New Materialism: Interviews & Cartographies

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Chapter 3

"Matter feels, converses, suffers, desires, yearns and remembers"

Interview with Karen Barad

Q1: "New materialism" as a term was coined by Manuel DeLanda and Rosi Braidotti in the second half of the 1990's[1]. New materialism shows how the mind is always already material (the mind is an idea of the body), how matter is necessarily something of the mind (the mind has the body as its object), and how nature and culture are always already "naturecultures" (Donna Haraway's term). New materialism opposes the transcendental and humanist (dualist) traditions that are haunting cultural theory, standing on the brink of both the modern and the post-postmodern era. The transcendental and humanist traditions, which are manifold yet consistently predicated on dualist structures, continue to stir debates that are being opened up by new materialists (think of the feminist polemic concerning the failed materialism in the work of Judith Butler, and of the Saussurian/Lacanian linguistic heritage in media and cultural studies). What can be labelled "new materialism" shifts these dualist structures by allowing for the conceptualization of the travelling of the fluxes of nature and culture, matter and mind, and opening up active theory formation.

In your emphasis on quantum physics, you seem to be proposing a very similar route. The idea behind "agential realism," in print since 1996 following the Bohrian approach to epistemology that you have published about since the mid-1980s, seems to ward off the dualisms that have haunted the humanities and *the sciences as well. Particularly in the case of measurement, this agential realism allows you to re-read Bohr's philosophy of quantum mechanics and to critique the*

fact that so many theorists refuse to come to terms with the material-discursive and performative nature of intra-actions.

Is this immanent enfolding of matter and meaning, which you refer to as "agential realism," and which we name a "new materialism," the quintessence of your critique of both the sciences and the humanities?

Karen Barad: The core of your question I have to say is spot on, but since you state what I am doing in terms of critique I wanted to start by saying something about critique. I am not interested in critique. In my opinion, critique is over-rated, over-emphasized, and over-utilized, to the detriment of feminism. As Bruno Latour signals in an article entitled "Why has critique run out of steam? From Matters of Fact to Matters of Concern" (2004), critique is a tool that keeps getting used out of habit perhaps, but it is no longer the tool needed for the kinds of situations we now face. Critique has been the tool of choice for so long, and our students find themselves so well-trained in critique that they can spit out a critique with the push of a button. Critique is too easy, especially when a commitment to reading with care no longer seems to be a fundamental element of critique. So as I explain to my students, reading and writing are ethical practices, and critique misses the mark. Now, I understand that there is a different valence to the notion of critique in Europe than there is in the United States; nonetheless, I think this point is important. Critique is all too often not a deconstructive practice, that is, a practice of reading for the constitutive exclusions of those ideas we can not do without, but a destructive practice meant to dismiss, to turn aside, to put someone or something down—another scholar, another feminist, a discipline, an approach, et cetera. So this is a practice of negativity that I think is about subtraction, distancing and othering. Latour suggests that we might turn to Alan Turing's notion of the critical instead of critique (Turing 1950), where going critical refers to the notion of critical mass—that is, when a single neutron enters a critical sample of nuclear material which produces a branching chain reaction that explodes with ideas. As a physicist I find this metaphor chilling and ominous. Instead, building on a suggestion of Donna Haraway, what I propose is the practice of diffraction, of reading diffractively for patterns of differences that make a difference. And I mean that not as an additive notion

opposed to subtraction, as I will explain in a little bit. Rather, I mean that in the sense of it being suggestive, creative and visionary.

In chapter 2 of *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Barad 2007) I discussed in detail what I call a diffractive methodology, a method of diffractively reading insights through one another, building new insights, and attentively and carefully reading for differences that matter in their fine details, together with the recognition that there intrinsic to this analysis is an ethics that is not predicated on externality but rather entanglement. Diffractive readings bring inventive provocations; they are good to think with. They are respectful, detailed, ethical engagements. I want to come back to the crux of your question now that I have said something about critique. I do not mean to pick on that, but I think it is important to say something about the notion of critique and to move it to thinking instead about these kinds of provocations and other kinds of engagements that we might practice.

So, coming back to the crux of your question, the entanglement of matter and meaning calls into question this set of dualisms that places nature on one side and culture on the other. And which separates off matters of fact from matters of concern (Bruno Latour) and matters of care (Maria Puig de la Bellacasa), and shifts them off to be dealt with by what we aptly call here in the States "separate academic divisions," whereby the division of labor is such that the natural sciences are assigned matters of fact and the humanities matters of concern, for example. It is difficult to see the diffraction patterns—the patterns of difference that make a difference—when the cordoning off of concerns into separate domains elides the resonances and dissonances that make up diffraction patterns that make the entanglements visible.

I would like to offer two examples to think with in engaging your question. I recently gave a keynote at a conference at the Stevens Institute of Technology,[2] which is in New Jersey. They are starting a very innovative revamping of their Humanities program. They are interested in taking insights from science studies, and running them back into the Humanities. This is the way they talk about it. What they propose is the reverse of how some would think of the potential impact of science studies: not to use the Humanities to think about the Sciences but to use the Sciences to rethink

the Humanities. This is their project and it was a very interesting conference. But there was something about the way in which it was being framed overall that I wanted to see if I could get into conversation with them about. First of all, there was the notion that what is needed is a synthesis; a synthesis or a joining of the Humanities and the Sciences as if they were always already separate rather than always already entangled. So that there would be Science with matters of fact, and nature, and so on, on one side, and Humanities, meaning, values, and culture, on the other, and somehow that there would be a joining of the two. So, we talked about the ways in which there are entanglements that already exist between the Humanities and the Sciences; they have not grown up separately from one another. I was just pointing out to them some of the limitations of thinking analogically as in looking for mirror images between the Sciences on the one hand and the Humanities on the other. And I was telling them about this wonderful story that Sharon Traweek tells about when she was doing fieldwork on the high energy physics community at the Stanford Linear Accelerator (SLAC). She is standing in a hall at SLAC, and notices a physicist staring at pictures of fractal images on the wall. She gazes upon the images and asks him: "Can you tell me what is so beautiful about those images?" The physicist turns to her with this puzzled look on his face and says: "I am not really sure why you asked the question. It's self-evident! Everywhere you look it is the same." And of course feminists are not trained to look or take pleasure in everything being the same, but to think about differences.

Of course the mirror image of that is that Science mirrors Culture, so we have a kind of scientific realism versus social constructivism, which are of course both about mirroring. Instead, what I propose is the notion of diffraction, drawing on the work of my colleague and friend Donna Haraway. As Donna says, "diffraction patterns record the history of interaction, interference, reinforcement, difference. Diffraction is about heterogeneous history, not about originals. Unlike reflections, diffractions do not displace the same elsewhere, in more or less distorted form, thereby giving rise to industries of [story-making about origins and truths]. Rather, diffraction can be a metaphor for another kind of critical consciousness." What I was pointing out is the difference in the shift from geometrical optics, from questions of mirroring and sameness, reflexivity, where to see

your image in the mirror there necessarily has to be a distance between you and the mirror. So there is a separation of subject and object, and objectivity is about mirror images of the world. And instead, the shift towards diffraction, towards differences that matter, is really a matter of what physicists call physical optics as compared to geometrical optics. Geometrical optics does not pay any attention to the nature of light. Actually, it is an approximation that gets used to study the optics of different lenses, or mirrors. And you just treat light as if it were a ray (an abstract notion). In other words, it is completely agnostic about whether light is a particle or a wave or anything else. It is just an approximation scheme for studying various apparatuses. By contrast, diffraction allows you to study both the nature of the apparatus and also the object. That is, both the nature of light and also the nature of the apparatus itself. I talk a lot about this in chapter 2 of *Meeting*. But what I wanted to bring out is the fact that we learn so much more about diffraction using quantum physics.

There is a difference between understanding diffraction as a classical physics phenomenon and understanding it quantum-mechanically. I have taken this wonderful metaphor that Donna has given us and I have run with it by adding important non-classical insights from quantum physics. Diffraction, understood using quantum physics, is not just a matter of interference, but of entanglement, an ethico-onto-epistemological matter. This difference is very important. It underlines the fact that knowing is a direct material engagement, a cutting together-apart, where cuts do violence but also open up and rework the agential conditions of possibility. There is not this knowing from a distance. Instead of there being a separation of subject and object, there is an entanglement of subject and object, which is called the "phenomenon." Objectivity, instead of being about offering an undistorted mirror image of the world, is about accountability to marks on bodies, and responsibility to the entanglements of which we are a part. That is the kind of shift that we get, if we move diffraction into the realm of quantum physics. All of this is to say that we come up with a different way of thinking about what insights the Sciences, the Humanities, the Arts, the Social Sciences, and let's not forget insights derived outside of academia, can bring to one another by diffractively reading them through one another for their various entanglements, and by being attentive to what gets excluded

as well as what comes to matter. So that we wind up with a very different way of engaging the relationship between the Sciences and the Humanities, which I think is the original question that you asked me.

And then, just really briefly my second example and I promise you I will not go on this long about every question, but just to set up some things in the beginning… I taught a lecture course this quarter called "Feminism in Science," which had Science students in the class as well as students from the Humanities, the Social Sciences, and the Arts, and we were talking about the notion of scientific literacy and how scientific literacy has grown up to be the sole responsibility of the Sciences. But what is scientific literacy? We spent millions of dollars on it in the United States and we are not really sure what it means at all, as a matter of fact. And after spending millions of dollars by whatever measure is provided for scientific literacy, we still have the same percentages of scientific literacy as before. According to these measures, scientific literacy is between three and six percent. And that is actually the same number of scientists and engineers that we have. That tells you something about the way in which scientific literacy is being understood, and how it is being measured, and how it is being thought about, and who needs to take responsibility for it, and so on. And so we talked about the fact that a different kind of literacy is actually required for doing science. That consideration of the ethical, social and legal implications of various new sciences and technologies after the fact is not robust enough. For example, we considered the new field of bioethics in which ethics is taken to be solely a matter of considering the imagined consequences of scientific projects that are already given. But the notion of consequences is based on the wrong temporality: asking after potential consequences is too little, too late, because ethics of course, is being done right at the lab bench. And so, as for what it takes to be scientifically literate, the question is what does it take in order to identify the various apparatuses of bodily production that are at stake here. And so in order to identify those we need a much broader sense of literacy and we need all kinds of people around the lab bench, so that scientific literacy should no longer be seen as being solely the responsibility of the Sciences. I think that is one of the ways in which we get ourselves in a lot of trouble in terms of education.

Q2: Could you explain to us a bit more what, how, or who the agent in agential realism "is"?

KB: First, I want to say that I try to stay away from using the term "agent," or even "actant," because these terms work against the relational ontology I am proposing. Also the notion that there are agents who have agency, or who grant agency, say, to non-humans (the granting of agency is an ironic notion, no?), pulls us back into the same old humanist orbits over and over again. And it is not easy to resist the gravitational force of humanism, especially when it comes to the question of "agency." But agency for me is not something that someone or something *has* to varying degrees, since I am trying to displace the very notion of independently existing individuals. This is not, however, to deny agency in its importance, but on the contrary, to rework the notion of agency in ways that are appropriate to relational ontologies. Agency is not held, it is not a property of persons or things; rather, agency is an enactment, a matter of possibilities for reconfiguring entanglements. So agency is not about choice in any liberal humanist sense; rather, it is about the possibilities and accountability entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices. One of the items that you asked about is the *how* of agency, and in a sense, the *how* is precisely in the specificity of the particular practices, so I cannot give a general answer to that, but perhaps I can say something helpful about the space of possibilities for agency.

Agency, on an agential realist account, does not require a clash of apparatuses, (as Butler once suggested) such as the contradictory norms of femininity, so that we are never successful in completely embodying femininity, because there are contradictory requirements. Agential realism does not require that kind of clash of apparatuses, because intra-actions to begin with are never determining, even when apparatuses are reinforcing. Intra-actions entail exclusions, and exclusions foreclose determinism. However, once determinism is foreclosed this does not leave us with the option of free will. I think we tend to think about causality and questions of agency in terms of either determinism on the one hand, or free will on the other. Cause and effect are supposed to follow one upon the other like billiard balls, and so we got into the habit of saying that we do not really

mean this in a causal sense. And I think to some degree, causality has become a dirty word, as realism is/was. And so I am trying to get people to talk about causality again, because I think that it is very, very important. If we have a group of people where we find that there is a lot of cancer in a certain community, I want to know something about the nature of that community and about causal relationships, because if I am at Love Canal in the United States, a populated area where a bunch of toxins were dumped and the people were getting cancers, then I might want to evacuate people. On the other hand, if I am at the Mayo Clinic, where they are treating cancer patients and there are a lot of people with cancer, it is not the thing to do. I really want us to specify more carefully the different kinds of causalities, and how to think causality again. And that is partly what I mean by the notion of "intra-action" as proposing a new way of thinking causality. It is not just a kind of neologism, which gets us to shift from interaction, where we start with separate entities and they interact, to intra-action, where there are interactions through which subject and object emerge, but actually as a new understanding of causality itself.

First of all, agency is about response-ability, about the possibilities of mutual response, which is not to deny, but to attend to power imbalances. Agency is about possibilities for worldly re-configurings. So agency is not something possessed by humans, or non-humans for that matter. It is an enactment. And it enlists, if you will, "non-humans" as well as "humans." At the same time, I want to be clear that what I am *not* talking about here is democratically distributing agency across an assemblage of humans and non-humans. Even though there are no agents per se, the notion of agency I am suggesting does not go against the crucial point of power imbalances. On the contrary. The specificity of intra-actions speaks to the particularities of the power imbalances of the complexity of a field of forces. I know that some people are very nervous about not having agency localized in the human subject, but I think that is the first step—recognizing that there is not this kind of localization or particular characterization of the human subject is the first step in taking account of power imbalances, not an undoing of it.

As a brief example, there is an article I just came across on the Internet by Chris Wilbert called "Profit, Plague and Poultry: The Intra-active Worlds of Highly Pathogenic Avian Flu" (Wilbert 2006), on the bio-geo-

politics of potential flu pandemics. Chris's analysis of the avian flu (H5N1) as a naturalcultural phenomenon highlights the importance of taking account of the agential entanglements of intra-acting human and non-human practices. Chris points out that while world health organizations and governments are placing migratory birds and small farm chicken producers under surveillance, the empirical data does not support these causal linkages. Rather, the disease follows the geographical diffraction patterns of large-scale factory farmed production of poultry. The latter gives rise to unprecedented densities of birds, making first-class lodgings for thriving and mutating zoonoses. Industrially produced meats, international veterinary practices, biosecurity practices, international trade agreements, transport networks, increased density of human populations, and more are among the various agential apparatuses at work. Causality is not interactional, but rather intra-actional. Making policy based on additive approaches to multiple causes, misses key factors in avoiding epidemics such as providing inexpensive forms of safe food for the poorest populations and the elimination of industrial forms of the mass killing of animals. So in addition to nicely illustrating the importance of paying attention to "human" and "non-human" forms of agency, as it were, there is a way in which Chris acknowledges what gets left out of practices of accounting when agency is attributed to human or non-human entities and left at that. What gets left out, you see, is a whole array of very complex material practices that contribute to a kind of epidemic that is not attributable either to the organisms themselves or to the kinds of things that people do. I do not know Chris. I bring it to your attention, because I think that he gives us an interesting case to think with.

Another example that may be helpful here is an example that Haraway (2008) talks about. It is an example that is raised by Barbara Smuts, who is an American bioanthropologist who went to Tanzania to investigate baboons in the wild for her doctoral research. She is told as a scientific investigator of non-human primates to keep her distance, so that her presence would not influence the behavior of the research subjects that she was studying. Distance is the condition of objectivity. Smuts talks about the fact that this advice was a complete disaster for her research, that she found herself unable to do any observations since the baboons were constantly attentive

to what she was doing. She finally realized that this was because Smuts was behaving so strangely to them, they just could not get over her. She was being a bad social subject in their circles. The only way to carry on and to do research objectively was to be responsible; that is, that objectivity, a theme that feminist science studies has been emphasizing all along, is the fact that objectivity is a matter of responsibility and not a matter of distancing at all. What ultimately did work was that she learned to be completely responsive to the non-human primates, and in that way she became a good baboon citizen. They could understand, at least intelligibly to the non-human primates, and as a result they left her alone and went about their business, making it possible for her to conduct her research.

Q3: *In* Meeting the Universe Halfway *and in several journal articles, you follow Haraway in proposing "diffraction," the relational nature of difference, as a methodology for treating theories and texts not as preexisting entities, but as intra-action, as forces from which other texts come into existence. On the other hand, you focus strongly on the work of Niels Bohr throughout your work. Your re-writing of the philosophy that is active in all of his texts seems to be neither dutiful nor undutiful to his ideas. And yet your work can be read as one of the strongest commentaries on the work of Bohr now available to academics. Perhaps the first one that succeeds in reading him into the Humanities. Next to Bohr, of course, you read many other scientists and scholars like Einstein, Schrödinger, but also Merleau-Ponty, Haraway of course, Deleuze, and Latour. Especially as concerns the philosophers and those scholars traditionally not read within the Sciences, you seem to read them very affirmatively, albeit in passing.*

How would you evaluate this conceptualization of the way in which you treat theories, taking into account your proposal for a diffractive methodology? In other words, is there a sense in which your work is not a meditation that agrees or disagrees with the work of Bohr, but one that is intra-active with it, creating both the work of Bohr and agential realism? And what are the generational implications of diffraction more generally? Feminists are usually wary of thought as governed by oedipality; feminists such as Rosi Braidotti have argued for a methodology that does not repeat the all-too-common Oedipal relation with Masters, affirming their status by negating the work, and this comes very close to your critique of critique actually. Does diffraction allow for a relation between texts and scholars that is

neither undutiful (affirming the Master by negating the work) nor dutiful (placing the "new" work in the Master's house)?

KB: Given what I already said about diffractive readings, I think it is clear that your question really beautifully states my relationship with the materials that I engaged with in doing diffractive readings. In the spirit of diffractive readings, I just want to say that I am really very grateful and indebted to you for your careful reading of my work. Thank you for that. I wholeheartedly agree with what you have said there in terms of the fact that I am neither looking to Bohr's work as scripture nor to somehow be the "undutiful daughter" to Bohr. But to read various insights through one another and to produce something new, new patterns of thinking-being, while at the same time being very attentive to what it is that Bohr is trying to say to us, and I think that you have done that with my work so I wanted to thank you for that.

Q4: Although "gender" is the term that seems to be the unquestionable foundation of the field of gender studies, its conceptual legacy has been specified as Anglo-American and linguistic. Feminist scholars working with gender usually set up an argument against a biological determinism or biological essentialism, and ascribe a fixed sexual ontology to major traditions in (scholarly) thought as well as to Continental feminist philosophy (e.g. the work of Luce Irigaray). Félix Guattari once summarized his take on these issues in an interview, stating:

> *If Gilles Deleuze and I have adopted the position of practically not speaking of sexuality, and instead speaking of desire, it's because we consider that the problems of life and creation are never reducible to physiological functions, reproductive functions, to some particular dimension of the body. They always involve elements that are either beyond the individual in the social or political field, or else before the individual level (Guattari and Rolnik [1982] 2008, 411).*

This non-representationalist take on "sexual difference" seems to come close to your reading of this concept. Your proposal for an onto-epistemology shows us how matter (among others bodily matter) and meaning are always already immanently enfolded and transitional. Yet instead of taking a term from psychoanalysis (like desire), you bring in physics (Bohr's conceptual apparatus). How then is quantum physics helping you in articulating your feminism?

KB: A decade ago I would often get the following question: "Since your work is not about women or gender, what does it have to do with feminism?" My answer, of course, was: "Everything." Happily, the question you have asked is light years beyond the kind of thinking that motivates that question. And I am assuming then that the level of conversation has shifted since that time, and that I can jump right in. Eros, desire, life forces run through everything, not only specific body parts or specific kind of engagements among body parts. Matter itself is not a substrate or a medium for the flow of desire. Materiality itself is always already a desiring dynamism, a reiterative reconfiguring, energized and energizing, enlivened and enlivening. I have been particularly interested in how matter comes to matter. How matter makes itself felt. This is a feminist project whether or not there are any women or people or any other macroscopic beings in sight. Along with other new materialist feminists—Vicki Kirby is notable in this regard—feeling, desiring and experiencing are not singular characteristics or capacities of human consciousness. Matter feels, converses, suffers, desires, yearns and remembers. You could also see Noela Davis' paper on new materialism on this topic (Davis 2009). I tried to make this point more vivid in chapter 7 of my book, which has received a lot of interest and attention, but less specifically feminist engagement. And I think there is a lot of important food for thought in this chapter, at least in my mind. So I want to go over this, because it is a chapter that gets deeply into the physics of things, and as a result many humanities and social sciences scholars assume it is irrelevant to what they are thinking about. I always teach physics in my feminist classes, in part precisely because it calls into question the exceptionally narrow framing of scientific concerns and scientific literacy in the way that I was just talking about. Who is responsible for engaging with science? I'd like to walk you through some of what's going on in that chapter, because I think it holds some really important ways for rethinking some key feminist issues about matter and space and time and so on.

I will give you a super-fast lesson of what you need to know about quantum physics and then come to what is in Chapter 7 to show you some of the results and what I think the implications are in terms of thinking about questions of social justice, which I think are key here. So here is my crash course on quantum physics.

According to classical physics, there are only two kinds of entities in the world; there are particles and there are waves. Particles are very different from waves. Particles are localized entities that occupy a particular place in space and in time, and you cannot have two particles in the same place at the same time. On the other hand, there are waves, and waves are not entities at all. Waves are disturbances in fields. If you think about ocean waves, you see that waves often overlap with one another. They *can* occupy the same place at the same time; that is part of what they are famous for doing. So on the one hand, we have something localized, and, on the other, we have something very non-localized. Very distinct kinds of entities, ontologically speaking. In physics, there is a very simple machine that can be used to find out whether it is a particle or a wave, and it is called a two-slit apparatus. When you take a bunch of balls and shoot them randomly at two slits, what you find is that most of the particles wind up directly across from the two slits. You get something called a "scatter pattern." You can think about the fact that if I am wildly throwing tennis balls in this room at the doorway, most of them are going to wind up right across from the doorway and a few of them will scatter to the sides. In contrast to that, think of a wave machine, making a disturbance in the water. And when the disturbance hits this kind of "breakwater" with two holes in it, what happens is that the disturbance bulges out on both sides and you get these kinds of concentric, overlapping circles that get forced through, just like when I drop two rocks in a pond simultaneously, I get an overlapping of concentric circles. That is a diffraction pattern and what you see is that there is a reinforcing of waves. When two waves meet, crest to crest, they make a higher wave. But sometimes you get a crest meeting a trough, and they cancel out. That makes for a very different kind of pattern.

Now, what happens if we test electrons with a two-slit apparatus? You might think, since we used to think of electrons as little tiny particles, that they would give me a particle pattern. But the result that we actually get is that electrons exhibit a diffraction or wave pattern. But as we saw, diffraction patterns are created by overlapping waves. But how can electrons overlap? They are particles. They cannot overlap with one another. You might think that the electrons are overlapping, but you can test that by sending one electron through at a time. If you send just one electron through at a time,

you built up this diffraction pattern. It seems like we cannot explain this diffraction pattern; it seems like a mystery how this particle seems to be acting like a wave. Einstein in particular was very upset about this and suggested that we do an experiment where we actually watch the electron go through the slits. I want to talk about this which-slit detector experiment, because this is what I am building up to. In this experiment, what I have done is replace the top slit with a slit on a spring. And if the particle goes through the top slit, it imparts some of its momentum to the top slit and it moves a little bit, then I will know "Oh, it went through the top slit." So, this is a way to measure which slit the electron is going through on its way to the screen. And Einstein said if we do this experiment we will catch the electron in the act of being both a particle, by going through one slit or the other, and a wave by showing this interference pattern and then it will show that quantum mechanics is self-contradictory and that we will have to find some other way of thinking about it. And Bohr said: "No, not so fast." If you do this experiment, you have now revised the apparatus. And what we observe in any experiment is a *phenomenon* or entanglement or the inseparability of the apparatus and the observed object. Bohr said that if Einstein were to make the adjustment to the two-slit apparatus he suggested, he is going to get a particle pattern, not a diffraction pattern. Now, one should lose sleep over this. Because what this is saying is that the ontology of the electron is changing depending upon how I measure it. Let me just finish the quantum physics lesson really quickly. Bohr has an explanation for this, which is to say, again, that the properties that we measure are not attributable to independent objects. Independent objects are abstract notions. This is the wrong objective referent. The actual objective referent is the phenomenon—the intra-action of what we call the electron and the apparatus. And so the fact that its ontology changes when we change the apparatus is not a surprise, because we are investigating an entirely different phenomenon.

I will now move into what is in Chapter 7 because I think, again, that there are important feminist "lessons" here. And of course when I say "feminist lessons," that is a distorting shorthand I need to qualify. Because, of course, what I am presenting with agential realism already has feminist lessons built in to it, and that is part of the beauty of Chapter 7. At least for me it is the incredible satisfaction of taking insights from feminist theory,

on the one hand, and insights from physics, on the other, and reading them through one another in building agential realism. And from there going back and seeing if agential realism can solve certain kinds of fundamental problems in quantum physics. And the fact that it is robust enough to do that, and that feminist theory has important things to say to physics is amazing, absolutely amazing, and key to the point I want to make as well. And in fact, when I was able to actually show that you could do science with agential realism and bring these important interests, the question came to me of whether or not I should publish this result in a physics journal or leave it for the book, so that physicists would have to go to a feminist book in order to find out some of the physics. I chose the latter, but in retrospect I think it was a mistake, because it took a very long time for the book to come out (more than three years) and because it seems that some physicists are engaging with my ideas without acknowledging it. Practices of publishing are always political.

Coming back to the issue at hand, Bohr and Heisenberg were totally at odds. Not only Bohr and Einstein, but also Bohr and Heisenberg. Heisenberg thought that the reason why it changes from a wave pattern to a particle pattern when you change the apparatus is because you are disturbing the particle. And this places a limit on what we can know, because each measurement disturbs what you are measuring. And he called that the "(Heisenberg) Uncertainty Principle," which I have found is more familiar to European audiences than American audiences. But Bohr argues with Heisenberg and says that he makes a fundamental error in proposing uncertainty, and what is at issue is not uncertainty at all, but rather indeterminacy. That is, when we make a measurement, what happens is that it is not a matter of disturbing something and our knowledge is uncertain as a result, but rather there are not inherent properties and there are not inherent boundaries of things that we want to call entities before the measurement intra-action. That is, Bohr is saying that things are indeterminate; there are no things before the measurement, and that the very act of measurement produces determinate boundaries and properties of things. So, his is an ontological principle rather than an epistemological one. In other words, for Bohr particles do not have a position independently of my measuring something called position.

Now, it seems that there is no scientific way to discern who is right, because what we are talking about is showing an empirical result about what happens before you do any measurement. So it seems like there is no way to ever resolve that. But actually we can. This is amazing! We can do experimental metaphysics now, which of course is just an indicator of the fact that there has never been a sharp boundary between physics, on the one hand, and metaphysics or philosophy, on the other. So there is an amazing and really astonishing experiment that physicists have only been able to do in the past decade or so since previously it was not technologically possible. And these famous *Gedanken-* or thought experiments of Bohr and Heisenberg could now be done for the first time, actually be performed in a laboratory. They never thought about them actually being done; they were not meant to be experiments that got actualized. They were meant to be experiments to think with, just tools to think with. But now it is technologically possible to actually do this experiment—to show what happens when I measure which-slit. Was Einstein right and do I catch the electron being both a particle and a wave showing that quantum theory is self-contradictory? Or is Bohr right that once I actually go ahead and measure which-slit, now I get a particle pattern and the interference pattern is gone? But even more beautifully than that, what the physicists have done in this case is to design an experiment where Heisenberg's explanation of disturbing something that already exists, cannot be part of the explanation. So Heisenberg is designed *out* of this experiment. If it happens, it is happening for some reason other than a disturbance.

What is happening is that there is a beam of atoms coming along; in fact, they are rubidium atoms, and before the rubidium atoms reach the double slit, what happens is that there is a laser beam which gives the rubidium atoms some energy. And what happens when the atom gets energy, the electron that is in the inner orbital of rubidium gets kicked up to a high energy level from the energy it got from the laser beam. Now it is in, what is called, an "excited state." See, there is already talk of desire in physics! And then it goes across and it goes to these cavities, these micromaser cavities. That is the which-slit detector. You do not have to know anything about micromaser cavities at all except this: when the rubidium atom in an excited state goes into one micromaser cavity or the other, the electron necessarily

drops back down to its ground state and in doing so it emits a photon and it leaves this trace photon in either the upper cavity or the lower cavity and then goes on its way through the two slits. So the rubidium atom goes on its way through the two slits and it hits the screen. And that is our experiment. Now, the reason why Heisenberg is not a part of this, is because you can show that by getting the rubidium atom into an excited state and having it come back down, it does nothing to affect the atom's forward momentum. It is *not* disturbed. Here physicists have very cleverly made a which-slit detector that does not disturb the rubidium atoms' forward momentum. So it is going to leave a telltale trace in detector one or detector two of which slit it went through without disturbing it. Now if you do this without the which-slit detector, just send rubidium atoms through double slits, you get a diffraction pattern. But if you put the laser there and the micromaser cavities and find out which slit it goes through, then it shifts to a scatter pattern or a particle pattern. But that second one definitely is a scatter pattern (rather than the alternating intensity pattern of waves). I just told you that there is no disturbance going on here so that is amazing already. It is amazing that you can now show that Bohr is right and not Einstein.

But now here is where we as feminists really need to pay attention, because now something really amazing is coming forward in this, which is that since I have not made a disturbance in actually measuring which slit the atom goes through, you might ask the question if, after it goes through and leaves a telltale trace (a photon) in one slit or the other, what happens if I erase that information? Will I get the diffraction pattern again? It would be very hard, if there was a disturbance, to completely "un-disturb" it just so. But there is no disturbance here, remember? So we can ask the question, if I erase the which-slit information, can I actually get the diffraction pattern? The eraser part here is that I am going to erase the which-slit information and here is how I do it. I have these two different cavities and I take the wall out between the two of them, the two micromaser cavities, and I put a photo-absorbing plate right in between them. Remember that the rubidium atoms are left in there and they have gone through and they hit the screen. But they leave a photon, a quantum of light, in either cavity one or in cavity two. If I put a photon absorbing plate in between, then if the photon gets absorbed, I have erased the information of which side it came from. So that

is how I am going to erase the information. And what I am going to do is I am going to put a set of shutters (like the shutters you have for blinds on the windows, and you can make it either shut so that the windows completely shut out the light or you can open them so the light comes through). So if we put shutters there, if the shutters are closed, I have the situation I had before where I know the which-slit information. But if I open the shutters, I give it the possibility of being erased.

And what happens here actually is that, if I do this experiment now and open the shutters, I can show that I actually get a diffraction pattern! Now this gets even stranger. So I have these rubidium atoms, they are heading toward the two-slit detector. They leave a telltale photon in one place or the other. They go through the two slits and I am going to let them already hit, completely hit the screen. Now *afterwards* I am going to decide whether or not to open the shutters and erase the information about which slit it goes through. That is called "delayed choice" mode. And if I trace the ones whose which-slit information is erased, I get a diffraction pattern. In other words, *after* the rubidium atom has already hit, I am able to determine whether or not it had behaved like a particle or a wave. In other words, whether or not it had gone through a single slit at a time, like a particle will, or gone through both slits at the same time like a wave will. *In other words, after it has already hit the screen and gone through the apparatus, I am able to determine its ontology, afterwards*.

So the point here is: how do physicists interpret this? The way physicists interpret this is by saying that we have the ability to change the past. Because I am changing how it went through the slit after it has already gone through the slits. So there is a talk about erasing what already was, restoring the diffraction pattern, and basically moving the clock backwards or changing how the particle went through after it has already gone through: *the ability to change the past*. Now I want to suggest, though, that that is a very convenient kind of nostalgic fantasy. I cannot blame physicists for engaging in this. I think this is a very seductive fantasy. Perhaps at one time or another all of us wish that we could change the past and the marks left on bodies, and change the ways in which we materialized the world, especially when we are not being careful, that we would like to undo what has been

done, that we would like to go back and do it differently. But is this really what this experiment is telling us about what is possible?

It turns out that if we look at this experiment more carefully—it is all explained in Chapter 7—the original diffraction pattern is *not* being restored whatsoever and there is no complete erasure going on here at all. What is happening here is that the experiment is not about engaging a past that already was. See, we assume that time is a given externality, just a parameter that marches forward, and that the past already happened and the present, that moment "now" just slipped away into the past, and that the future is yet to come. But if we examine this carefully, again using the insights from feminist theory, from post-structuralist theory, and things that Cultural Studies has been telling us, and so on, and bring them into the physics here, what we can see is that what is going on actually is *the making of temporality*. There are questions of temporality that are coming to the fore here. What we are seeing here is that time is not given, it is not universally given, but rather that time is articulated and re-synchronized through various material practices. In other words, just like position, momentum, wave and particle, *time itself* only makes sense in the context of particular phenomena. So what is going on here is that physicists are actually making time in marking time, and that there is a certain way in which what we take to be the "past" and what we take to be the "present" and the "future" are entangled with one another. What we have learned from this experiment is that what exists are intra-active entanglements. That is the only reason we get a diffraction pattern again, by the way.

And importantly, the original diffraction pattern doesn't return, a new one is created, one in which the diffraction (that is, entanglement effects) is a bit challenging to trace. So, the issue is not one of erasure and return. What is at issue is an entanglement, intra-activity. The "past" was never simply there to begin with, and the "future" is not what will unfold, but "past" and "future" are iteratively reconfigured and enfolded through the world's ongoing intra-activity. There is no inherently determinate relationship between past, present, and future. In rethinking causality as intra-activity and not as this kind of billiard-ball causality—cause followed by an effect—the fantasy of erasure is not possible, but possibilities for reparation exist. That "changing the past" in the sense of undoing certain

discrete moments in time is an illusion. The past, like the future though, is not closed. But "erasure" is not what is at issue. In an important sense, the "past" is open to change. It can be redeemed, productively reconfigured in an iterative unfolding of spacetimematter. But its sedimenting effects, its trace, can not be erased. The memory of its materializing effects is written into the world. So changing the past is never without costs, or responsibility. A recent Ph.D. student of mine, Astrid Schrader (whose work is really remarkable, well worth looking out for) has an amazing paper in *Social Studies of Science* entitled "Responding to *Pfiesteria piscicida* (the Fish Killer): Phantomatic Ontologies, Indeterminacy, and Responsibility in Toxic Microbiology" (2010), showing how previously incompatible experiments on a tiny aquatic organism with large environmental policy stakes can be reconciled by tracing how time is differently made/synchronized through different laboratory practices. She argues that memory is not a matter of the past, but recreates the past each time it is invoked.

What I am trying to make clear is—all of this is an answer to your question, believe it or not—a sample of what I have learned from engaging with quantum physics that helps me further my understanding of feminist issues and practices. My passion for my work is utterly and completely grounded, and hopefully always with its feet attached to the ground, in questions of justice and ethics. This is what totally drives me. So I think there is a way in which the physics here actually helps me to bring an important materialist sense to Derridean notions of justice-to-come. That is not justice which we presume we know what it is in advance and which is forever fixed. So just to end this short answer with a couple of quotes from Derrida:

> [The concern is] not with horizons of modified—past or future—presents, but with a "past" that has never been present, and which never will be, whose future to come will never be a *production* or a reproduction in the form of presence (Derrida [1968] 1982, 21; original emphasis).

And furthermore that:

> 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 […]. Without this *non-contemporaneity with itself of the living present* […] without this responsibility and this respect for justice concerning those who *are not there*, of those who are no longer or who are not yet *present and living*, what sense would there be to ask the question "where?" "where tomorrow?" "whither?" (Derrida [1993] 2006, xviii; original emphasis).

So this is an example of what I learned from my diffractive engagements with physics: what responsibility entails in our active engagement of sedimenting out the world in certain kinds of ways and not others. Being attentive to ways in which we are re-doing, with each intra-action materially re-doing the material configurings of spacetimemattering. The past and the present and the future are always being reworked. And so that says that the phenomena are diffracted and temporally and spatially distributed across multiple times and spaces, and that our responsibility to questions of social justice have to be thought about in terms of a different kind of causality. It seems very important to me to be bringing physics to feminism as well as feminism to physics. (To understand my response as something learned from physics and applied to feminism is to have misunderstood something fundamental about what I am trying to say.)

Q5: A lot of scholars within the Humanities have great difficulties with posthumanist theories especially because they seem to lack an ethics, and you already talked about ethics. Especially when you bring in physics, this critique will no doubt be even stronger. At several moments in your work, however, one gets the impression that the ethics implicit in your approach is of great importance to you, as you already mentioned. Obviously when one wants to be part of feminist debates, it is impossible not *to articulate onto-epistemology as an* ethico-*onto-epistemology. In your "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter" (Barad 2003) your emphasis on the material-discursive seems to critique the idea of the "medium." This idea seems to claim that there are cases in which meaning can be non-material, idealistically traveling through space while not being affected by matter, actually remaining ultimately*

"the same," or unaltered. Your texts show that this idea of the medium is in conflict with the argument that matter and meaning are necessarily entangled.

Our question then would be how to understand this relational ontology that rejects the metaphysics of what used to be called "relata," of words and things. How is an ethics at work in how matter comes to matter?

KB: I think that you can already probably see from what I have been saying that I believe that questions of ethics and of justice are always already threaded through the very fabric of the world. They are not an additional concern that gets added on or placed in our field of vision now and again by particular kinds of concern. Being is threaded through with mattering. Epistemology, ontology, and ethics are inseparable. Matters of fact, matters of concern, and matters of care are shot through with one another. Or to put it in yet another way: matter and meaning cannot be severed. In my agential realist account, matter is a dynamic expression/articulation of the world in its intra-active becoming. All bodies, including but not limited to human bodies, come to matter through the world's iterative intra-activity, its performativity. Boundaries, properties, and meanings are differentially enacted through the intra-activity of mattering. Differentiating is not about radical exteriorities (we saw that in the experiments I just talked about) but rather what I call agential separability. That is, differentiating is not about Othering, separating, but on the contrary, about making connections and commitments. So the very nature of materiality itself is an entanglement. Hence, what is on the other side of the agential cut is never separate from us. Agential separability is not individuation. Ethics is therefore not about right responses to a radically exteriorized other, but about responsibility and accountability for the lively relationalities of becoming, of which we are a part. Ethics is about mattering, about taking account of the entangled materializations of which we are part, including new configurations, new subjectivities, new possibilities. Even the smallest cuts matter. Responsibility, then, is a matter of the ability to respond. Listening for the response of the other and an obligation to be responsive to the other, who is not entirely separate from what we call the self. This way of thinking ontology, epistemology, and ethics together makes for a world that is always already an ethical matter.

Q6: Finally, if you then propose a materialist ethics through physics, similar to the way people like Badiou (2007) and Meillassoux ([2006] 2008) re-absolutize the scope of mathematics, you indeed stir up post-Kantian academia. This has to have consequences for how you value various disciplines. Not falling into the traps of disciplinarity, multi-disciplinarity, inter-disciplinarity, or post-disciplinarity, how would you then qualify your manifesto for academic research?

KB: Well, manifesto is a thing that my friend and colleague Donna Haraway can get into, but I cannot claim that term. [Laughs.] Of course, she means it ironically. Agential realism is not a manifesto, it does not take for granted that all is or will or can be made manifest. On the contrary, it is a call, a plea, a provocation, a cry, a passionate yearning for an appreciation of, attention to the tissue of ethicality that runs through the world. Ethics and justice are at the core of my concerns or rather, it runs through "my" very being, all being. Again, for me, ethics is not a concern we add to the questions of matter, but rather is the very nature of what it means to matter.

Notes

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2. *Science, Technology, and the Humanities: A New Synthesis*, April 24-25, 2009.