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Atom as the Next Frontier: Literary Materialism in Fitz-James O'Brien's "The Diamond Lens" (1858) and Ray Cummings's "The Girl in the Golden Atom" (1919)

DOI: 10.7311/PJAS.17/2023.06

Abstract: The article is a comparison of settings in two intertextually linked stories about the universe in an atom: Fitz-James O'Brien's "The Diamond Lens" (1858) and Ray Cummings's "The Girl in the Golden Atom" (1919). The argument is that fictional representations of microscopic structure of matter were influenced both by contemporary science and by contemporary imagery of the American frontier, linking both stories to literary representations of the American West. The article presents a number of popular-science texts as possible influences, especially on Cummings's story. The theoretical background is based on Gaston Bachelard's concept of cognitive obstacles, and on the recent theories of "cultural materialism." The comparison of atomic imagery in both stories suggests that the changing scientific ideas about the atom, which the stories obviously reflect, could be combined with the changing image of Western adventure and its frontier setting, as if there was an uncanny compatibility between the two seemingly distant realms of imagination.

Keywords: atom, Fitz-James O'Brien, Ray Cummings, materialism, Gaston Bachelard

Fitz-James O'Brien's "The Diamond Lens" (1858) and Ray Cummings's "The Girl in the Golden Atom" (1919) are early variants of the universe-in-the-atom theme, and thus occupy a special place in the history of American science fiction. The two stories span, as it were, the era of scientific romance, the former being written shortly after Poe, and the latter shortly before the emergence of modern science fiction in the 1920s. In criticism and literary history, both stories are usually mentioned together: critics (Bleiler, Stableford) describe "The Girl in the Golden Atom" as a pastiche (or spinoff) of O'Brien's story. Predictably, in both stories the representation of the atom seems to be strongly related to contemporary popular-science publications: O'Brien's universe in the atom is described as a colorful garden, related to contemporary "microscopic science" (Sommerville), whereas Cummings describes an elaborate atom-world, called "the Oroid," based on the atom that was emerging in physics and chemistry at the turn of the 20th century. O'Brien's descriptions are entirely visual, whereas Cummings uses a variety of dynamic tactile imagery, as characters shrink, enter the atom, and move through ragged, rocky landscapes inside. The two images of the atom, although they are ostensibly based on contemporary science, seem to have been influenced by other areas of American history of ideas: the aesthetics of ladscape description in the American romance, "the pastoral ideal" discussed by Leo Marx, and the mythology of the American frontier, as it developed late in the 19th century. The paper, thus, focuses on how the two stories integrated scientific materialism into their more general ideological backgrounds.

O'Brien's and Cummings's representation of matter share a predilection for substantialist representation of matter, a sense of complexity, confusion, scenes of contemplation of matter as source of wonderful and unknown phenomena, interest in (fantastic) rarefied and near-spiritual forms of matter, and confusion about the concepts of atomic chemistry, which are at the same time frequently referred to. The following comparison of "The Diamond Lens" and "The Girl in the Golden Atom" suggests that at the beginning of the 20th century matter became more complex, unstable, dangerous, and unpredictable. The first, obvious observation is that O'Brien's atomic imagery is visual, whereas Cummings represents the atomic world through visual, tactile, and kinetic imagery, because his characters enter the atom. This conclusion has a number of historical contexts, because both stories seem to be rooted in their contemporary traditions of adventure romance, including the conventional descriptions of frontier landscape. Both O'Brien and Cummings seem to combine imaginary frontier landscape with references to contemporary science; atom, as it were, is treated as another frontier. However, because both stories are set in an atom, they effectively combine two themes: Western expansion (adventure romance) and materialism, the nature of matter. In terms of Bachelard's cognitive obstacles, frontier landscape is a source of sensual imagery used for structuring and conceptualizing of atomic chemistry. This combination seems to have confusing and surprising consequences.

Apart from the two stories, the essay will discuss a number of popular-science texts which seem to be relevant, either as scientific and ideological background, or as possible direct influence. This section will also present a number of critical articles whose themes are similar to those discussed here. Fitz-James O'Brien's story was first published in 1858 in *Atlantic Monthly* and has been repeatedly recognized as an important early example of science fiction, and generally as an important American short story: it was published in at least two mainstream anthologies in the 19th century (Hale; *Atlantic Tales*), in *Weird Tales* (1929), in an early issue of *Amazing Stories* (1.9, 1926), and then in various anthologies of science fiction, perhaps most notably in James Gunn's *Road to Science Fiction* (1979), which is the edition used in the present discussion. The story is about a scientist obsessed with microscopes, who sees (with a fantastically magnifying lens) into mysteries of nature. Is mainly an "optical" story about watching and about the limitations of the human gaze. Although the story seems to have never been analysed in this way, it is a good exaple of the affinity between visual representation, the male gaze, and sexual violence, as the protagonist "discovers" a sort of microscopic garden of Eden in a droplet of water, inhabited by a beautiful woman-like being, who dies under male gaze when the droplet dries out, because it has been exposed on a glass pan under the microscope. Moreover, the fantastic microscope itself is a product of violence, since the protagonist murders a man to get an appropriate diamond for the lens. Thus, literally, male curiosity kills (Cf. Rose; Mulvey). However, the story is also about materiality, since the protagonist learns how to manipulate the arrangement of atoms in the diamond, and then looks into an atom to see beautiful things; optics, the science of atoms that bend light, is a paradoxical point of proximity between the gaze and matter, a version of the body-mind problem. The story has been recently discussed by Kevin Corstorphine (2015), together with the rest of O'Brien's fantastic tales, such as "What Was It?," "The Lost Room," and "The Wondersmith." Corstorphine focuses on the images related to seeing and watching, such as the microscope in "The Diamond Lens," or a surveillance machine in "The Wondersmith," concluding that although the stories use the established "trappings of the Gothic," they also "display a fascinating engagement with contemporary development in science and culture" (14).

Ray Cummings's "The Girl in the Golden Atom" was first published in *All-Story Weekly* in 1919, and has been regarded as a lesser-known classic of science fiction, regularly anthologized, republished, and mentioned in histories (Wolfe). It has been described by Stableford (30) as a combination of O'Brien's idea with H.G. Wells's *Time Machine* (1895) and Edgar Rice Burroughs's *Princess of Mars* (1912). The protagonist enters a microscopic world, has many cloak-and-dagger adventures, loves the microscopic princess Lylda, then returns to the macroscopic world to tell his story. Finally, the protagonist re-enters the atom and disappears. As discovered by Mullen (1999), the similarity between plots of H.G. Wells's *Time Machine* and "The Girl in the Golden Atom" was actually mentioned in the blurb, when Cummings's story was republished in *Argosy-Allstory Weekly* in 1930. Cummings published a sequel in 1920, and expanded the original story into a novel, published in 1923 (Wolfe). The novel version is the text discussed here, because it includes more descriptions of the atomic setting, and more references to atomic science.

Descriptions in both stories will be compared with contemporary scientific backgroud texts. Their selection does not include original scholarly publications, but relatively popular and accessible works designed for general reading. For O'Brien's story, the background material includes publications on microscopy and atomic chemistry, whereas contexts for Cummings's story are presentations of the new atomic theories emerging at the end of the 19th century. Thus, "The Diamond Lens" will be discussed with reference to Mary Sommerville's *On Molecular and Microscopic Science* (1869), and C.R. Goring's *Microscopic Illustrations of Living Objects* (1845). The background for "The Girl in the Golden Atom" includes, most importantly, the American translation of Jean Babtiste Perrin's *Atoms* (1916), a few other books that described recent developments in atomic physics in the 1910s, and a number of magazine articles about the triumph of atomic theory in chemistry. Secondary sources include, again, histories of contemporary atomic science, and Matthew Lavine's cultural history, *The First Atomic Age: Scientists, Radiations, and the American Public, 1895-1945* (2013). There is also a number of relevant studies in the history of microscopy, and the cultural impact of microscopy in the 19th century, such as Laura Otis's *Membranes: Metaphors of Invasion in Nineteenth-Century Literature, Science, and Politics* (1999), which focused on the growing importance of biological cells and their boundaries in popular science after the 1850s. Otis described the transition in life sciences from miasmatic theories of disease, which linked illnesses with places and conditions, to germ theories, which put more emphasis on individuals as carriers of disease. Otis observed that tha biological cell became, in the second half of the 19th century, a metaphor of a human individual, and the membrane, or cell wall, was seen as a metaphorical equivalent of the boundary between an individual and the surrounding nature (13). The fictional examples in Otis's book, however, were written after 1850, and mostly illustrate the "cellullar" or "germinal" imagery of life. O'Brien's story, by comparison, seems to be more "miasmatic," in the sense that his microscopic setting is not marked by clear boundaries, barriers, cells, and such, but seems to be an open and indefinite space filled with sprawling vegetation; this will be discussed further in the anlytical section.

Martin Willis's study on *Vision, Science, and Literature* (2011) is similarly focused on the second half of the 19th century, and does not mention O'Brien's story. The history of microscopy, which forms the background of the story, has been thoroughly described in Jutta Schickore's *The Microscope and the Eye* (2007), which mentions experiements with lens made of various crystals (88), but Schickore's book does not discuss fiction inspired by microscopy.

The Atom as Garden: Fitz-James O'Brien's "The Diamond Lens"

The optical beauty in O'Brien's story has been linked to Victorian children's literature about fairies; Laura Forsberg demonstrated that many Victorian fairy books would also mention the wonders of the microscope, and generally the wonders of science. In "Nature's Invisibilia: The Victorian Microscope and the Miniature Fairy" (2015), Forsberg analyzes "The Diamond Lens" in the context of numerous Victorian books for children, published between 1850 and 1900, with J.M. Barrie's *Peter Pan* as the final link: "fairy fictions and microscopic facts mingled to produce a unique body of literature, suffused with half-believing, half-doubting wonder at the possibility of nestled worlds of microscopic and fairy life" (662). According to Forsberg, the nature of early microscopy made it compatible with the "half-believing" fantastic convention in literature:

> The experience of gazing through the microscope was otherworldly not just because of the strange appearance of the creatures beneath the lens but also because the act of looking through the microscope severed the observer from the world of full-sized reality. Although most Victorian microscopes had a variety of lens magnifications, there was no simple way to "zoom" in or out on the sample; the microscopist gazed either at the familiar world of full-sized reality or at the fantastic world of microscopic life. Microscopists often described feeling disconnected from all ordinary thoughts and sensations. (661)

This description matches O'Brien's use of the diamond lens as a window opening into another world, which gradually disconnects the protagonist from the macroscopic one. Commenting on Victorian fairy books, the critic observes that science and fantasy were described as complementing and compatible products of imagination: "Scientists invoked the fantastic in order to capture the imaginative power of their observations, while fairy fictions immersed themselves in scientific vision of the world to give a sense of reality" (662). This important observation seems to offer no distinction between O'Brien's story and Ray Cummings's "The Girl in the Golden Atom" (1919), which combines fantasy and science in a similar way.

In an a very relevant article, even though it does not actually refer to the story, Stefanie Markovits (2010) points out to the surprising link between the gaze and materiality, which she interprets with reference to early versions of aesthetic formalism in Victorian criticism: diamonds, because of their regular structure, and because of their translucency and radiance, were simultaneously symbols of beauty and beautiful things; Victorian critics who used diamonds as metaphors were apparently engaged in "a consideration of both containing forms (chapters, stanzas, temporal frames) and things contained (abstract—like themes and plots—and more concrete, as in the objects and people that help define the world of the realist novel)" (Markovits 593). Chemically speaking, the formal regularity of diamonds (and other crystals) is a macroscopic image (by multiplication) of their microscopic, atomic structures, because crystals are made, like geometric jigsaw puzzles, of small regular polyhedrons. In the shapes of crystals, as it were, matter displays its secret microscopic structure, right before human eyes. No wonder that crystals were frequently used as mysterious attributes or symbols:

> Of glass, crystal, and diamond, the last is the most obviously form-oriented, the most discretely thing-like. Throughout the nineteenth century, diamonds made their way from the fringes of empire to its center, even as new colonial sources for the stones were discovered Victorian literature registers the diamond's increased visibility; novels almost always mention a ring or necklace, if only casually. More strikingly, diamonds prove crucial to the plotting of Victorian novels as diverse as *The Moonstone* (1868), *The Eustace Diamonds* (1871-73), *Lorna Doone* (1869), *Daniel Deronda* (1876), and *Tess of the D'Urbervilles* (1891). (594)

As Markovits observes, the fascination was "not naïve" (595), because it was related to Goethe's doctrine of *Naturformen* (and presumably to its extension in Ernst Haeckel's *Kunstformen der Natur*): the Victorians valued crystals not only as jewellery, but also as displays of atomic structure, its regularity and its mystery, as monuments of the human gaze, probing into mysteries of nature. Diamonds, in particular, were very important examples because it was generally known in the 19th century that they are a form of carbon, and the difference between coal and diamond is formal, rather than substantial. Markovits quotes from Victorian articles that appropriately describe diamonds as both things (valuable jewels) and forms of human "revolutions" (i.e. fortunes and histories); by extension, crystallographic metaphors were applied (with crystals as vehicles of regularity and fixity) to all sorts of arguments from design, e.g. that women should stay at home because they are like jewels in a crown (597). O'Brien's story, thus, appears to be one of many intriguing and slightly disturbing Victorian texts about diamonds, such as Thomas Carlyle's "The Diamond Necklace" (1833), Christina Rosetti's "A Diamond or a Coal" (1870), or Arthur Conan Doyle's "Adventure of the Blue Carbuncle" (1892).

Microscopic structure of matter is represented in two ways in O'Brien's story: first visible in the form of crystal, and then *through* that crystal, when it serves as the lens. To make the lens, the protagonist runs strong electric current through a gigantic diamond, to reorder its crystaline structure. This is like making a second-degree diamond. The lens, thus, is a sort of new, transparent kind of matter, through which the protagonist can see the ordinary matter. This is reflected in the structure of the story: the Gothic-criminal section about the construction of the microscope is as long as the second section about what is seen through the microscope. For the protagonist, obsessed with microscopic observation, magnification is a window into a mysterious interior of matter, which relates the story to Bachelard's notion of the substantialist obstacle: observables are "put into" a microscopic dimension and kept there as self-explanatory properties of atoms. Thus, the protagonist is looking to "the original atom" as a basic, underlying unit of material reality.

As he gazes through the microscope for the first time, the narrator makes reference to "Alexander's famous wish", presumably describing his desire "to search out the uttermost parts of land and sea" (Loeb 332 a-b). This exploration, crucially, is limited to a play of light and gaze. The microscopic world is clearly described in terms of an exotic and beautiful garden, but filled with floating "copses" whose nature is not explained. O'Brien does not suggest, even implicitly, that he is describing atoms, but the initial (and the most extensive) description suggests a sort of submarine Romantic otherworld:

> It was, however, no brilliant void into which I looked. On every side I beheld beautiful inorganic forms, of unknown texture, and colored with the most enchanting hues. These forms presented the appearance of what might be called, for want of a more specific definition, foliated clouds of the highest rarity; that is, they undulated and broke into vegetable formations, and were tinged with splendors compared with which the gilding of our autumn woodlands is as dross compared with gold. Far away into the illimitable distance stretched long avenues of these gaseous forests, dimly transparent, and painted with prismatic hues of unimaginable brilliancy. The pendent branches waved along the fluid glades until every vista seemed to break through half-lucent ranks of many-colored drooping silken pennons. What seemed to be either fruits or flowers, pied with a thousand hues, lustrous and ever varying, bubbled from the crowns of this fairy foliage. No hills, no lakes, no rivers, no forms animate or inanimate, were to be seen, save those vast auroral copses that floated serenely in the luminous stillness, with leaves and fruits and flowers gleaming with unknown fires, unrealizable by mere imagination.

The narrator discovers an inhabitants of this world, a beautiful microscopic woman whom he names Animula, and he immediately falls in love with her, but she is obviously beyond his reach: "The agony of my sensations, as I arrived at this conclusion, startled me. I tried to reject the conviction that my reason forced upon me. I battled against the fatal conclusion—but in vain. It was so. I had no escape from it. I loved an animalcule!" The animalcule is an inhabitant of a Victorian fantasy world made open by the microscope; she is visible, but the story plays on the inaccessibility and separateness of Animula's world.

O'Brien's imagery is vivid too in its descriptions of luminous and colourful world of microscopic "islands," presumably similar to the motes visible in a microscopic image of a drop of water. The distinct quality of O'Brien's descriptions of the setting is that they often express amazement at the natural beauty of landscape, with the beautiful "unimaginable brilliancy" and sublime "illimitable distance." Such phrases seem to be strongly related to the contemporary descriptions of sublime and pastoral landscapes in the contemporary romance fiction by James Fenimore Cooper, in fiction by other romance writers, in Henry David Thoreau's non-fiction, and, occasionally, in Edgar Allan Poe's texts. It has been demonstrated, especially with reference to Cooper's fiction, that early representations of American frontier landscape were influenced by the Romantic aesthetic of the sublime and the picturesque; the American frontier, in early adventure romances, was usually a forest of astonishing visual beauty. Perhaps most generally, Christopher Mulvey wrote about the "informed vision" of educated travelers, who described landscapes with references to paintings and aesthetic theories of the beautiful and the sublime (23-36). Similarly but more specifically, Cooper's references to picturesque beauty were discussed by Blake Nevius (1976), who observed that Cooper's violent frontier adventures seem incompatible with their peaceful settings.

By comparison, when the protagonist of Cummings's story enters the atomic world, he also sees a forest, but it is a ruined description is brief and neutral, and many settings are rocky and dangerous. It would seem that the sublime and picturesque imagination of the 1850s was replaced with a more austere visual imagery in Cummings's text, but augmented by addition of tactile imagery. O'Brien's imagery is very similar to descriptions of the American frontier as an ideal landscape, represented in terms of the beautiful, the sublime, and the picturesque. Such descriptions usually emphasized the virginal, unspoiled quality of the ideal landscape. Critics who focused on settings in early American adventure romances usually linked this imagery to ideas of pastoralism and the state of nature, most importantly to Jean-Jacques Rousseau's criticism of civilization and to English and American pastoral aesthetics (Marx; Kolodny). As a literary setting, the "first American frontier" (Miller 12) was conceived as a beautiful, conventional backdrop for visual contemplation (Franklin). O'Brien's story uses the conventional landscape of early American adventure romance, but combines it with contemporary ideas about the structure of matter: the picturesque ideal lanscape seems to have been somehow compatible with uncertainty about the existence and nature of atoms. This is by no means an obvious conclusion: visual contemplation, inaccessibility, and beauty and picturesqueness suggest more of an orderly, harmonious setting, like a garden.

An important fact about visual imagery in "The Diamond Lens" is that O'Brien's protagonist does not see atoms as spheres or marbles, but more like bundles of verdant foliage: the "crowns of this fairy foliage," and floating "copses" are perhaps something like festoons in a garden, but generally the description is charged with the tone of confusion, both spatial and visual, as the structures are "unreliazable by mere imagination." Thus, when the narrator sees atoms, for all his raptures at their beauty, he cannot tell what he sees exactly. This is perhaps a reflection of the uncertain status of atoms in contemporary chemistry: numerous non-literary texts suggest that atoms were often described as hypothetical, perhaps dubious entities. Consequently, O'Brien's descriptions seem to saturate atoms with imagery derived from contemporary popular-science books about microscopy, in particular with imagery related to observations of polarization effects on crystaline surfaces and observations of vegetable cells.

A set of very good contexts for O'Brien's story can be found in Mary Sommerville's *On Molecular and Microscopic Science* (1869). Although it came out later than "The Diamond Lens," Sommerville's bestselling book discusses observations and effects that were well known earlier, and mentioned in earlier literature. It is also a good example of the 19th-century scientific treatise, which combined original research with popular science, and general philosophy of nature. More specifically, Sommerville's book explicitly and eloquently combines microscopy with atomic chemistry, suggesting that atomic chemistry, optics, and microbiology are parts of a more a general, interdisciplinary inquiry into microscopic nature of matter. The author, like most chemists of the day, states that "[w]e know nothing of the forms either of atoms or of those groups of atoms which we call molecules" (2), and that properties of atoms can only be inferred indirectly from macroscopic observations. To this end, *On Molecular and Microscopic Science* refers to chemistry, crystallography, and optics. Thus, having described various microscopic observations of crystals (50-70), Sommerville focuses on polarization effects, observing that "polarization forms the most admirable connection between light, heat, and crystalline structure; showing peculiar arrangements of the molecules in regions otherwise unapporachable, and too refined for our perceptions" (71). The author also included numerous comments on the dazzling beauty and radiance of crystaline surfaces. Earlier, C.R. Goring made similar observations, suggesting that microscopy can contribute to physics of matter: "By simple modification of its polarizing apparatus, the microscope becomes of great value in investigating some of the physical properties of matter" (29). Both Goring's and Sommerville's books progress from microscopic observation of crystals to observation of living things, starting with the smallest cells, which were assumed to be the most primitive, basic units of life. Thus, Sommerville describes the primordial cell as a container of protoplasm, and a basic unit of life: "In its earliest stage the primordial cell is a globular mass of an azotized colourless organizable liquid, called protoplasm, the life blood of vegetation, containing albuminous matter and dextrine or starch-gum" (170). In O'Brien's book the way to microscopic mysteries of matter is presented in reverse order, like zooming in from biological observations to optical effects in crystals. In the resulting imagery from O'Brien's story, biology and optics is combined into an ideal garden-like landscape, with imagery related to animals, plants, and rocks, which is vaguely similar to the following description by Sommerville:

> It has been mentioned that in the primordial cell the solid coloured particles often form a nucleus in the centre of the viscind liquid called protoplasm, which is continually diminshed by the increase of the watery vegetable sap. At length the protoplasm in the hairs is reduced to mere threads extending from the cell wall to the nucleus, so that the latter looks like a spider in the middle of its web. These threads are really streams of the viscid protoplasm flowing through the more liguid cell sap from the nucleus to the cell wall, where they turn and flow back in another thread. (412)

Microscopic science was, in a way, an interdisciplinary project, unifying physics, chemistry and biology into a contemplation of nature's beauty. The analysis suggests that "The Diamond Lens" was a fictionalized version of microscopic science. However, the link between

What is crucial for the present discussion, is that the narrator does not look at atoms, but directly at another world of idealistically conceived beauty: "I now comprehended how it was that the Count de Gabalis peopled his mystic world with sylphs—beautiful beings whose breath of life was lambent fire, and who sported forever in regions of purest ether and purest light. The Rosicrucian had anticipated the wonder that I had practically realized." Thus, although O'Brien's treatment of the construction of the microscope requires an implicit reference to crystallography and atomistic theory, his representation of the microscopic Eden is not atomic: perhaps the magnifying power was not sufficient, but more likely it was more than sufficient, opening the vista of a trans-atomic world, which is fleeting, mortal, but somehow immaterial. Instead of treating his visions as matter, the narrator focuses on their optical beauty, focusing on their refracted and emitted light.

The Rough Atom in "The Girl in the Golden Atom" by Ray Cummings

In Cumming's story, the protagonist can initially see the microscopic world, but then the lens mysteriously explodes and the strategy of representation becomes precisely the opposite from O'Brien's "The Diamond Lens": although he can no longer see the microscopic world, he can enter it after he shrinks to sub-atomic size (as a chemist, he invents the necessary pills that can shrink and magnify him). Thus, the author opens a world of atoms by filling the microscopic Eden with tactile imagery (at some stage, the character gets bumped by atoms, then has to tread among them).

The narrator, described as "the Chemist," begins by a brief spin-off of O'Brien's story, with the same visual regime of a conquering gaze. This time, however, the chemist explicitly talks about looking inside an atom:

> 'Gentlemen,' resumed the Chemist, 'what I saw staggered even my own imagination. With trembling hands I put the ring in place, looking directly down into that scratch. For a moment I saw nothing. I was like a person coming suddenly out of the sunlight into a darkened room. I knew there was something visible in my view, but my eyes did not seem able to receive the impressions. I realize now they were not yet adjusted to the new form of light. Gradually, as I looked, objects of definite shape began to emerge from the blackness.… 'Gentlemen, I want to make clear to you now—as clear as I can—the peculiar aspect of everything that I saw under this microscope. I seemed to be inside an immense cave. One side, near at hand, I could now make out quite clearly. The walls were extraordinarily rough and indented, with a peculiar phosphorescent light on the projections and blackness in the hollows. I say phosphorescent light, for that is the nearest word I can find to describe it—a curious radiation, quite different from the reflected light to which we are accustomed.' (Cummings 4)

Already at this point, the narrator is anticipating the tactile representation that will dominate in subsequent chapters, because as he sees the microscopic girl that will become love interest, his desire to touch is half-satisfied optically: "Her lips were a deep red, although I felt rather than saw the colour." This optical contact, however, is terminated by accidental destruction of the microscope, an ending which is similar to the ending of O'Brien's story, but with an atomic twist: the "peculiar light-radiations" from the atom, when magnified by the microscope, have shattered the lens. This happened because of the immensity of the microscopic world, and because of the general immensity of everything:

> 'As a matter of fact, I do believe that to be the case,' said the Chemist earnestly. 'I believe that every particle of matter in our universe contains within it an equally complex and complete a universe, which to its inhabitants seems

> as large as ours. I think, also that the whole realm of our interplanetary space, our solar system and all the remote stars of the heavens are contained within the atom of some other universe as gigantic to us as we are to the universe in that ring.'
> 'Gosh!' said the Very Young Man. (7-8)

In this, Cummings's vision is closer to atomic chemistry, because it conceives of the world in terms of tangible forces, rather than O'Brien's optics, which seem to have been a set of images of impalpable ideals.

As background context for Cummings's story, the confident tone of popular-science articles written after the periodical table became generally known is exemplified by a triumphant article about meteorites published in *Cosmopolitan* in 1890. Presumably, not only the periodic table, but also advances in chemical analysis made the following statement (its tone) possible:

> It is well known that the different compounds which constitute this earth have been resolved into sixty-six elements…. Of these sixty-six elements, thirty four have been recognized among the substances brought to our earth by meteorites. Not one new substance, unknown to us before, has been detected; nor, excepting in a single doubtful case, has the spectral analysis of the heavenly bodies revealed the possibility of an unknown element.… Moreover, these elements come to us from the infinity of interplanetary space, combined in minerals often identical with, always similar to analogous combinations of like elements on our earth. (Heard 217)

The author then compares meteorites to witnesses, confessing "nothing but truth and only truth" when questioned in the universal language of sixty-six elements. Thus, the "man can stand before God, holding a fragment of a star and say, 'Lord we understand thy laws!'" (218). The confidence springs from the new habit of thinking about matter, as a set of infinitely varied compound particles that consist of a small number of types of building blocks.

Cummings's story was written during the relatively brief time between the discovery of radioactivity and the establishment of new models of the atom, as created (among others) by J.J. Thompson, Ernest Rutherford, and Niels Bohr in the 1910s. It was a rapid progress, recognized as one of the greatest events in the history of science, whose stepping stones include Niels Bohr's 1913 paper ("On the Constitution of Atoms and Molecules") on planetary electrons, and Rutherford's discovery of the proton announced in 1917 in the paper on "Collision of α Particles with Light Atoms" (both papers were published in *The Philosophical Magazine*). The emerging model, created in response to a series of experiments and discoveries, is well known and taught to schoolchildren today, even though the model has been replaced by subsequent developments of quantum physics: this was the planetary atom, with a nucleus made of protons and neutrons, and electrons flying on orbits around the nucleus. For chemistry, this model made it possible to answer the questions posed by Dalton and Prout a hundred years earlier. As it has been already mentioned on several occasions, there had been speculations that atoms are made of the same basic building block, which was supposed to be the atom of hydrogen. The speculation implied that atomic masses of elements would be multiplications of the atomic mass of hydrogen, and it had been impossible to explain why this was the case only for some elements. In the 1910s, Prout's hypthesis and Mendeleev's table suddenly could be based on a systematic, visual model of the atom: the atomic mass was roughly equal to the number of protons and neutrons in the nucleus, the atomic number (i.e. the position of an element in Mendeleev's table) was equal to the number of protons, and valency was about the number of electrons flying around various orbits around the nucleus. It was a neat visualization, which gave matter a sense of predictability and regularity, but the tone of confidence was lost again after the discovery of radioactivity and the emergence of nuclear physics, leading to a new confusion, reflected in Cummings's story.

When the story was published, scientific descriptions of atom have recently transitioned from the "plum pudding model" by J.J. Thomson to the "planetary" model developed by Ernest Rutherford (and other physicists) in the first two decades of the 20th century. The "ten original papers" which presented new models of the atom were compiled by Lakhtakia, and three of them (by Thomson, Rutherford, and Niels Bohr) are particularly important as the distant background for Cummings's book (233-308). The importance of Thompson's model was that it presented the atom as a composite object; it theoretically divided the atom into parts to account for various physical observations (the emission of electrons from a metallic surface in a Crookes tube). Thomson envisioned the atom in terms of "plum pudding", or even the "raisin muffin" (Lakhtakia 36-38): electrons were negative raisins stuck in an electrically positive doughnut (Reeves 29). Thus, the atom in Cummings's story is a hollow sphere ("the Oroid"), inhabited on both sides, with caves and tunnels between its inner and outer surface. Inside of the hollow sphere, there are celestial bodies, which are presumed to be inhabited too, by creatures even smaller than the "Oroids" (the inhabitants of the atom). Because it is a hollow sphere, Cummings's atom is not strictly based on Rutherford's planetary model, but seems a combination of Thomson's and Rutherford's models. Cummings's imagery is most likely based not on Thomson's and Rutherford's papers directly, but on more popular representations of atomic science published in the 1900s.

In the first decade of the 20th century, there was a number of popular discussions of the rapid change in the atomic theory of matter; those discussions were related to the general interest in radioactivity at the same time (Lavine). Among the general and accessible contemporary presentations of new developments there were Marion Erwin's *The Universe and the Atom* (1915), F.B. Venable's *The Study of the Atom* (1904), Ernest D. Wilson's *The Structure of the Atom* (1916), and above all the English translation of Jean Babtiste Perrin's *Les Atomes* (1916). They all presented a comprehensible picture of how the new atom models were influencing other sciences, chemistry in particular, and how they were changing the idea of materiality. Cummings's story seems to have been derived from some of the concepts which presented in such books, perhaps because the discoveries of atomic physics were instantly becoming general knowledge at the time, although the comprehensive study by Lavine suggests that early in the 20th century fiction and popular science were mostly about rays, not atoms.

These books share the surprise at the complexity and dynamic quality of the new atom. Venable, for instance describes atoms as "aggregates of electric charges in a violent motion" (277) and mentions "radiation of light or an ether wave of some kind"

(278) emitted and absorbed by accelerating and decelerating electrons. This perhaps corresponds to the luminosity frequently mentioned in descriptions of the setting in Cummings's story. Wilson even finishes his book, a lucid presentation of discoveries by Rutherford, Moseley and Bohr, with the suggestion of the universe in the atom, including the grain-of-sand quotation from Blake's "Auguries of Innocence". However, both Wilson's and Venable's books seem to have been addressed to a narrow academic and technical readership. Moreover, all three books refer to Perrin's book, which is the most imaginatively written one, and seems to have had the widest range of readers. Some specific images used by Perrin also suggest that the book was a direct influence on Cummings's story.

Perrin's *Atoms* (1916) was first published in French in 1913. The book was like a popular lecture on contemporary atomic theories, and its scientifically most important part was an accessible discussion of Perrin's sedimentation experiments, which confirmed Einstein's theory of Brownian motions. Perrin was later awarded Nobel prize for these experiments. With reference to Cummings's story, the preface to the book includes an imaginary journey into microscopic universe, following a shrinking "spherule." Perrin puts a particular emphasis on the passage from high-density barrage of Brownian motions to the nil-density of subatomic space:

> One step further and the radius becomes of the same order as the molecular radius. Then, as a general rule (in a gas at any rate), our spherule will lie in intramolecular space, where its mean density will henceforth be *nil*, at our given point the true density will be nil also.… If the spherule were to become even smaller, it may be that we should attain a measure of continuity, until we reached a new order of smallness; but more probably (especially in the atomic nucleus, which radioactivity shows to possess an extremely complicated structure) the mean density would soon fall to nothing and remain there, as will the true density also, except in certain very rare positions, where it will reach values enormously greater than any before.… The conclusion we have just reached by considering a continuously diminishing sphere can also be arrived at by imagining a continuously enlarging sphere, that successively embraces planets, solar system, stars, and nebulae. Thus we find ourselves face to face with the now familiar conception developed by Pascal when he showed that man lies 'suspended between two infinities.' (xii-xiii)

This comment corresponds to several speculative passages about atoms within atoms, and worlds within worlds in Cummings's story, for instance: "I believe that every particle of matter in our universe contains within it an equally complex and complete a universe, which to its inhabitants seems as large as ours. I think, also that the whole realm of our interplanetary space, our solar system and all the remote stars of the heavens are contained within the atom of some other universe as gigantic to us as we are to the universe in that ring" (Cummings 4). The protagonist, as it seems, has already brought, through his shrinking, many gigantic universes into the subatomic world.

The descriptions of radiation and darkness in Cummings's story seem to have been inspired by Perrin's remarks on light and colour in *Atoms*; the French chemist was pointing out to various emissions (electromagnetic emissions and radioactivity) as indications of various atomic phenomena. Thus for instance, Perrin describes the observation of colourful bubbles as a way of sighting layers of near-atomic thickness, in a fragment which seems quite similar to several passages in Cummings's story, when the protagonist shrinks and sees various colours of radiance and gleaming light:

> The study of 'thin films' can lead us even further. During the blowing of a soap bubble we often notice, in addition to the familiar brilliant colours, small round black spots with well-defined edges. These spots might be taken for holes, and their appearance is almost immediately followed by the rupture of the bubble. They may be readily observed while washing the hands, on a film of soapy water stretched between the thumb and the forefinger. When this film is held vertically the water in it gradually drains to the bottom, while the upper part becomes thinner and thinner, which process can be followed by the colour changes that occur. After it has been become purple and pale yellow, the appearance of black spots will soon be noticed; they run together, forming a black space, which may fill the quarter of the height of the film before it breaks.… In the first place, these black spots are not holes, for it is easy to show, as was done by Newton, who first studied them, that, though black by contrast, they nevertheless reflect light, and that new round, sharp-edged spots ultimately appear within the original spots; the new spots are still darker and hence thinner, and *also* reflect feeble images of bright objects, such as the sun. (Perrin 49-50)

In Cummings's story, there are similar descriptions of what the protagonist sees first through the microscope: "It was a blackness that seemed also to radiate light, if you can imagine such a condition; a blackness that seemed not empty, but merely withholding its contents just beyond my vision" (4). This is part of a longer descriptive passage, which emphasizes the protagonist's confusion and amazement. Looking at the surface of the atom is like entering a cave: "Except for a dim suggestion of roof over the cave, and its floor, I could distinguish nothing. After a moment this floor became clearer. It seemed to be—well, perhaps I might call it black marble—smooth, glossy, yet somewhat translucent. In the foreground the floor was apparently liquid. In no way did it differ in appearance from the solid part, except that its surface seemed to be in motion" (4). Similar descriptions follow, when the protagonist returns from his first shrinking voyage into the atom:

> I found myself now, as I looked about, walking upon a narrow, though ever broadening, curved path. The ground beneath my feet appeared to be a rough, yellowish quartz. This path grew rougher as I advanced. Below the bulging edges of the path, on both sides, lay a shining black plain, ridged and indented, and with a sunlike sheen on the higher portions of the ridges. On the one hand this black plain stretched in an unbroken expanse to the horizon. On the other, it appeared as a circular valley, enclosed by a shining yellow wall. (27)

This is the initial part of the voyage, where the narrator can still discern the curvature of the golden ring, and about to shrink into sub-atomic sizes. The shrinking is accompanied by a shift from visual imagery to descriptions of rough surfaces and violent movements, a shift to tactile imagery.

Cummings's tactile imagery is, according the theoretical framework assumed in this study, an example of the animist obstacle: the structure of matter is presented in terms of violent sensual perceptions based on images of collisions, bodily harm, gusts of wind, bumps, strain, injury. Thus, for example, when the protagonist (the Chemist) first shrinks to enter into the world of the atom, he is badly bruised, and the descriptions of setting include epithets related to roughness and sharpness. The surface of the golden ring is now "shaggy and rough," and covered with "bowlders, hundreds of feet in diameter" (27). Having shrunk to near-atomic size, takes another dose of shrinking pills, and briefly loses consciousness, only to awake on the surface of the atom:

> After my vertigo had passed somewhat—it was much more severe this time—I looked up and found my surroundings growing at a far more rapid rate than before. I staggered to the edge of the pit. It was opening up and widening out at an astounding rate. Already its sides were becoming rough and broken, and I saw many places where a descent would be possible.
> The feeling of sleep that had formerly merely oppressed me, combined now with my physical fatigue and the larger dose of the drug I had taken, became almost intolerable. I yielded to it for a moment, lying down on a crag near the edge of the pit. I must have become almost immediately unconscious, and remained so for a considerable time. I can remember a horrible sensation of sliding headlong for what seemed like hours. I felt that I was sliding or falling downward. I tried to rouse but could not. Then came absolute oblivion.
> When I recovered my senses I was lying partly covered by a mass of smooth, shining pebbles. I was bruised and battered from head to foot—in a far worse condition than you first saw me when I returned. (30)

In a way, Cummings's contemporary knowledge about atoms is presented in tactile terms, in descriptions of smoothness and roughness, and in descriptions of bodily fatigue and harm.

In another reference to contemporary science, the author describes the battering that protagonists get, while shrinking to near-atomic size, as a hurricane, which is reminiscent of the Brownian motions of small microscopic objects bumped by atoms:

> They had just started again in the direction of the hills when, almost without warning, and with a great whistle and roar, a gale of wind swept down upon them. They stood still and looked at each other with startled faces, bracing with their feet against its pressure.
> 'Oh, golly, what's this?' cried the Very Young Man, and sat down suddenly upon the ground to keep from being blown forward.
> The wind increased rapidly in violence until, in a moment, all three of the men were crouching upon the ground for shelter. (113)

Similarly, tactile imagery is employed to the description of optical phenomena in the initial subplot of the novel, when the Chemist builds a microscope that can make the atomic world visible. The subplot ends with a destruction of the lens caused, as it seems, by magnification of the light itself: "I can appreciate, though, that through that lens I was magnifying tremendously those peculiar light-radiations that I have described. I believe the molecules of the lens were shattered by them—I had exposed it longer to them that evening than any of the others" (7). Again, the imagery is based on damage caused by magnification. For Bachelard, these descriptions can be interpreted as examples of optics the substantial obstacle: the bumping and scratching makes atoms more "material," or more substantialist. Cummings's world is sensual in that it is often based on descriptions of direct and violent contact. Bumping in the atomic microscale, in his novel, is an explanation of physical effects in the macroscale. The macroscopic effects are less violent because atoms cannot harm the large observer, but when he or she takes the shrinking pills, their world becomes rough and ragged, and thus not substantially different from the everyday experience of matter.

Thus, Cummings's imagery seems to be related to arid and dangerous settings of contemporary aventure romance, perhaps most importantly to Burroughs's novels about Mars. Instead of an ideal lanscape, Cumming's presents a setting that is a site of struggle against nature. Hence, there is so much bruising, effort and exhaustion, rough boulders, shart edges, glaring heat etc. Perhaps this is suggestive of contemporary Western novels, and of the Darwinian struggle known from contemporary naturalist fiction (or the combination of both in Jack London's fiction). The intriguing conclusion, however, is that struggle against nature is compatible with Cummings's appreciation of contemporary atomic theory. When atom could be confidently described in terms of atomic numbers and weights, and when descriptions of its structure were based on images of rapid, dynamic motion, the atom somehow became compatible with images of physical struggle in a rocky Western desert.

Comparison and Conclusions

In the context of the American romance, Cummings's story is an example of continuity of the romance tradition after 1865, not as an outdated survival, not as an antiquity piece, but as a result of keen interest in natural science and in the nature of matter. Somehow, at the very core of realist interest in matter, there was a potential to produce a romance, which was the preferred contemporary term for early forms of science fiction, as in the scientific romances by H.G Wells in Britain and, less famously, by Edgar Fawcett in America. As it has been demonstrated, the imagery was often related to the imagery fo the American adventure romance, to Gothic and pastoral adventures, to the American Transcendentalist cult of nature, and to frontier experience. Similar relation was detected by Cogell (1978), who discussed links between 20th-century American science fiction and the American pastoral aesthetics, as described by Leo Marx in *The Machine in the Garden*. The microscopic structure of matter, which was inaccessible wonderland in O'Brien's story, becomes an acccessible land of adventure in Cummings's version. Thus, for a brief time, the atom could be incorporated into the American wilderness myth, the atom was a new imaginary frontier, an uncharted territory of free adventure, power play, and opportunity. This surprising placement of the frontier, squeezed into the invisible microscopic world, is part of the enduring legacy of the American romance as well.

The most important difference, however, is the type of sensual imagery, which includes not only visual imagery, but also descriptions of touch and bodily strain, and the plot device, because Cummings's story is about a voyage, it makes the microscopic world accessible. On closer scrutiny, it seems that these two changes were related to the changes in atomic theory of matter, in physics and chemistry of the time. Thus, it seems that science not only changed as a theme and background of fiction, but also changed the fiction itself, the convenctions and array of devices used in fantastic fiction (and perhaps in realistic fiction as well). Additionally, the change seems to have been related to the general interest in chemistry, not only physics or natural science in general, because chemistry seems to offer more oppotrunities to relate atomic concepts to everyday experience, especially for development of sensual and substantialist imagery. The imagery employed by O'Brien is related to the contemporary aesthetics of sublime and picturesque beauty, that is to visual contemplation of natural landscape. Cummings, on the other hand, created an imaginary atom which is primarily a site of struggle against nature and against human enemies. Both ways, the atomic settings seem to be based on contemporary visions of the American frontier. By projecting those visions onto atoms, both authors created ideologically charged ideal and imaginary landscapes, both authors seem to suggest that certain elements of imagery are actually properties of matter: O'Brien's matter is imbued with the beauty of vegetable life, suggesting that the macroscopic beauty of a picturesque landscape is a magnification and multiplication of the primordial, microscopic beauty of atoms. For Cummings, matter is a hostile environment, based on tactile imagery of strain, exhaustion, struggle, and bodily harm. Correspondingly, his atoms are initially rough, sharp, bumpy, and when magnified enough to be entered, they become arid and luminous landscapes, described in terms of vast distances and the effort needed to negotiate them. Thus, the properties of Cummings's matter are related to the sensual obstacles: the macroscopic matter is what offers resistance to human effort, and does harm to human body, because this is what atoms do on the microscopic level.

Cummings's tactile imagery can be related to contemporary Western fronties mythology, as it developed late in the 19th century. At that time, the influence of sublime and picturesque aesthetics was less important than metaphorical imagery related to resistance and struggle, which was usually combined with brief and rough references to racial and social Darwinism; this is the traditionally accepted observation which goes back to Frederick Jackson Turner's original book, and has been developed in American studies, beginning with seminal work by Henry Nash Smith (1950, 240), subsequently developed by Burton (1965), Cronon (1987), or the recent essays in Jada Ach and Gary Reger's collection (2020), and by Stephen J. Mexal's *The Conservative Aesthetic: Theodore Roosevelt, Popular Darwinism, and the American Literary West* (2020). The sources discussed in the latter book are directly comparable to Cummings's imagery.

More generally, the transition between O'Brien's and Cummings's settings suggests that the imaginary atoms were shaped, as it were, from two sides. On the one hand the imaginary atoms were influenced by contemporary science, most likely filtered through popular-science publications. On the other hand, imaginary matter conformed to a more general change in aesthetics and ideology, which were the sources of imagery used to represent scientific concepts. In Bachelard's framework, the use of such imagery leads to development of cognitive obstacles, escpecially the obstacle of immediacy and the sensual obstacle. Hence, both stories resulted from an interaction between scientific developments and conventional aesthetics of the time. This might seem an obvious thing to say, but the mechanism of the interaction is not a straightforward one, as indicated by the two very unusual and aesthetically diverse sets of imagery in O'Brien's and Cummings's stories. The microscopic structure of matter in "The Diamond Lens" inspires delight, but is otherwise an inaccessible fantasy world, an ideal landscape infinitely removed from the protagonist's macroscopic world. In terms of Bachelard's cognitive obstacles, O'Brien's atoms result from the substantialist obstacle, as they "contain" the vitality of living things, and the precious, ideal beauty of nature. Cummings's atom, on the other hand, results from the sensual obstacle, because it is built of images of strain, bodily harm, pain, and the violent tactile imagery. In both stories, important aspirations and preconceptions were projected onto the authors' imaginative constructions of microscopic matter, to explain what the authors probably considered as important qualities of their macroscopic worlds.

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