky's writing on the subject, echoing her in a 1915 letter: "Is not every part of the material universe – including the immaterial ether – a microcosm?" (quoted in Henderson 1986, 228).

The ether, along with Bergson's philosophy, figures in Apollinaire's fellow poet Jules Romains's theory of collective consciousness, which he termed *Unanimism* (see, e.g., Martin 1969; Antliff and Leighten 2001, 93–95). In his 1908 prose poem *La Vie Unanime* Romains celebrated the experience of immersion in a vibrating, energy-filled ether on a Paris street. The section of the poem titled "Dynamism," which also speaks of "rays that cannot be seen to vibrate," begins with the epigram "*The present vibrates*" and includes this passage: "The current/crowd, which struggles to pass through/And gets hooked on the hedges of molecules, bleeds. The ripples of ether part, [vibrating] with excitement" (Romains [1913], 79). The Salon Cubists circle was close to Romains, and it has been argued that the presence of smoke in their paintings was an allusion to Unanimism's celebration of urban experience, an idea that takes on new significance in relation to the ether (Sund 1984).

The ether was also at the heart of Boccioni's artistic theory. At the conclusion of his 1914 treatise *Pittura scultura futuriste* Boccioni reveals the formative role of the ether as ultimate sign of continuity in his conception of the 1913 sculpture *Unique Forms of Continuity in Space* (fig. 3), for which *Muscular Dynamism* is a study (Henderson 2002, 133–38). Believing that "solid bodies are only atmosphere condensed," Boccioni here creates a remarkable image of successive muscular displacements that deny the boundaries of the body and leave traces or imprints on the surrounding ether, suggesting "ether drag." In his treatise Boccioni specifically equates the "materialization of the ethereal fluid, the imponderable" with "the unique form of continuity in space" (Boccioni 1975, 104). In the end, *Muscular Dynamism*, with its continuous interpenetration of figure and space, may be even more successful as a representation of the fluid continuity suggested by the ether (cover illustration).

Boccioni also related *Unique Forms of Continuity in Space* to the spatial fourth dimension. He appears to have thought of the sculpture alternatively as a four-dimensional entity passing through three-dimensional space and registering a succession of different appearances – "a continuous projection of forces and forms intuited in their

Fig. 3. Umberto Boccioni, *Unique Forms of Continuity in Space*, 1913, bronze. Museum of Modern Art, New York. Acquired through the Lillie P. Bliss Bequest. Digital Image © The Museum of Modern Art/Licensed by SCALA/Art Resource, NY.

infinite unfolding" (Boccioni 1975, 73). In defining a dynamic fourth dimension for Futurism in his 1914 treatise, Boccioni was claiming the fourth dimension for Futurism and reacting to the prominent role the spatial fourth dimension played in Cubist theory.

In contrast to later interpretations that attempted to tie Picasso's Cubism and Apollinaire's criticism to the temporal fourth dimension of Einstein's space-time world, Cubism's fourth dimension basically signified a suprasensible spatial dimension that might hold a truth higher than that of visible reality.[68] With its roots in *n*-dimensional geometry and with significations ranging from geometry and science to philosophy, mysticism, and occultism, the fourth dimension generated a huge amount of popular literature in Europe and the United States. In tandem with the scientific issues discussed above, the possible existence of an additional dimension of space would certainly have encouraged Picasso's bold pictorial invention. In the *Portrait of Kahnweiler*, for example, the geometrical faceting of objects suggests a more complex reality beyond immediate perception. Picasso's painting, in fact, shares with contemporary geometrical diagrams of four-dimensional figures differently shaded angular components in ambiguous spatial relationships as well as a sense of shifting views of an object fused into one (fig. 4). Ultimately, the interpenetration of form and space – derived in large part from contemporary scientific ideas – denies the possibility of reading the painting's space as three-dimensional.[69]

Discussions of Picasso and the fourth dimension have hinged on the presence in his circle of the insurance actuary Maurice Princet as well as Apollinaire's declaration in his *Les Peintres Cubistes* that the fourth dimension was part of the "language of the modern studios" (Apollinaire 1944, 12). According to Apollinaire's text, the fourth dimension offered artists a rationale for distorting or deforming objects according to a higher law and for rejecting three-dimensional, one-point perspective, which now seemed quite irrelevant (Apollinaire 1944, 12; Henderson 1983, 75–89). In their 1912 book *Du Cubisme* Metzinger and Gleizes also discussed Cubism's new mobile perspectives in relation to Henri Poincaré's advocacy of perception using senses other than vision, i.e., tactile and motor sensations, and his idea that "motor space would have as many dimensions as we have muscles" (Poincaré 1902, 72–73).[70]

Poincaré and Princet are crucial figures for Arthur Miller in his recent book *Einstein, Picasso: Space, Time and the Beauty That Causes Havoc*. In contrast to the numerous authors who have attempted to find direct links or correlations between

[68] Duchamp was the one early twentieth-century artists who actually explored four-dimensional geometry itself, and his playful response to the fourth dimension in various guises is central to the *Large Glass* project (see Henderson 1983, chap. 3; and Henderson 1998; see also Adcock 1983).

[69] For a fuller discussion of this issue, see Henderson 1983, 57–59. Artist Tony Robbin has made a careful analysis of the geometry in Jouffret's *Traité élémentaire* and argues convincingly in his forthcoming Yale University Press book that Picasso's *Portrait of Kahnweiler*, among other works, responds directly to Jouffret's technique of X-ray-like "see-through" views of complex four-dimensional solids. The moment when such formal comparisons are convincing is 1910-1911, unlike the case for an earlier impact made by Arthur Miller in *Einstein, Picasso* (see n. 71).

[70] For Gleizes' and Metzinger's discussion, see Herbert 1964, 8; see also Henderson 1983, 81–83, where this connection was first proposed. On Poincaré's importance for Cubism as well as Duchamp, see ibid., 71–73, 81–85, 93–99; chap. 4.

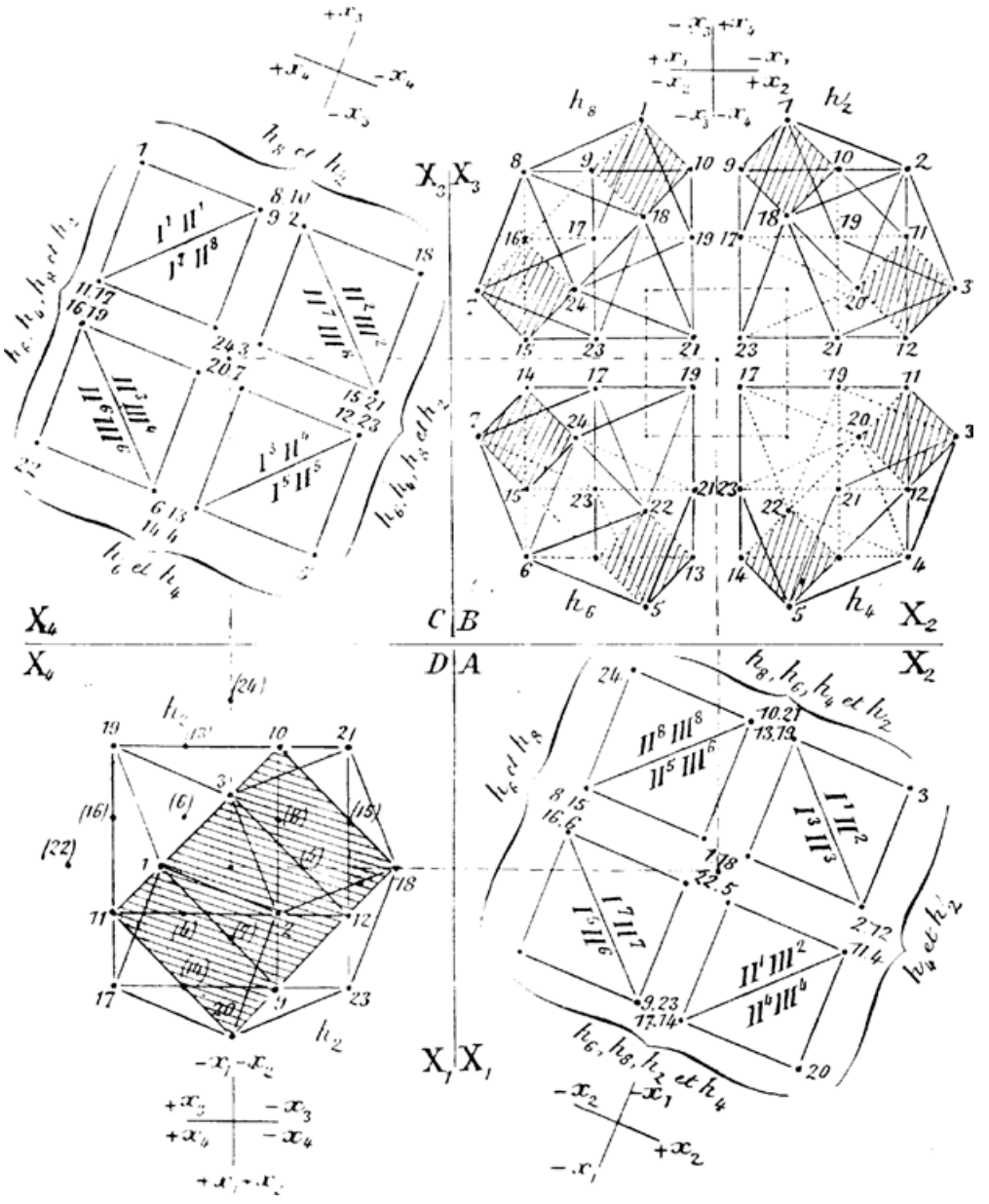

Fig. 4. "Plane projections of the sixteen fundamental octahedrons of the ikosatetrahedroid." From E. Jouffret, *Traite élémentaire de la géométrie à quatre dimensions* (Paris: Gauthier-Villars, 1903), fig. 40.

Picasso and Einstein, Miller explores the "parallel biographies" of the two, arguing for their common sources in the figure of Henri Poincaré and the field of four-dimensional geometry (via Minkowski and Poincaré for Einstein, via Princet for

Picasso).[71] Nonetheless, Miller's title still evokes for the potential reader the myth that some historical link existed between these cultural icons. As Duchamp observed in a 1967 interview, "The public always needs a banner; whether it be Picasso, Einstein, or some other" (Cabanne [1967] 1971, 26). From the vantage point of the 1960s, Duchamp was summing up a phenomenon he had observed developing since the 1920s: the emergence of the perception of Picasso as *the* modern artist and Einstein as *the* scientist of the twentieth century.[72] Duchamp was an especially sensitive witness to this, since he knew personally that the art world of prewar Paris – including Cubism – had involved a variety of artists, including himself, and that the science in question had not been Einstein's.

Along with Giedion's 1941 *Space, Time, and Architecture*, Apollinaire's *Les Peintres Cubistes* text on the fourth dimension played a definitive role in the emergence of the Cubism-Relativity myth in New York in the 1940s. Giedion had cited Apollinaire's discussion of the fourth dimension and identified it as time, even though the poet repeatedly referred to space (Giedion 1941, 357; Apollinaire 1944, 12). When *The Cubist Painters* was published in George Wittenborn's "Documents of Modern Art" series in 1944, its readers could easily have drawn a similar conclusion. Reflecting the goal of Wittenborn and series editor Robert Motherwell to establish modern art's legitimacy, the books of the series bore on the back cover a text emphasizing that modern art "assimilat[ed] the ideas and morphology of the twentieth century" and was "the expression of our *own* historical epoch" (Apollinaire 1944, back cover; italics mine). Here the stage was set for what became the classic confusion between Cubism *then* and science *now*. Kepes' references to space-time in his *Language of Vision* of the same year – along with Moholy-Nagy's even more influential celebration of Einstein and space-time as basic to understanding of modern life and art in his 1947 *Vision in Motion* – only exacerbated the situation.

By the 1940s both the spatial fourth dimension and ether physics had faded from popular consciousness, occluded by Einstein and Relativity Theory. Largely forgotten

[71] Miller, however, is too eager to identify the primary impetus for the development of Cubism as four-dimensional geometry, as preached to Picasso by the insurance actuary Princet. Miller places this moment too early (i.e., the *Demoiselles d'Avignon* in 1907) and gives too little credence to sources within art that were also driving Picasso's rethinking of painting. The image of Picasso simply as Princet's willing geometry student in 1907 is hard to accept, even for someone who believes the fourth dimension played a vital role in the subsequent evolution of the style. Any geometrically oriented form in 1907 is for Miller a sure sign of the impact of Princet and Poincaré – as is the mere mention of "tactility" by Picasso, Braque and anyone else (see, e.g., Miller 2001, 131, 165). In both cases he misses the central role of Picasso's artistic milieu, in which both African art and Cézanne encouraged the geometricizing of form and in which the issue of tactility in painting was a key concern, separate from Poincaré's discussions of "tactile and motor spaces" (Poincaré 1902, 72–73).

[72] The Cubism-Relativity myth also discouraged scholars from investigating the bonafide impact of Einstein and the "space-time" world of Relativity Theory after its popularization began in 1919. These sites of response ranged from 1920s Berlin and the Paris of the Surrealists during the 1920s–1930s to New York in the 1940s and the kinetic art scene that first coalesced in Paris in the 1950s. (Gamwell 2002, chap. 10, expands upon my initial work on space-time and art in the 1920s [Henderson 1983]). Parkinson 2005 provides the first detailed examination of the Surrealist response to Relativity Theory. The new introduction for the MIT reprint of Henderson 1983, to appear in 2005, addresses the impact of Einstein and space-time on artists in New York and Paris in the 1950s.

were the scientific heroes of the pre-World War I era in France: the Curies, Poincaré, and science popularizer Gustave Le Bon, as well as Röntgen, Rutherford, Lodge, and Crookes. Lodge and Crookes, along with Flammarion – with their openness to the occult and involvement in the Society for Psychical Research – are pointed reminders of the wider range of activities that were often classed as "science" in the late nineteenth and the early twentieth century. Occultists regularly drew on the latest science to support their causes, particularly in the linkages regularly made between X-rays and spirit photography, radioactivity and alchemy, telegraphy and telepathy, and, as noted earlier, electromagnetism and Magnetism.[73] Such analogies were also drawn from the side of science, as in Crookes' prominent declaration in his 1898 Presidential Address before the British Association for the Advancement of Science that "ether vibrations have powers and attributes equal to any demand – even to the transmission of thought" (Crookes 1899, 31).

That capability of vibratory thought transfer attributed to the ether was vital to the art theory of the painters Kandinsky and František Kupka, who conceived their abstract canvases as the source of vibrations meant to resonate in a viewer (see, e.g., Henderson 2002).[74] Similarly, the poet Ezra Pound responded to the theme of ethereal telegraphy/telepathy, comparing artists and poets to antennae "on the watch for new emotions, new vibrations sensible to faculties as yet ill understood" (Pound 1912, 500). As in the case of these modernists – along with the writings of Cubists, Futurists, and Duchamp – the operative words that emerge from analyzing early twentieth-century cultural discourse are not *space-time* and *relativity*, but rather terms such as *invisible*, *energy*, *ether*, *vibration*, and *fourth dimension*. Late classical ether physics – not relativity theory – was the armature of the cultural matrix that stimulated the imaginations of modern artists and writers before the later 1910s and 1920s. Scholars of early modernism in general will surely benefit by turning their attention to this long-eclipsed, but vitally important, moment in the history of science and culture. "Sifted science will do your arts good," James Joyce declared in *Finnegans Wake* (Joyce 1959, 440), and, as this issue of *Science in Context* demonstrates, many modern artists clearly agreed.[75]

[73] See again n. 62. For these pairings, see Henderson 1998.

[74] On Kupka's engagement with science, see also Musée d'Orsay 2003.

[75] For a sampling of contemporary artists who have responded to science, see, e.g., Kemp 2000. Among young twenty-first century artists nourished by science, some of the most inventive responses are those of artist Matthew Ritchie; see, e.g., the exhibition catalog *Matthew Ritchie: Proposition Player* (Herbert 2003). In a variation on the tradition of Duchamp, who took a job in a library in order to read, and Smithson, who purchased paperback books on science, Ritchie found his inspiration in students' cast-off textbooks while working as a building superintendent near New York University. Responding to "the exhilaration of connecting with knowledge," Ritchie explains, "I looked at things like high temperature physics and biology and the relationship between them that collectively forms what we would like to believe is an objective truth about the nature of our times. All that was cooking away in my brain, and then bizarrely enough, I decided to force it into the brightly colored waistcoat of contemporary painting" (see ibid., 17).

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