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Climate Mathematics

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Abstract

This essay is a critical response to Geoff Mann and Joel Wainwright's (2018) *Climate Leviathan*. It focuses on the political alternative fleshed out towards the end of the book: "Climate X." For Mann and Wainwright, X is a variable to "solve for." I seek to take this seriously as a mathematical statement, exploring the extent to which a politics of Climate X can be considered *algebraic*, especially in light of Mann and Wainwright's references to "fragments" in the work of Theodor Adorno and Walter Benjamin. The book's algebraic approach, I argue, reduces the fragment (X), and politics along with it, to something numerable. From a different reading of Adorno and Benjamin, I show how two other fields of mathematics—set theory and fractal geometry—help address some of the pitfalls of Climate X, while pointing towards another climate politics that embraces deviation, infinity, and nothingness.

Keywords

Climate; mathematics; politics; algebra; fractals; geometry

Squaring the Circle

Unveiled in February 2019, the Green New Deal (GND) has had a fracturing effect on the left. The proposed resolution calls for a massive state spending program, whose goals would be to decarbonize the economy, create jobs, and invest in infrastructure. While some argue that these initiatives open up a "new terrain" for radical politics (Riofrancos 2019) others forecast that the GND will ultimately reentrench capitalist interests (Bernes 2019).

As debates over the GND rage on, *Climate Leviathan* appears increasingly important. Geoff Mann and Joel Wainwright's 2018 book presents a bold and much needed theoretical framework for critically engaging with initiatives like the GND, among other potential political responses to climate

change. Outlined in the book are four archetypical futures, which are depicted as four squares on a Euclidean plane (see p. 29). The first, and most relevant to the GND, is the Climate Leviathan. Inspired by Thomas Hobbes, Climate Leviathan is an ostensibly green version of global capitalism, one that is governed by a planetary sovereign. Other possible futures include the reactionary capitalist Climate Behemoth, and the non-capitalist but state-run Climate Mao.

Critical of all these futures, Mann and Wainwright's account helps us think speculatively and cautiously about political solutions to climate change. A radical solution, they argue, demands a different future altogether. After Leviathan, Behemoth, and Mao are vanquished one by one, the final line of the book rhetorically asks: "What remains? All we have and all we ever had: X to solve for, a world to win" (2018: x). Climate X is Mann and Wainwright's "radical alternative," a break with the current order of things. Unlike the other futures with which it competes, Climate X is staunchly non-capitalist and non-sovereign, and the form it takes remains "open to the future."

This commentary raises issues with Climate X. Mann and Wainwright's alternative is symptomatic of a larger political tendency on the left with regards to climate change: the desire to imagine "solutions." Solutions impart a certain fixity and finality to political action; they account neither for historical contingency nor for a future that breaks with the current order of things. In the end, solutions are intrinsic to a set of problems, and thus remain bound to their present environment and to that environment's social divisions (around class, race, gender, and so forth). By treating climate crisis as something to be solved, these divisions are extended into the future, finding their way into the most radical of solutions. For if there is a "winning" outcome to the problems of climate change, there will surely be those who lose out in the process, those who get left out of the equation altogether, failing to be of use to the political cause. Rather than emancipatory, solutions are good business. As the growing environmental services industry shows, solutions to climate change increasingly provide a major "fix" for capital accumulation, while keeping exclusionary structures intact (see MacFarlane 2019).

To fully illustrate the limits of a problem-solving approach to politics, I seek to take Mann and Wainwright seriously in their allusions to mathematics. Climate X is, after all, something that needs to be "solved for." Its X is a "variable" that must be filled in (2018: 174, 193). Such gestures are not just rhetorical. Mann and Wainwright's larger project can be conceived as kind of *political algebra* that generates climate solutions as numerable and imaginable values. As I show in the section below, this political algebra is derived from a particular reading of Adorno and Benjamin concerning the role of the *fragment*. The rest of the paper draws on another reading of Adorno and Benjamin, which points to a very different kind of mathematics, one rooted in *set theory* and *fractal geometry*. Mathematical concepts in these areas can, I argue, help us think politics beyond the numerable and imaginable—towards something radically infinite. The goal is to contribute to the ongoing "mathematical turn" in critical human geography (Barnes 2019; O'Sullivan et al. 2019; Billé 2018; Martin and Secor 2014).

Above all, what needs to be recognized is that sometimes the solution to a mathematical problem is not possible. Thomas Hobbes, whom Mann and Wainwright rely on so heavily, found this out the hard way. In his 1655 book *De Corpore*, Hobbes rather arrogantly claimed to have solved the ancient geometric problem of "squaring the circle" (constructing a square with an area equal to that of a given circle using only straightedge and compass). His claims were misguided and led to much public ridicule (see Jesseph 1999). To their credit, Mann and Wainwright fully accept the "risk of being very wrong." But what would it mean to make this *risk* itself the driving force of politics? What if solving climate change is akin to "squaring the circle"? What does a politics look like that addresses mathematical impossibility?

Political Algebra

At the very end of *Climate Leviathan*, Mann and Wainwright reframe their discussion of Climate X around Theodor Adorno's and Walter Benjamin's notions of the fragment. It's a small part of the book, taking up just ¾ of a page, but it provides much of the philosophical justification for Mann and Wainwright's form of critique and their larger arguments about climate politics. Rather than a rigid blueprint for action, Climate X is said to be found in "the ruins and fragments of our natural-historical moment" (2018: 197). Fragments, as Mann and Wainwright consider them, point towards new "possibilities." The implication is that they are able to do so because they allow us to experience "transience." In Adorno and Benjamin's sense, transience is experienced as "both crisis and opportunity." It provides a momentary passageway into "another world." As a source of transience, the fragment can thus be placed at the core of *Climate Leviathan*, as that which "offers a vision of alternatives" (p. xii).

But Mann and Wainwright's treatment of the fragment also shows how this vision is premised on an algebraic procedure. Algebra comes from the Arabic word *al-jabr*, meaning "reunion of broken parts." Algebra uses symbols such as variables to represent the properties and relationships of abstract things, placing them in expressions and equations. Fragments are algebraic for Mann and Wainwright because they are treated as variables. The task is to solve them—to see them "for what they truly are" (p. 197). As in algebra, Climate X "must be able to become and include what it needs to be to point us toward (at least the beginnings of) a solution." Radical politics is framed as a "logical result" of critical procedures (p. 183). It is all about finding the correct alternatives to fill in the variables and solve the problem. It is about getting the numbers right.

While providing a clear method for progressive climate politics, Mann and Wainwright's algebra comes with a set of limitations. In solving for X, Mann and Wainwright are forced to reduce the fragment—and politics along with it—to an issue of identity. In alegebra, identity is a relation of equality (X = Y) that is always true, no matter what values are picked. Viewed through identity, the fragment is made into an abstract variable that can be isolated and determined through its equivalence with other things. This equalization (the algebraic procedure) allows us to assign the fragment a stable value. As a result, the content of politics (X) becomes something numerable. It can be measured, counted, and fixed as a whole, and thus acquires a certain logical completeness. The goal of struggle, we might say, becomes a matter of good arithmetic. This is really the utopian principle in mathematical form: where the ideal future is the completion of some present calculation.

This does not mean that X is singular, homogenized, or universal. On the contrary, Mann and Wainwright clearly state that "there is no one Climate X" (p. 189). It is not a "set of all" struggles, nor will it ever be a "unified phenomenon" (p. 193). And yet it is precisely this critique of universality, which runs through *Climate Leviathan*, that leads to a politics of addition: "Bundle together the most radical strategies of the climate justice movement […] and you will glimpse Benjamin's vision of another world" (p. 197). Here what matters is the (non-universal) bundle itself—X as a sum—rather than particular and concrete struggles. Particularity is only registered when it can be identified as useful for solving X.

Political algebra thus demands a certain style of abstract thinking. According to mathematician W. W. Sawyer (1943), when we are unable to solve a problem in algebra it is due to a failure of the imagination. Mann and Wainwright say something similar with regard to climate change. The

"planetary crisis," they argue, is largely a "crisis of the imagination […] the result of an inability to conceive any alternative" (2018: 197). What's called for is a kind of political modal logic that allows us to map out possible worlds, from the negative ones (Leviathan, Behemoth, Mao) to the positive ones (X). If we lack a radical climate politics, so the reasoning goes, it is because we are unable to imagine a winning formula, which is the same as being unable to calculate it. But the game is always rigged: it generates its own justification. Framing the problem in terms of an imagination shortage bolsters the demand for new climate alternatives, and for books like *Climate Leviathan*.

While some of these imaginations may be genuinely useful for climate struggle, they often reinscribe social divisions through their claims to novelty. To see how this happens, it's helpful again to return to the issue of algebra. In solving for X, Mann and Wainwright's project is subject to three major critiques. First, as decades of feminist geographers have pointed out, the desire to fix a broken world—to make it pure and whole again by *filling in X*—can reflect a patriarchal desire for mastery while ignoring the many ways in which, today, "political struggle is fractured" (Staeheli and Lawson 1995: 325; see also Rose 1995). Second, the quest for an unknown alternative—where *X marks the spot*—seems at times to frame the planetary future as a kind of *terra nullius*, a totally "open" space that may be "won." While Mann and Wainwright are rightly skeptical of utopianism, more critical attention needs to be given to the potential imperialism lurking behind an open, unoccupied X (cf. Shaw et al. 2006). The third critique, and perhaps the strangest for self-proclaimed Marxists, is that Climate X runs the risk of turning politics into a marketplace of consumption where different alternatives are treated as exchangeable commodities—and *X becomes an expression of value*. In *Capital*, Marx famously uses algebraic variables like X to explain relations of commodity exchange. Algebra allows him to demonstrate how two commodities come to acquire an expression of equivalence between them: "*x* commodity A = *y* commodity B" (Marx 1992: 139). Exchange value itself, it seems for Marx, relies on society's ability to solve for X.

These problems are most apparent when Mann and Wainwright (2018: 189) single out "two broad but distinct trajectories" that might lead to Climate X: indigenous struggles and the tradition of the anticapitalist Left, which they understand as rooted in Marxist ideas. The political task as they see it is not to merge the two, "or subordinate one to the other, but to find some means by which they support each other." However the issue is that, within Mann and Wainwright's political algebra, these trajectories are easily abstracted and operationalized as constants, so to speak, which can be used to solve for an imagined X. This leads to a rather selective reading of Marxism and indigenous thought. For one, Mann and Wainwright claim that "Marxism has never been very good at answering" the question of "living radically differently" (p. 193). But this is to ignore a long history of Marxist feminism, including within geography, that has sought very explicitly to challenge and rework the conditions of life by drawing attention to social reproduction (see e.g. Mitchell et al. 2004).

The second issue is that Mann and Wainwright's algebraic approach makes both anticapitalist and indigenous struggles into countable—and thus *extractable*—resources, to the extent they are conceived in terms of some political end. This is especially the case for issues of indigeneity, which receive only cursory attention in the book but are framed as "some of the richest resources we have" for thinking about how to live differently (2018: 194). There is a danger here not only of romanticizing the other but of reinforcing a colonial logic that works to make indigenous practices commensurable with an instrumental rationality, one that includes political algebra (cf. Herman 2008). This is perhaps unsurprising, since western mathematics has often been weaponized for imperialist ends (see Bishop 1990). As Brenna Bhandar (2018: 35) has recently noted, "political arithmetic" has long generated the legal and ideological grounds for indigenous dispossession, often by providing the "objective" basis for determining who and what is useful. The point is not to write off Mann and Wainwright's politics as

colonial or imperialist (they remain deeply critical of these projects) but to draw attention to some of the pitfalls of theorizing struggles as the means to a future X.

Lastly, Mann and Wainwright's trajectories make revolution look a lot like commodity consumption. It's as if we can select from a list of readymade leftist alternatives: "Marxian," "indigenous," and so forth. Since there is "no one Climate X," these alternatives can all be freely exchanged. Some are ascribed greater political value than others. Books like *Climate Leviathan* provide catalogs for making smart consumer choices. They encourage us to collect the "richest resources" in our shopping chart, amassing them into one big "bundle." It is through act of collecting that we might gain a new experience, see a new world, decode X.

To be fair, Mann and Wainwright never do solve for X. They admit that they "cannot really say anything definitive" about it (2018: 193). And yet they maintain the political importance of trying to imagine it anyway. But what if Climate X exists beyond our current problem sets? What if it turns out to be something like Area X in Jeff Vandermeer's 2014 Southern Reach Trilogy: an entirely remote terrain, literally alien to society? What if X is unimaginable—and we're faced with the "stark impossibility of thinking *that*".[1]

Set Theory

As a politics, algebraic reasoning stands on shaky grounds. Mann and Wainwright's political algebra is rooted in a particular interpretation of Adorno and Benjamin, according to which fragments reveal "what they truly are." But there is another, more negative reading. As I see it, the fragment is powerful for Adorno and Benjamin not for what it is but for *what it is not*. In Adorno's (2013) work, fragments provide evidence of the "non-identical," or the ultimate failure of concepts to grasp their objects. Necessarily incomplete, fragments mediate their own loss or negativity. The totality (X) they allow us to think is thus never numerable. It is always "false" and "inconceivable as such" (Adorno 1973: 28). Benjamin, meanwhile, stresses the redemptive qualities of the fragment. In *The Origin of German Tragic Drama* he argues that Baroque allegory, in rendering the world a "heap of ruins," ultimately "means precisely the non-existence of what it presents" (Benjamin 1998: 226, 223). For both thinkers, fragments point beyond their ruined, finite selves—to something radically non-numerable. A fragmentary politics, then, is not an algebraic practice of solving for some X. It is rather the act of cancelling out X altogether, of releasing politics and thought to the infinite (∞) and to nothingness ($\emptyset$).

In his reading of Fichte and the Romantics, Benjamin (1996: 129) discusses an infinite form of reflection that is not "empty" but rather "substantial and filled." A thinking based on infinity would not, in this case, seek to fill in vacant variables as algebra does. These variables would already be substantiated from the start. And they would appear in an "infinitude of connectedness" that can only be "grasped in a mediated way" (quoted in Clemens 2011: 100). In other parts of his early work, Benjamin outlines a nihilist politics that is grounded (groundlessly) in a messianic conception of nothingness, one that forecloses the possibility of historical prediction (see Khatib 2013). Nothingness, traditionally understood as the negation of being, forms an anti-foundationalist origin point for Benjamin's politics of redemption, as well as Adorno's negative dialectical thought. For them, and for

[1] In the preface to *The Order of Things*, Foucault (2005) recalls a passage in Borges about a "certain Chinese encyclopedia." The "wonderment" that accompanies this fiction taxonomy is, he argues, the limit of our own system of thought, "the stark impossibility of thinking *that*." Mathematics, too, is often described in terms of wonder and awe. With its strings of symbols (not unlike a taxonomy) algebraic equations might be understood in a Borgesian sense, as helping point to that which can't be thought.

others, nothingness is not absence but "the infinite plenitude of openness" (Barad 2012: 16). Infinity and nothingness are deeply intertwined.

Both infinity and nothingness cause problems for algebra, often leading to what are known as "indeterminate forms," expressions whose limits require further analysis to calculate (for example, how do you solve the equation: $\infty - \infty = X$?). If we are to take infinity and nothingness seriously in climate politics we must look beyond algebra to other branches of mathematics. One place we might start, which would allow us to maintain the threads with Adorno and Benjamin, is set theory. Set theory became popular in philosophy with Alain Badiou's 1988 *Being and Event*. But it played a role, many decades prior, in the development of Benjamin's theory of historical time. During his university studies, Benjamin had a keen interest in mathematics. In Bern, he attended Henoch Berliner's seminars on number theory, one of which he described as "uncanny" (Fenves 2011: 113). Benjamin was also the nephew of prominent mathematician, Arthur Schoenflies, with whom he often met and whose work he would frequently consult. Schoenflies was an early proponent of set theory, describing it as a science that "undertook the division of infinite sets according to their power and showed, in particular, that algebraic numbers form a countable set, whereas the continuum is not countable" (quoted in Fenves 2011: 113). The influence of these ideas on Benjamin is evident in the diaries of his friend, Gershom Scholem. In August 1916, Benjamin began a conversation with Scholem by making a "difficult remark" about historical chronology. In Scholem's recollection, the remark was that "years are countable, but in contrast to most countables, not numerable" (quoted in Fenves 2011: 256–258). For numerability, Scholem notes, would presuppose exchangeability, "and this applies neither to numbers nor to years: they are in no way exchangeable."

Fragments and ruins—and thus any politics of Climate X—must be considered along similar lines of non-numerability. Otherwise, they remain fixed points within what Adorno called *second nature*. In his 1932 essay on "The Idea of Natural History," Adorno (1984: 118) builds on Lukács and Benjamin to define second nature as a "petrified estranged complex of meaning that is no longer able to awaken inwardness; it is a charnel-house of rotted interiorities." Such an "alienated, reified, dead world" is filled with fragments that, because petrified, are exchangeable—numerable. This is a world bound by finitude: a countable set of hollowed-out objects.

But at the same time, second nature cannot be solved or revealed for what it truly is, as Mann and Wainwright seem to think. While petrified, second nature remains ungraspable: it "cannot be decoded but encounters us as ciphers" (Adorno 1984: 118). It is through this failure to decode that natural-historical fragments are charged with a critical power. For when nature is viewed, askance, through the "cipher" of history, and vice versa, it comes to signify its own transience. As a result, fragments become uncaged from what they *are*. They reveal something else altogether: an "original-history" (p. 121) that voids whatever appears as permanent and unbroken. In the spirit of Benjamin's nihilism, we might think of this original-history as an original nothingness, a moment of radical undecidability that prevents fragments from being fully solved, counted, or spoken for. It is this negative moment that Mann and Wainwright pass over. Instead, they assume the numerability of natural-historical fragments and hold open the possibility of a final solution. But this is to misinterpret Adorno's idea of natural history. His position is not, as Mann and Wainwright suggest, one of "utopian hope for a potential reconvergence of nature and history" (2018: 193). Adorno's point is much more dialectical. From him, the "signification" between nature and history "means that the elements of nature and history are not fused with each other, rather they break apart and interweave at the same time" (Adorno 1984: 121)

There is no algebra here. The political task, according to Adorno, is not to place an equal sign between nature and history but to render them as jagged ciphers of one another, making each non-

numerable in the sense of being always incomplete. While Mann and Wainwright highlight this transience, they fail to account for its full complexity. For Adorno transience is not about revealing finitude. It is paradoxically an "eternal transience"—a moment of the infinite. As he put it years later in *Negative Dialectics*: "eternity appears, not as such, but diffracted through the most perishable" (Adorno 1973: 360). Set theory helps to make sense of this apparent contradiction. What we end up grasping is something like an infinite set, whose fragmentary contents are ungraspable and yet somehow—impossibly—reflected in the object of the set itself. If Adorno is to be taken seriously here, Mann and Wainwright are wrong to dismiss the "set of all" as an illusion. Climate politics must be reconceived in terms of what they call an oxymoron: "universal solidarity." Such universality is *diffracted* through the particular (cf. Tomba 2019). The rest of this essay explores what this diffraction might actually look like.

Fractal Geography

At one point in the exchange between Benjamin and Scholem in 1916, their discussion shifted course. They moved from set theory to geometry. Apparently, Scholem posed the question of whether the flow of time had a fractal shape (Fenves 2011). In the spatial domain, fractals are complex geometric patterns that are "self-similar" across an infinite number of scales. Self-similarity occurs when a whole shares statistical properties with (i.e., is similar in shape to) its parts. Famous examples in the material world include snowflakes and coastlines. The term "fractal," based on the Latin *fractus* meaning broken or shattered, wasn't in use until 1975 when it was coined by Benoit Mandelbrot (2012: 265). But the field of fractal geometry had been developing in Germany for some time, especially after 1872 when Karl Weierstraß presented the first example of what we would now consider a fractal equation (Mandelbrot 1982). In formal terms, fractals describe mathematical functions that are continuous but nondifferential. The curve of such a function is unimaginable and difficult to describe in Euclidean language, since "every point consists in a sharp turn" (Fenves 2011: 111). In the case of the Koch snowflake, the quintessential example of a fractal, a finite area is bounded by an infinite curve, meaning that the perimeter of the shape diverges to infinity (Lanoiselée et al. 2018).

Fractals are not unknown to geographers. In his 2012 book *Fractal Geography,* André Dauphiné discusses how the fractal paradigm has made its way into both physical and human geography (while abolishing the distinction in the process). In human geography, the calculation of fractal dimensions has played a major role in the fields of urban studies and network studies. And yet most geographic engagements with fractals, including Dauphiné's, have been in areas of quantitative analysis and GIS.[2] Fractal geometry has not as of yet been explored as a basis for critical social theory.

What would it mean to think of Mann and Wainwright's Climate X, not as the solution to an algebraic problem, but in fractal terms? This would require reconceiving the scale and space of politics. Recent work in critical geography helps to push analysis in a fractal direction. Important in terms of scale have been discussions of "flat ontology" (Springer 2014; Woodward et al. 2012; Marston et al. 2005; Marston 2000). This literature has drawn attention to the problems inherent in dominant, hierarchy-based understandings of scale and has to varying degrees disavowed the concept of scale altogether. Fractals contribute to these critiques of scale, since within them self-similarity extends from "arbitrarily large to arbitrarily small scales" (Voss 1988, 30). And yet they do not completely do away with the concept. For it is in moving between levels that patterns of self-similarity become perceptible.

[2] The term "fractal geography" has also been used by geographers to describe the infinite repetition of images and narrative in film (e.g. Lukinbeal 2004).

In terms of climate politics, this means that struggle must be conceived relationally as emerging and operating across scales, while also always embodied (self-similar) on a particular scale.

In addition to scale, fractal politics demands a very different engagement with space. It refuses to situate political action on a static Euclidean plane, where straight lines and fixed boundaries separate different options, parceling out Leviathan, Behemoth, Mao, and X. Politics, rather, emerges in and through the unimaginable curvature of space-time itself. Though not necessarily fractal, one way geographers have conceived of such a bending is through *topology*. Topology is "qualitative geometry" (Harvey 1969). It is a branch of mathematics dealing with spatial properties that are preserved through various processes of distortion or "continuous deformations" such as bending, crumbling, or stretching, but not breaking (Secor 2013). Having emerged out of set theory in the nineteenth century, topology is concerned only with the connectedness between points. Important for its foundation was the work of German mathematician Bernhard Riemann, with whose non-Euclidean geometry Benjamin was familiar (see Benjamin 2006). Riemann introduced a way of studying n-dimensional surfaces with curvatures that cannot be determined *a priori* but only locally at each of their points. These spaces, known as manifolds, are the focus of many areas of topology (Laugwitz 2009).

While it has played an important role in geography since the 1960s, when it was taken up by the likes of William Bunge and David Harvey, topological thinking is experiencing a revival (Paasi 2011). Recently critical geographers like Martin and Secor have turned to the topological as "a way of conceptualizing non-Euclidean space" (2014: 422).[3] With its twists and turns, which complicate notions of inside and outside, topology has played an especially important role in feminist geopolitics, helping geographers grasp the embodiment of statecraft and global capitalism, along with relational spaces of violence and care (see, e.g., Bartos 2018; Mitchell and Kallio 2017; Mountz 2011).

And yet, while it attends to the curvature of space-time, topology does not allow for a *break*. It leaves no space for rupture, discontinuity, or potential failure. Fractal geometry, on the other hand, forces us to engage with contingency. A fractal has a Hausdorff dimension[4]—a measure of chaos—that exceeds its topological dimension (Mandelbrot 1982). Chaos refers to *deterministic complexity* or the "unpredictable dynamic behavior of relatively simple deterministic systems" (O'Sullivan 2004: 283). According to chaos theory, minor changes in initial conditions can lead to wildly divergent outcomes. Chaotic behavior has long been recognized in weather and climate systems, which are famously difficult to forecast. Mann and Wainwright themselves mention the "occasional pounding of stochastic events" (2018: 7). Chaos should be recognized within political struggles as well. What's become clear, especially after the failures of state socialism in the twentieth century, is that the future outcomes of struggle are largely unpredictable and cannot be achieved through a prefigurative politics of programs,

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[3] Non-Euclidean space is not, however, necessarily implied in topology. Euclidean geometry lingers within topological manifolds, at least at the local level of points. It is only when venturing beyond the local that space may appear to operate according to different geometries.

[4] German mathematician Felix Hausdorff first introduced the "Hausdorff dimension" in 1918. It has since has played an important role in defining fractals (Brown and Liebovitch 2010). Earlier, in 1914, Hausdorff published a revolutionary study of set theory in which he worked out the notion of topological dimension. Hausdorff's first philosophical treatise was included on one of Benjamin's reading lists (Fenves 2011). Like Benjamin, Hausdorff chose to commit suicide after a failed emigration attempt from Nazi Germany (Siegmund-Schultze 2009).

councils, or parties. The terrain of radical politics today must be seen as a *fractal geography*—reaching out like tendrils, to some unknown horizon. It's a matter of chance.

Taking fractal geography seriously means engaging with a different kind of thinking altogether. It requires a materialist approach that is more irregular and chaotic than Mann and Wainwright would have it, and that can more fully embrace the "risk of being wrong." Such a materialism is perhaps similar to what Louis Althusser called *aleatory materialism*. In his later work, Althusser describes an aleatory materialist tradition running from Derrida back to Epicurus, passing through figures such as Spinoza and even Hobbes (see Bargu 2012). Particularly important is Lucretius, whose concept of the *clinamen*—the unpredictable swerve of atoms—has long served as a model for a materialism based on contingency and chance. Fractal geography brings the *clinamen* into the fray of climate change. This is really a return. After all, *clinamen* and *climate* share the same Greek root-verb κλίνειν (*klinein*), meaning to lean, slope, or deviate (Ford 2016). Today, Lucretius's deviating atoms are reflected in the periodic deluges of acid rain and in the veering streams of refrigerants and chlorofluorocarbons floating up into the clouds, gouging out holes in the ozone layer, morphing earth's climate irreversibly.

I do not mean to imply, however, that the aleatory materialism of fractals *actually* exists in the material world of passing time. The radical elements of fractal geometry, its infinite curves, remain on a theoretical level. A snowflake doesn't have infinity in any observable, empirical, or "applied" sense. To reduce fractal geometry (and geography) to a crude materialism that only includes the "natural world" is not only mathematically dubious. It also reinforces the colonial logic on which modern geography was built, according to which anything that appears "spiritual" or "magical" must be removed from the territory of analysis (Herman 2008).

The aleatory materialism of fractal geography is not actual but speculative. It is more of a heuristic guide for thought and action than a way of seeing objects "for what they truly are." Rather than grouping climate politics into future categories, fractal geography allows us to conceive of struggles as *klinein*: inclined, like the slope of a non-linear function, towards the cracks and swerves that already exist in the world, those that are opened up now and again by crisis and class conflict (see Neel 2018). From the Paris Commune to the Occupy Wall Street, history is filled with these fractures, which continue to give off flashes of other worlds. Such events leave behind what Badiou (2006) calls "points." Points localize infinite multiplicity and allow for a moment of decision, to affirm or deny what is given (MacFarlane 2017). For Badiou, the task of militants is to remain faithful to these points, to align their bodies with the residues of past events, and to reconstruct them within the limits of the present. This alignment can be fleshed out in fractal terms, in the sense that struggles gain ground by achieving "self-similarity" with the fractured points that have been opened before them, occupying the spaces of past struggles, faithfully taking on their shapes. And since every point in a fractal designates a "sharp turn," taking up the mantle of the past always means to change that past, literally making it revolutionary. This is a Benjaminian politics of redemption read in a fractal dimension, where redemption implies a radical reorganization—a turning—of space-time. The world itself must be diffracted.

Exploding the Equation

Fractures only intensify with growing climate chaos, which reveal the transience of our natural-historical conjuncture. Mann and Wainwright are correct to point to the "opportunity" embedded in this moment. But as I have argued here, political opportunity is not algebraic: it is not about solving for some future unknown. Rather, the opportunity *is* the fracture itself, insofar as it renders the present order false. This is to place X, the fracture, not at the end of a calculation, but as its axiomatic conditions of possibility—as the grounds for politics itself. Climate struggle is less about coming up

with future "solutions" than experimenting with what is already here, working to bring a dormant X into existence rather than producing it anew. This X is unsolvable within, and thus poses a challenge to, the structures of the capitalist present. All equations are necessarily left incomplete. Instead, radical thought and action is the refusal to make X legible within the current order of space-time. Never a true whole, X is always fractured, negated, cancelled out. This radical X̶ provides the critical measure or asymptote for the function that is revolutionary politics. Some have called this communism: "the *real* movement which abolishes the present state of things."

Climate X̶ comes closer to Geoff Mann's (2008) earlier work on a negative geography of necessity. Through a reading of Marx and Hegel, Mann claims that doing geography "is at least as much about necessity as it is about possibility, maybe more" (p. 921). For him, necessity is not the force of history but the very act of explaining history or why things "are what they have become" (p. 931). This is accomplished through a process of negation that denounces what is immediately "given" in experience. From this argument, Mann develops a critique of his future book: "The effort to identify 'possible worlds' is meaningless without the simultaneous effort to critically explain, as Marx did, why the world is not otherwise, and in doing so, to explode the 'given' from which the not-given can emerge" (2008: 931).

Climate Leviathan, as I have argued here, is precisely such an effort to identify "possible worlds" with regard to climate change. If Climate X is to avoid meaninglessness it must, by Mann's own reasoning, explain and ultimately negate its own conditions of givenness. This looks much closer to a geometric proof than an algebraic equation. There's nothing to solve for. There's no "world to win." There's only this world and the need to "prove" that it can be something else. Rather than imagining what that might look like, the world as it exists must be worked out and grappled with, tediously at times, through the procedures of politics—its infinite curvatures laid bare. This requires a major shift in how climate change is formulated. Instead of coming up with "solutions" to environmental problems, the problems themselves must be seen as the fractured grounds on which particular struggles are constellated at a planetary level. Such a constellation of struggle is formed, and takes on its fractal shape, in and through the act of overcoming itself, of recognizing and abolishing its local and global (i.e. finite and terrestrial) limits.[5] The real Climate X is our world blasted out of its equation, so that its cracks are left showing and it no longer appears whole, but rather wholly false. It is only by turning the world in this way, sharply, that the end times of climate collapse can be reworked into the beginnings of something infinitely better.

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[5] Struggle must be conceived, then, in an extraterrestrial or *cosmic* sense. Developing this point is well beyond the scope of the current essay, but one potential starting place is the work of Benjamin's friend Ernst Bloch. In *A Philosophy of the Future* (1970) Bloch draws on Riemann's non-Euclidean geometry as the basis for a multidimensional concept of history, one that highlights non-European temporalities. Such a "multiverse," Bloch argues, requires not only a new anthropology but a new cosmology that can account for the micro- and macrocosmic (i.e., astronomical) conditions of space-time. In the context of climate politics, following what I have argued here, it is important that this cosmology not be considered as a "solution." Cosmic solutions ultimately reinforce the imperial logics of capitalist expansion and extraction. We can already see this in the case of Elon Musk's SpaceX and other private space companies, whose extraterrestrial ventures are increasingly viewed as viable "fixes" not just for capital accumulation but for climate destruction, whether through the harvesting and monetization of non-earth resources or the colonization of other worlds. Against the capitalist the takeover of outer space, a cosmic politics, while remaining exploratory, must be fundamentally redemptive – working to end finitude and suffering across all dimensions, times, and scales.

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