Karen Barad:
Troubling Time/s and Ecologies of Nothingness: Re-turning, Re-membering, and Facing the Incalculable

Translation: Daniela Vránová, John Comer
Published with a kind permission of Lawrence Wishart publishers.

This paper examines the political-ontoepistemological-ethical implications of temporal dis/junction by reading insights from Quantum Field Theory and Kyoko Hayashi's account of the destruction wrought by the Nagasaki bombing through one another.

No justice... seems possible or thinkable without the principle of some responsibility, beyond all living present, within that which disjoins the living present, before the ghosts of those who are not yet born or who are already dead, be they victims of wars, political or other kinds of violence, nationalist, racist, colonialist, sexist, or other kinds of exterminations, victims of the oppressions of capitalist imperialism or any of the forms of totalitarianism.[1]

In these troubling times, the urgency to trouble time, to shake it to its core, and to produce collective imaginaries that undo pervasive conceptions of temporality that take progress as inevitable and the past as something that has passed and is no longer with us is something so tangible, so visceral, that it can be felt in our individual and collective bodies. This urgency is both new and not new. With fascism on the rise around the globe and the threat of an accelerated nuclear arms race at hand, tied to a perverse sense of the usability of nuclear weapons, the false security of global strategic deterrence based on MAD (the military doctrine of Mutually Assured Destruction) left exposed and undone by madness, compulsiveness, and hubris, the twentieth century is anything but past/passed. The same can surely be said of previous centuries.

And if debates on marking the origins of the Anthropocene suggest anything beyond an exacting reading of the layering of sediments used to justify adding a new segment of time to earth's geological clock, it is perhaps that the

structure of temporality that timelines (in their linearity) smuggle into the discussion is inadequate to this moment. For if the climate experts in their official report to the International Geological Congress meeting in Cape Town in August 2016 mark the origin of the new epoch to be 'defined by the radioactive elements dispersed across the planet by nuclear bomb tests' beginning in 1950[2] , and strong arguments have been made by scientists and nonscientists that offer reasons for using other dates as the 'golden spike,' the debates have mostly been about laying down the marker at the right time (whether at 1492, 1610, 1945, 1950, or 1963-66), and they have not for the most part questioned whether these times ought to be thought of as falling in a line, as if they were separated from one another by temporal distance.[3] But rather than understand these differing proposals as merely a simple disagreement about origins, perhaps we should take this as evidence that faith in the existence of a singular determinate origin and the unilinear nature of time itself (the fact that only one moment exists at a time) is waning. Is there a sense of temporality that could provide a different way of positioning these markers of history and understand 1492 as living inside 1945, for example, and even vice versa?

INTRODUCTION: CLOCK 1

Time isn't what it used to be. Perhaps it never was. It surely hasn't been itself since the 'Doomsday Clock' was set at just minutes to midnight – the untimely hour of time's own demise.

The 'Doomsday Clock' of the *Bulletin of the Atomic Scientists*, introduced in 1947, represents scientists' estimation of our proximity to global catastrophe. A device once tuned to the Cold War, the setting of the clock was initially solely synchronised to the prospect of nuclear apocalypse, but in 2007 it was recalibrated to include climate change as an additional significant threat to earthly survival. This is a rather strange clock, a nonmechanical symbolic clock, a bit of sincere theatrics, that is an expression of the scientific community's estimation of global precarity in the present. Doomsday Clock time doesn't simply progress on its own, moving forward without fail, and it isn't synchronised to one particular physical phenomenon, but rather to global politics and technological progress. A nonlinear device that is reset once each year, the Doomsday device clocks sociopolitical, technoscientific events, and its measure is marked by the distance from the endpoint – midnight, the

apocalypse – rather than some origin point. Time is synchronised to a future of No Future.

This is time fixated on its own dissolution. Setting time on edge, it offers both a grim view of our prospects and a false sense of globalism assuming a homogeneity of times and spaces, eliding the uneven distribution of nuclear and climate crises' resources and precarity. Furthermore, it has the anesthetising effect of diverting questions of responsibility and of focusing on the apocalyptic phantasm of total war, thereby distracting attention from the realities of war in its ongoingness. And this includes nuclear war.

The first atomic bomb was not the one dropped on Hiroshima:

> "The world's first atomic bomb was detonated on July 16, 1945, in New Mexico – home to nineteen American Indian pueblos, two Apache tribes and some chapters of the Navajo Nation."[4]

That is, it was exploded within range of 'the Americans' own people, Turtle Island's original inhabitants, the Indigenous Peoples of the southwest. And nuclear war didn't cease when the bomb dropped on Nagasaki on 9 August, 1945. Masahide Koto argues nuclear war has been taking place on this earth in the name of 'nuclear testing', since the first nuclear explosion at Alamogordo in 1945.[5] Since then more than 2,000 nuclear bombs have been exploded:

> "The primary targets ... have been invariably the sovereign nations of Fourth World and indigenous peoples. Thus history has witnessed the nuclear wars against the Marshall Islands (66 times), French Polynesia (175 times), Australian Aborigines (9 times), Newe Sogobia (the Western Shoshone Nation) (814 times), Christmas Island (24 times), Hawaii (Kalama Island, also known as Johnston Island) (twelve times), the Republic of Kazakhstan (467 times), and Uighur (Xinjian Province, China) (36 times)." (*H-Bomb Guinea Pigs*)

In our 'post-atomic age', time is synchronised to the apocalypse-to-come, and the present is caught in a pose of holding its breath in an attempt to forestall the onset of nuclear war, as if it had ever been a thing of the past. This singular sense of temporality is fixed and fixated on the event horizon of total annihilation, calibrated to fear and the elision of the ongoingness of war in our hyper-militarised present. Masahide Kato calls this totalising view, the globalised spacetime grid, the 'obliteration of the history of undeclared

nuclear war' that has been ongoing since Second World War (*Nuclear Globalism*, p339).

CLOCK 2

Time has been shattered, exploded into bits, dispersed by the wind. Moments caught up in turbulent flows forming eddies, circling back around, returning, reconfiguring what might yet have been.

Hiroshima, 6 August 1945, 8:15 a.m. Clock mechanisms melted by the heat of the blast. The city clocks, clocks in plazas, stores, homes, on wrists, and in pockets, forever synchronised to one particular moment. Two hands etched into eternity – a larger one pointing due east and a smaller one pointing a bit south from west. Two hands seared into the face of time. Time is arrested; ghosts roam the streets. Although time is off its hinges, frozen and disengaged for all time, moments continue to pour down like black rain and settle on charred bodies and buildings; sticking to the air, they are breathed in, ingested, and come to rest in the marrow of bones, lying dormant, like little time bombs ticking inside *hibakushas* (atomic bomb victim survivors, literally explosion-affected people). A pocket watch is all a son has left of his father. Clocks are powerful symbols in Hiroshima. The Hiroshima Peace Clock Tower chimes every day at 8:15 a.m. The Hiroshima Peace Memorial Museum 'Peace Watch Tower' has a digital clock synchronised to peace instead of war that is reset back to zero every time there is a nuclear test anywhere in the world. Nuclear geopolitics, an entanglement of histories of violence, condensed into this one moment of spacetime, this one clock, this one now.

CLOCK 3

Time itself has gone atomic. Time no longer has a face or hands, but it does have a rhythm, a pulse. The atoms barely moving, habituated to temperatures near absolute zero, quantum leaps – dis/continuities – define the continuous march of time.

Atomic clocks are postwar gadgets tuned to resonance and precision. Suggested by Nobel laureate physicist I. I. Rabi in 1945, the first atomic clock, a laboratory instrument that must be kept by a high-tech time keeper, was

constructed in 1949. Now there's no telling time without it. Global time, universal time, cosmic time – all keeping rhythm with the smallest bits of matter. The total colonisation of spacetime synchronised to the heartbeat of an atom. Globalism is tied not only to the militarisation of space but also of time. The latest atomic clock [is] so precise that it won't lose or gain a single second in 15 billion years – roughly the age of our universe. Who on earth needs such precise clocks, you might ask. Actually, nothing less than the global economy – the mechanical guts of capitalism, including GPS, telecommunications, and high-speed transfer on internet lines – depends upon it.

TELLING TIME/S

Each of these different clock times – the Doomsday Clock, the Hiroshima clocks, and atomic clocks – is tied to quantum physics. Quantum physics gave birth to the atomic age. It is no secret that it is deeply entangled with the military-industrial complex. Though different from one another, each of these clock times treats time as determinate and singular; in essence, each clock has a pointer pointing at a single position on a clock face and marks one time at a time. Although each of these clocks is informed by quantum physics, none of them is based on quantum physics' radical rethinking of the nature of time.

Clock time is what Walter Benjamin poignantly calls 'homogenous empty time'.[6] Whether calibrated to a projected future, an individual event, or a periodically recurring phenomenon, time is attuned to a succession of discrete moments, where a moment is understood to be the thinnest slice of time and where each successive moment replaces the one before it. This is the time of capitalism, colonialism, and militarism.

But homogeneous empty time is not a universal conception of time. Daniel Wildcat, drawing on the work of indigenous philosopher Vine Deloria, makes a critical intervention into modernist conceptions of time and history:

> "It is of critical practical importance that some cultures express history as primarily temporal and others express history as fundamentally spatial in character. Once history-as-time is universalised and human beings are, so to speak, all put on the same clock, it is inevitable that in the big picture of human history some peoples will be viewed as 'on time,' 'ahead of time,' or 'running late'. It makes little difference that the clock hands rotate in

> circles, for they are thought of and acted on as if they were wheels moving down a single road called progress.

This road ought to be the ultimate metaphor for Western civilisation and modernity, for it is an ideological abstraction. As John Mohawk concisely elaborated in his essay 'The Right of Animal Nations to Survive,' the metaphysics of progress presents itself as the greatest threat to the future biology of the planet...American Indian or indigenous traditions resist ideas of universal homogeneous world history; there is no single road per se to human improvement. There are many paths, each situated in the actual places, such as prairies, forests, deserts, and so forth, and environments where our tribal societies and cultures emerged. The experiences of time and history are shaped by places."[7]

A multiplicity of paths and histories and the situatedness of time are also aspects of quantum temporality, which is not to suggest that (specific) quantum and (specific) indigenous approaches are identical or commensurate or have the same effect or stakes, but they do share in offering profound disruptions of the conception of homogenous empty time.

In this essay on troubling time/s, my focus is on a novella by Kyoko Hayashi and her (semiautobiographical) account of a Nagasaki *hibakusha*'s journey through time, place, history, and memory in search of a way to justly mourn the victims of atomic bombings.[8] *From Trinity to Trinity* brings us full circle, through the unnamed protagonist's pilgrimage from Nagasaki to Trinity, in ways that powerfully attend to entanglements of colonialism, racism, and militarism that connect these disparate lands.

And yet, even while the protagonist discovers a profound kinship with the bomb's first victims – namely, the desert plants and animals – in the end, there is no mention of the effects of the blast on the 19,000 people who lived within a fifty-mile radius of the Trinity Test (*H-Bomb Guinea Pigs*). One might wonder how Hayashi could have neglected this. Although *From Trinity to Trinity* was published in 2010, it is an astonishing fact that this was four years before the U.S. government would recognise the possibility of human casualties from the Trinity test and announce the beginning of a study of the high incident of cancers among the area's inhabitants and whether this could be traced to radioactive fallout from the blast.[9] That is, it took the U.S. government nearly seventy years to acknowledge that it was even worthwhile to do a study of the possible adverse effects on the people who were exposed to radioactive fallout from the 1945 Trinity test, despite the fact that following

the test blast, 'American Indians would begin to experience many types of cancers – rare cancers as well as multiple primary cancers' (*H-bomb Guinea Pigs*). Whether or not Hayashi had any knowledge of the increased rates of cancer on the people who were downwind from the blast, it seems crucial to start here. At the same time, since it will take the rest of this extended essay to give my diffractive reading of quantum physics' radical reworking of time through *From Trinity to Trinity*, I need to postpone the discussion of how (specific) indigenous (and Japanese) conceptions of time matter to this account.[10] For now, then, I turn to the question of how quantum physics understands the nature of time, knowing that it will be crucial to return to these threads and weave them into the entangled tale.

Quantum theory troubles time in multiple ways, some of which will be explored in this essay. Quantum physics not only deconstructs the strict determinism of Newtonian physics, where the future unfolds predictably from the past, but it also blows away the progressivist notion of time – Benjamin's 'homogenous and empty' time – disrupting first-world efforts to harness it as a totalising system on behalf of universalism and its projects, such as imperialism. Quantum physics opens up radical spaces for exploring the possibilities for change from inside hegemonic systems of domination. Its radical political imaginaries might usefully join forces with indigenous and other subjugated knowledge practices rather than being a tool solely in the hands of the National Security Agency, although there is that, too. But tools are never entirely faithful to their masters.

This essay is about quantum theory's troubling of the nature of time and being, or rather, time-being. At the same time, it is also a story about the troubling times quantum theory has ushered in. That is, inside the nucleus of the story of the troubling of time is the troubled times unleashed by quantum theory's role in the making of the atom bomb and vice versa. These stories inhabit each other – a strange topology that already anticipates the kind of temporal imaginaries suggested by quantum theory.

Much as some folks want to exoticise quantum theory and think of it as living off on some remote island (deemed the 'microworld'), safely quarantined from life as we know it (here in the 'macroworld' where life is fantasised as solidly Newtonian), this geography is but a marker of an imperialist and colonising worldview (where 'anthropologists' for the object world, otherwise known as physicists, get to speak for the 'natives', those radically Other beings that refuse to be good modernist subjects, and the same time are inanimate and lacking in agency). Quantum theory, despite tales to the contrary, is not restricted to

some alleged micro-realm (which always already assumes that the notion of scale is a given, while this very notion, together with the nature of space, time, and matter, is radically rethought). Nor does quantum theory live in the realm of rarified ideas that now and again has applications for the real world. Quantum physics is a material practice with direct ties to the military-industrial complex – its very existence entangled with war, militarism, racism, colonialism, capitalism, and imperialism. At the same time, quantum theory disrupts classical Newtonian physics (together with its most cherished ideas of space, time, matter, and causality), which has its own problematic legacy in the service of war, colonialism, and empire building. If Newtonian physics had designs on capturing nothing less than the heavens and the earth under its rule, quantum physics troubles the very ideas of totality and closure – not only Newtonian attempts, but also its own. Quantum indeterminacy works against such attempts. Quantum indeterminacy is not a form of unknowingness, nor even a kind of formlessness; rather, it is a dynamism that entails its own undoings from within. That is, the dynamism of quantum in/determinacy can be found within physics, and not only within Derridean deconstruction.[11]

This essay seeks to further the political project of opening up the seeming totality called 'physics' in order to nurture the cracks and bring forward its radical possibilities.[12] As such, this essay touches at once upon both the destructive and deconstructive aspects of quantum theory. Raising questions of history, memory, and politics (all of which are rooted in and invested in particular conceptions of time and being), this essay is ultimately about the possibilities of justice-to-come, the tracing of entanglements of violent histories of colonialism (with its practices of erasure and avoidance) as an integral part of an embodied practice of re-membering – which is not about going back to what was, but rather about the material reconfiguring of spacetimemattering in ways that attempt to do justice to account for the devastation wrought as well as to produce openings, new possible histories by which time-beings might find ways to endure.

NO SMALL MATTER

What is the scale of nuclear forces? When the splitting of an atom, indeed, its tiny nucleus, destroys cities and remakes the geopolitical field on a global scale, how can anything like an ontological commitment to a line in the sand between 'micro' and 'macro' continue to hold sway on our political imaginaries? When incalculable devastation entailing uncountable deaths is

unleashed in the harnessing of a force that is so fantastically limited in extension that its job is merely to hold together the nucleus of an atom, a tiny fraction of a speck, a mere wisp of existence, then surely anything like some allegedly preordained geometrical notion of scale must have long ago been blown to smithereens, and the tracing of entanglements might well be a better analytical choice than a nested notion of scale (neighborhood ⊂ city ⊂ state ⊂ nation) with each larger region presuming to encompass the other like Russian dolls. That is, when a force extending a mere millionth of a billionth of a meter in length reaches global proportions, destroys cities in a flash, and reconfigures geopolitical alliances, energy resources, security regimes, and other large-scale features of the planet, this should explode the naturalisation of the geometrical notion of nested scales that remains operative when the question arises as to what quantum physics has to do with the (so-called) macroworld.[13]

What is the scale of time? When the cascading energies of the nuclei that were split in an atomic bomb explosion live on in the interior and exterior of collective and individual bodies resetting decay times of cellular clocks, how can anything like a fixed, singular, and external notion of time retain its relevance or even its meaning? In a flash, bodies near Ground Zero become particulate, vaporised –, while *hibakushas*, in the immediate vicinity and downwind, ingest radioactive isotopes that indefinitely rework body molecules all the while manufacturing future cancers, like little time bombs waiting to go off.[14] What would constitute an event when an atomic bomb that exploded at one moment in time continues to go off? The temporality of radiation exposure is not one of immediacy; or rather, it reworks this notion, which must then rework calculations of how to understand what comes before and after, while thinking generationally. Radioactivity inhabits time-beings and resynchronises and reconfigures temporalities/spacetimematterings. Radioactive decay elongates, disperses, and exponentially frays time's coherence. Time is unstable, continually leaking away from itself.

What is the scale of matter? There was a time when matter stood outside of time. Matter fell from grace during the twentieth century. It became mortal. Very soon after that it was murdered, exploded at its core, torn to shreds, blown to smithereens. The smallest of smallest bits, the heart of the atom, was broken apart with a violence that made the earth and the gods quake. In an instant, in a flash of light brighter than a thousand suns, the distance between Heaven and Earth was obliterated – not merely imaginatively crossed by Newton's natural theophilosophy, but physically crossed out by a mushroom

cloud reaching into the stratosphere. 'I am become death, the destroyer of worlds'.[15]

The indeterminacy of space, time, and matter at the core of quantum field theory troubles the scalar distinction between the world of subatomic particles and that of colonialism, war, nuclear physics research, and environmental destruction. Quantum field theory (QFT) – a theory combining quantum physics, special relativity, and classical field theory – produced radical changes in our understanding of the nature of space, time, and matter. QFT also enabled the development of a fundamental theory of the nuclear forces (or fields) proposed by Heideki Yukawa in 1935. After the war, Yukawa was awarded the Noble Prize for his accomplishment; he was the first Japanese physicist so recognised. Physicists working at the forefront of the development of QFT (since the 1930s and continuing after the war) were integrally involved in the production of wartime technologies, including the atom bomb.[16]

In these troubling times, how can we not trouble time? Nothing less than the nature of and possibilities for change and conceptions of history, memory, causality, politics, and justice are conditioned by it. At the very core of QFT are questions of time and being. The indeterminacy of time-being opens up the nature of matter to a dynamism of the play of being and nothingness. Is there something about the nature of this dynamism that might lend some insight into what the practice of the politically committed work of mourning attuned to justice might look like? Or that would make it possible to trace the practices of historical erasure and political a-*void*-ance, to hear the silent cries, the murmuring silence of the void in its materiality and potentiality? What are the conditions of im/possibilities of living-dying in voids produced by technoscientific research and development, projects entangled with the military-industrial complex and other forms of colonial conquest?

The structure of this essay is diffractive rather than progressive. There is not a linear presentation of quantum physics. Instead, I present aspects of quantum physics' rethinking of the nature of time (spacetimemattering) and illuminate these by diffractively reading them through segments of a novella, *From Trinity to Trinity*, by Kyoko Hayashi, a writer who, at the age of fourteen, lived through the bombing of Nagasaki. Hayashi's story and the story of QFT inhabit each other, and this diffractive reading is itself a performance of this strange topology.

Diffraction as methodology is a matter of reading insights through rather than against each other to make evident the always-already entanglement of

specifics ideas in their materiality. The point will not be to make analogies, but rather to explore patterns of difference/différance – differentiating- entangling – that not only sprout from, and remain entangled with, specific material conditions in their intra-active restucturing, but are enfolded in the patterning in ways that trouble binaries such as macro/micro, nature/culture, center/periphery, and general/specific that tempt and support analogical analysis.

SPACETIME DIFFRACTION & THE SUPERPOSITION OF ALL POSSIBLE HISTORIES: QUANTUM PHYSICS' DISRUPTION OF THE IMPERIALISM OF UNIVERSAL SPACE AND TIME

> "Moving from flight to flight, more of us have come to see, not only that we live in many worlds at the same time, but also that these worlds are, in fact, all in the same place – the place each one of us is here and now... Thus, Two does not necessarily imply separateness for it is never really equated with duality, and One does not necessarily exclude multiplicity for it never expresses itself in one single form, or in uniformity."[17]

Diffraction is a matter of patterning attuned to differences. But not all differences are the same. Classical physics figures diffraction in terms of a comparison between this and that. However, from the perspective of quantum physics, diffraction is allied with the fundamental quantum physics notions of *superposition* and *entanglement*, where difference is a matter of *differences within*, not the 'apartheid type of difference'.[18]

Waves make diffraction patterns (think of the pattern made by dropping two stones in a still pond, for example) precisely because multiple waves can be in the same place at the same time, and a given wave can be in multiple places at the same time. Particles do neither; by definition, particles are localised entities that take up space: they can be here or there, but not in two places at once.

However, it turns out that particles can produce diffraction patterns, given an apparatus that allows for this possibility. How can this be? According to quantum physics this is because a *given particle* can be in a state of *superposition*. To be in a state of superposition between two positions, for example, is not to be here *or* there, or even simply here *and* there: rather, it is to be *indeterminately* here-there – that is, there is *no fact of the matter* (it is not simply that it is unknown) as to whether it is here or there. As a result of this

indeterminacy of position (the precise principle is the position-momentum indeterminacy principle), particles exhibit diffraction patterns under circumstances that make evident the superposition (for instance, a barrier of appropriate dimensions with two openings that allow the passage of a particle will do). Or rather, when they do exhibit a diffraction pattern it is an expression of the fact that they are in a *state of superposition*.

Note that while it is tempting to say that a given particle in a state of superposition is in two places at once, this is a simplification that doesn't fully capture the complexities: for one thing a *particle*, by definition, has a determinate position (for example, is either here or there); and furthermore, if one were to perform a measurement to directly test the hypothesis that a particle is in two places at once by meauring its position, then it surely wouldn't be(!), because a particle whose position is detected will behave like a good particle and only ever show up in one place at a time, even though the pattern produced when the position isn't being measured (as in the case of a two-slit experiment) can only be accounted for if it went through both slits at once (that is, if 'it' behaves like a *wave*, in which case 'it' isn't a particle).

Diffraction patterns are very common, but not always evident. The special circumstances produced in laboratories function to make particular patterns evident (at the expense of others). But patterns of differences (differencing/ différancing) are arguably at the core of what matter is (relational différancing all the way down) and are at the heart of how quantum physics understands the world.[19] Indeed, Nobel laureate physicist Richard Feynman proposed an understanding of quantum physics based wholly on the notion of diffraction (that is, superposition). To grasp this proposal, it is first of all important to note that according to quantum physics, *there is no determinate path* that a particle takes in going from one position to another – that is, no such path exists. But what physicists can do is calculate the probability that a given particle that starts out *here* will wind up *there*. The quantum probabilities are calculated by taking account of all possible paths connecting the two points. Feynman derives this result starting with a two-slit diffraction grating (a barrier with two slits) and calculates the total probability that a particle that starts out on one side of the barrier winds up at a particular spot on the other side (in particular, this entails a sum of all possible ways of making it from one side to the other, where each possible way is weighted according to its corresponding probability) (see Figure 9-1A). He then takes the limit of considering a diffraction grating with an infinite number of slits that a particle can go through – representing the possibility of crossing the barrier anywhere along

its (infinite) length (that is, all points in a given plane) – and summing over an infinite number of such gratings, thereby summing over all planes (see Figure 9-1B), and hence covering all of space (see Figure 9-1C). The total probability then is related to the superposition of all possible paths (see Figure 9-1D); this superposition of all possible paths manifests as a diffraction pattern. According to this Feynman path integral formulation, the total probability is a superposition or a sum of *all possible paths – they all coexist and mutually contribute to the overall pattern*, else there wouldn't be a diffraction pattern.

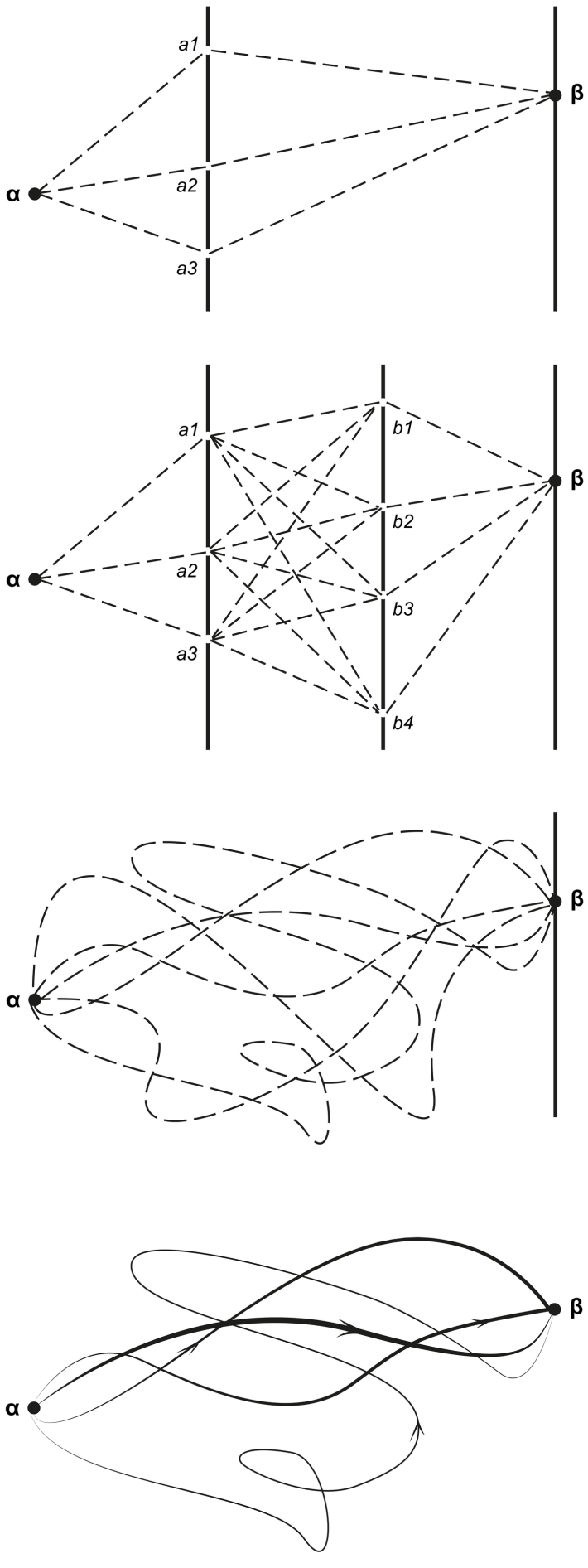

Figure 1: In these four diagrams, α indicates the source of particles or the origin point, and β is a point on the screen marking the place where the particle

arrives. A) Shows a diffraction grating with multiple slits (a1, a2, and a3). B) Shows multiple diffraction gratings (a & b) each with multiple slits. C) Diagram suggesting the limit case in which there are an infinite number of diffraction gratings with an infinite number of slits, which then allows the particle to be anywhere between the source α and the screen β. D) Shows some possible paths, all of which must be included in a Feynman path integral.

Quantum physics opens up another possibility beyond the relatively familiar phenomenon of spatial diffraction: namely, temporal diffraction. This takes a bit of getting used to, even more so than spatial diffraction, but temporal diffraction has in fact been observed experimentally.[20] One way to observe temporal diffraction is to take a disk with one or more slits carved in it; make a hole in the center of the disk and push an axel through it and rotate the disk on the axel; then, direct a beam of light or particles at the rotating disk (so that the beam is parallel to the axel and the light or particles only pass through when they encounter the open slit in the disk). In this way, the beam encounters slits *separated in time* from one another (rather than being separated in space, which is the more usual configuration of spatial diffraction). While spatial diffraction is a manifestation of the position-momentum indeterminacy principle, *temporal diffraction* is a manifestation of another, much less well-known, indeterminacy principle: namely, the time-energy indeterminacy principle. As a result of this indeterminacy principle, a given entity can be in (a state of) *superposition of different times*. This means that a given particle can be in a state of indeterminately coexisting at multiple times – for example, yesterday, today, and tomorrow.

However, given this temporality is not merely multiple, but rather temporalities are specifically entangled and threaded through one another such that there is no determinate answer to the question: What time is it? There is no determinate time only a specific *temporal indeterminacy*. The diffraction pattern, in this case, is a manifestation of different times bleeding through one another. As in the case of spatial diffraction, this means that it's not that some event taking place at one time or another, but we don't know which; rather, the point is that temporal diffraction is the manifestation of an *ontological indeterminacy of time*: there is no fact of the matter to when it is taking place. (Furthermore, in an important sense, although it's not usually talked about this way, the time-energy indeterminacy principle lies at the very heart of QFT. More on this later).

In fact, it is possible to do a diffraction experiment in both space and time at once, whereupon a *single particle* will coexist in a superposition of multiple places and times (*Diffraction of Matter Waves*). In this case of spacetime diffraction, a diffraction pattern can be accounted for by taking account of *all*

possible histories (configurings of spacetime), understanding that each such possibility coexists with all others. In particular, then, in its four- dimensional (relativistic spacetime) QFT elaboration, the probability that a particle that starts here-now will wind up there-then entails *taking account of all possible histories*, or rather, spacetimemattering configurings.[21] Crucially, these 'possibilities' are not to be thought of in the usual way: the diffraction pattern is not a manifestation of an uncertainty in our knowledge – it is not that each history is merely possible, until we know more and then ultimately only one will be actualized – the superposition marks ontology indeterminacy (not epistemological uncertainty) and the diffraction pattern indicates that each history coexists with the others.

According to quantum physics, then, a diffraction pattern is a manifestation of a superposition. Interestingly, although linearity is a prime target of temporality analyses, superpositions are in fact based on linearity: not a linearity of moments or events evenly distributed in time, but a linear combination *of* (different) times. Hence, while contemporary rejections of linearity abound, especially in discussions of temporality, this story does not eschew *linearity* but rather opens it up to its radical potential. So, despite the fact that linearity – in particular, linear time – has been fingered as a particularly pernicious idea integral to Enlightenment thinking, the handmaiden to an ideology of progress and associated notions of the unidirectionality of time and temporal successionism, I am arguing that (even) linearity is susceptible to radical reworkings from within. This troubling of the assumed problematics of linearity and the associated quantum reworkings of the classical notion of time operate in concert with, not as a rejection of, an array of recent critical reassessments of temporality that for various reasons trouble the linear conception of time and suggest alternative conceptions of time that include temporal multiplicity and other configurations. (Note that quantum physics' notion of temporal superposition suggests a phenomenon that is far more subtle, that is to say, more complex and far stranger than multiplicity *per se*).

Any suggestion that the notion of the linearity of time is unsalvageable and ought to be replaced with a new, arguably superior, notion of time would be ironic, since it would be to fall into the logic of progress and supersessionism. What is needed is an understanding of temporality where the 'new' and the 'old' might coexist, where one does not triumph by replacing and overcoming the other.[22] Quantum superpositions and, relatedly, quantum entanglements open up possibilities for understanding how the 'new' and the 'old' – indeed,

multiple temporalities – are diffractively threaded through and are inseparable from one another.

FROM TRINITY TO TRINITY

Time and being are themes at the heart of *From Trinity to Trinity*, a remarkable novella by award-winning author Kyoko Hayashi.[23] Having spent her early childhood years abroad, living in Shanghai, and having returned to Nagasaki at the age of fourteen in March 1945, Hayashi spent the majority of her life chronicling the experiences of *hibakusha* and other victims of colonial violence (paying particular attention to Japanese state aggression against China; also noteworthy is Japan's colonisation of Korea, resulting in the little acknowledged fact that between 40,000 and 70,000 Koreans who were conscripted into hard labor by the Japanese died in the bombings of Hiroshima and Nagasaki).[24] Having lived through an event that refuses to end, that decays with time but will forever continue to happen, Hayashi sought to unpack some of the infinite density of one particular spacetime point: Nagasaki, Japan, 9 August 1945, 11:02 a.m – a moment shot through with many other times, places, and histories.

Kyoko Hayashi's novella *From Trinity to Trinity* traces the spacetime wanderings of an older unnamed woman on a spiritual-political pilgrimage, a journey of re-turning to a land she had never before visited but knew better than the geography of her own body, a wounded land whose history of violation radiates inside her bones.

Making her way to Trinity Site in New Mexico where the first atomic bomb test took place, Hayashi's protagonist 'travel hops' from one spacetime point to another, circling back, re-turning and turning our attention to a multiplicity of entangled colonial histories condensed into 9 August: she is at once in Nagasaki working alongside classmates in the Mitsubishi arms factory; on a U.S. Air Force base in New Mexico visiting the National Atomic Museum as a lone Japanese visitor among otherwise white tourists who are there to learn about the U.S. 'nuclear defense history'; in Nagasaki counting fifty-two empty chairs belonging to classmates who did not return, would never return when school started again; and recounting the history of sixteenth-century Spanish explorers colonising the land now called 'New Mexico' while walking next to Little Boy and Fat Man, sitting like two iron coffins, in the museum at Los Alamos.

Her goal is not one of personal healing per se, but rather a political and spiritual commitment to take responsibility for re-membering the countless people who were robbed of their own deaths by unspeakable violence. Centring the relationship between time and justice, she is committed to the work of mourning as a political embodied labor – a commitment to justice beyond the living present and 'concerning those who are not there... those who are no longer or who are not yet *present and living'* (*Specters of Marx*, pxix). Nuclear entanglements do not abide by some notion of modalised presents; time is spectral, diffracted. The bomb is still going off when she walks through the ruins of Nagasaki to Ground Zero in the days following 9 August, when her gums bleed when she is old, when her son faces with each new day the temporality of the future coming from the past, the prospect of getting leukemia as a second-generation *hibakusha*.

From Trinity to Trinity is a story that embodies questions of history, memory, politics, nationalism, colonialism, race, species, violence, and temporality. Hayashi's point is not to try to make sense out of senselessness, as if a rational story could be made of the madness, or a refreshingly mad story made of the rationalisms, but rather, to take hold of the radical possibility of the *undoing* of 9 August. This is a journey across spacetime, nation states, species being, and questions of being/nonbeing.

But it should not be mistaken for a time-travel story, not in the usual sense. This travel-hopping tale is very different from time-travel novels where the protagonist is an autonomous unified subject who continues to live in the time of 'their present' while returning to a past that once was, a past that continues to exist and remains accessible to those with sufficient ingenuity and technical know-how, in an attempt to rework some crucial point in a chain of events that will then propagate forward in deterministic fashion in a rewriting of history. Hayashi's travel hopping does not lend itself to such stories. In Hayashi's story, what is at stake is not setting time aright (as if that were possible), but rather the undoing of time, of universal time, of the notion that moments exist one at a time, everywhere the same, and replace one another in succession (much like identical entities passing by in the evenly spaced rhythms of Fordist assembly lines, the new being readied to replace the old); it is also a story of time-being that undoes modernity's unified notion of self and what it means to be human. The travel hopper must risk her sense of self, which never will have been one, or itself. Travel hopping – tracing the entanglements of spacetimemattering – is not the same as writing a linear chronology as a matter of personal or collective history. Travel-hopping is the embodied material

labour of cutting through/undoing colonialist thinking in an attempt to come to terms with the unfathomable violences of colonialism in their specific material entanglements. How else might she begin to approach the infinite inhumanity of this weapon of instantaneous mass destruction that in a flash obliterates time?

TRACING ENTANGLEMENTS AND THE MATERIAL TRACES OF ERASURE

Tracing entanglements is no easy task. It takes work.

During the waning decades of the twentieth century, arguably the most murderous century in history, the notion that the past might be open to revision through a 'quantum eraser' came to the fore. The quantum-eraser experiment is a variation of a two-slit diffraction experiment, an experiment that Feynman said contains all the mysteries of quantum physics. Against this fantastic claim of the possibility of erasure, I argue that in paying close attention to the material labors entailed, the claim of erasure's possibility fades, while at the same time bringing to the fore a relational-ontology sensibility to questions of time, memory, and history.[25]

The key features of the quantum-eraser experiment are as follows. Recall that the famous two-slit experiment can be used to show that 'particles' under appropriate conditions exhibit wave behaviour (thereby belying their status as particles) – namely, they produce a diffraction pattern; this pattern is produced only if each individual particle is in a state of superposition that includes the possibility of going through both openings at once, as a good wave does (see Figure 9-2A). On the other hand, if you modify a two-slit apparatus by adding a device to measure which slit a particle goes through, it does in fact go through one slit or the other, like a good particle, contributing to the creation of a pattern characteristic of particles – that is, a scatter pattern, not a diffraction pattern (see Figure 9-2B).[26] If the experimenter now adds a device that enables the erasure of the information about which slit a particle goes through *after* it's already gone through the diffraction grating... remarkably, a diffraction pattern appears! – indicating that each particle *will have gone through* both slits at once! (See Figure 9-2C.) This raises the seemingly impossible possibility that one can determine *after* the fact whether the particle will have gone through one slit or the other – like a (well-behaved classical) particle does – or through both slits at the same time – like a wave –

after it has already passed through the diffraction grating and made a mark on the screen. The claim made by the physicists who proposed and conducted the quantum-eraser experiment is that this is evidence of changing the past. But it's important to slow down and carefully examine the evidence behind this claim because the nature of time and being, or rather, time-being, is itself in question and can't be assumed.

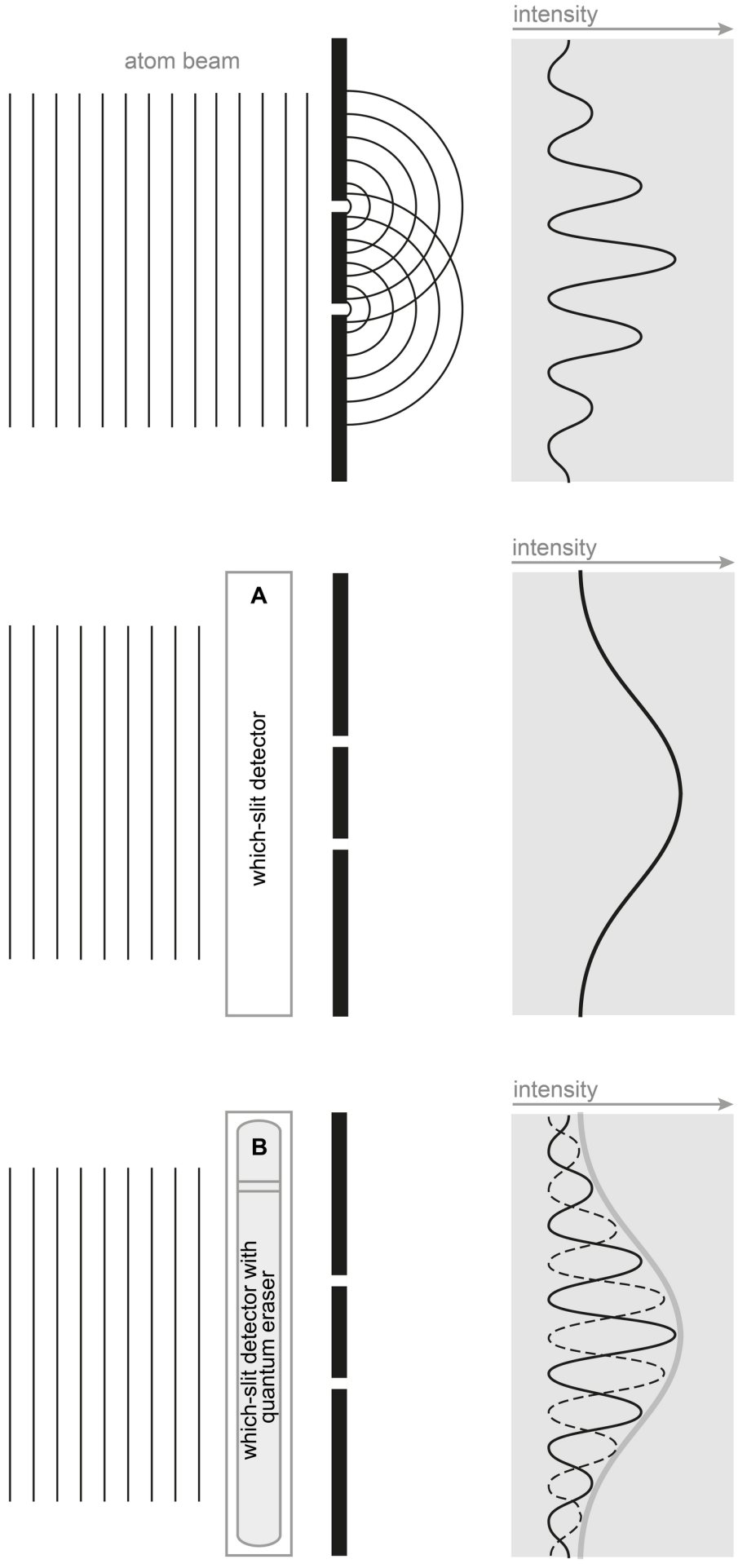

Figure 2: This set of diagrams illustrates some variations on a two-slit experiment. The source used in each case are atoms. The graphs to the right show the

resulting patterns made after many individual particles pass through the two-slit diffraction grating (one at a time). A) An illustration of the usual two-slit experiment. The graph shows the resulting diffraction pattern (characteristic of waves which make a diffraction pattern as a result of the fact that they go through both slits at once and combine on the other side of the barrier). B) An illustration of a two-slit experiment modified with a which-slit detector which enables a detection of which slit each individual particle passes through. The graph shows a resulting scatter pattern (characteristic of particles), indicating that each particle did in fact go through one slit or the other. C) An illustration of a quantum eraser experiment which entails which-slit detection followed by the erasure of the information regarding which slit each individual particle passed through. Significantly, the graph shows that inside the scatter pattern there is an extant diffraction pattern that can be found by tracing the entanglements.

For one thing, something not remarked upon by the experimenters is that what this experiment tells us is not simply that a given particle will have done something different in the past but that the very nature of its being, *its ontology, in the past remains open to future reworkings* (that is, whether it will have been a wave or a particle, which are ontologically different kinds). In particular, I have argued that this experiment offers empirical evidence for a relational ontology that runs counter to a metaphysics of presence. Indeed, I have argued that the quantum-eraser experiment can be understood as offering empirical evidence for a *hauntology* (see *Quantum Entanglements*).

The physicists who proposed the quantum-eraser experiment interpret these results as the possibility of 'changing the past'; they speak of the diffraction pattern as having been 'recovered' (as if the original pattern has returned) and the which-slit information having been 'erased'. But this interpretation is based upon assumptions, assumptions concerning the nature of being and time, that are being called into question *by this very experiment*.

Crucially, the diffraction pattern is not immediately evident once the information is erased. That is, it is not the case that the original diffraction pattern returns. Rather, a different diffraction pattern (not the original one) can be found within the scatter pattern if and only if the experimenter is clever enough to know how to trace the existing entanglement. This point is crucially important. For the labour expended in tracing the entanglements (including figuring out how to find the extant entanglements and then tracing them) is a necessary step in making the experiment work. Remarkably, *this experiment makes evident that entanglements survive the measurement process, and furthermore, that material traces of attempts at erasure can be found in tracing the entanglements*. Indeed, these experiments show that while it is possible to erase particular marks that seem to suggest that the 'past' has been changed, it is a fantasy to believe that this constitutes an erasure of all traces of this history. *Erasure is a material practice that leaves its trace in the very worlding of the world*.

Hence, the quantum-eraser experiment winds up being ironically named for there is no erasure finally; indeed, the traces of erasure are written into the iterative materialisations in their openness. Not only does this experiment call into question the classical Newtonian conceptions of time, as an unabated continuous flow moving inexorably from past to future, where the past is passed and the future will unfold on the basis of what is the case in the present moment, but also the assumed existence of a present-past and the very possibility of erasure without trace. I have argued that an interpretation that seems to be in better accord with the empirical evidence than the one offered by the experimenters is that *while the past is never finished and the future is not what will unfold, the world holds the memories of its iterative reconfigurings*. All reconfigurings, including atomic blasts, violent ruptures, and tears in the fabric of being – of spacetimemattering – *are sedimented into the world in its iterative becoming and must be taken into account in an objective (that is, responsible and accountable) analysis*.

Our atomic past not only haunts the present but is alive in the thickness of the here and now (a point that will be thickened in the QFT section of this essay). One manifestation of the fact that 'now' is shot through with 'then' is the Fukushima disaster and its continuing consequences, which are directly entangled with the U.S. bombing of Hiroshima and Nagasaki. In the aftermath of the war, the U.S.-based Atoms for Peace Program was used to convince Japan to develop nuclear energy for peaceful purposes while the United States used the program to shield the buildup of its nuclear arsenal during the Cold War. Hauntings are not immaterial, and they are not mere recollections or reverberations of what was. Hauntings are an integral part of existing material conditions. This past – nuclear time, decay time, dead time, atomic clock time, doomsday clock time, a superposition of dispersed times cut together-apart – is literally swirling around with the radioactivity in the ocean. Time itself is nationalised, racialised, out of joint. The entanglements of nuclear energy and nuclear weapons, nationalism, racism, global exchange and lack of exchange of information and energy resources, water systems, earthquakes, plate tectonics, geopolitics, criticality (in atomic and political senses), and more are part of this ongoing material history that is embedded in the question of Japan's future reliance on nuclear energy, where time itself is left open to decay.

HISTORY, MEMORY, AND TRACES OF ERASURE: ON THE WAY TO TRINITY

> "Soon my eyes caught some big letters on a panel: 'Count Down to Nagasaki'. [...]
> [Our protagonist is visiting the National Atomic Museum in New Mexico, an unexpected stop on the way to Trinity Site.[27]]
> I felt time stop in front of the panel.
> 'Count Down to Nagasaki'. While the time towards death in Nagasaki was ticking, what were Kana and I doing in the Ohashi Arms Factory?
> ...at the very moment the bomb left the plane, I was trying to locate the sound of a small roar the factory chief told us he had just heard.
> I closed my eyes and bowed my head to the photograph. The ruin of a fire printed underneath the explanation was the city of Nagasaki with Inasayama across the river. Bockscar pilot Sweeny said in the first report of the attack on Nagasaki. Here is the photograph of that destroyed city. The photo shows a burned field, but under what is seen on that printed paper is teacher T, who died instantly, and classmates A, O, and others" (*From Trinity to Trinity*, pp16-17).

In this brief passage, where chronology has no p(l)ace, where multiple temporalities present themselves without any one of them being present, the very coexistence of time-beings disassembling the allegedly determinate distinction between individual and collective, memory and history, Hayashi offers us a pointed contestation of official museum history: that is, a tale told in chronological time, a scientised and sanitised account of 'objective reality' – the god's-eye view from above, the view from nowhere. Disrupting this chronology helps us see through the photograph to what is behind it: namely, all the various material-discursive apparatuses of production that make up this exhibit – what it contains, what it erases, which facts matter and how they are collected and framed. What the official photo shows is an aerial view of a city destroyed, the leveling of buildings into a structural void. What the museum history invisiblises is *the structure of the void* – the entangled material histories of death and dying, all the ravages of untold violence, histories of colonialism, racism, and militarism, and all the attempted erasures that constitute it.[28] By contrast, what is at stake for Hayashi is a matter of empirical reality: the reality (literally) on the ground.

We come to see that what the photo shows is *not* the bare facts of history, but rather a record of erasures: the literal erasure of lives obliterated like so many buildings, people who had been in the streets on foot and on bicycles, workers stacking shelves in neighborhood shops, school children working in factories, old people and children in their homes; but also a particular framing of the

event that makes use of distance to sanitise the suffering and devastation of lives, while erasing *some* histories of violence and not others. Japanese imperialist aggression is the given background against which this history is shot, while U.S. imperialism and militarism are outside the frame. Erasures upon erasures.

But erasures are never complete – traces always remain. In her disjointed time-hopping, Hayashi's narrator is bodily tracing these extant entanglements.

The official photograph freezes time and reifies space. But there were other photographs taken during the bombing of Hiroshima and Nagasaki, photographs on the ground, not ones engineered by humans designed to capture the successes of military operations, but rather very up-close and personal photos taken by the bomb itself. Shadows of incinerated bodies – human and nonhuman – captured on walls made into photographic plates by the intensity of the blast.

What lies inside the boundaries of a shadow? Where are its edges? Diffraction unsettles colonialist assumptions of space and time: beginnings and ends, continuity and discontinuity, interior and exterior.

Standing in the museum, Hayashi notes another integral part of the official museum history and its contemporary framing:

> "There were no black or Mexican visitors. Not only in this museum but also in Los Alamos and at the all the visitors were white" (*From Trinity to Trinity*, p20).

Jumping in time but continuing the thought, Hayashi introduces another invisibilised piece of the story, one so covered-over by colonialism's practices of erasure that the very question of the ground on which the exhibit stands seems all but entirely buried. What is the story of this very land that the museum stands on – why here? What is the connection of this land to the obliterated Japanese city shown in the photograph? Standing in the museum, Hayashi traces the entanglements of colonial histories: of late sixteenth-century European colonial conquest of Native American peoples and lands, entangled with the early twentieth-century U.S. colonial annexation of New Mexico in the wake of the U.S. invasion of Mexico half a century earlier, entangled with the mid-twentieth-century war-time designation of native land deemed uninhabited as 'Trinity Site,' entangled with the testing of the plutonium bomb at Trinity Site, entangled with the same kind of bomb being dropped

a month later on Nagasaki, entangled with uranium mining and nuclear-waste burial on indigenous lands in the American Southwest, entangled with the Fukushima disaster, entangled with existing and future cancers of *all* the atom bomb survivors and their offspring, including the (human and nonhuman) 'no-bodies' who were downwind from the Trinity test site.[29]

Attempts at erasure always leave material traces: what is erased is preserved in the entanglements, in the diffraction patterns of being/becoming. In tracing the material entanglements extant in practices of erasure, Hayashi's narrator gives us a sense of *how* boundaries of lands and bodies get diffractively materialised and sedimented through one another. The various forms of violence, including all the erasures, are written into the very fabric of the world, into the specific configurings of spacetimemattering, so that it is crucial that she make the pilgrimage to trace the entanglements with her marked and wounded body. Hayashi's narrator bodily traces these entanglements of colonialist histories, violent erasures, and avoidances as an integral part of a sacred practice of re-membering – which is not a going back to what was, but rather a material reconfiguring of spacetimemattering in ways that attempt to do justice to account for the devastation wrought and to produce openings, new possible histories, reconfigurings of spacetimemattering through which time-beings might find a way to endure.

QUANTUM FIELD THEORY: THE UN/MAKING OF SELF AND THE MATERIAL CONDITIONS FOR LIVING AND DYING IN THE VOID

Land occupation, as a mode of empire building, has been and continues to be tied to a logics of the void.[30] Namely, justification for occupying land is often given on the basis of colonialist practices of traveling to 'new' lands and 'discovering' all matter of 'voids': for example, claims of population voids (for instance, lands allegedly unpopulated before the arrival of the settlers), land devoid of property ownership, territorial sovereignty, development, civilisation, or inhabitants with specific labor relations to specific parcels of land. The doctrine of *terra nullius* is one such tool of empire building. Whatever the specific nature of the alleged absence, a particular understanding of the notion of the *void* defines the colonialist practices of avoidance and erasure.

The void occupied a central place in Newton's natural philosophy. He wavered about the existence of an ether permeating empty space, but unlike

many of his contemporaries who were still committed Aristotelians and equated matter with extension, Newton insisted that the void was a spatial frame of reference within and against which motion takes place. Matter is discrete and finite, and the void is continuous and infinite. The void extends indefinitely in all directions, and bits of matter take their position in the void. All in all, the void is quite *literally* universal (measuring the full extent of the universe and beyond) and therefore only very sparsely populated. And since property rests with matter as one of its founding characteristics, the absence of matter is the absence of property and the absence of energy, work, and change. The void, in classical physics, is *that which literally doesn't matter*. It is merely that which frames what is absolute. While the so-called voyages of discovery, bringing data (including astronomical and tidal changes) culled from European journeys to non-European sites aided Newton in his efforts to develop a natural philosophy that united heaven and earth, Newtonian physics helped consolidate and give scientific credence to colonialist endeavors to make claims on lands that were said to be de-void of persons in possession of culture and reason.[31]

If classical physics insists that the void has no matter and no energy, the quantum principle of ontological indeterminacy – in particular the indeterminacy relation between energy and time – calls into question the existence of such a zero-energy/zero-matter state or rather makes it into a question with no decidable answer. Not a settled matter, or rather, no matter. And if the energy of the vacuum is not determinately zero, it isn't determinately empty (since energy and matter are equivalent: E=mc^2).

That is, according to QFT, the vacuum can't be determinately nothing because the indeterminacy principle allows for fluctuations of the quantum vacuum. How can we understand 'vacuum fluctuations'? If the physicist's conception of a field can be likened to a drumhead, with a zero-energy state being akin to a perfectly still drumhead and a field with a finite energy being a drumhead in one of its (quantised) vibrational modes (like the 3D analog of harmonics of a string), then while the classical vacuum state would be perfectly still, without any vibrations, a quantum vacuum state, although it has zero-energy, is *not* determinately still as a result of the energy-time indeterminacy principle. *Vacuum fluctuations are the indeterminate vibrations of the vacuum or zero-energy state. Indeed, the vacuum is far from empty, for it is filled with all possible indeterminate yearnings of time-being; or in this drum analogy, the vacuum is filled with the indeterminate murmurings of all possible sounds: it is*

a speaking silence. What stories of creation and annihilation is the void telling? How might we approach the possibility of listening?

Putting this point in the complementary language of particles rather than fields, we can understand vacuum fluctuations in terms of the existence of virtual particles: *virtual particles are quanta of the vacuum fluctuations*. That is *virtual particles are quantised indeterminacies-in-action. Virtuality is the indeterminacy of being/nonbeing, a ghostly non/existence*. The void is a spectral realm; not even nothing can be free of ghosts. Virtual particles do not traffic in a metaphysics of presence. They do not exist in space and time. They are ghostly non/ existences that teeter on the edge of the infinitely thin blade between being and nonbeing. They speak of indeterminacy. Or rather, no determinate words are spoken by the vacuum, only a speaking silence that is neither silence nor speech, but the conditions of im/possibility for non/existence. There are an infinite number of possibilities, but not everything is possible. The vacuum isn't empty, but neither is there any-thing in it. Hence, we can see that indeterminacy is key not only to the existence of matter but also to its nonexistence – that is, to the nature of the void.[32]

In fact, this indeterminacy is responsible not only for the void not being nothing (while not being something), but it may in fact be the source of all that is – a womb that births existence. Particles (together with their corresponding antiparticles, in pairs) can be created out of the vacuum by putting the right amount of energy into the vacuum, thereby giving a virtual particle (-antiparticle pair) enough energy to emerge from the vacuum; similarly, particles (together with their corresponding antiparticles, in pairs) can go back into the vacuum, emitting the excess energy.[33] Hence, birth and death are not the sole prerogative of the animate world. 'Inanimate' beings also have finite lives. 'Particles can be born and particles can die,' explains one physicist. In fact, 'it is a matter of birth, life, and death that requires the development of a new subject in physics, that of quantum field theory... Quantum field theory is a response to the ephemeral nature of life'.[34]

The void is a lively tension that troubles the opposition between living and dying (without collapsing their important material differences); the void is a dynamism of indeterminacy, a threading through of living with dying and dying with living, a desiring orientation toward being/becoming that cannot a-void matters of life and death. *The vacuum is far from empty; rather, it is flush with yearning, with innumerable possibilities/ imaginings of what was, could be, might yet have been, all coexisting.* Don't for a minute think that there are no material effects of yearning and imagining. Virtual particles are experimenting

with the im/possibilities of non/being, but that doesn't mean they aren't real; on the contrary. Consider this headline: 'It's Confirmed: Matter Is Merely Vacuum Fluctuations'.[35] The article explains that most of the mass of an atom, its nucleus made of protons and neutrons (which constitute the bulk of an atom) is due not to its constituent particles (the quarks), which only account for a mere 1 percent of its mass, but rather to the contributions from virtual particles.[36] *The void can hardly be thought of as that which doesn't matter!*

QFT not only reworks the classical understanding of the void, but also of matter in its inseparability from the void. Consider the classical physics view of an electron, one of the simplest particles – a point particle – a particle so small as to be of zero dimensions. Not only is it without extension, it is without an interior, completely devoid of structure. And yet it causes a great deal of trouble, both for classical and quantum physics.[37]

According to QFT, as a result of time-being indeterminacy, the electron does not exist as an isolated particle but is always already inseparable from the wild activities of the vacuum. That is, the electron is always (already) intra-acting with the virtual particles of the vacuum in every imaginable way. Let's take just a very small peek 'into' the electron and the infinite number of wild things going on.

Electrons are charged particles, which means they are susceptible to, or we might even say inclined toward, touching and being touched. Indeed, touching, according to physics, is but an electromagnetic intra-action between charged particles. (The reason the desk feels solid, or the cat's coat feels soft, or we can even hold coffee cups and one another's hands, is an effect of electromagnetic repulsion. All we really ever feel is the electromagnetic force, not the other whose touch we seek.) The electromagnetic force experienced between two charged particles depends on the relative nature of their charges: opposites attract, and like charges repel one another.

Now, since a charged particle emits an electromagnetic field and charged particles positioned in electromagnetic fields feel an electromagnetic force on them, the electron being charged both emits and intra-acts with its own field. This self-touching intra-action – a constitutive part of what an electron is – turns out to be a source of unending anxiety in the physics community. Commenting specifically on the electron's self-energy intra-action, the physicist Richard Feynman expressed *horror* at the electron's monstrous nature and its perverse ways of engaging with the world: 'Instead of going directly from one point to another, the electron goes along for a while and suddenly

emits a [virtual] photon [which is the carrier of the electromagnetic field]; then (horrors!) it absorbs its own photon. Perhaps there's something 'immoral' about that, but the electron does it!' This self-energy/self-touching term has also been labeled a 'perversion of the theory' because its value is infinite, which is an unacceptable answer to any question about the nature of the electron (such as, what is its mass or charge?). Apparently, touching oneself, or being touched by or in touch with oneself – the ambiguity may itself be the key to the trouble – is not simply troubling but a *moral* violation, the very source of all the trouble.

But it's worse (better) that that! For this simple self-energy intra-action is not a process that happens in isolation, either. All kinds of more involved things can and do occur in its intra-action with this frothy brew of nothingness. In fact, there is a virtual exploration of every possibility, an infinite set of possible ways of self-touching through touching others in all possible ways. So there is an infinity of infinities.[38]

In fact, Feynman proposed a 'renormalisation' procedure that attempts to reel in the electron's queerness, its unruliness. According to this procedure the 'bare' electron (which is mathematically infinite) is 'dressed' with the infinite contributions of the virtual particles of the vacuum such that, in the end, the physical electron is finite. (I'm using technical language here!) That is, what renormalisation entails is the subtraction of two infinities to get something finite. This renormalisation procedure necessarily entails taking into account the infinite possible intra-actions with all virtual particles in all possible ways – that is, all possible histories.

Hence, according to QFT, *even the smallest bits of matter are an enormous multitude!* Each 'individual' is made up of all possible histories of virtual intra-actions with all others; or rather, according to QFT, there is no such thing as a discrete individual with its own roster of properties. In fact, *the 'other' – the constitutively excluded – is always already within: the very notion of the 'self' is a troubling of the interior/exterior distinction.* Matter in the indeterminacy of its being un/does identity and unsettles the very foundations of non/being. Together with Derrida, we might then say, 'Identity… can only affirm itself as identity to itself by opening itself to the hospitality of a difference from itself or of a difference with itself. Condition of the self, such a difference from and with itself would then be its very thing … the stranger at home'[39] (A 10/28). What is being called into question here is the very nature of the 'self'; all 'selves' are not themselves but rather the iterative intra-activity of all matter of time-beings. *The self is dispersed/diffracted through being and time*. In an

undoing of the inside/outside distinction, it is undecidable whether there is an implosion of otherness or a dispersion of self throughout spacetimemattering.[40]

Hence, matter is an enfolding, an involution: it can't help touching itself, and in this self-touching it comes into contact with the infinite alterity that it is. Ontological indeterminacy, an unending dynamism of the opening up of possibilities, is at the core of mattering. How strange that indeterminacy, in its infinite undoing of closure, is the condition for the possibility of all structures in their dynamically reconfiguring stabilities (and instabilities).

According to QFT, there is no a-void-ing the fact that the void is far from empty. Indeed, nothingness is an infinite plentitude, not a thing, but a dynamic of iterative re-opening that cannot be disentangled from (what) matter(s).

RE-TURNING AND RE-MEMBERING AS COUNTERHEGEMONIC PRACTICES: A COUNTERPOLITICS TO COLONIALISM'S AVOIDANCES AND ERASURES

> "Ironically, the land that was denounced as became cultivated by the invaders' bloody battles and desires (*From Trinity to Trinity*, p24). Every *hibakusha* knows their survival carries within it the wailing and silence of the dead" (p xi).

The climax of the novella is the narrator's trip to Trinity Site, the place where the first plutonium bomb was detonated on July 16, 1945, at 5:29 a.m. It is here, at the end of her journey, the very place where it all began, standing in the midst of a desert, inside a fenced area with nothing inside it save a monument to nothingness – to Ground Zero – that the fullness of these embodied tracings of all the various colonial entanglements comes full circle. Hayashi is committed to being a chronicler of 9 August.[41] Given that she deliberately writes against the grain of chronology, perhaps Hayashi's commitment to tracing the material entanglements condensed into the spacetime point of 9 August might be more aptly captured by the more unconventional title 'travel-hopping scribe' of 9 August.[42] *From Trinity to Trinity* is not a time-travel novel but a time-diffraction tale, an embodied pilgrimage committed to tracing the material entanglements: a risky journey of placing one's body in touch with the matter/materiality of specific colonialist

histories – an embodied accounting of some of the sums of all possible histories (Feynman's path integral approach), or 'super-many-times' (as in Japanese Nobel laureate physicist Sin-Itiro Tomonaga's QFT approach), an iterative circling back around (as in Japanese Nobel laureate physicist Hideki Yukawa's *maru* or circle approach) – touching the infinite alterity that constitutes a point.[43] What is the structure of the infinity of a point labeled (on some calendars as) 9 August? Re-turning to a point to face the incalculable.

Re-turning is a troubling matter, a matter of troubling. Loop diagrams in QFT are calculational devices representing processes in which there is a re- turn to – a touching of – the self. Loops are the ones that cause the most trouble for ruling conceptions of space, time, matter, causality, and nothingness.

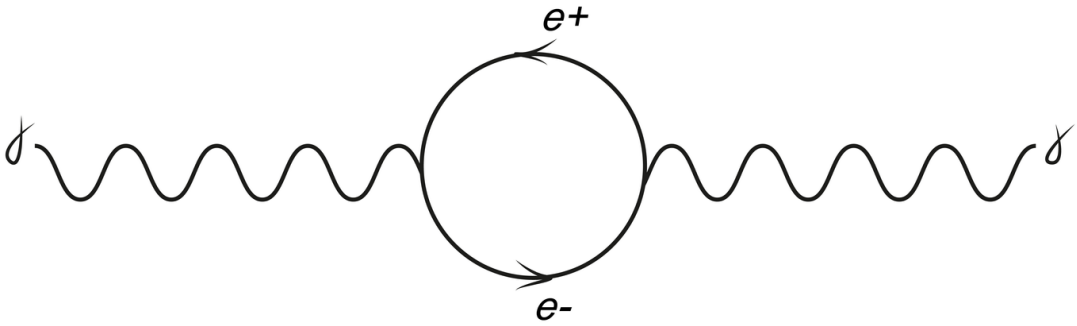

Figure 3. This 'Feynman diagram' is one expression of the non/emptiness of the void. It represents the void performing a vacuum fluctuation (just one of an infinite number of fluctuations of the void in its specific structuration). This one shows the virtual creation and annihilation of an electron-positron pair (which are jointly created and annihilated, and where the positron is an anti-electron, that is, its anti-matter partner). This can also be understood as a photon self-energy diagram. Wavy lines represent photons (quanta of the electromagnetic field, or light-particles, a particular case of which might be a gamma ray or high-energy radiation relevant to nuclear decay), while solid lines are electrons (and positrons): e- represents a virtual electron traveling forward in time, and e+ a virtual positron moving backward in time.) The loop diagram is (itself) infinite and needs to be renormalized; it represents but one of an infinite set of possible spacetimemattering-histories. That is, there are an infinity of infinities that constitute each finitude. The diagram displays fluctuations of the nothingness: virtual creation-annihilation, birth-death, with all the potential that that holds. It sets up an interesting set of reverberations with a diagram we might draw of the pilgrimage of Hayashi's travel-hopping narrator who re-turns to the spacetime point Trinity July 16, 1945, from another crucial spacetime point Nagasaki April 9, 1945. Braving a re-turn to the void, the narrator risks this self-energy intra-action, this undoing of self, and is thereby transformed from victim to survivor, in concert with all entangled beings ('human' and 'nonhuman') who are hibakusha. In particular, this diagram is part of a self-intra-action diagram where touching oneself involves touching Others. The renormalized self is a collectivity, not an individual, in an undoing not only of self/other but human/nonhuman. Hence, as Hayashi points out, revenge doesn't make any sense. Redemption and re-membering are made possible by the fact that nothingness (the wounded desert, the devastated cityscape) is not empty.

Being a 9 August travel-hopping scribe is different from being a historian. For one thing, travel-hopping involves making the journey in spacetime, tracing the multiple histories with one's body, putting the self at risk as part of a committed response-ability to those who have died and those not yet born. It

entails re-cognising material kinship with this exploded/imploded moment in time.

> "I am going to Trinity [she tells her friend] ... the truth is, even today I still want to break away from August 9 (...) I have always wished I was not related to August 9.
> ... Katsura [my son] is a second-generation hibakusha. (...) he disliked being an inmate on death row without a prison term. (...) He wanted to live away from August 9.
> ... Trinity is the starting point of my August 9. It is also the final destination of hibakusha. From Trinity to Trinity – .
> If I make that journey, I can hold August 9 within my life circle. If I can never be free from the event, I should end my relationship by swallowing it" (*From Trinity to Trinity*, pp.9, 11).

What does it mean to swallow an event? Perhaps this is an evocation of the *ouroboros*, the mythical symbol of the serpent biting its tail, representing 'creation out of destruction, Life out of Death' (p 28).[44] Or perhaps it means to ingest the event like radiation: to take it into your gut, to feel it leach into your bones, mutate your innards, and reset your cellular clocks. Perhaps it is about the im/possibility of metabolising the trauma, transforming the self from victim to survivor. Perhaps it is a way of un/doing the self, of touching oneself through touching all others, taking in multitudes of Others that make up the very matter of one's being in order to materially transform the self and one's material sense of self.[45] Perhaps it is about the willingness to put oneself at risk, to place one's body on this wounded land, to be in touch with it, to have a felt sense of its textures, to come to terms with a shared sense of vulnerability and invisibility, to feel the ways that this land, this void, which marks the colonisers' continuing practices of *avoidance*, always already inhabits the core, the nucleus of your being.

> "I walked to ... .
> From this point in July, fifty years ago, the flash of light of the atomic bomb ran all directions in the desert. I heard, on the day of the experiment, it had been raining hard since morning, unusual in New Mexico. The experiment was carried out in the heavy rain. The flash of light boiled the downpour and, with that white froth, ruined the fields, burned the helpless mountains, and shot up to the sky. And then silence. Without time to defend and fight back, the wilderness was forced into silence."[46]

Let us pause before this silence, before rushing on, this silence threaded through with all matter of murmurings, so many cries that might yet have been but never were.

> "From the bottom of the ground, from the exposed red faces of faraway mountains, from the brown wasteland, the waves of silence came lapping and made me shudder. How hot it must have been –
> Until now as I stand at the , I have thought it was we humans who were the first atomic bomb victims on Earth. I was wrong. Here are my senior *hibakusha*. They are here but cannot cry or yell. Tears filled my eyes" (*From Trinity to Trinity*, pp.49-50).

Here at Ground Zero, time-being was shaken to its core: matter was split off from itself – traumatised. Violence tears holes in the very fabric of the world in its sedimenting iterative intra-activity. Woundedness is not reserved for human beings alone (and an account of woundedness must at the same time bring into the story the many thousands of people who were downwind from the blast).

Landscapes are not stages, containers, or mere environments for human and nonhuman actors. Landscape is not merely visually akin to a body; it is the skin of the earth.[47] Land is not property or territory; it is a time-being marked by its own wounds and vitality, a layered material geo-neuro-bio- graphy of bones and bodies, ashes and earth, where death and life meet. Etymological entanglements already hint at a troubling of assumed boundaries between allegedly different kinds: Earth, *humus* (from the Latin), is part of the etymology of human, and similarly, *Adam* (Hebrew: [hu]man[kind]) derives from *adamah* (Hebrew: ground, land, earth), giving lie to assertions of firm distinctions between human and nonhuman, suggesting a relationship of kin rather than kind – a cutting together-apart.[48] Time-beings do not merely inhabit, but rather are *of* the landtimescape – the spacetimemattering of the world in its sedimenting enfoldings of iterative intra-activity. Memory is not merely a subjective capacity of the human mind; rather, 'human' and 'mind' are part of the landtimescape – spacetimemattering – of the world. Memory is written into the worlding of the world in its specificity, the ineliminable trace of the sedimenting historicity of its iterative reconfiguring.

> "We are heading for Los Alamos. It is a steep mountainous road. One side of the road is a cliff, and below it I can see the mesas we saw on our way to Santa Fe. The wind that blows in the canyon seems to carry grasses and bushes away, so there is no green on the cliffs of the mesas. Stones and dirt

> also get blown away, so the cliffs have small holes like the ones an insect bites in cabbage leaves. Seen from far away, these holes are round as if they were hit by an adult's fist. Holes of the same size are scattered on the surface of the cliffs, and gray stones are partly visible here and there. The wind blew away the dirt that covered buried stones, and when the stones fell, holes remained. So stones lay under the mesas. These stones that fell off the cliffs are the dead of the mesas. I remember my classroom when the second semester started after the defeat of the War. In my grade, fifty-two students died. So we had one less class when we formed new classes" (*From Trinity to Trinity*, p29).

Hayashi understands land, in this case, this marked void, this silenced land, as the ground for respectful just and nonviolent mourning, for re-membering. Re-membering is a bodily activity of re-turning. She must place her body on this wounded ground to hear its murmuring silences and muted cries, to re-member and reconfigure the spacetimemattering of all *hibakusha* in their material entanglements.

> "I have always been aware of being a *hibakusha*. But as soon as I started walking through the small passage within the fenced area led by a guide, my always-present awareness of being a victim disappeared from my mind. It was as if I became a fourteen-year-old again. I may have been walking toward an unknown as though I were someone from the before August 9, but it was when I stood in front of the memorial that I was truly exposed to the atomic bomb.
> Looking back, I did not shed a tear on August 9. As I ran with the pack of people whose hands, feet, faces no longer looked human, no tears came to me... .
> For the first time here at Trinity, however, I might be crying with human tears that I did not shed on August 9. Standing on the land that speaks no words, I shivered, feeling its pain. Until today, I have lived with merciless pains that hurt my mind and body. But it could have been the pain of the skin that grew from August 9. Here in this desert I had momentarily forgotten my life as a *hibakusha*" (p50-51).

It is here, in the midst of the nothingness, the place where living and dying meet, where time-being is exposed as indeterminately multiple and filled with all matter of desiring im/possibilities, that the travel-hopping scribe can finally lay to rest her fifty-two classmates who were denied their own deaths. Long ago she had taken on this response-ability for the fifty-two and carried them around with her all these years. It is in putting herself at risk, in risking her

sense of self, this work of embodied re-membering, that she can finally release her tears and let them rain down on the ground.

> "When I told you I was coming to Trinity, you asked me if I was an atomic bomb maniac. I wonder with what I can possibly fill the fifty-two spaces that were once lived by fifty-two schoolmates in my grade. I want to embrace the emptied spaces but my hand reaches towards nothing (p 33)."

In re-turning to the nothingness, she brings one void in its particularity (Nagasaki) to another (Trinity), not to renormalise these infinite violences, avoidances, and erasures, but to bring to bear the clouds of im/possibilities that surround these entangled events.[49] What does it mean to confront the nothingness, to touch its fullness? This is a question that cannot be answered in the abstract, not once and for all, but must be asked over and over again with one's body.

This question, which must be lived, re-turns us to a question that has been held in suspension: for whom is Ground Zero empty? Clearly, this land is far from empty: on the contrary, it is teeming with all matter of im/possibilities – material conditions of living and dying. Living and dying in this void are a multitude of beings excluded from the designation of 'human'. Not only those beings living at Ground Zero at the time of the Trinity test, including rattlesnakes, insects, plants, rocks, and soil, but also all those time-beings downwind from the test site, including those who often don't get counted as (fully) human, together with the bones and ghosts of their deceased ancestors and their future offspring. That is, what resides in the void are all those who endure despite layer upon layer of colonial and racialised violence, all those whom Man counts as Other, variously marked as subhuman, nonhuman, inhuman, or not even acknowledged as worthy of a mark or being named. In fact, this parcel of land, designated as 'the wilderness of New Mexico,' on and around the Trinity site, is 'home to nineteen American Indian pueblos, two Apache tribes, and some chapters of the Navajo Nation'. The fact that there were 19,000 people living within a fifty-mile radius of the secret test is something that was not only ignored by the U.S. government until 2014, but unfortunately, is not mentioned by Hayashi, though they surely belong among her kin.

For Hayashi, it is precisely the question of re-membering and just mourning that defines being human, which is not to define its nature as some particular singularity, thereby rooting the story in the soil of human exceptionalism, but rather to bring it back around to questions of the nature of the 'human' (in its

differential constitution). What makes us human is not our alleged distinctiveness from – the nonhuman, the inhuman, the subhuman, the more-than-human, those who do not matter – but rather our relationship with and responsibility to the dead, to the ghosts of the past and the future.[50] The pilgrimage of Hayashi's unnamed protagonist is a work of mourning, a concerted ongoing labor, never finished or complete; where mourning is not about making memorials, but rather about ontologically reconfiguring a past that never was on behalf of possibilities for a better future, not as performed by a willful liberal humanist subject, but in the tracings of entanglements of multiple time-beings through which the unnamed protagonist is herself constituted. It is in bodily bringing together the different structures of nothingness – tracing their entanglements – that the world can mourn, and that the unnamed come to matter and are recognised as part of the ongoing reworlding of the world.

Hayashi's political-ethical commitment to the activism of re-membering the *hibakusha* has been a life practice of tracing the entangled violences of colonialism, racism, nationalism dispersed across spacetime. Crucial to this ongoing labor of mourning is the work of re-turning – turning it over and over again[51] – decomposition, composting, turning over the humus, undoing the notion of the human founded on the poisoned soil of human exceptionalism.[52] Not to privilege all other beings over the human, in some perverse reversal, but to begin to come to terms with the infinite depths of our inhumanity, and out of the resulting devastation, to nourish the infinitely rich ground of possibilities for living and dying otherwise.

Acknowledgments: I am grateful to Elaine Gan for her careful and skillful crafting of the diagrams. Thanks are due to Cleo Woelfle-Erskine, Vivian Underhill, Lani Hanna, and Noya Kansky for their careful reading and helpful feedback.

---

1. Jacques Derrida (1994), *Specters of Marx: The State of the Debt, the Work of Mourning, & the New International*, NY: Routledge, Peggy Kamuf (trans), pviii/15-16. (Hereafter *Specters of Marx*.) ↩
2. Damian Carrington, 'The Anthropocene Epoch: Scientists Declare Dawn of Human-Influenced Age,' *Guardian*, 2016, https://www.theguardian.com/environment/2016/ aug/29/declare-anthropocene-

epoch-experts-urge-geological-congress-human-impact-earth. Under consideration for a specific date marking the new epoch: July 16, 1945, the date of the Trinity test. ↩

3. Particularly incisive critiques include those by Zoe Todd, 'Relationships,' *Theorizing the Contemporary, Cultural Anthropology*, 2016, https:// culanth.org/ fieldsights/799-relationships; Neel Ahuja, 'The Anthropocene Debate: On the limits of Colonial Geology,' blog, 2016, https://ahuja.sites.ucsc.edu/2016/09/09/ the-anthropocene-debate-on-the-limits-of-colonial-geology/); and Dana Luciano, 'The Inhuman Anthropocene,' *LA Review of Books*, 2016, http://avidly.lareviewofbooks.org/2015/03/22/ the-inhuman-anthropocene/. ↩
4. Much has been made of the dropping of the first atomic bomb on two now-infamous cities, Hiroshima and Nagasaki, and the health-nightmare aftermath. But only now [2014] is the spotlight being put onto those who had the actual first atomic bombdropped in their vicinity—it was the Americans' own people, Turtle Island's original inhabitants, the Indigenous Peoples of the southwest. The world's first atomic bomb was detonated on July 16, 1945, in New Mexico—home to 19 American Indian pueblos, two Apache tribes and some chapters of the Navajo Nation. Manhattan Project scientists exploded the device containing six kilograms of plutonium 239 on a 100-foot tower at the Trinity Site in the Jornada del Muerto (Journey of Death) Valley at what is now the U.S. Army's White Sands Missile Range. The blast was the equivalent of 21 kilotons of TNT. At the time an estimated 19,000 people lived within a 50-mile radius&. Tanya H. Lee, 'H-Bomb Guinea Pigs! Natives Suffering Decades after New Mexico Tests', *Indian Country Media Network* (2014), http://indiancountrytodaymedianetwork.com/ 2014/03/05/guinea-pigs-indigenous-people-suffering- decades-after-new-mexico-h-bomb-testing-153856. (Hereafter *H-Bomb Guinea Pigs*). ↩
5. Masahide Kato, 'Nuclear Globalism: Traversing Rockets, Satellites, and Nuclear War via the Strategic Gaze', *Alternatives* 18, 1993, p348. (Hereafter *Nuclear Globalism*). ↩
6. Walter Benjamin, 'On the concept of history', Walter Benjamin: *Selected Writings* Volume 4:1938-1940, eds Howard Eiland and Michael Jennings, Cambridge, Cambridge University Press, 2006. ↩
7. Daniel R. Wildcat, 'Indigenizing the Future: Why We Must Think Spatially in the Twenty-First Century, American Studies 46, nos. 3 and 4, 2005, pp417-440; *Indigenous Studies* 1, 2005-6, 433-34. ↩
8. Kyoko Hayashi, *From Trinity to Trinity*, Barrytown, N.Y, Station Hill, 2010. (Hereafter From Trinity to Trinity). ↩
9. Dan Frosch, 'Decades after Nuclear Test, U.S. Studies Cancer Fallout: Examination Will Probe Radiation Exposure near 1945 Trinity Blast in New Mexico', *Wall Street Journal*, 15 September, 2014. ↩
10. This essay is an excerpt from a current book project, Karen Barad, *Infinity, Nothingness, and Justice-to-Come*, which contains a more extended discussion of the issues, including an investigation into how specific indigenous temporalities (of American Southwest tribes) and specific Japanese conceptions of temporality matter to this story. (Hereafter *Infinity, Nothingness*). ↩
11. 'Quantum Entanglements and Hauntological Relations of Inheritance: Dis/continuities, SpaceTime Enfoldings, and Justice-to- Come', *Derrida Today* 3, no.2, 2010, pp 240-68. (Hereafter *Quantum Entanglements*). For another, book-length diffraction of physics and Derridean deconstruction, see Vicki Kirby, *Quantum Anthropologies. Life at Large*, Durham, N.C, Duke University Press, 2011. ↩
12. See Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, Durham, N.C, Duke University Press, 2007. (Hereafter *Meeting the Universe Halfway*). ↩
13. Entanglements call into question the geometrical notions of scale and proximity; topology, with its focus on issues of connectivity and boundary, becomes a more apt analytical tool. It's not that scale doesn't matter; the point is that it isn't simply given and what appears far apart might actually be as close as the object in question; indeed, it may be an inseparable part of it. See the concept of *spacetimemattering* in *Meeting the Universe Halfway*. ↩
14. See also the brilliant analysis of nuclear temporalities in Joseph Masco, *Nuclear Borderlands: The Manhattan Project in Post-Cold War New Mexico*, Princeton: Princeton University Press, 2006. (Hereafter *Nuclear Borderlands*). ↩

15. This line from the *Bhagavad Gita* was famously quoted by physicist J. Robert Oppenheimer (his translation from the Sanskrit) in the wake of the first atomic bomb explosion. ↩
16. This is only to suggest the barest hints of a rich history, which can't be told here. For a more in-depth account as it relates to the story being told here, see Barad, *Infinity, Nothingness, and Justice-to-Come*. One crucially important reference is Silvan S. Schweber, *QED and the Men Who Made It: Dyson, Feynman, Schwinger, and Tomonaga*, Princeton, Princeton University Press, 1994. ↩
17. Trinh T. Minh-ha, *Elsewhere, Within Here: Immigration, Refugeeism and the Boundary Event*, London, Routledge, 2010, p56. ↩
18. Trinh T.Minh- ha, 'Not You/Like You: Post-Colonial Women and the Interlocking Question of Identity and Difference', *Inscriptions, special issues Feminism and the Critique of Colonial Discourse*, 3-4, 1988: http://culturalstudies.ucsc.edu/PUBS/Inscriptions/vol_3-4/minh-ha.html. ↩
19. And not just some so-called microworld, as if there were a line in the sand between 'micro' and 'macro,' as if scale were already given. As Bohr was fond of pointing out, if Planck's constant (the measure of discreteness or lack of continuity of the physical world) had been larger, then we wouldn't have talked ourselves into a metaphysics of individualism to begin with. In a performative relational ontology, it's differentiating entanglings all the way down. ↩
20. See, for example, Marcos Moshinsky, 'Diffraction in Time', *Physical Review* 88, no. 3, 1952, pp625-31, and Časlav Brukner and Anton Zeilinger, 'Diffraction of Matter Waves in Space and in Time', Physical Review A 56, no. 5, 1997, pp3804-24. (Hereafter *Diffraction of Matter Waves*). ↩
21. There were several different variations of the sum over all possible histories' approach to QFT that were proposed: Feynman's path-integral approach, Tomonaga's super-many-times approach, and Yukawa's *maru* or circle approach, each inspired by Dirac's many-times formulation of relativistic quantum mechanics. For more details on these approaches and how they figure in the story of QFT and the atom bomb, see Barad, *Infinity, Nothingness*. ↩
22. On the irony of the 'new' in 'new materialisms' and capitalism's push to continually discard the old in favor of the new (as discussed in Barad, *Meeting the Universe Halfway*), see Barad, 'Nothing Is New There Is Nothing That Is Not New,' invited keynote address for the 'What's New about New Materialism?' Conference, University of California Berkeley, May 5, 2012. ↩
23. Kyoko Hayashi, *From Trinity to Trinity*, Barrytown, N.Y, Station Hill, 2010. The translation from Japanese to English and the substantial Introduction and Afterword are by dancer and choreographer Eiko Otake, who has recently done some amazing artist-activist work on Fukushima. I engage with this latter work in Barad, 'Ecologies of Nothingness: Haunted Spacetimescapes, Dances of Devastation and Endurance', (unpublished paper). ↩
24. See especially Lianying Shan, 'Implicating Colonial Memory and the Atomic Bombing: Hayashi Kyoko's Short Stories, Southeast Review of Asian Studies, vol XXVII, online: http://www.uky.edu/Centers/ Asia/SECAAS/ Seras/2005/Shan. htm. For Korean atomic bomb casualty statistics see for example, 'South Korea A-Bomb Victims Angered by Obama's Hiroshima Visit', NDTV, 26 May, 2016, online: http://www.ndtv.com/world-news/south-korea-a-bomb-victims-angered-by-obamas-hiroshima-visit-1412418. ↩
25. I offer only an abbreviated discussion of the quantum-eraser experiment here. For a detailed description and analysis, see Barad, *Meeting the Universe Halfway*. I also try to highlight some of its implications in my article *Quantum Entanglements*, pp240-68. ↩
26. Wave-particle duality is discussed at length in chap. 3 of Barad, *Meeting the Universe Halfway*. On the quantum-eraser experiment, see chapter 7. ↩
27. The National Atomic Museum was rebuilt at another location under a new name National Museum of Nuclear Science and History in 2009. ↩
28. On the point that the void has structure (!), see the section to follow on QFT. ↩
29. I have taken the liberty of supplementing Hayashi's tracings to include some of the other most evident entanglements. ↩

30. This section includes excerpts from Barad, *What Is the Measure of Nothingness? Infinity, Virtuality, Justice/ Was Ist das Maß des Nichts? Unendlichkeit, Virtualität, Gerechtigkeit* (Berlin: Hatje Cantz Verlag, 2012), and Barad, 'On Touching—The Inhuman That Therefore I Am (v1.1),' in *Power of Material/Politics of Materiality*, ed. Susanne Witzgall and Kirsten Stakemeier (Berlin: Diaphanes, 2015), 1:153–64 (originally published in *differences* 23, no. 3 [2012], but with very unfortunate typographical errors). ↩
31. This is far too rapid a trot through a thick set of histories, but I'm afraid it will have to suffice for now. For far more developed and detailed accounts, see Karen O'Brien, '"These Nations Newton Made His Own": Poetry, Knowledge, and British Imperial Globalization,' in *The Postcolonial Enlightenment: Eighteenth-Century Colonialism and Postcolonial Theory*, ed. Daniel Carey and Lynn Festa, New York, Oxford University Press, 2009, p290. See also Margaret C. Jacobs and Larry Stewart, *Practical Matters: Newton's Science in the service of Industry and Empire 1687-1851*, Cambridge, Mass., Harvard University Press, 2004, and Sylvia Wynter, 'Unsettling the Coloniality of Being/Power/Truth/ Freedom,' CR: The New Centennial Review 3, no. 3, 2003, pp257-337. ↩
32. In reading this paragraph, in particular, it is well to remember my specific use of the slash, as in im/possibility: to evoke the enactment of an agential cut that cuts together-apart (one move), differentiating-entangling. ↩
33. It is through this means that physicists create new particles using accelerators, by putting energy into the vacuum. (See, for example, the discovery of the Higgs particle at CERN in July 2012.) The existence of antiparticles was postulated by Paul Dirac in 1928 in an essay in which he put forward a relativistic theory of quantum mechanics. The first antiparticle to be discovered was a positron (an antielectron) in 1932. Antiparticles have the same mass but opposite charge as the corresponding particle (e.g., while electrons have a negative charge, positrons have the same mass as an electron but a charge of opposite sign), and they travel backwards in time. More on this in Barad, *Infinity, Nothingness.* ↩
34. A. Zee, *Quantum Field Theory in a Nutshell*, Princeton, Princeton University Press, 2010, pp3-4. ↩
35. Stephen Battersby, New Scientist, November 20, 2008. www. newscientist.com/ article/dn16095-its-confirmedmatter-is-merelyvacuum-fluctuations.html (accessed February 2012). ↩
36. As we'll soon see, all particles, including quarks (which are the constituent particles of protons and neutrons making up the nucleus of an atom), are inseparable from and constituted by the virtual fluctuations of the vacuum. ↩
37. From the point of view of classical physics, either the electron is unstable or its mass is infinite, not good choices, but physicists thought this puzzle might be solved by providing a quantum physics understanding of matter. But the quantum account of matter presented its own set of difficulties. The difficulties, whether from a classical or quantum-physics vantage point, stem from the particle's so-called self-energy: in particular, because it is a charged particle, it emits an electromagnetic field, and in calculating its mass one must take account of its interactions with itself (i.e its infinite self-energy). ↩
38. For more details see Barad, 'TransMaterialities: Trans/Matter/Realities and Queer Political Imaginings,' *GLQ: A Journal of Lesbian and Gay Studies* 21, nos. 2 and 3 (2015): 387–422. ↩
39. Jacques Derrida, *Aporias*, Palo Alto, Stanford University Press, 1993, p10. ↩
40. This is true of moments of time as well as bits of matter (being), each of which is indeterminately infinitely large and infinitesimally small, where each bit is specifically constituted through an infinity of intra-actions with all others. ↩
41. As described by Eiko Otake, the book's translator, in Hayashi, *From Trinity to Trinity*, xii. ↩
42. This honorific is of course inspired by Hayashi's own term, 'travel hopping' (which in any case sets up wonderful resonances and dissonances with the overused and much misunderstood term 'quantum leaping,' which has been (mis) appropriated by capitalist markets to sell all kinds of consumer products). ↩
43. These seldom mentioned alternative approaches by Japanese physicists seemed important to include here even if I have don't have time/space to discuss them in this paper. Much more needs to be said and I consider these approaches in some details in a forthcoming book (see below). The various approaches

to QFT, whether that proposed by Feynman (superposition of all possible histories), Tomonaga (super-many-times), or Yukawa (*maru*), refer to abstract studies in theoretical physics that queried fundamental notions like universality, singularity, materiality, nothingness, and alternative histories. Each approach is shot through with efforts to understand nuclear forces and build atomic bombs. In each case there is evidence of a breach of alleged divisions between social, political, and natural forces, including those distinctions said to exist between practical physics, technological prowess, and highly abstract physical theories; as well as between pure science and militarisms, capitalisms, nationalisms, colonialisms, racisms; and between politics and physics. For a more detailed discussion see Barad, *Infinity, Nothingness*. ↩

44. 'The ouroboros has several meanings interwoven into it. Foremost is the symbolism of the serpent biting, devouring, or eating its own tail. This symbolizes the cyclic Nature of the Universe: creation out of destruction, Life out of Death. The ouroboros eats its own tail to sustain its life, in an eternal cycle of renewal'; copied all over the web; original source not clear; see, for example, http://www.tokenrock.com/explain-ouroboros-70.html. 'Life is a circle, into which O'Keeffe offered her bones. Is it reincarnation?'; *From Trinity to Trinity*, 28. ↩
45. Not only her fifty-two classmates, all of whom she's been carrying around all these years, but also her other fellow *hibakushas* here in New Mexico, including the land, the people, the rattlesnakes, the wind. ↩
46. There is a factual error here: while it is true that it did rain that morning and the rain was quite unusual, the test was delayed until the rain stopped. This error is noted and addressed by the translator, Eiko Otake. I take up this point further in Barad, *Infinity, Nothingness*. ↩
47. Hayashi references American painter Georgia O'Keeffe frequently. The vibratory bodily sensuality of the land is uniquely vividly expressed in O'Keeffe's nonrepresentational realist paintings of the New Mexico desert. Hayashi specifically mentions the fact that O'Keeffe's bones are scattered on the mountain peak. *From Trinity to Trinity*, p3. At the same time, it is important to note that some of O'Keefe's paintings have been objected to for their cultural appropriation. For example, Pueblo neighbors of the Georgia O'Keeffe Museum 'have expressed strong opinions against public exhibition of Katsinam, including katsina tithu, in sculptures and paintings,' which O'Keefe began to paint after seeing them in Peublo ceremonies and dances performed in 1929. See for example, Martha Schwendener, 'The Spirit of Cultural Objects: A Review of 'Georgia O'Keeffe in New Mexico,' at the Montclair Art Museum,' *The New York Times*, January 4, 2013. The very question of different understandings of landscape – particularly, the important differences between American cultural conceptions and those of indigenous and Japanese cultures – is important to this discussion, and requires further elaboration. ↩
48. See Barad, 'Diffracting Diffraction: Cutting Together-Apart,' in *Parallax* 20, no. 3 (2014): 168–87, for more details on the agential realist notion of 'cutting together-apart' (that is, differentiating-entangling). (Hereafter *Diffracting Diffraction*). ↩
49. It was crucial to Hayashi's efforts to come to terms with humanity's inhumanity that she be in touch with all matter of inhumanness, including that which courses through all being. The reference to clouds here is simultaneously to clouds of virtual particles and rain clouds. ↩
50. Which is not to suggest that this way of marking the human is yet another opportunity for human exceptionalism, since all time-beings mourn. ↩
51. See Barad, *Diffracting Diffraction*. ↩
52. With gratitude to Donna Haraway, Maria Puig de la Bellacasa, and Kristina Lyons, among others, for the rich soil of this fertile material imagery. ↩

Karen Michelle Barad is an American feminist theorist, known particularly for their theory of agential realism. They are currently Professor of Feminist Studies, Philosophy, and History of Consciousness at the University of California, Santa Cruz.

They are the author of Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning. Their research topics include feminist theory, physics, twentieth-century continental philosophy, epistemology, ontology, philosophy of physics, cultural studies of science, and feminist science studies. Barad serves on the advisory board for the feminist academic journals Catalyst: Feminism, Theory, Technoscience and Signs: Journal of Women in Culture and Society.