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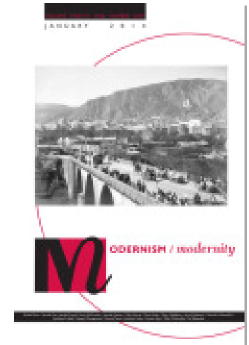

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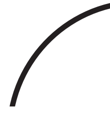

Poetry, Physics, and the Scientific Attitude at Mid-Century

Peter Middleton

The Mid-Century Poet

The mid-century American poet "is part of this world, socially aware," and therefore able to "construct an image around a bomb-sight and employ test tubes, tabloid headlines and X-rays as the natural props of poetry."[1] Poetry as news of war and peace was not news; what Rolf Fjelde, an editor of *Poetry New York*, thought was new was the expectation that a poet would be something of a scientist, perhaps what W. V. O. Quine drily called the "lay physicist."[2] Revealingly, Fjelde did not see any need to elaborate on what cultural changes had drawn poets to science; he apparently shared the widespread view endorsed by Wallace Stevens in his 1948 essay "Imagination as Value" that American poets were living in "a civilization based on science."[3] There was considerable evidence for this belief amongst poets. Fjelde was reviewing John Ciardi's anthology of *Mid-Century American Poets*, one of whose contributors, Karl Shapiro, writes as if to be an American is indeed to be a lay physicist. His "Elegy for a Dead Soldier" envisions the American future now lost to the dead man as: "The quantum of all art and science curled / In the horn of plenty" (perhaps echoing Ezra Pound's opening sentence to Chapter One of the *ABC of Reading*: "We live in an age of science and of abundance").[4]

Fjelde's optimism about the rapprochement between science and poetry looked well-justified at the time. He had after all, along with the other three young editors of the magazine, Keith Botsford, Roger Shattuck (who later edited the 'Pataphysics issue of *Evergreen Review*), and Harvey Shapiro, all Yale graduates,

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 chosen to publish in the same issue of *Poetry New York* an essay with the title "Projective Verse" by the then unknown poet Charles Olson calling for a new poetry based on "FIELD COMPOSITION."[5] This essay relied heavily on extended tacit analogies between poetry and nuclear physics to argue that poems should arrange their elements to create a field of forces held together in a "high energy-construct," a construction that sounds similar in principle to those other high-energy structures of the time, the synchrocyclotron and the atom bomb.[6] In addition to Olson's concept of the nuclear poem, Fjelde could look to plenty of other proximal examples of poetry engaging with science; the same issue of the magazine also contained an extract from Book IV of William Carlos Williams's *Paterson* comparing money to uranium, and arguing that we have a choice whether to employ its radioactivity as a destructive energy (a "hurricane"), or to use its "Beta rays" constructively in medical practice to "cure the cancer / —the cancer, usury."[7] Never mind that Williams had misremembered his physics, confusing the fluorescing electrons once called Beta Rays by their discoverers Ernest Rutherford and Paul Villard at the beginning of the twentieth-century shortly before Williams went to university, with the gamma rays or electromagnetic radiation actually used in nuclear medicine, the orientation of his metaphorics was clear. Poetry should look to the new physics for inspiration. Fjelde might also have been struck that one of the contributors to the Ciardi anthology, Richard Eberhart, wrote that through their reliance on imagination, "science and poetry join, as in Einstein's Unified Field Theory."[8] And another contributor, Muriel Rukeyser, had not only written a biography of the American chemist Josiah Willard Gibbs (whom Daniel Kevles describes as "one of the major theoretical physicists of the nineteenth century"),[9] in which she contended that "the world of the poet…is the scientist's world," she had also published in 1949 a book-length defense of poetry, *The Life of Poetry*, that called for a poetry modern enough to work with "the methods of science."[10] Olson, Williams, and Rukeyser were part of a wider trend: Wallace Stevens, Marianne Moore, and others were also actively exploring the affinities and dissonances between poetry and the sciences.

In this article I shall trace three intersecting histories: the epistemological and discursive claims being made by and on behalf of physics; the jostling by other disciplines for a share of the epistemic authority of quantum physics; and the ambitious attempts of Rukeyser and Olson, the mid-century poets who claimed most strongly that scientists and poets could share benchspace, to sketch out a new scientifically aware poetics. This will necessarily be a highly selective account of a complex history, and I will only be able to mention briefly natural sciences other than physics, human sciences, contemporaneous philosophies of science, and debates in literary theory, that all played a part in this history. My aim is to show that the poetics that Muriel Rukeyser and Charles Olson developed at mid-century were bids to enter poetry in the widespread competition between disciplines across the natural, social and human sciences for a share of the epistemic authority accruing to the manifestly successful methods of inquiry in nuclear physics. Another way of saying this is that Rukeyser and Olson wanted poets to adopt what was commonly referred to as the "scientific attitude."[11] Much is still to be learned from this history about how poetry negotiates epistemic issues.

Is Literature Conditioned by Science?

How can we explain this interest? For some scientists, American civic values and beliefs were increasingly grounded in science. Harlow Shapley, an astronomer and the director of the Harvard College Observatory, insisted in self-congratulatory style in *Harper's* in 1945 that "fortunately, we are all scientists."[12] His adverb's evident favoritism towards the sciences points towards another related conviction given currency in the science journals: the unscientific arts belonged to a more primitive stage of human development. This was one theme of a 1949 article in the popular science magazine, *The Scientific Monthly*, by a neurophysiologist, Ralph W. Gerard, who explained that science is "a state of mind or philosophy, and a procedure, and the results of these," and that scientific knowledge is both "a creation of man and is a work of art."[13] If science is now an art, an advanced art, what then of the older arts such as painting or poetry? Gerard is unconcerned about the circularity of using scientific knowledge to judge those arts wanting. "Art is concerned mainly with private feeling, science with public thinking," and because neuroscience has shown that "emotional behaviour, and probably consciousness, depend on the activity of phylogenetically ancient brain parts, which are similar through much of the vertebrate subphylum," it follows that the new arts of mid-century science are inevitably superseding the more "ancient" cultural practices. Did mid-century poets put test tubes in their poems in an attempt to prove that they too were scientific Americans, creators not just with backbone but with advanced, modern brains?

This explanation is fine as far as it goes, but it makes the poets sound more passive than they actually were in the face of scientific development, and too far removed from what Vannevar Bush, in his 1945 report on the future of science in America, famously called "the endless frontier" of scientific research.[14] Nuclear physics was unavoidable at mid-century, whether in the form of Einstein's famous energy equation and the political impact of the dropping of the atom bomb on civilian populations in Japan that it made possible, or because of the fraught debates about whether or not America should build a much more powerful "super" or hydrogen bomb that spilled out of secret conclaves into the public arena, or because of what *Fortune* magazine called the "glamour" of physics as a profession (a status reinforced by high salaries and elevated social status for physicists),[15] or due to the much-discussed expectation that nuclear energy would soon provide universal power. The literary evidence also suggests that poets did not expect the mere fact of their citizenship to be enough to make their poetry scientific. Poets had several other reasons why they might want to engage with science: nuclear physics possessed enormous intellectual capital; technologies associated with physics were transforming everyday life; and the success of quantum theory at explaining the constitution of the universe made its methods of inquiry appear enticing additions to more traditional tools of intellectual curiosity. One of the most famous of all nuclear scientists, Erwin Schrödinger, had recently claimed that quantum physics would soon explain the genetic basis of life itself.[16] The scientifically trained poet William Carlos Williams, in a 1948 lecture, dismissively argues that the poetry of a "ruined industrial

background of waste and destruction" associated with Auden's generation is "becoming old-fashioned with the new physics taking its place".[17] By alluding to the latent powers of destruction in nuclear energy, Williams is also making an implicit connection between the new physics and its social impact. Many poets believed, in the words of the science journalist Fred Dudley, that it is "through poem, novel, drama, essay, we experiment with science until at last we know what to do with it—and are of course confronted with still newer science."[18]

By "experiment," Dudley probably meant no more than innovative literary treatments of the ethical and aesthetic consequences of such issues as the exploitation of atomic energy for war and peace, but the ambiguity of the phrase "experiment with science" gestures at a third possibility. A few poets, notably Rukeyser and Olson, wanted to explore the possibility of making use of scientific techniques, including their experimental methods, in new forms of poetic inquiry. Even some scientists were speculating that this might be possible.

Writing in 1954 in *Science*, June Zimmerman Fullmer, then a metallurgist at the Carnegie Institute of Technology in Pittsburgh, and later a historian of Humphrey Davy, summed up recent mid-century debates about modern poetry and science, and reached some encouragingly positive statements about how the "scientific attitude" might be possible in poetry.[19] Poets aspiring to engage actively with science, instead of attributing agency and ethics to material objects, can usefully work with science's "newer theoretical concepts and broad points of view" if they recognise that the scientific approach depends on the skilful use of abstraction: "The essential nature of the abstracting process is the same, whether it be used to extract the properties of a collection of selenium atoms or the characteristics of a man's philosophic dilemma."[20] Fullmer's use of the phrase "scientific attitude" was, however, becoming anachronistic, as was the related belief that to be a scientist required special virtue.[21]

Fullmer also flags the problem that both Rukeyser and Olson will struggle with. Fullmer is only willing to go so far in endorsing the epistemological autonomy of the putative scientific poem, saying that poetry will "probably never suggest the direction of future scientific inquiries," and its role will be to "provide a fairly reliable index of the extent of popularization of major scientific advances," or to use Dudley's terms, it will limit itself to experimenting with the settled results of authoritative *scientific* experiments.[22] Fullmer's essay provoked skeptical, bad-tempered ripostes from both sides. "Scientific poetry is a bore" wrote Herbert Hirsch, a researcher in the Division of Cancer Biology at the University of Minnesota, who thought that modern poets displayed a decidedly "antiscientific attitude," and did not see how Fullmer could believe "that it is the task of poetry to interpret man's place in nature."[23] The literary critic John Hagopian was irritated by Fullmer's relegation of poetry to a secondary cultural role: "Mrs Fuller [sic] is simply wrong in asserting that 'the thought processes that are successful in transforming scientific techniques are, in some measure, similar to those operating to transform poetic techniques.'"[24] From his literary point of view, poems are constructed from subjective, affective elements, guided by unconscious processes.

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Hagopian spoke for a substantial literary constituency of dissent from the sort of optimism shown by Fjelde, especially visible in two substantial studies of science and poetry from 1950, Hyatt Howe Waggoner's *The Heel of Elohim: Science and Values in Modern American Poetry*, and Douglas Bush's *Science and English Poetry: A Historical Sketch 1590–1950*. All three critics were agreed that the newer poets were scientific Americans, but they disagreed about what this entailed. Whereas Fjelde celebrated a comfortable relation between poetry and science as a welcome development, the older scholars were so alarmed at the growing cultural hegemony of scientific thought they were prepared to add polemic to scholarship. Waggoner depicts poets engaged in "defensive reactions against science," struggling with the idea that "man is not free, that he is the product of his genes and his conditioning and the vagaries of his id."[25]

Douglas Bush, an eminent Harvard critic who had recently produced a volume in the magisterial Oxford History of English Literature, *The Early Seventeenth Century* (1945), issued an even starker warning: "All modern poetry has been conditioned by science, even those areas that seem farthest removed from it."[26] He may have thought he was doing little more than endorsing Cleanth Brooks's judgement made ten years earlier that "all poetry since the middle of the seventeenth century has been characterized by the impingement of science upon the poet's world."[27] Bush's conceptual addition of "conditioning" makes the new prosody echo with the barking of Pavlov's dogs. Publication of two substantial books in one year both defending poetry against the incursion of the scientific attitude would have seemed to confirm R. S. Crane's somewhat cynical observation made two years earlier that his contemporaries displayed "a morbid obsession" with "the problem of justifying and preserving poetry in an age of science" that "has resulted in an extraordinary florescence of modern apologies for poesy."[28]

By mid-century, release from the extreme constraints under which the sciences had operated during the war was complete enough for researchers to be venturing in many new directions. They were also engaged in a sharp-elbowed struggle for continuing government investment that necessitated new rhetorical advocacies for the sciences, destabilized disciplinary boundaries to an unusual degree, and in some cases even rendered existing scientific and epistemic authority questionable. We can observe a modern version of a process that Mary Poovey describes in her study of literature and economics in the eighteenth and nineteenth centuries, when "writers tried to differentiate among kinds of writing—so that they could rank them, acquire social authority for some but not others, produce disciplinary norms, and claim for themselves institutional positions."[29] By the mid-twentieth century, the legitimation of disciplinary knowledge was increasingly the responsibility of tightly regulated networks of review and publication that delegated representativeness to their writers, making the acquisition of social and epistemic authority in domains over which natural and social scientists were extending their research increasingly hard for those, like poets, who were outside the institutional networks.

One way to enter the fray was to tailgate currently authoritative epistemic metaphors. The following sections of this essay trace instances of such appropriation, especially in the case of the concept that was becoming defining metaphor in nuclear physics, the

 field. Although the reiteration of this metaphor across multiple disciplines can be tracked back to a central authoritative usage by prominent, attested theories in nuclear physics, each discipline attributes to the field concept its own specific internal, conceptual architecture. Such endogenous conceptual architecture is not only dependent on the local disciplinary ontology, it is also significantly epistemological, and its consequent wider epistemic status is a matter of considerable negotiation and dissent, both within disciplines, and even more so between them.

Epistemological competition

The epistemic authority of nuclear physics drew scientists from other fields keen to share in the possibilities of extending into other spheres of human knowledge the ascendancy of its scientific method so brilliantly demonstrated by quantum theory. Norbert Wiener's Humboldtian account of *Cybernetics* (1948), widely read by poets, typifies this moment. Robert Von Hallberg aptly describes cybernetics as a "dramatically expansionist approach to knowledge, for its advocates propose to explain and manage vast fields of inquiry."[30] Wiener is as at home talking about Leibniz, Locke, or Hume, as he is talking about computers, brains and their pathologies of ataxia and Parkinson's disease, library cataloguing, or steam engines. He strategically and repeatedly reminds his readers that information theory and its statistical foundations have strong affinities with quantum theory, because the tendency to informational error "seemed to have something in common with the contrasting problems of the measure of position and momentum to be found in the Heisenberg quantum mechanics, as described according to his Principle of Uncertainty."[31] Both Rukeyser and Olson were influenced by Wiener's expansive vision of a new science: Rukeyser discussed *Cybernetics* in *The Life of Poetry* and Olson actually cited from it in his breakthrough poem "The Kingfishers" (1950).

Wiener was a mathematician who leveraged his aspirations to unite natural and social sciences with the epistemic credit of quantum physics. Social scientists themselves were arguing hard for the right to call themselves scientists—a long campaign to have their fields of science recognized by the National Science Foundation (NSF) marks these "epistemological competitions"—and saw opportunities to assert their own rights to epistemic authority by showing that their disciplines could also employ the nuclear model's epistemological structure of fields, matter transformed to energy, mediated invisibilities, and universal reductionism.[32] George Lundberg, a professor of sociology at the University of Washington, might say that "we cannot expect atomic fission to reveal the nature of the social atom and the manner of its control," but his very manner of saying it, as well as his answer to the question posed by his dramatically titled book, *Can Science Save Us?*—yes!—indicated that his social scientific method was shadowing the emerging physics of fissile nuclear particles.[33]

Psychologists were also borrowing epistemological metaphors from the latest physics. The eminent group psychologist, Kurt Lewin, had developed a theory of group or "field" psychology whose elaboration relied on the field trope not just for its metaphorical force but for the conceptual structure and epistemological authority invested in

it by physics. He explains that a psychological fact cannot be understood in isolation: "The 'meaning' of the single fact depends upon its position in the field; or, to say the same in more dynamical terms, the different parts of a field are mutually interdependent."[34] Therefore the aim of any new scientific theory in social psychology should be to integrate a wide range of phenomena and "treat cultural, historical, sociological, psychological, and physical facts on a common ground."[35] Ground can be both literal and metaphorical. The psychologist who is an empirical scientist

> finds himself in the midst of a rich and vast land full of strange happenings: there are men killing themselves; a child playing; a child forming his lips trying to say his first word; a person who having fallen in love and being caught in an unhappy situation is not willing or not able to find a way out; there is the mystical state called hypnosis, where the will of one person seems to govern another person; there is the reaching out for higher, and more difficult goals; loyalty to a group; dreaming; planning; exploring the world; and so on without end. It is an immense continent full of fascination and power and full of stretches of land where no one ever has set foot. Psychology is out to conquer this continent, to find out where its treasures are hidden, to investigate its danger spots, to master its vast forces, and to utilize its energies.[36]

This social scientist is determined that the psychologists will be out on a frontier of knowledge that sounds remarkably like a domain that until recently would have also belonged in part to poets. Lewin only implies that psychology is displacing the arts; the sociologist Lundberg is much blunter in his dismissal of old-fashioned thinkers who believe "that the poet, the philosopher, the novelist, and the classical scholar, rather than the social scientist, are still the authorities on human relations."[37] Although "social science seems to encroach upon traditional, vested areas in the academic world," rational thinkers will soon grasp the inevitability of the arts relinquishing their vested interests, since these are based not on the reason that grounds the sciences, but on emotion that drives the older arts. The social sciences are not *encroaching* on the arts; they are claiming territory rightly their own.[38]

Nuclear physics had such hegemonic cultural authority at the time that even thinkers whose domains might seem very far indeed from that of quantum physics nevertheless drew on its metaphors and epistemic status. Even literary critics were ready to lay claim to a little of the epistemic authority of the new physics. In a nervous gesture in the penultimate paragraph of *Theory of Literature* (1949), René Wellek and Austin Warren try to dispel the impression that they are advocating a European, idealist model of literature by insisting that their literary theory aligns with scientific developments: "If we reject some of the preconceptions of nineteenth-century scientism—its atomism, its excessive determinism, its skeptical relativism—we are thereby in agreement with well-nigh all of the physical and social sciences, for with them today, revolutionary concepts such as patterns, fields, and *Gestalt* have superseded the old concepts of atomism, and with them determinism is no longer a generally accepted dogma." Even if they were not aware that the dominance of the field concept in particle physics had been vindicated by the success of QED (quantum electrodynamics) at the end of the

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1940s, both philosophers and critics probably knew that field theory carried the *imprimatur* of Albert Einstein himself. Right up to the end of his life he was claiming that "the revolution begun by the introduction of the field" continued despite the success of statistical quantum mechanical theories of the discontinuous character of material systems.[39] In their final paragraph, Wellek and Warren optimistically claim that the whole "nineteenth-century epistemology" that reduced the humanities "to the status of pseudo-sciences" is no longer valid, with the unexplored but prescient implication that literary theory itself might lay claim to scientific status of some kind.[40] It seemed as if every field of inquiry had to have its own field theory.

The mid-century atom

Why did nuclear physics entice so many scientists from other disciplines, along with intellectuals in the arts, to emulate its concepts and methods? Was it the bomb? This familiar answer opens a survey essay on "Atomic Structure and Energy" published in 1949 in *American Scientist* by John Dunning, a professor of physics at Columbia who had worked with Enrico Fermi, (*American Scientist* describes him as "in the very top rank of modern physicists"): "The atomic bomb dramatized the opening of this so-called Atomic Age."[41] This same year Rukeyser said in similar terms that the previous remoteness of the scientist from society ended with the bomb: "The function of science was declared, loud enough for the unborn to hear."[42] The atom's energy had not only been released, it had been politicised. Poets were no different from other intellectuals; everyone wanted to know more about this science, whose constantly changing names (including atomic physics, nuclear physics, quantum physics, particle physics, and high-energy physics) confusingly indicated the rapidity with which this knowledge was developing and altering its empirical or theoretical orientation. They wanted to know how it could be, in the words of an introduction to the science of the atomic bomb by Selig Hecht (whom Olson knew at Clark University in the mid 1930s), "that energy and mass are different aspects of the same basic cosmic stuff, and that the two can be converted one into the other."[43] This and many similar attempts to explain in non-technical language the theories and discoveries of the new physics opened the exciting possibility that a discourse about the structure of materials and the material world could be converted into a discourse about this "cosmic stuff" *energy*, which was a much more familiar notion than atomic structure. The nuclear atom was made all the more alluring by increasingly visible government attempts to keep as much as possible its weapons potential secret. In 1950, a fierce struggle between physicists and government over control of information broke into the open: the April 1950 issues of *Scientific American* and *Bulletin of the Atomic Scientists* had to be withdrawn and reprinted to censor paragraphs from the great publicist for the new science, Hans Bethe, whose articles about the hydrogen bomb the Atomic Energy Commission feared had given away secrets about the importance of using heavy isotopes of hydrogen in the manufacture of the atom bomb.[44]

The bomb might be enough to explain why nuclear physics should generate curiosity and critique amongst researchers and intellectuals in many disciplines, but is not sufficient to explain why its very epistemology should have been so widely emulated. Why should physics, particularly nuclear physics, appear the epitome of the methodology of rigorous inquiry even in quite different realms such as the study of mind or society, let alone the creation of poetry, given its uncompromising mathematical abstraction, reliance on heavy machinery for empirical research, and focus on inanimate matter? Actual physics experimentation required messy engineering: the endless problems that 1940s physicists had with the fiddly, temperamental cloud chamber could typify this.[45] All this high-energy machinery would seem very far from the needs of psychology or genetics, let alone poetry.

To explain the hold over the mid-century imagination exercised by nuclear physics we need to reflect on the totalizing power of its theory, and on a paradox of this totalisation, its deliberate acting out of epistemic uncertainty. One unusually striking instance of the universalizing claims of nuclear physics appears in Hans Bethe's description of the mid-century atom for a radio audience in 1945, as "the hero of the day…the most democratic hero you can choose, because it is everywhere and in everything." Democratic? Bethe is not just aligning physics with the defense of democracy that defined the politics of the Allies, he is also alluding to the universality, vast explanatory power, and cosmological reach, of atomic physics, which treats everything in the material world as if it were constructed of the same very few humble constituents. We need to listen closely to how the discourse of nuclear physics around "mid-century" represents the material world as constituted *entirely* of forces of attraction and repulsion, explosive energies, electrical fields, and a tiny number of distinct types of particle. John Dunning offers a revealing aside as he sets the scene for his account of contemporary nuclear physics: "It has long been accepted that you and I and all the world around us are made of some 92 basic types of atoms which we call elements."[46] His friendly formulation makes it possible to elide the many supervening levels of organisation between an atom and the ego, and to infer that selfhood, language, belief, and the body, are all naturally constructed, independently of human agency or cognition, from the constituents which the discourse of the reductionist science has clearly in its purview: energy fields and particles. A poet might reasonably infer that poetry should also be investigating these constituents of the cosmos.

Nuclear physics was enjoying a peacetime success that seemed to confirm the power of its pantheoretical ambitions. At this time about twenty particles had been discovered, the more recent ones by studying cloud chamber tracks of cosmic rays, including two mesons, the pion and the muon. In 1948, *Time* magazine announced the artificial creation of mesons at the Rad Lab at Berkeley, and expressed the hope that this would "lead in the direction of a vastly better source of atomic energy than the fission of uranium."[47] Great things were expected of nuclear research: it was predicted that airplanes would be powered by atomic engines, and nuclear radiation would cure cancer. In August 1950, *Science News Letter* confidently anticipated "a mathematical concept or law that will apply to the universe as a whole as well as to the microcosmos

of the atom will be worked out."[48] Behind much of this exaggerated optimism was the impressive success of quantum electrodynamics, a field theory of the electron. Success yes, but also making ever more plain just how elusive certainty was.

In a 1948 article in *Physical Review* (and therefore aimed at the specialists), the physicist Julian Schwinger worries about the risk of distortion in attempts to conceptualize recent experimental findings that diverge from prediction: "Attempts to avoid the divergence difficulties of quantum electrodynamics by mutilation of the theory have been uniformly unsuccessful."[49] Trying to predict the behavior of the electron in an electromagnetic field created problems for quantum physicists because it gained extra mass/energy that "was theoretically infinite and experimentally real." Further research in the theory of quantum electrodynamics by Schwinger himself, and by Richard Feynman, Freeman Dyson, and Sin-Itiro Tomonga in Japan, did result in a successful model of the electron based on justifiable, careful elimination of unwanted infinities in the equations, or what was known as "renormalization" (one of many latent metaphors whose resonance the literary critic is tempted to unpack).[50] Success was encapsulated in its clever acronym QED, although for these physicists there was also a kind of protective irony: no one was quite sure what the *quod* was, nor how best its *demonstrandum* could be achieved, and they were open about the problems of the *erat*. The mathematics, the unobservability of particles, and the imperfections of theory meant that the mid-century atom was also an epistemological puzzle. This mid-century atom was highly mathematical, which created challenges even for the experts, many of whom shared an anxiety that the mathematical modelling might be creating too much distance from actual processes, a concern indicated by Freeman Dyson when he says that "one must assume provisionally that the mathematical formalism corresponds to something existing in nature."[51]

Something existing in nature: but what? Physicists loved to talk about the unknown as if they had rights over it, and argued openly about different methods of discovering its hidden possibilities. Theorists like Richard Feynman were inclined to think that theory was leading the way, not least because they had already theorized uncertainty. It is revealing that in a graduation address at Brown in 1947, the theoretical physicist Richard Tolman, former chief science advisor to General Leslie Groves on the Manhattan Project, having just a few minutes to talk about the "new and improved ideas provided by quantum mechanics" mentions at once Werner Heisenberg's uncertainty principle: "We can now see that a complete knowledge of the state of a physical system at any given instant is not sufficient to permit an exact prediction of that system's future behavior" due to "the uncontrolled disturbances introduced by the very act of observation."[52]

Laboratory researchers were also keen to lay claim to be able to negotiate with the unknown. Dunning believed the new "high-energy nuclear machines should be adequate to explore a completely unknown realm."[53] One of the researchers responsible for creating mesons at Berkeley, Evans Hayward, explains in an article about their use of a cloud chamber as part of the detection process that it "makes visible, and therefore enables one to photograph, the paths of charged particles: electrons, protons, mesons,

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etc."[54] This was a very eloquent "etc." Cloud chamber photographs were the closest the non-specialists could get to seeing the mid-century atom. In these widely publicized images the outsider could glimpse white particle tracks on a deep black background accompanied by many peripheral white dots and dashes, the whole picture looking like nothing so much as chalk scratches on a heavily used blackboard. Those residual unexplained marks acted as visual reminders that much about these particle interactions was yet to be understood.[55] These marks appeared to be vivid traces of the intersection of the known and the unknown. Isidor Rabi, another of the Los Alamos scientists, described the nucleus as the site where "vast energy is locked" and "mysterious forces of attraction" hold protons and neutrons fast together against powerful forces of repulsion. Talking about the "mysteriousness" of these forces was deliberate.[56] Rabi admits that he is trying to point out the "limitless unknown" of nuclear physics to call attention to the opportunities in the field for "young men and women to make great discoveries" (he is unusual in appealing to both genders). Poets also heard the call.

Borrowed Energy: Muriel Rukeyser and Charles Olson

"The poems of the next moment are at hand," announces Rukeyser in *The Life of Poetry* (1949), a moment when political hopes for "one world," a secular vision latent in the unity of science, and the "unity of imagination," will finally be realized.[57] *The Life of Poetry* is a passionate defense of poetry's potential to adumbrate, in Adorno's phrase, "the possibility of the non-existing."[58] "It is a great thing," says Rukeyser, "to come to the unbegun places of our living and to say: Now we will find the words."[59] In practice she does not always quite find them, and as a sympathetic reviewer of her life of Gibbs noted, her style can be "oracular." At times she drifts into Rooseveltian speech-making (with notable echoes of the "four freedoms" speech of 1941).

"Radio poetry is not yet born"- *The Life of Poetry* ranges across many cultural practices in an effort to hasten the realization of such unbegun potentials.[60] The new poetry will draw on the blues and popular song; it will learn from the techniques of cinema, the "quick, rhythmic juxtapositions" and other constructional strategies, cinematic techniques that owe much to the new sciences: "This gathering-together of elements so that they move together according to a newly visible system is becoming evident in all our sciences" and is able "to deal with any unity which depends on many elements, all inter-dependent."[61] Poets will come to recognize that the layout of the poem can be a kinesthetic notation, that "punctuation is biological…the physical indication of the body-rhythms which the reader is to acknowledge."[62] And poets will not only learn from biology, they will also learn from the dominant science of their time, physics, that they are working with energy: "Exchange is creation. In poetry, the exchange is of energy. Human energy is transferred, and from the poem it reaches the reader. Human energy, which is consciousness, the capacity to produce change in existing conditions."[63] Olson would adopt this analogy between physical and imaginative energy, right down to the phrasing, for his discussion of the relation of poet and reader in "Projective Verse," where he writes that "a poem is energy transferred from

where the poet got it (he will have some several causations), by way of the poem itself to, all the way over to, the reader."[64]

By the time late in the book that Rukeyser begins her detailed discussion of science and poetry, she has not only explored the interdependence of poetry on the contemporary arts of music, song, film, and radio, and discussed poetry's historical burdens in America, she has also crucially acknowledged that scientists now "claim their right of experiment and inquiry" over most aspects of modern life.[65] How then can poets engage in the epistemological competition of the time and stake their own claims at the frontiers of experiment and inquiry? Rukeyser makes a crucial move that will distinguish her approach from Olson's, and accepts the primacy of the new natural sciences to epistemic authority. She does not believe, like Heidegger and Whitehead, Olson's favored thinkers, that science is simply a subset of a wider, more inclusive knowledge-in-the-making in which poetry might one day play a starring role. In the words of a recent critique of anti-scientific philosophies, she does not patronize "scientific assertions about the world as impoverished abstractions" that have been imposed on a "more fundamental sub-representational or pre-theoretical relation to phenomena" only accessible to poetry.[66]

Then Rukeyser takes a bold step. Having conceded that science rightly belongs on the frontiers of knowledge, she challenges the idea that the most that poetry can aspire to in its dealings with the sciences is to "provide a fairly reliable index of the extent of popularization of major scientific advances." She doubts whether a valuably scientific poetry can be created solely from what she variously calls the "answers," the "discoveries," and "the by-products, the half-understood findings of science."[67] If poets want their poetry to be a valid "kind of knowledge" for their time, the equal of science and not its primitive antecedent, they should turn instead to the "questions" or "methods" of science, a shift that may entail borrowing actual practices of experiment, reasoning, observation and inquiry current in the sciences and putting them to use in the making of poems anywhere from preliminary research to final composition.

What would this look like in practice? Rukeyser takes up the promising idea of a poetics of system, justifying its relevance on the grounds that today "science is a system of relations."[68] Starting from this definition of modern science, she argues that poems too can be considered scientific when they model human relations as a system. One of her main demonstrations of how poems can be scientific occurs during a discussion of the importance of parataxis for modern poetry. Her understanding of parataxis is broad. It can be manifest in cinematic cutting from one image to another as in film, and when a cultural text jumps from the dominance of one emotion to that of another. Such paratactical processes can also be described, so she then claims, in the geometric language of Willard Gibbs's theory of the role of phase space in statistical mechanics. A phase space is a mathematical, usually geometrical, representation of different states of a system, such as a gas, as points in space. Rukeyser offers a highly original application of this methodology to the study of poetic form:

> The poems which depend on several emotions, each carrying its images, move like a cluster traveling from one set of positions to another: the group ABCDE, say, moving to A'B'C'D'E'; a constellation. This gathering-together of elements so that they move together according to a newly visible system is becoming evident in all our sciences, and it is natural that it should be borrowed from the statistical mechanics that Gibbs developed which depicts the molecules in a gas in just such terms of translocation across what is known as "phase space."[69]

Such a model, she adds, gives poets a means "to deal with any unity which depends on many elements, all inter-dependent."[70]

Despite the awkwardness of the analogy with phase space mathematics, her proposal has some promising features: it not only emphasises the interdependence of *all* the elements of a poem (which may include linguistic, affective, cognitive, visual, or aural elements—a list that is not exhaustive because there may be others yet "unbegun"), it also recognizes that the resultant system is not static, but a complex series of unfolding transformations. Poetic truth becomes "an agreement of components" within a system.[71] She sums up her poetics like this:

> In a poem, these components are, not the words or images, but the relations between words and images…All of these words were known, as the results leading to a scientific discovery may have been known. But they were not arranged before the poet seized them and discovered their pattern. This arrangement turns them into a new poem, a new science.[72]

The poem is a system, or construct, which models some aspect of the world and shares with scientific models the potentiality to discover truths about the world.

The difficulty with this poetics begins to be apparent when we ask what it means to discover a pattern. Aren't all poems patterned—a pattern being a manifestation of intentionality, discursive regularities, or underlying laws—and don't all poems tacitly claim that their patterns (enactments, images, narratives) have some relation, however distant, with the world? Why should one poet be credited with a special, quasi-scientific achievement in arranging words in a pattern, and not another? And what does the construction of a system have to do with the rigorous fallibilism of research inquiry?

Rukeyser's reasoning, and her attraction to the concept of a spatial system, becomes clearer if we track the passage summing up her poetics in *The Life of Poetry* back to its source in a very similar passage from her biography of Gibbs. There she argues that his use of theory to create a new and enlightening arrangement of existing empirical results "turns them into a new tool, a new science."[73] She is commenting on an extended quotation from the preface to his *Statistical Mechanics* in which Gibbs disavows allegiance to any correspondence theory of truth for his new science: "There can be no mistake in regard to the agreement of the hypotheses with the facts of nature, for nothing is assumed in that respect." All he aspires to is "agreement between the premises and the conclusions," that is to a mathematically rigorous coherent modelling of the mechanics.[74] In saying that a poem is a system, Rukeyser is therefore comparing the poem to a mathematical construct that simulates the development of a simplified version of

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the actual world, by starting with a limited set of empirical data and discovering new patterns within it. Climate change models work this way.

Unfortunately for Rukeyser, the epistemic metaphor of phase space, even when generalized into the idea of system, does not do all the work that she hopes for. Its weaknesses are twofold: its formalist approach to truth leaves it unable to reveal areas of uncertainty, and the internalism of the concept of a system makes it hard to conceive how the poem could be related to the rest of the textual, let alone the extratextual, universe. Valuable as it is to think of the poem as a system, construct, or hypothetical model, this is an epistemic metaphor that doesn't make room for uncertainty, discontinuity and incommensurablity amongst the constituents of the poem. Nor does this metaphor make visible any epistemological competition with other knowledges.

Olson's "Projective Verse" attempts to remedy these shortcomings. A fraction of the length of Rukeyser's book, his essay condenses similar ideas about breath, form, scoring, speed, energy, and science into its terse, vocative prose, as if his essay were the accompanying practical instructions to her extended defense of the unbegun poetry of the later twentieth century. Despite these affinities, his essay distinguishes itself sharply from Rukeyser's book in two ways.[75] Firstly, unlike Rukeyser, Olson never mentions science explicitly. Unlike Rukeyser and Williams, he does not say openly that a new poetry must engage with the new physics, although the essay's repeated use of tokens from scientific discourse certainly leaves readers with the impression that the new poet should resemble one of Fjelde's mid-century scientifically literate poets. Readers are likely to have the atomic bomb spring to mind when Olson says that the poet should aim to create a poem that is a "high energy-construct and, at all points, an energy-discharge."[76] Not mentioning science is canny. It enables Olson to avoid having to locate his poetic practice in some possibly subordinate relation to the epistemic authority of the natural and perhaps even the social sciences. Questions of epistemic legitimacy can be sidelined. Secondly, whereas Rukeyser's essay is a defense of poetry that looks backward to identify cultural tributaries to the poetry of the future, Olson's essay is a manifesto for the future, consciously employing the public relations strategies of earlier Futurist, Dadaist and Surrealist manifestos. Even its title alludes to one of the three features that Martin Puchner argues can be found in all manifestos: "theatrical posing, unauthorized speech, projective positioning."[77] By calling the essay "*Projective* Verse," Olson is knowingly invoking the manifesto's foundational power to call a new movement into being through its projection of a new aesthetic practice, as well as naming this new, or "unbegun" poetry. With considerable chutzpah given his marginality at the time, Olson claims naming rights over both the new poetry ("projective") and its poetics ("composition by field"). The names stuck. Projective verse became widely used to designate the type of poetry written by Olson and some of his acolytes, though it was rarely used conceptually to analyze their practice. Field composition became an even more pervasive name for the practice of Olson and the New American poets as they were often called, usually in the phrase "open field poetry," and it was interpreted as a conceptually rich descriptor of this textual practice.

By introducing these two terms, *projective* and *field*, and not directly using the catch-all notion of "science" with its implicit exclusion of the arts, Olson is able to shake off preconceptions about the possible interrelations between poetry and science. At mid-century both terms were actively referent to theories and practices in domains that included physics, social science, philosophy, and aesthetics, and each had different degrees of connection to the scientific ideal. Moreover, informal usage associated the terms "project" and "field" respectively with two key features of any organized research, inquiry and knowledge. So although Olson's concepts of "projective" verse and "field" composition might appear quite distinct, the structural tensions internal to the assemblage of semantic domains comprised by each concept are actually very similar, as we shall see.

Olson's sources for the idea of the "projective" included the following: the mathematics of projection that he had read in H. M. S. Coxeter's books on geometry and polytopes and the association with A. N. Whitehead's geometric metaphysics[78]; the psychoanalytical idea of an unconscious imposition of a figuration on another person or event; Martin Heidegger's concepts of *entwerfen* and *projektion* as somewhat misleadingly explained by Werner Brock in his introduction to the first main translation of Heidegger, *Existence and Being* (1949), in terms of project and projection[79]; and the use of the word to describe a research enterprise. A projective verse would therefore be rooted in the deepest potentialities of being, would operate both in the psychic and material worlds, and would productively emulate the work of scientific research at those margins of knowledge where the actualities are least controlled by existing rigorous science. But as a conceptual matrix for the new poetics, the idea of the projective was too full of contradictions to be effective as a tool of *analysis*, relying as it did on what were seen increasingly to be questionable interpretations of Heidegger, and even more troublingly, carrying largely negative associations with the psychological process of projection. Psychoanalytically speaking, to be projective is to be self-deceived, and this runs counter to the desired emphasis on poetic feats of accurate imaginative reach.

The metaphor of field was more robust, and historically has proven far more fertile and coherent as a conceptual matrix for poetry and literary theory, continuing to be used up to the present day in studies of modern American poetry. Already well established in psychology in the work of Kurt Lewin and the group psychologists, it would later resurface in French sociology in the work of Pierre Bourdieu, and arguably as a latent metaphorical substrate in the social philosophy of Gilles Deleuze and Felix Guattari. Field metaphors were also firmly entrenched in aesthetics and literary studies. I. A. Richards, who in addition to helping create academic literary studies did so much to lay the groundwork for the study of poetry and science, drew on his own knowledge of behavioural psychology and philosophies of art to talk extensively of fields of "attention," "stimulation," and "phenomena," as well as fields of "investigation" and "facts."[80] Similar discourse was widely used in aesthetics in the 1940s.

The concept of a field also has a long scientific history that is relevant to its success. In her classic study *Force and Fields* (1961), Mary Hesse traces the idea of field in physics, which she carefully designates a "model," a provisional description of the actual

world in metaphoric terms (the implications of the metaphors needs to be empirically checked against experiment) back to the attempt to understand the action of forces at a distance.[81] This complex history is a backstory to the quantum field concept. According to Martin Krieger, the idea of a field in nuclear physics is abstracted from the experience of a fluid flowing from a source, and identified with certain characteristics necessary to make this epistemic metaphor a useful tool to nuclear physicists: a field is generally smooth, connected to particles, balances the inflow and outflow of energy, and enframes the idea of a *path* through the field as a means of understanding the instabilities and peculiarities of specific particles: "Fields also provide for local interactions, by, in effect, transporting the effect of one particle over to another particle with which it is to interact."[82] Although Krieger is specifically discussing particle physics, other disciplines who borrow the concept are likely to retain at least some of these features because of the "fertility" of the field model in suggesting further lines of investigation.[83]

What Olson realises is that the concept of field can do more than signal poetry's advance towards the frontiers of knowledge. It can help address two seemingly intransigent problems for the analysis of poems without encountering the limitations that Rukeyser faces: the difficulty of figuring out how each component and type of component contributes to the overall meaning of a poem; and the difficulty of accounting for the relations between the poem's components and knowledges outside the poem. To address the first difficulty, it appears as if we need to identify every type of component individually and then produce a determining theory of exactly how it operates (rhythm requires prosody, words require linguistics, images require an elaborate theory of symbols, and so forth). Too many components of poems, such as the white spaces, the force of diacritical marks, the pauses for breath, and other paratextual phenomena, lack either functional explanation or are interpretively ambiguous. To address the other difficulty, we seem to need some theory about the relation between poetic propositions and propositions in other fields, such as the sciences. Olson's concept of the field absorbs the uncertainties of these degrees of freedom. Now we start with the idea that every constituent, every particle of the poem whatever it is, contributes to the overall field of the poem, which in turn interacts with other fields, scaling outwards from poems to knowledges and social formations.[84] No wonder Olson frequently invoked Heisenberg's uncertainty principle and was so evidently drawn to nuclear physics as a discipline defined by epistemic frontiers. His idea of field composition provides a means of thinking through the many implications of treating poetry as a mode of inquiry that might be as valid as those of other sciences.[85]

Conclusion

Genetics, cybernetics, psychology, even philosophy, might vire epistemic authority from quantum physics, but they were, after all, further investing in an already existing status as valid forms of *research* and their reputable cognitive methodologies provided frameworks of inquiry that led to recognized knowledge. Poetry started much further back; poetry, as many thinkers did not hesitate to argue, was seemingly incapable of

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inquiry, and could only produce what I. A. Richards had called in the founding modern study of science and poetry, "pseudo-statements," or fake propositions with no truth value.[86] If poets were to claim some territory on Vannevar Bush's endless frontier of knowledge alongside Lundberg, Lewin, Wiener and other new scientists of the human as well as the natural world, they would need methodological credit. Could they too base their claims on an endorsement of the physics paradigm of reducing complexity to fundamental particles and their interactions? If so, how could they also plausibly lay claim to the idea that poetry might be a mode of inquiry?

Rukeyser and Olson boldly attempt to do this. Both use metaphors from physics to do epistemic work. Rukeyser argues that by being as informed as possible about current natural scientific theories and methods the poet can create poems that employ observation and reasoning to construct experimental systems with the potential to contribute to the knowledges valued in contemporary American society.[87] Olson pushes back at the encroaching sciences, especially what he saw as the carpetbagging social and human sciences, claiming for poetry a superiority as research, if it adopts a fallibilist type of inquiry founded in a synthesis of materialist and idealist thought. Neither proposal was well understood at the time. When *The Life of Poetry* and "Projective Verse" enjoyed their second acts in American cultural life, their similar genesis in the mid-century epistemological competitions with other sciences for a share of the epistemic authority of nuclear physics, would be forgotten. And by the time these texts were out on that wider stage, the very idea that there was such a thing as the "scientific attitude," that character trait by which Fullmer identified poems, where science and poetry converged, had been replaced by more abstract and depersonalized ideas of method, paradigm, and discourse. Crucial aspects of the tenor and tensions within their reasoning had faded from sight. Revisiting their mid-century poetics and the debates around poetry and science out of which the poetics emerged, it is possible to see how we might now advance our thinking about what George Levine reminds us are "the variousness and incompleteness of writers' and scientists' interrelations" that remain a challenge to our existing theories of literature, knowledge and the sciences themselves.[88] We can glimpse the possibility of less ideologically polarized understandings of the role of epistemology in poetry—and science.

Notes

This essay is based on research for a forthcoming book on American poetry and science in the cold war.

1. Rolf Fjelde, "Mid-Century American Poets" [Review of John Ciardi ed., *Mid-Century American Poets* (New York, 1950)], *Poetry New York* 3 (1950): 38–40, 38.

2. W. V. O. Quine, *From a Logical Point of View: 9 Logico-Philosophical Essays*, 2nd edition (Cambridge, MA: Harvard University Press, 1961), 44.

3. Wallace Stevens, *Collected Poetry and Prose* (New York: Library of America / Penguin Books, 1997), 728.

4. Karl Shapiro, "Elegy for a Dead Soldier," in John Ciardi, *Mid-Century American Poets* (New York: Twayne 1950), 96. The poem advertising familiarity with test tubes was Richard Eberhart, "The Cancer Cells." Ezra Pound, *ABC of Reading* (London: George Routledge and Sons, 1934), 1.

5. Capitals in original. Charles Olson, "Projective Verse vs. The Non-Projective," *Poetry New York* 3 (1950):13–22, 14. The essay has been reprinted several times and is now known simply as "Projective Verse."

6. Olson, "Projective Verse," 13.

7. In one of the relatively rare instances of a poet revising a poem to take account of the accuracy with which it reports on a scientific issue, Williams altered this passage to read: "Release the Gamma rays that cure the cancer / .. the cancer, usury" [original spacing]. William Carlos Williams, *Paterson* (New York: New Directions, 1963), 182.

8. Richard Eberhart, "Notes on Poetry," in Ciardi, *Mid-Century American Poets*, 227.

9. Daniel J. Kevles, *The Physicists: The History of a Scientific Community in Modern America* (Cambridge, MA: Harvard University Press 1995), 31.

10. Muriel Rukeyser, *Willard Gibbs* (Garden City, NY: Doubleday, Doran & Company, 1942), 11; Muriel Rukeyser, *The Life of Poetry* (Ashfield, MA: Paris Press, 1996), 163.

11. The idea that scientists possess a special cognitive orientation or "scientific attitude" has its roots in the nineteenth century. In the 1940s it was briefly given renewed currency by the publication of a defense of science, written at the time when it seemed possible that Britain too would be invaded by the Nazis, by the British biologist C. H. Waddington entitled *The Scientific Attitude* (Harmondsworth, Mddx.: Penguin, 1941). He defines this orientation as an interest in "how things work as causal systems" (9), and expands on its contrast with the arts: "it is the matter-of-fact as against the romantic, the objective as against the subjective, the empirical, the unprejudiced, the *ad hoc* as against the *a priori*" (46). Although he is skeptical about the public tendency to show a "semi-reverent attitude to scientists as people" (98) and insists that science is an extension of common-sense, he does believe that science implies "a certain moral outlook" (124). As Steven Shapin and others have argued, the idea that the scientist require a special voluntaristic orientating commitment over and above the orientation provided by the forms of reasoning embedded in the knowledge and social relations of science was losing ground during this time. Waddington's publisher lists a New York address for this book, but it seems likely that it was not generally available in America until after the war, particularly in a revised Pelican edition published in 1948.

12. Harlow Shapley, "Status Quo or Pioneer? The Fate of American Science," *Harper's* (October, 1945): 312–317, 312.

13. Ralph W. Gerard, "The Scope of Science," *The Scientific Monthly* 64.6 (1947): 496–512, 500, 499, 496.

14. Bush hits this note hard: "Science offers a largely unexplored hinterland for the pioneer who has the tools for his task." For those wanting to find new frontiers the sciences were the place to be. Bush argues that the rewards of such exploration both for the Nation and the individual are great, and that new knowledge which "can be obtained only through basic scientific research" is essential to the health, wealth and security of the nation. Vannevar Bush, *Science: The Endless Frontier* [A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945], www.nsf.gov/od/lpa/nsf50/vbush1945.htm. Accessed 7/1/2011.

15. The Staff of *Fortune* Magazine, "The Scientists," *American Scientist* 37.1 (1949): 109.

16. Erwin Schrödinger, *What is Life?: The Physical Aspect of the Living Cell* (Cambridge: University Press, 1944). The book was published in the United States in 1946.

17. William Carlos Williams, "The Poem as a Field of Action," *Selected Essays* (New York: New Directions, 1969), 282. The essay began as a lecture given at the University of Washington in 1948, but was not printed until 1954 when it appeared from Random House in the *Selected Essays*.

18. Fred A. Dudley, "The Impact of Science on Literature," *Science* 115. 2990 (1952): 412–415, 414.

19. J. Z. Fullmer, "Contemporary Science and the Poets," *Science* New Series 119. 3103 (June 18, 1954): 855–859. This essay was followed by two further sets of responses: John V. Hagopian, Herbert M. Hirsch, Ansel Adams, J. Z. Fullmer, "Communications: Contemporary Science and the Poets Reconsidered," *Science*, New Series, 120. 3127 (Dec. 3, 1954): 951–955; and H. David Hammond and J. Z. Fullmer, "More on Contemporary Science and the Poets," *Science*, New Series, 121.3148 (April 29, 1955): 647–648.

20. Fullmer, "Contemporary Science and the Poets," 859.

21. Steven Shapin argues that the once taken for granted idea that scientists had superior moral authority was replaced around the 1940s by the assumption of moral equivalence between scientists and non-scientists, though he also argues that personal authority of various kinds has remained a crucial factor in scientific communities. Steven Shapin, *The Scientific Life: A Moral History of a Late Modern Vocation* (Chicago: University of Chicago Press, 2008), 89–90 and *passim*.

22. Fullmer, "Contemporary Science and the Poets," 859.

23. Herbert Hirsch, in John V. Hagopian et. al., "Communications," 953, 952.

24. John V. Hagopian et. al., "Communications," 952.

25. Hyatt Howe Waggoner, *The Heel of Elohim: Science and Values in Modern American Poetry* (Norman: University of Oklahoma Press, 1950), 208, 16. Other significant studies of science and poetry of that period include: Frederick William Conner, *Cosmic Evolution: A Study of the Interpretation of Evolution by American Poets from Emerson to Robinson* (Gainesville: University of Florida Press, 1949); Norman Holmes Pearson, "The American Poet in Relation to Science," *American Quarterly* 1.2 (1949): 116–126; and Oscar Cargill, "Science and the Literary Imagination in the United States," *College English* 13.2 (1951): 90–94.

26. Douglas Bush, *Science and English Poetry: A Historical Sketch 1590–1950* (New York: Oxford University Press, 1950), 151.

27. Cleanth Brooks, *Modern Poetry and the Tradition* (Chapel Hill: The University of North Carolina Press, 1939), 174.

28. R. S. Crane, "Cleanth Brooks: Or, the Bankruptcy of Critical Monism," *Modern Philology* 45.4 (1948): 226–245, 243. Crane mentions I. A. Richards, Cleanth Brooks, and John Crowe Ransom as key participants in the defense of poetry.

29. Mary Poovey, *Genres of the Credit Economy: Mediating Value in Eighteenth- and Nineteenth-Century Britain* (Chicago: University of Chicago Press, 2008), 345.

30. Robert Von Hallberg, *American Poetry and Culture 1945–1980* Cambridge, MA: Harvard University Press, 1985), 38. He suggests that avant-garde poets "subjected to scrutiny in verse" the cybernetic ideas of feedback and system.

31. Norbert Wiener, *Cybernetics: or Control and Communication in the Animal and the Machine* (New York: J. Wiley, 1948), 16.

32. I have borrowed this phrase from Sarah Winter, *Freud and the Institution of Psychoanalytic Knowledge* (Stanford, CA: Stanford University Press, 1999), 223. She writes that Freud's "cultural theory gives evidence of his strategic supposition that the institutional resources attached to an academic discipline will become available to his 'new science' if, in part through the agency and example of his writings, it can win epistemological competitions with other fields." Her argument appears to assume that this is a zero-sum struggle for resources; my assumption is that these resources are expanding and at any one time elastic, since they include cultural as well as financial capital.

33. George A. Lundberg, *Can Science Save Us?* (New York: Longmans, Green and co 1947), 104.

34. Kurt Lewin, "Field Theory and Experiment in Social Psychology: Concepts and Methods," *The American Journal of Sociology* 44.6 (1939): 868–896, 889.

35. Lewin, "Field Theory," 871.

36. Kurt J. Lewin, "Formalization and Progress in Psychology" (1940), in *Resolving Social Conflicts: Field Theory in Social Science* (Washington D. C.: American Psychological Association 1997), 169.

37. Lundberg, *Can Science Save Us?*, 83.

38. Lundberg, 82.

39. Albert Einstein, "Autobiographical Notes," in Paul Arthur Schilpp, *Albert Einstein, Philosopher-Scientist* (Evanston, IL: Library of Living Philosophers, 1949), 37.

40. René Wellek and Austin Warren, *Theory of Literature* (New York: Harcourt, Brace, 1949), 298.

41. J. R. Dunning, "Atomic Structure and Energy," *American Scientist* 37.4 (October 1949): 505–527, 505. The editorial note about his status is on p. 475 of the same issue.

42. Rukeyser, *The Life of Poetry*, 160.

43. Selig Hecht, *Explaining the Atom* (New York: The Viking Press, 1947).

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44. E. Rabinowich, Editorial: "It's not what's said it's who says it," *Bulletin of the Atomic Scientists* VI. 5 (May, 1950): 130.

45. In "Recent Developments in Particle Physics," *Science*, New Series 165. 3898 (1969), Alvarez talks of how "unsuitable for the job" it was (1071–1091, 1074). In his autobiography, *Adventures of a Physicist* (New York: Basic Books, 1987) he explains how experimental physicists were frustrated by the cloud chamber's limitations for studying the new particles: "We could produce them with the Bevatron and wanted to study them, but none of the existing techniques used to track particles was well suited to studying the basic reactions of strange-particle physics" (185). Alvarez went on to design the Bubble Chamber and record the discovery of many new particles.

46. Dunning, "Atomic Structure and Energy," 507.

47. Cited in Helge Kragh, *Quantum Generations: A History of Physics in the Twentieth Century* (Princeton: Princeton University Press, 1999), 312–313.

48. Watson Davis, "From Now On: The Atom," *The Science News-Letter* 58.7 (August 12, 1950): 98.

49. Julian Schwinger, "Quantum Electrodynamics. I. A Covariant Formulation", *Physical Review* Series II, 74.10 (November 15, 1948): 1439–1461, 1439.

50. James Gleick, *Genius: Richard Feynman and Modern Physics* (London: Little, Brown 1992), 240.

51. F. J. Dyson, "The *S* Matrix in Quantum Electrodynamics," *Physical Review* Series II 75. 11 (June 1, 1949): 1736–1755, 1754.

52. Richard C. Tolman, "A Survey of the Sciences," *Science*, New Series, 10. 2746 (Aug. 15, 1947): 135–140, 137.

53. Dunning, "Atomic Structure and Energy," 527.

54. Evans Hayward, "The Use of Cloud Chambers with Pulsed Accelerators," *Science* 111. 2884 (April 7, 1950): 349–355, 349.

55. Andrew Pickering, *The Mangle of Practice: Time, Agency, and Science* (Chicago: University of Chicago Press 1995), 52.

56. Isidor I. Rabi, "The Atomic Nucleus," in Warren Weaver ed., *The Scientists Speak* (New York: Boni & Gaer, 1947), 102.

57. Rukeyser, *The Life of Poetry*, 155, 163. From her enthusiastic endorsement of the historian of science George Sarton (162–163), it is evident that Rukeyser thinks of the diverse sciences as converging on one unified science, because she too would like to hope that such a unified science would lead to a unification of humanity in a shared knowledge of the cosmos, since scientific knowledge, because it is knowledge of a mind-independent universe has to be the same in every language and culture.

58. Theodor Adorno, *Aesthetic Theory*, trans. Robert Hullot-Kentor (Minneapolis: University of Minnesota Press 1997), 132. In *Adorno: A Critical Introduction* (New York: Routledge, 1998), Simon Jarvis gives this is a more intelligibly idiomatic translation: "the possibility that the non-existent could exist" (115). Jarvis provides a context that clarifies the reasoning behind his amended translation: "What makes a work of art more than the empirical world from which it distinguishes itself is something non-existent: 'that works of art are there, however, points to the possibility that the non-existent could exist'" (115). This is often taken to imply that art keeps alive hopes of change by its very contradictory nature, but Adorno's typically paradoxical formulation also relies on a key feature of the sorts of inquiry that nuclear physics represented for many intellectuals, its dramatic engagement in prospective speculation that could lead to the emergence of actualities from theories.

59. Louise Kertesz describes this attitude in Rukeyser as "American 'meliorism'" in *The Poetic Vision of Muriel Rukeyser* (Baton Rouge: Louisiana State University Press 1980), 366.

60. Rukeyser, *The Life of Poetry*, 131.

61. Rukeyser, *The Life of Poetry*, 19.

62. Rukeyser, *The Life of Poetry*, 117.

63. Rukeyser, *The Life of Poetry*, 173.

64. Charles Olson, "Projective Verse," *Collected Prose*, edited by Donald Allen and Benjamin Friedlander (Berkeley: University of California Press, 1997), 240. Olson continues: "Okay. Then the poem itself must, at all points, be a high energy-construct and, at all points, an energy-discharge. So: how is the poet to accomplish same energy, how is he, what is the process by which a poet gets in, at

all points energy at least the equivalent of the energy which propelled him in the first place, yet an energy which is peculiar to verse alone and which will be, obviously, also different from the energy which the reader, because he is a third term, will take away?"

65. Rukeyser, *The Life of Poetry*, 17.

66. Jay Brassier, *Nihil Unbound: Enlightenment and Extinction* (New York: Palgrave Macmillan, 2007), 50. He is discussing modern philosophers rather than writers, but the judgement could apply to intellectuals in many humanities disciplines.

67. Rukeyser, *The Life of Poetry*, 162, 163, 176. For examples of poems that do focus primarily on these options see Kurt Brown's excellent anthology *Verse & Universe: Poems about Science and Mathematics* (Minneapolis, MN: Milkweed Editions, 1998). As the editor explains in his introduction, "different fields of knowledge are explored for themes, images, metaphors, and language that might be used in the making of new and unique poems" and "reveal for the rest of us unexpected meanings in the work of scientists and mathematicians" (xiii).

68. Rukeyser, *The Life of Poetry*, 165.

69. Rukeyser, *The Life of Poetry*, 19.

70. Rukeyser, *The Life of Poetry*, 19.

71. Rukeyser, *The Life of Poetry*, 167.

72. Rukeyser, *The Life of Poetry*, 178.

73. Rukeyser, *Willard Gibbs*, 339.

74. Josiah Willard Gibbs, *Elementary Principles in Statistical Mechanics* (Cambridge: Cambridge University Press, 2010 [1902]), x. Cited in Rukeyser, Willard Gibbs, 339.

75. There is now a long-running argument about Olson's originality, or lack of it, in "Projective Verse." Marjorie Perloff showed in a key article, "Charles Olson and the 'Inferior Predecessors': 'Projective Verse' Revisited" (*ELH* 40 (1973): 285–306) that many ideas attributed to him on the basis of "Projective Verse" were actually derived from unacknowledged modernist sources, though she does not mention Rukeyser. In a recent rejoinder, *Charles Olson at the Harbor* (Vancouver, B. C.: Talonbooks, 2008), Ralph Maud takes issue with her largely on the grounds that either Olson could not have read, or there is no direct evidence that he did read, the texts that she cites as sources, or that Olson's language is different, rather than on the more central issue of the genealogy of the poetic concepts (168–172).

76. Olson, *Collected Prose*, 240.

77. Martin Puchner, *Poetry of the Revolution: Marx, Manifestos, and the Avant-Gardes* (Princeton, NJ: Princeton University Press, 2006), 151.

78. In *Adventures of Ideas* (Cambridge, 1933), Whitehead links subjectivity, energy, and geometry: "Our perception of this geometrical order of the Universe brings with it the denial of the restriction of inheritance to mere personal order. For personal order means one-dimensional serial order. And space is many-dimensional…There is thus an analogy between the transference of energy from particular occasion to particular occasion in physical nature and the transference of affective tone, with its emotional energy, from one occasion to another in any human personality…But the human body is indubitably a complex of occasions which are part of spatial nature" (242–243). He also describes projective geometry as a "science of cross-classification" whose interest lies in its being a field of mathematics that studies numerical relations which are not directly based on measurement (176).

79. In his Introduction to Martin Heidegger, *Existence and Being* (London: Vision Press, 1949), Werner Brock makes it sound as if the new physics is the leading edge of *Dasein*'s potential, manifested in its projective acts. In his extended outline of *Being and Time*, Brock claims that a science is made possible when objects and beings are considered as *vorhanden* ("present-at-hand"), and gives as "the classical example" of this "the genesis of mathematical physics, which is decisively guided by the mathematical 'project' of Nature itself" because "only in the light of such a 'project' of Nature can 'facts' be discovered and 'experiments' be planned" (100). This idea that Nature should be understood in terms of projection develops from an earlier discussion of "thrownness" or *Geworfenheit*, and "project" or *Entwurf*: "The 'project' of understanding is always essentially concerned with 'potentialities', in all possible respects" (51). In this passage, Brock then comes close to outlining a projective methodology

as he parses the word in the following sentences, saying that "such 'projecting' has nothing to do with a well thought-out 'plan'" (51) because "Dasein has always 'projected' itself already, and continues to 'project', as long as it is" (51). On the issue of translation, see Miles Groth, *Translating Heidegger* (Amherst, NY: Humanity Books, 2004), 100.

80. I. A. Richards, *Principles of Literary Criticism*, 2nd ed. (London: Kegan Paul, Trench, Trubner, 1926), 143, 185, 241, 29, 70.

81. Mary Hesse, *Forces and Fields: The Concept of Action at a Distance in the History of Physics* (London: T. Nelson, 1961), 27.

82. Martin H. Krieger, *Doing Physics: How Physicists Take Hold of the World* (Bloomington: Indiana University Press, 1992), 27.

83. The "fertility" of scientific metaphors is discussed by Ernan McMullin, "A Case for Scientific Realism" in J. Leplin, ed., *Scientific Realism* (Berkeley: University of California Press, 1984), 8–40. Reprinted in Yuri Balashov and Alex Rosenberg, eds., *Philosophy of Science: Contemporary Readings* (London: Routledge, 2002), 248–280. Thomas Kuhn discusses the "open-endedness" of metaphors for scientific research in "Metaphor in Science," in Andrew Ortony, *Metaphor and Thought* (Cambridge, UK: Cambridge University press 1993), 533–542.

84. In *The Grounding of American Poetry: Charles Olson and the Emersonian Tradition* (Cambridge, UK: Cambridge University Press, 1993), Stephen Fredman points out that in one sense "the 'field' spoken of by poets like Pound, Williams, Olson, Duncan, and Creeley is an alternate ground to the stanzaic measures provided by traditional poetics (147).

85. The concept of the field in Olson's poetics has been given widely varying interpretations by literary critics. Charles Altieri makes extensive use of the concept of a poetic field in his writings to describe an otherwise fluid semantic space of thinking and feeling generated by a poem, notably in *Self and Sensibility in Contemporary American Poetry* (Cambridge, UK: Cambridge University Press, 1984). In *The Culture of Spontaneity: Improvisation and the Arts in Postwar America* (Chicago: University of Chicago Press, 1998), Daniel Belgrad has shown that some influential 1940s theories of society drew on analogies with energy fields. He argues that "as opposed to the atomistic individualism of classical liberalism, the energy field model of human experience defined it as emerging from a 'field of force' that was prior to any human identity" (120). Anne Dewey, in *Beyond Maximus: The Construction of Public Voice in Black Mountain Poetry* (Stanford, CA: Stanford University Press, 2007), takes such arguments further in her discussion of Olson and his contemporaries. She argues that "since the nineteenth century, writers have used the scientific model of the force field to describe collective economic, political, and ethnic forces as the dominant agents of history" and that Olson's field poetics involves "the poem tracking multiple forces in the force field" of history (207). In these and most other cases the emphasis falls on the metaphoric elaboration of the idea rather than its more direct historical interrelations, epistemic and rhetorical, with the discourse of contemporary physics.

86. In *Science and Poetry* (London: Kegan Paul, Trench, Trubner, 1926) I. A. Richards wrote that "in its use of words poetry is just the reverse of science" (24). If poetry's "pseudo-statements" (and propositions in poetry can never be more than simulations of propositions) can even claim to be "true" this "kind of truth is so opposed to scientific 'truth' that it is a pity to use so similar a word." The book went through several editions. The 1935 edition (reprinted in *Poetries and Sciences* (New York: Norton, 1970) reads slightly more cautiously. Now it is "most poetry" that is opposed to science, and Richards uses scare quotes for both uses of "truth."

87. For a discussion of why it can be valid to talk of a plurality of knowledges, see Chapter One of Peter Burke, *A Social History of Knowledge: From Gutenberg to Diderot* (Cambridge, UK: Blackwell, 2000).

88. George Levine, *Realism, Ethics and Secularism: Essays on Victorian Literature and Science* (Cambridge, UK: Cambridge University Press, 2008), 181.