

Beyond reflexivity and representation: Diffraction as a methodological sensitivity in science studies

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Abstract:

Against the backdrop of the broad reception of Karen Barad's framework of agential realism, it comes as a surprise that there has been little discussion so far of her core concept of diffraction in the social studies of science. This article aims to evaluate the methodological potentials of a diffractive approach for science studies. In order to achieve this, I will examine Barad's take on quantum mechanics, which serves as the foundation for her ethico-onto-epistemological framework of agential realism. In doing so, I will unpack the crucial role played by diffraction in reworking the relation between the objects of observation and the agencies of observation, and subsequently in reshaping the question of the referent of objectivity. Building on this analysis, I propose the notion of the researcher as transducer, demonstrating how such a take allows for the emergence of an understanding of the researcher as themselves materializing in intra-action with other human and more-than-human forces and practices. As I will show, such a diffractive approach not only shifts our attention even more to the performative power of research as a *material* practice but also to the constitutive nature of knowledge-making practices, along with their ethical and political implications.

Keywords: agential realism, diffraction, feminist science studies, Karen Barad, new materialism, reflexivity, representationalism

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Introduction

In *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, quantum physicist and feminist science studies scholar Karen Barad develops a take on the study of science-in-the-making that takes ‘insights about scientific practices and about nature [...] and diffracts them back onto the science itself’ (Barad 2007, 36). Contesting what she identifies as the representationalist paradigm in both science and science studies, Barad proposes a form of realism which is not concerned with questions of adequately representing a reality that is independent of observation, but instead with the interferences, interventions, and responsibilities that arise when we consider knowledge production as a material practice of *intra-acting*¹ with the world as part of it.

While Barad’s framework of agential realism has been taken up in a number of fields such as post-qualitative research and posthumanist qualitative research (Lather and St. Pierre 2013; Mauthner 2019), new materialist pedagogies (Bozalek et al. 2016; Hickey-Moody et al. 2016; Geerts and Carstens 2021), feminist science and technology studies (Barla 2016; Mehrabi 2016; Lorenz-Meyer 2014; Treusch 2020; Schmitz 2014), and feminist social and political theory (Bargetz and Sanos 2020, Hoppe 2017), to name but a few, deeper-going analyses of her core concept of diffraction, and how it resonates with ongoing theoretical and methodological debates in the social studies of science, remain a desideratum.² This is particularly striking given the fact that, as I will demonstrate, Barad not only situates herself in the field of science studies but also aims at developing more promising ‘theoretical tools needed to move conversations in science studies’ (Barad 2007, 24-5). As a matter of fact, where such discussions take place, they

focus almost exclusively on the problems and shortcomings of agential realism. Trevor Pinch (2011), for example, not only finds it ‘more than a little odd that a metaphysical position in science studies should depend upon the outcome of experiments in physics’ (Pinch 2011, 432), but also identifies ‘a form of scientism’ at work. For Pinch, using science ‘and a highly prestigious form of elite science at that’ in order to make a point in science studies boils down to playing ‘a dangerous game’ (Pinch 2011, 440). Similarly, Michael Lynch (2014) asserts that he does ‘not understand what is original about it [agential realism, JB] or how it expresses a feminist standpoint’ (Lynch 2014, 139). Without having read Barad's work in its entirety, as he admits,³ Lynch sees her posthumanism (which he refuses to write without quotation marks throughout his article) as involving the ‘mistake’ of ignoring ‘the ineradicable necessity of human communicative understanding as a condition for relationality and objective knowledge’ (Lynch 2014, 144).

In this article, I will demonstrate that this is far from being the only convincing reading of Barad's agential realism in the context of science studies. My intention is not to eschew critique of agential realism. In fact, I do agree with some of the arguments brought up in the aforementioned interventions and elsewhere. For example, in spite of her reassurance that ‘[p]hysics can't be bootstrapped into giving a full account of the social world’ (Barad 2007, 24), agential realism does evoke a certain unease when it comes to the role quantum physics plays as a kind of *Leitwissenschaft* for understanding the world in its full complexity.⁴ Likewise, the question what it means in epistemological, ethical, and political terms when scientists are doing science studies—meaning, what might be gained and lost through an approach that tears down not only the disciplinary but also the conceptual and methodological boundaries between doing science and studying how science-in-the-making is done—certainly demands more attention.

Therefore, rather than arguing against these concerns—even though they occasionally fail to do justice to the complexity and originality of agential realism—the aim of this article is

twofold. Since the problematization of what Barad calls the representationalist paradigm in both science and science studies forms the foundation of agential realism, I will first scrutinize Barad's understanding of representation and how it relates to the metaphor and phenomenon of reflection. Expanding on Barad's discussion of representationalism, reflection, and diffraction in an attempt at reading it through various accounts of representation and reflexivity in science and technology studies, I will not only bring to the fore a rich body of work that has shifted the perspective from the question of how knowledge represents a stable and observation-independent reality to a relational understanding of scientific practices, but also show how a diffractive methodology promises to go even beyond reflexive approaches by contesting the very practices through which the authority about representations and that which they purport to represent remains located in the subject position of the researcher.

Second, tracing the feminist history of the notion of diffraction from Trinh T. Minh-ha's critique of identity and sameness to Donna Haraway's material-semiotic analysis to Barad's ontological take that is informed by quantum mechanics as much as by poststructuralist theory, I will outline how diffraction (being more and something else than only the term for a physical phenomenon unique to wave behaviour) can serve as a conceptual and methodological sensitivity for science studies that not only reworks the position and the role of the subject in the process of knowledge production but also considers knowledge production to be inseparable from ethics and politics. Third, against this backdrop, I will propose the notion of the researcher as transducer in order to challenge the long-standing idea that the researcher exists prior to inquiry. Not only does this intervention contest the inter-subjective limitations of representationalist and reflexive approaches alongside methodological individualism, as I will demonstrate, it also pushes for deeper considerations of the entanglement of the material/izing dimensions of knowledge production with questions of responsibility and accountability in science studies.

Turning the mirror around: representation, reflection, and reflexivity

Representationalism refers to the idea that words can and indeed do mirror a preexisting reality (Barad 2003, 2007; Haraway 1992, 1997; Rouse 1996). Assuming that the world is composed of individual entities with inherent attributes that exist prior to their interactions and relations, representationalist approaches aim at establishing a correspondence between representations and the phenomena which they purport to represent. In Barad's (2003, 105–6; 2007, 48; see also Barad and Gandorfer 2021, 15–20) understanding, this idea that stems from the Cartesian division between the internal senses and the external world, supports both realist and social constructionist approaches to (scientific) knowledge production. Where realism and constructionism⁵ would differ is only on the question of the referent—meaning, 'whether scientific knowledge represents things in the world as they really are (i.e., nature) or objects that are the product of social activities (i.e., culture)' (Barad 2007, 48). Following Joseph Rouse's (1996) identification of representationalism as 'a Cartesian legacy, a linguistic variation on Descartes' insistence that we have a direct and privileged access to the contents of our thoughts that we lack towards the "external" world' (Rouse 1996, 209), what troubles Barad is not only the question of whether representations can accurately represent their referents, but also the problem that representationalism apparently considers language to be more trustworthy than matter. 'What compels the belief that we have a direct access to cultural representations and their content that we lack toward the things represented?', Barad (2003, 801) asks, and implies that where representationalism has led to the idea that language allows direct (that is, unmediated) access to reality, it is reality itself in its materiality and agentiality that gets lost.

'Mirrors upon mirrors'

According to Barad, most of the epistemological and ontological concepts and methods underpinning science and science studies are haunted by the belief that representations can mirror the world as it really is. This becomes particularly clear when Barad (2003) emphasizes

that representationalism produces a ‘geometrical optics’ that is forever caught in ‘the infinite play of images between two facing mirrors’ where ‘the epistemological gets bounced back and forth, but nothing more is seen’ (Barad 2003, 802–3). Here, Barad heavily draws on Donna Haraway’s (1992) problematization of reflection as operating according to the logic of ‘displac[ing] the same elsewhere, setting up the worries about copy and original and the search for the authentic and really real’ (Haraway 1992, 16). Grounded in representationalism, reflection—or more precisely, the practice of reflexivity in the process of knowledge production—would therefore boil down to the illusion of being able to accurately mirror a pre-existing reality:

Representation raised to the nth power does not disrupt the geometry that holds object and subject at a distance as the very condition for knowledge’s possibility. Mirrors upon mirrors, reflexivity entails the same old geometrical optics of reflections. (Barad 2007, 88)

For Haraway and even more so for Barad, reflection and reflexivity are insufficient not only because they are based on the belief that our senses and methods have a direct access to the objects or referents of representation, but also because they assume that our methods and practices of representation have no effect on the phenomena they purport to represent. Such a take on the relationship between subjects and objects of knowledge, or the relationship between knowledge and its objective referents, fails in the eyes of both Haraway and Barad to take ‘account of the fact that knowing does not come from standing at a distance and representing but rather from *a direct material engagement with the world*’ (Barad 2007, 49; original emphasis). What is more, it ignores the fact that humans are not the only ones actively involved in the practice of knowledge production, and nor is the world a passive object awaiting its representation.

Reflexivity and representation beyond geometrical optics

More recently, scholars in qualitative social science research have mounted a defence of

reflexivity (see, e.g. Lumsden 2019; Whitaker and Atkinson 2019; Zienkowski 2017). These approaches not only stress that reflexivity remains a valuable concept and method in the social sciences precisely because it draws attention to the researcher as part of the world being studied as well as to the epistemological and political impact of our research practices, but also problematize that reflexivity has become a ‘caricature’ in some agential realist, new materialist, and post-qualitative readings (see Lumsden 2019, 60).⁶ Poignantly, these interventions remind us that reflexivity *can* shift our attention to the involvement of the researcher, their values, and their standpoint, troubling a clear-cut differentiation between subjects and objects of research, between facts and values, as well as between representations and their referents. As Linda Finlay and Brendan Gough (2003) stress—instead of referring to practices of mirroring a preexisting reality—being reflexive as a researcher can raise awareness for ‘the intersubjective dynamics between researcher and the researched’, acknowledging in so doing that researchers ‘(co-)construct their research findings’ (Finlay and Gough 2003, ix). Reflexivity, then, entails that the knowledge produced is always and necessarily the result of interpretation, rather than an accurate copy of the phenomenon it refers to.

Locating the researcher in the midst of the relations, practices, and phenomena that are studied has been a central claim of feminist approaches to scientific knowledge production, too. Feminist epistemologies demonstrate how reflexivity allows us to contest hegemonic understandings of scientific objectivity and authority that rely on the epistemic trick of eliminating the embodied location of the knowledge producer. Notwithstanding her criticisms of representationalism and the optical metaphor of reflection, Haraway’s (1988) concept of situated knowledges, for example, can be read as a reflexive approach as it stresses the crucial role played by location and embodiment in the practices of knowledge production. For Haraway, situated knowledges stand for nothing less than ‘objectivity as positioned rationality’—meaning, ‘the joining of partial views and halting voices’ (Haraway 1988, 590).

Similarly, Sandra Harding (1993) not only questions conventional conceptions of objectivity for not being able to fulfil their (impossible) promises of providing us with value-neutral knowledge, but also proposes the notion of ‘strong objectivity’. Insofar as such an understanding of objectivity ‘requires that the subject of knowledge be placed on the same critical, causal plane as the object of knowledge’, it also demands a ‘strong reflexivity’ (Harding 1993, 69). This is due to the fact that ‘beliefs function as evidence at every stage in scientific inquiry’, be it in ‘the selection of problems’, ‘the formation of hypothesis’, ‘the collection of data’, or ‘the interpretation and sorting of data’ (Harding 1993, 69).

While I share the concern of turning reflexivity into a caricature, I do not think that this holds true for Barad’s framework. There *are* indeed places where Barad appears to equate reflexivity with reflection somewhat too hastily. This might be the case when she argues that ‘reflexivity does nothing more than mirror mirroring’, entailing ‘the same old geometrical optics of reflections’ (Barad 2007, 88). Or when she suspects that ‘[i]f the goal of reflexivity is to analyze the “instrument” [...] along with the data, reflection is the wrong metaphor’ (Barad 2007, 418n17), and thus warns ‘against an over-reliance on mirroring (whether reflective/reflexive – thereby invoking the very same optics! – or not)’ (Barad 2011a, 445). However, it is precisely also a ‘re-turning’⁷ to Barad’s framework of agential realism that allows us to read reflexivity and diffraction through one another, instead of oppositional. In fact, such a take not only demonstrates that the boundaries between reflexivity and reflection are ambiguous and constantly shifting, it also rearticulates the need for theoretical and methodological approaches that contest an a priori differentiation between the subject and the object of research in an attempt at escaping the reduction of the relationship between the knower and the known to a mere epistemological one which leaves the power to represent and the authority over that which is represented solely in the hands of the researcher.

Moreover, despite that Barad has been criticized for not giving enough attention to

contestations of representationalism and performative approaches in science studies, dealing with them mainly in footnotes (see Pinch 2011, 438–9), it is precisely through such a re-turning to her engagement with reflection, reflexivity, and their entanglement with representationalism that a rich body of work in science and technology studies is brought to the fore that has shifted the perspective from the question of how knowledge represents a stable and observation-independent reality to the question of how science is done in practice—and how these practices in turn shape or co-produce the world that they study. For instance, Bruno Latour’s notion of the ‘modern Constitution’ (Latour 1991, 13–5) amounts not only to a powerful critique of the assumption that there is a gap between world and words, nature and culture, nonhumans and humans, but also to a mobilization of world-changing practices as an alternative to the idea of mirroring a supposedly preexisting world. Hence, for Latour, representation is not only an epistemological matter but also concerns ‘the dynamics of the collective which is re-presenting, that is, presenting again, the question of the common world, and is constantly testing the faithfulness of the reconsideration’ (Latour 2004, 248).

A similar understanding of knowledge and the physical world as co-constitutive has been proposed by Steve Woolgar. Drawing on Foucault’s understanding of discourse, Woolgar (1986) stresses that the distinction between ‘a thing and what is said about that thing’ is ‘actively created’, rather than a ‘pre-given feature of our world’ (Woolgar 1986, 314). In *The Mangle of Practice*, Andrew Pickering makes an even stronger argument in this direction, developing what he calls ‘the dance of agency’—that is, the open-ended folding of human and material, or disciplinary, agencies in scientific practices (Pickering 1995, 21–5). For Pickering, rather than representing phenomena, socio-technical practices and infrastructures enact the very objects with which they engage. The notion of enactment is not to be confused with the idea of social construction, as it does not treat human practices as the only ones through which the world is enacted, nor does it understand the world as a passive object which is only made meaningful in

a second step. Rather, human practices are always already entangled with the more-than-human, and as such are part of the world in its ongoing enactment. Hence, instead of being a mere social construction, the world is always in-the-making, meaning the effect of open-ended practices in which not only humans take part.

Finally, actor-network theory (Akrich 1992; Callon 1986; Latour 2005) and material semiotics (Law 2004; Law and Lien 2018), too, can be understood as a set of tools and sensibilities for exploring how scientific and other practices are simultaneously material and semiotic. Suspending dichotomies such as subject and object, human and nonhuman, and social and technological, these approaches have explored how ‘the enactment of materially and discursively heterogenous relations [...] produce[s] and reshuffle[s] all kinds of actors including objects, subjects, human beings, machines, animals, “nature,” ideas, organizations, inequalities, scale and sizes, and geographical arrangements’ (Law 2009: 141). Praxeographic approaches in anthropology and social science research draw on this idea, emphasizing that social phenomena cannot be understood as stable and given entities, but rather materialize and become meaningful through particular encounters or practices. This comes down to the notion that there is nothing outside of practice (Rouse 2002; Schatzki et al. 2000). Being concerned with the very practices that enact particular materialities, structures, and realities, these approaches have emphasized that as a researcher, one is always part of the phenomenon that is being investigated (Mol et al. 2010). For example, in *The Body Multiple*, Annemarie Mol explores ‘the way medicine enacts the object of its concern and treatment’ (Mol 2002, vii) and in doing so argues that *practices*, rather than substances, structures, or actors, are the fundamental unit of analysis. It is in fact only through practices that ‘ontologies are brought into being, sustained, or allowed to wither away in common, day-to-day, sociomaterial practices’ (Mol 2002, 6). Or to put it differently, it is ‘in the act, and only then and there, [that] something is—being enacted’ (Mol 2002, 33). This is why Mol argues that once ‘practice

becomes our entrance into the world, ontology is no longer a monist whole. Ontology-in-practices is multiple' (Mol 2002, 157). It is also for this reason that decolonial scholars such as Helen Verran (2014), Eduardo Viveiros de Castro (2014), and many others stress that anthropological inquiry, amongst other things, is a form of ontology, and that the entities anthropologists deal with are always relations and comparisons that arise in practices. If the practices change, then so too do the entities they enact. Exploring how different normativities and realities are woven together, these approaches stress that studying science in-the-making is always and necessarily about the stabilization and destabilization of worlds, rather than their mere representation.

Building on this non-oppositional reading of reflection and diffraction, in the pages to follow, I will argue that a diffractive methodology however not only allows us to take into account 'the constitutive nature of practices' (Barad 2007, 57) in both science and science studies even stronger than reflexive approaches can do, but also allows for the emergence of a radicalized (i.e. intra-active) understanding of the role and position of the researcher as part of the world they seek to understand. Instead of assuming that the researcher exists prior to inquiry, the notion of the researcher as transducer that I will put forward challenges the inter-subjective limitations of reflexive approaches, demonstrating that it is not enough to reflect on the epistemological *consequences* of knowing. Instead, knowing is reworked as a material engagement with the world as part of it, and hence becomes inseparable from the practice of responding to the Other as an ethical and political obligation.

Diffracting diffraction

In the past few years, a growing body of work has emerged that engages with what is often termed 'diffractive methodologies' (Murriss and Bozalek 2019; Van der Tuin 2014)⁸ and 'diffractive reading' (Geerts and Van der Tuin 2016; Merten 2020; Thiele 2014; Van der Tuin 2011), or sometimes also 'quantum literacy' (Bühlmann et al. 2017) and 'quantum thinking'

(Sellberg and Hinton 2015), drawing attention to the epistemological, ontological, and ethical aspects of scientific research and knowledge production. These accounts and methods have largely been developed in response to a deep dissatisfaction with what is often described as the representationalist paradigm in both science and science studies. Challenging representationalist understandings of scientific knowledge production and objectivity in favour of more situated, relational, and processual accounts, diffraction has become a key concept in feminist new materialist analyses exploring the mutual constitution of matter and meaning. Tracing back the concept of diffraction to postcolonial feminist scholar Trinh T. Minh-ha's work on identity, difference, and representation, in what follows, I will neither aim at drawing an analogy between Minh-Ha's, Haraway's, and Barad's thought, nor do I want to posit a linear development of the concept. Instead, I will propose a reading of diffraction which itself is already diffracted through Haraway's (1992; 1997; 2000) take on Minh-Ha, Barad's (2014) reading of both Haraway and Minh-Ha, as well as through crucial contributions on the feminist genealogy of diffraction, as they have been put forward by de Freitas (2017); Geerts and Van der Tuin (2016; 2021), Hinton (2013), and others.⁹

Stepping out of the mirror

In 'Not You/Like You', Trinh contests understandings of identity and politics that rely 'on the concept of an essential, authentic core that remains hidden' (Trinh 1988, 415). What troubles Trinh is that in such accounts, the Other is usually conceived of as the antithesis to the self—that is, as the 'non-I'. Through this construction of the Other as the 'non-I', the self only reflects itself in a distorted form, while the Other remains confined behind the mirror. As the 'I' only encounters itself in the mirror, time and again, difference—whose essence remains hidden forever—becomes 'separatism' for Trinh:

If identity refers to the whole pattern of sameness within a being, the style of a continuing me that permeated all the changes undergone, then difference remains within the boundary

of that which distinguishes one identity from another. [...] Difference in such a context is that which undermines the very idea of identity, differing to infinity the layers of totality that forms I. (Trinh 1988, 415–6)

However, for Trinh, a ‘different terrain of consciousness’ (Trinh 1988, 416) is possible, from which difference—if understood as being about *differencing* rather than about opposing—could allow us to question both categories of absolute sameness and separateness. Being ‘two’, here, does not ‘necessarily imply separateness for it is never really equated with duality’, while being ‘one’ is not about the exclusion of ‘multiplicity for it never expresses itself in one single for, or in uniformity’ (Trinh 2010, 56). It is against this backdrop that Trinh, affirming that ‘I am like you’ while at the same time persisting that ‘I am different’, Trinh proposes the notion of the ‘inappropriate other’ (Trinh 1988, 418) in order to diffract the representationalist imitation game. Even though Trinh is not using the notion of diffraction herself, the claims she makes can be read as an argument for an understanding of difference as a *relational* phenomenon, since such a take on identity and difference as *differencing* radically breaks with ‘the apartheid-based, segregational type of difference’ that is characterized by seeing difference as that which is ‘to-be-captured, to-be-assimilated, and eventually, to-be-wholly-eradicated’ (Geerts and van der Tuin 2021, 173–4).

Taking up this thought, in her essay ‘The Promises of Monsters’, Donna Haraway (1992) deploys diffraction as a feminist conceptual lens and heuristic tool for addressing and rethinking difference beyond binary opposition. It is in particular Trinh’s critique of difference and her notion of the ‘inappropriate other’ that Haraway mobilizes in order to arrive at a non-dualistic model of difference and identity that promises to disrupt a geometrical optics of closure.

[T]o be an ‘inappropriate/d other’ means to be in critical, deconstructive relationality, in a diffracting rather than reflecting (ratio)nality as the means of making potent connection that exceeds domination. To be inappropriate/d is not to fit in the taxon, to be dislocated

from the available maps specifying kinds of actors and kinds of narratives, not to be originally fixed by difference. (Haraway 1992, 299)

The notion of the ‘inappropriate/d other’ provokes a different take, a different geometry or optics on the relationship between nature and culture, humans and nonhumans, and organisms and machines. In her seminal book *Modest_Witness@Second_Millennium*, Haraway (1997) goes even further and considers diffraction as both an optical metaphor and a methodological sensitivity for feminist and other critical analyses of a world that has been thoroughly transformed by the technosciences. Challenging objectivism, with its ‘god trick of seeing everything from nowhere’ (Haraway 1997, 136)—meaning an epistemological practice that promises the illusion of objectivity by eliminating the embodied location of the knowledge producer—Haraway proposes diffraction as a more situated and responsible mode of knowledge production. While geometrical optics is founded on an a priori distinction between reflections and the phenomena, properties, and identities being reflected, a diffractive approach maps differences as they interfere in practices. Although diffraction is an optical metaphor like reflection, ‘it carries more dynamism and potency’ since it is not about mirroring originals but about patterns that ‘record the history of interaction, interference, reinforcement, difference’ (Haraway 2000, 102).

For Haraway, as a ‘narrative’ or ‘political technology’ for meaning-making (Haraway 2000, 102), diffraction allows us to shift our images of difference from oppositional to differential, and in doing so to move our ideas of scientific knowledge and its production from reflecting or mirroring reality *as it is* to embedded, situated, and relational accounts of realities-in-their-becoming. Similarly, to Trinh, whose motivation lies in a fundamental critique of Western concepts of identity which she sees as inseparably tied to dominance and violence against the Other (see also Geerts 2021), Haraway’s desire to modify our tools of knowledge production and meaning-making, too, is fuelled by the biopolitical, neoliberal, and

technoscientific realities and rationalities of our present (see Haraway 1987; 1997). It is in this sense that diffraction is not just a metaphor for Haraway but also a much-needed semiotic heuristic tool that allows us to map how ‘meanings are made and lived’ (Haraway 1997, 14).

Interferences

Transferring the notion of diffraction from geometrical optics to quantum mechanics, Karen Barad shifts our attention to the queer¹⁰ behaviour of matter and how it fundamentally affects our practices of scientific observation, knowledge production, and meaning-making. Acknowledging that diffraction owes ‘much to a thick legacy of feminist theorizing about difference’ (Barad 2014, 168), Barad goes a step further in considering it neither as a mere metaphor nor primarily as a semiotic tool for thinking about differences. Unlike Haraway, Barad sees diffraction both as a methodological tool *and* as an object of study itself, as I will demonstrate.

As a physical phenomenon, diffraction refers to the patterns produced by waves—irrespective of whether it is a water wave, a radio wave, or an x-ray wave—when they interfere with one another. For Barad, attending to these patterns not only tells us something about the interfering waves, but also about the phenomenon or apparatus¹¹ that produces them. However, diffraction is not limited to macroscopic reality but also lies at the heart of what is called the ‘wave-particle duality paradox’ (Barad 2007, 29; see also Seth 2013, 844–5). Re-turning to the debate between Niels Bohr and Werner Heisenberg on the mystery of why, depending on the apparatus of observation, electrons behave either as waves or as particles, but never as both at the same time, Barad (2003; 2007) demonstrates that while Heisenberg’s (1927; see also Cassidy 2009) response in the form of the uncertainty principle remains limited to the epistemological realm, since it sizes the limits of what we can know about the world, Bohr’s (1949)¹² solution not only suggests that there is no stable observation-independent reality but also that measurements are to be understood as *cuts*, resolving indeterminacy locally and

temporarily. Hence, for Bohr, what counts as real is enacted through specific measuring apparatuses. It is indeed only through these apparatuses and the cuts they enact that specific phenomena along with their boundaries and properties become determinate—at the exclusion of other phenomena, properties, and boundaries. In essence, this idea boils down to regarding the observer always and necessarily as part of the phenomenon that she seeks to understand. ‘[T]here is no unambiguous way to differentiate between the object and the agencies of observation. As no inherent cut exists between object and agencies of observation, measured values cannot be attributed to observation-independent objects’ (Barad 2007, 196). It is the idea of Bohr’s that electrons ‘*perform* particle-ness under certain experimental circumstances and wave-ness under others’ that leads Barad (2014, 173; original emphasis) to the conclusion that materialities, meanings, identities, and in fact even temporalities are the effects of enacted cuts, rather than preexisting phenomena independent of observation.

In an important sense, diffraction is not only about the indeterminacy of space but also of time, or ‘time-being’, as Barad (2017; 2019) puts it. Drawing on the time-energy indeterminacy principle in quantum field theory, which holds that ‘a given entity can be in (a state of) *superposition of different times*’ (Barad 2017, 67; original emphasis), in her more recent work, Barad proposes the notion of temporal diffraction for thinking the entanglement of events through time. This idea should not be mistaken as an argument against the linearity of time, and that it ‘ought to be replaced with a new, arguably superior, notion of time’, as this would ‘fall into the logic of progress and suppressionism’ (Barad 2017, 69). Rather, following the insights of quantum field theory, Barad (2019, 528) concludes that each moment is ‘made up of a superimposition of all moments’. It is also for this reason that temporal diffraction demands us to think ‘the “new” and the “old”’ as ‘diffractively threaded through’ and as ‘inseparable from one another’ (Barad 2017, 69), reworking the linearity of events from *within* in so doing.¹³

Expanding on these considerations, Barad's framework of agential realism rejects a metaphysics that departs from 'things' as ontologically basic units and time as a series of discrete moments. At the same time, she also tries to 'save Bohr from himself' (Pinch 2011, 437) by contesting his humanist notion of subjectivity with a more-than-human account of scientific practices. In doing so, Barad arrives at an approach that she considers to be 'a *legitimate interpretation* of quantum mechanics' (Barad 2007, 94), with diffraction at its heart as both ontological phenomenon *and* methodological sensitivity. In this light, diffraction enables us to examine not only the conditions for the possibility of objectivity, measurement, and intelligibility but also 'the relationship between discursive practices and the material world' (Barad 2007, 94).

Diffraction as phenomenon and methodology

As an ontological phenomenon, diffraction is both a matter of interferences and '*differential entanglements*' (Barad 2007, 381; original emphasis). Even though the notion of entanglement is employed more and more as a concept and a metaphor in social science research and the humanities, it often loses its complex scientific and philosophical meaning,¹⁴ becoming just another elaborate word for connection, relationship, interaction, or network. However, the phenomenon of quantum entanglement is something else, underpinning the whole concept of quantum mechanics.¹⁵ Quantum entanglement occurs when two particles become inextricably linked with one another, so that the measurement of one of them affects the other particle, regardless of the distance between the two. In their entangled state, both particles are interacting for a brief moment, sharing physical states such as their momentum, position, or polarization (Brody 2020). As this relationship between their fundamental properties does not happen by pure chance, quantum entanglement is often referred to as 'spooky action at a distance',¹⁶ remaining a mystery until today. It is this understanding of entanglement that challenges both the notion of dichotomy and that of a holistic one-ness, allowing us to take into

account how it is through intra-actions that the boundaries and properties of a given phenomenon come to matter, stabilize, and destabilize, and do so at the exclusion of other boundaries and properties. Such an approach breaks not only with representationalism and the epistemic practice of separating observer and observed from one another, but also with the ontological claim that *relata* precede their relations.

As a methodological sensitivity, diffraction reworks the triad of things, knower, and knowledge, shifting the focus from questions of correspondence to practices of doing. The practices of mirroring sameness are interrupted here, giving way to the production of ‘patterns of difference that make a difference’ (Barad 2007, 72). By that, Barad means that instead of imitating a preexisting reality whose truths are believed to be revealed through observations, diffraction as a methodology sensitizes us to the intra-actions that performatively enact that which counts as real. Eschewing the metaphysics of individualism and representationalism, the agential (rather than Cartesian) cuts that intra-actions enact allow the distinction between subjects and objects of knowledge to be resolved locally and temporarily. Diffraction therefore entails a necessary differentializing from the objects of knowledge through the enactment of agential cuts. Barad is very clear in saying that the enactment of cuts is ‘not a matter of choice in the liberal humanist sense’ but ‘of specific material practices’ (Barad 2007, 217), and that it is only through agential cuts that separability is possible. What is more, the separations enacted are always and necessarily a ‘*local* resolution *within* the phenomenon of the inherent ontological indeterminacy’ (Barad 2003, 815; original emphasis).

Similarly to reflexivity, diffraction, therefore, is not a method that is applied but rather a methodological sensitivity that attunes us to the intra-acting entanglements of the material and the discursive, and how these entanglements play a role in our practices of knowledge production. Since diffraction is not a method, there is also no checklist or steps to follow in order to arrive at a specific outcome. Instead of stopping at the idea of a co-production of subject

and object (of knowledge), diffraction rather provides us with an understanding of knowledge-making practices as ‘socio-material enactments that contribute to, and are part of, the phenomena we describe’ (Barad 2007, 26).

Consequently, for Barad, ‘a diffractive methodology is respectful of the entanglement of ideas and other materials in ways that reflexive methodologies are not’ (Barad 2007, 29). In substance ontologies, matter is treated as passive bits and pieces or even as a mere surface that is inscribed with meaning, whereas diffraction pays attention to the agential cuts through which not only epistemological but also ontological indeterminacy is resolved within a given phenomenon, providing ‘*the condition for the possibility of objectivity*’ (Barad 2007, 175; original emphasis). Resonating with and even radicalizing the famous claim in science and technology studies that ‘things could have been otherwise’, diffraction demonstrates that measurements or inquiries are material enactments that come at a price, as with every materialization something else is necessarily excluded from mattering.¹⁷ It is in this crucial sense that diffraction not only highlights the mutual enactments but also the exclusions of entangled phenomena. Adopting diffraction as a methodological sensitivity hence means starting from the idea that the objects of observation are inseparable from the agencies of observation until inquiry, meaning specific agential cuts, takes place and resolves indeterminacy locally. It is precisely in this regard that the notion of the researcher as transducer, as I propose below, allows us to better understand the role and position of the researcher within a diffractive framework.

The researcher as transducer

Perhaps one of the most striking examples of the application of agential realism that Barad provides us with is the case of the piezoelectric crystal. Forming the key component of the ultrasound transducer, the piezoelectric crystal enables images of embryos and fetuses to be produced in obstetric ultrasonography. As it concentrates or expands, the crystal can either

sense ultrasonic waves or emit them, which then can be mapped onto a screen, resulting in images that tell us something about the materiality of the bodies being observed (see Barad 2007, 189–91). The transducer for ultrasonography, for this reason, is not only regarded as a crucial tool for mapping the materiality of bodies in clinical contexts, but also in feminist and other critical theories that engage with questions of the body and its materialization. It is precisely its dual function as both receiver and transmitter of ultrasonic waves that renders the piezoelectric crystal ‘the soul’ of an observing apparatus, which does not only ‘map the terrain of the body’, but also makes and remakes boundaries, including those between human and nonhuman, body and technology, as well as self and other (see Barad 2007, 194–201).

[T]he transducer does not allow us to peer innocently at the fetus, nor does it simply offer constraints on what we can see; rather, it helps produce and is part of the body it images. That is, the marks on the computer screen (the sonogram images, sonic diffraction patterns translated into an electronic image) refer to a *phenomenon* that is constituted in the interaction of the ‘object’ (commonly referred to as the ‘fetus’) and the ‘agencies of observation.’ (Barad 2007, 202; original emphasis)

The case of the ultrasound transducer in the context of obstetric ultrasonography is therefore much more than a mere example, as I want to argue, since it not only provides us with an understanding of Barad’s reconfigured notion of the apparatus, but also allows us to arrive at a diffracted understanding of the researcher and her role in the process of knowledge production, contesting humanist understandings of subjectivity and objectivity in doing so. In order to fully grasp the originality of this proposition however, it is important to understand what an apparatus is and is not. I am less interested in a case study here, let alone an empirical inquiry. In what follows, I will rather draw on Barad’s discussion of the transducer in order to think about and further complicate the role and the position of the researcher in the process of knowledge production in a diffractive approach.

Sharing a conceptual genealogy with both Bohr’s idea of apparatuses and Foucault’s

post-Althusserian notion of the apparatus (*dispositif*) (see Barad 2001, 86; see also Barla 2019), apparatuses in Barad's understanding are not conceived as preexisting entities or instruments but as 'themselves constituted through particular practices that are perpetually open to rearrangements, rearticulations, and other reworkings' (Barad 2007, 203). Since apparatuses are 'always in the process of intra-acting with other apparatuses' (Barad 2007, 203), the question almost instantly arises as to where a given apparatus ends and another begins. However, this question misses the crucial point, because apparatuses have no intrinsic boundaries and are always part of other apparatuses. The search for intrinsic boundaries and acting subjects who are making the cuts, hence, breaks down to a humanist flattening of agential realism, missing the meaning of intra-action and entanglement entirely.

It is nevertheless possible to determine how the boundaries and properties of a given apparatus come to matter and hence how that which counts as 'outside-within', rather than an absolute outside, is enacted in practice. Both 'outside' and 'inside' materialize when intra-actions enact a cut that resolves indeterminacy locally. It is in this regard that the example of the piezoelectric transducer not only contests the representationalist paradigm, which assumes that the world is composed of individual entities with determinate boundaries and properties, but also demonstrates the inseparability of the objects of observation from the agencies of observation. Since in the absence of cuts boundaries remain indeterminate until measurements take place, the phenomenon that acts as objective referent manifests through the intra-action of the object of knowledge (that is, the foetus) and the agencies of observation (of which the researcher is part), including instruments, technologies, discourses, and norms—all of which are apparatuses.

If Barad treats the piezoelectric crystal as 'the soul' of the apparatus of observation (see Barad 2007, 189), what would that mean for the role of the researcher within an agential realist framework? What would it mean to understand the researcher themselves as a transducer?¹⁸

Does such an account allow us to treat the researcher as not only part of the apparatuses of observation but also as an apparatus itself that diffracts the forces she intra-acts with, producing difference-as-it-emerges rather than mirroring sameness? Would such a notion of the researcher as transducer be able not only to destabilize the authority of the researcher as the autonomous subject/'I' that reflects the objects of observation (yet without releasing her from responsibility and accountability for the fact that some worlds are materialized over others), but also to pay attention to the objects of observation as actively involved in the processes of materialization and meaning-making? I do think that it is not only fruitful but necessary to engage with these questions in order to arrive at a fuller understanding of the entangled state of being, knowing, and responsibility in a diffractive approach in science studies.

Taking seriously the call to start from relations instead of *relata* (see Barad 2003, 812; Barad 2007, 140) first and foremost means radically breaking with the possibility of producing knowledge from afar by mirroring the objects of knowledge. Even though in a diffractive framework there are no inherent cuts that separate the objects of observation from the agencies of observation—so that the knowledge produced can neither be attributed to a reality independent of observation nor to a human self/'I'—the researcher still remains 'the soul' of the apparatus of observation. Responding to the ways in which “the world kicks back” (Barad 2007, 215), the researcher is not only a key component of the agencies of observation that produce knowledge but in a crucial sense also responsible and accountable for the materialities and meanings that she enacts (as part of the apparatus of observation), as well as for those that are foreclosed.

In this light, the notion of the researcher as a transducer not only decentres the humanist subject of knowledge but also undermines the long-standing idea that the researcher exists prior to inquiry.¹⁹ If 'subject' and 'object' are the effects of specific encounters—meaning, material-discursive entanglements and the agential cuts that are enacted in and through apparatuses,

rather than ontologically preexisting units—and if the doer therefore does not precede the deed, then the researcher also materializes and re-materializes in these very practices. Or put differently, since *‘[t]he boundary between the ‘object of observation’ and the ‘agencies of observation’ is indeterminate in the absence of a specific physical arrangement of the apparatus’* (Barad 2007, 114; original emphasis), the researcher themselves is stabilized and destabilized in intra-action with a plethora of other human and more-than-human entities, spaces, and practices. At the same time, what gets transduced through the researcher (as an event or apparatus themselves) are not detached entities, forces, or agencies but intra-acting phenomena.

In contrast to the representationalist paradigm, in which the researcher reflects a world that is kept at a distance, separating the self/’I’ from the Other in doing so, the notion of the researcher as transducer renders the self/’I’ a multiplicity itself that sediments out of iterative intra-active practices. Demonstrating that it is not enough to reflect on the observer’s role in helping to constitute knowledge, such a take allows us to shift our attention to the performativity of our own research practices, attuning us to the fact that knowing is a material engagement. In this way, it goes beyond reflexive approaches which stress the epistemological *consequences* of knowing, or the co-construction of facts and artefacts. Moreover, such an approach contrasts with those strands of science and technology studies which do extend the focus to nature and non-human agents, only to ignore their active role in practices of knowledge production (Bloor 1991), or to reduce them to ‘man-made’ objects or mere artefacts which are appropriated, inscribed, invested, or deployed in order to enable human action, politics, and morality (see, e.g. Akrich 1992; Pinch and Bijker 1984; Winner 1980). Instead, a diffractive take on both the researcher and scientific knowledge production attunes us to the very practices through which that which counts as ‘the human subject’ or ‘the nonhuman’ (and not only its representation) is enacted, stabilized, *and* destabilized through material-discursive practices and agential cuts.

Such a take goes also beyond more recent reworkings of reflexivity such as ‘recursivity’ (Fortun 2001). Recursivity allows us to position the researcher ‘within processes she affects’ and ‘competing calls for response’; it ‘interrupts her and demands a reply. Thinking in terms of recursivity is a way to hold ethnography responsible for advocacy’ (Fortun 2001, 23). In a diffractive approach, responsibility is not only about *advocacy*, but also about the materialization of the research field, the subjects of research, the knowledges produced, and the constitutive exclusions enacted as part of the world/phenomenon that is to be understood and made meaningful. Since both the world and our knowledge about it are ‘sedimented out of particular practices that we have a role in shaping’ (Barad 2007, 203), adopting diffraction as a sensitivity not only challenges methodological individualism but also urges us not to forget that ethics and politics are inseparably tied to practices of materialization and meaning-making. Attending to differential/izing inclusions and exclusions that are intra-actively enacted thus prompts epistemic accountability *and* ethical responsibility for which worlds are materialized over others.

Diffraction as a methodological sensitivity and the notion of the researcher as transducer should, however, not be mistaken as a call for (re-)turning to (quantum) physics as *Leitwissenschaft*, or for getting rid of questions of responsibility and justice all together. On the contrary, it is Barad who reminds us that agential realism is neither about employing physics as a lens for seeing the world in a particular way, nor is there a ‘general conception of quantum physics’ (Barad and Gandorfer 2021, 39-40) or quantum physics in the singular form. Much less is quantum physics an inherently liberatory project—as the history of the entanglement of physics with colonialism, war, the violent displacement of indigenous people, extractivist capitalism, and environmental destruction shows (see also Barad 2017; 2019). Rather, what is at stake is nothing less than, the ‘opening up’ of ‘the seeming totality called “physics” in order to nurture the cracks and bring forward its radical possibilities’ (Barad 2017, 62) for justice-to-

come. Since our being in the world is always already entangled with the being of human *and* more-than-human others, responsibility ‘cannot be restricted to human-human encounters when the very boundaries and constitution of the “human” are continually being reconfigured and “our” role in these and other reconfigurings is precisely what “we” have to face’ (Barad 2007, 392). Drawing on Derrida’s reading of Levinas, for whom ethics is not located in the self but derives from (the entanglements with) the Other,²⁰ the ethics that is foregrounded here becomes cut loose from its ties to individual responsibility and ‘rethought in the rethinking of space, time, and matter as spacetime-mattering (in its iterative intra-activity) such that ethical responsibility is understood as a matter of what comes to matter and what is excluded from mattering, that is, as matters of justice’ (Barad and Gandorfer 2021, 31). Or put differently, responsibility *for* the Other gives way to a responsiveness *to* and the ability to respond *with* the Other.

Starting from relational, situated, and embodied intra-actions therefore means acknowledging that *knowing* always entails *responding* to the Other as both an ethical *and* a political practice. Insofar as intra-actions are not only ethical obligations but also material practices of ‘responding as composing with otherness’ (Hoppe 2020), it has been argued that Barad seems to miss the full potential offered by a diffractive approach for a *relational* understanding of politics (Lemke 2015). While it is true that Barad does not engage directly with the question of the political in detail, she does stress that since intra-actions always entail exclusions, ‘it is not merely values and ethics that are at stake but also the political’ (Barad and Gandorfer 2021, 25). In fact, in her more recent work, Barad (2019) suggests that matter and politics are inextricably entangled and that there is no outside to matter/ializing. Even the void itself is ‘an infinite plenitude [...] that cannot be disentangled from (what) matter(s) (Barad 2019, 542; see also Barad 2012b). However, despite that Barad urges us to understand that the void is not ‘that which literally doesn’t matter’ and that matter is ‘always already caught up with the in/determinate dynamics of the no-thingness of the void’ (Barad 2019, 528), not only

the relationship between politics and the political but also the role of the political with regard to that which has not been materialized and (temporarily or not) remains in a state of nothingness/non-becoming is yet to be explored in more detail.

In a crucial sense, a diffractive take on scientific knowledge production with the notion of researcher as transducer at its heart, as it has been proposed in this article, does also raise a number of important questions. For example, if we were to start from relations rather than relata, can there still be at least a strategic use of an ‘I’ in the process of knowledge production? What does it mean epistemologically and ethically to consider the ‘object of investigation’ and ‘apparatus of investigation’ as mutually exclusive? Does such an account fully escape the endless play of mirroring sameness and identity? I believe that ‘we’ will only be able to answer these and other crucial questions once ‘we’ fully engage in a diffractive approach to scientific knowledge production.

Conclusions

Even though Karen Barad’s framework of agential realism has received a lot of attention in the past few years, in a strange sense, precisely the social studies of science still lack detailed engagements with the diffraction as a conceptual and methodological sensitivity. In this article, I have shown that diffraction however could be an important theoretical and methodological tool that is needed to move conversations in science studies. Re-turning to Barad’s engagement with representationalism, reflection, and diffraction in an attempt at reading it through different accounts of representation and reflexivity in science and technology studies, I have not only argued that—although reflection and reflexivity should not be treated as being the same—diffraction allows for an even stronger understanding of knowledge production as a material engagement with the world as part of it to emerge, but have also shown that a diffractive methodology contests the practices that locate authority about representations and that which they purport to represent in the subject position of the (self-reflexive) researcher.

Expanding on Barad's understanding of diffraction, I have furthermore demonstrated that diffraction attunes us to the ways in which the boundaries and properties of the phenomena that we seek to understand are enacted through methods and methodology themselves—that is, through our research practices as part of the agencies of observation. In this light, I proposed the notion of the researcher as transducer in order to shift our attention to the performative power of research practices, allowing us to understand that our knowledge-making practices and the knowledge that they produce do not merely *shape* or *inscribe* the phenomena that we seek to understand but *help them to come to matter*. In its critical stance towards geometrical optics of closure and practices of knowing from a distance, such a take transforms both practices of knowledge-making and our ethical and political coordinates in reorienting the place and perspective of the researcher in the process of knowledge production. Whereas reflexivity and recursivity highlight the necessity of questioning the social position, feelings, values, and beliefs of the researcher and how they influence encounters with the Other as well as the knowledge produced in these encounters, a diffractive approach, as I have demonstrated, goes even further in undermining the long-standing idea that the researcher exists prior to inquiry. Rather than an autonomous subject that is calling the shots, the researcher themselves becomes a phenomenon that is stabilized and destabilized in intra-action with the agencies of observation and the objects of observation.

This does not mean dissolving the subject of research once and for all. On the contrary, I have emphasized that, being 'the soul' of the apparatus, the researcher (as crucial component of the agencies of observation) remains the one who is responsible for the cuts that she enacts, demonstrating that our methodological considerations and tools are inextricably bound up with questions of accountability and responsibility for the constitutive nature of our research practices. However, as '[d]ifferent material intra-actions produce different materializations of the world', and indeed different worlds, 'it matters to the world how the world comes to matter'

(Barad 2007, 380). It is in this sense that diffraction allows us to pay attention not only to the constructions and materializations but also to the frictions, foreclosures, and constitutive exclusions in the processes of materialization. Lastly, taking a diffractive approach to scientific knowledge production should not be misunderstood as an attempt to discard reflexivity, or to establish yet another dualism with reflexivity and diffraction as conceptual counterparts (see also Bozalek and Zembylas 2017). Instead, it should be understood as a call to diffract reflexivity even further, so as not to revert to the practice of drawing exclusionary demarcation lines. Because after reworking the human/ist subject, representation, and even matter, methodology, too, will never be the same.

Notes

1. Barad (2007, 33) proposes the neologism *intra-action* in order to signify ‘the mutual constitution of entangled agencies’. In contrast to the notion of *interaction*, ‘which assumes that there are separate individual agencies that precede their interaction, the notion of intra-action recognizes that distinct agencies do not precede, but rather emerge through, their intra-action’ (Barad 2007, 33). I shall revisit this idea in more detail later on.
2. A notable exception is Hollin et al. (2017).
3. In fact, Lynch admits that it would have required ‘a more extensive reading of Barad’s writings, because the limited sections I have read are usually self-referential’ (Lynch 2014, 140). Only to add that his ‘limited forays into Barad’s writings [which consisted of a monograph and around nine contributions to journals and edited volumes in 2011; JB] have not inspired me to continue such a time-consuming and arduous undertaking’ (Lynch 2014, 140).
4. In the course of this article, I will diffract this apprehension itself in an attempt at foregrounding a different understanding of physics and its entanglement with questions of objectivity, ethics, and justice that lies at the heart of Barad’s framework.
5. It is worth noting that while Barad has a rather clear understanding of realism—namely, as all those approaches that assume that phenomena have inherent properties that exist regardless of whether anyone is observing them, which then can be measured in order to reveal their properties along with their boundaries—constructionism, as Barad conceives it, not only refers to both linguistic and social constructivist approaches but also seems to be used synonymously with epistemic relativism in parts of her work.

6. Although Lumsden (2019) does make a point in stressing that reflexivity becomes a caricature in some critical readings, she runs the risk of repeating the same mistake by throwing together agential realism, new materialisms, posthumanisms, poststructuralist theories, and post-qualitative inquires. In fact, most of her concerns apply to post-qualitative research, rather than to agential realism and new materialisms. What is more, her argument that all these different theoretical and methodological perspectives re-scribe humanist values ‘by extending agency, vitality, and social phenomena to non-human material’ (Lumsden 2019, 61) ignores the fact that for Haraway and even more so for Barad, agency is neither ‘something that humans and even nonhumans have to varying degrees’ nor is it ‘a binary proposition, either on or off’ (Barad 2007, 172). Agency, instead, ‘is a matter of intra-acting; it is an enactment’ (Barad 2003, 826).
7. Barad (2014, 168) proposes the notion of ‘re-turning’ for highlighting an epistemological and political practice that is not about ‘returning as in reflecting on or going back to a past that was, but re-turning as in turning it over and over again – iteratively intra-acting, diffracting anew, in the making of new temporalities (spacetimematterings), new diffraction patterns’.
8. According to van der Tuin (2019, 17), diffraction as a methodological tool makes what may be its first philosophical appearance in Henri Bergson’s *Time and Free Will*, where Bergson refers to interference patterns as a tool to think with *and* about the self.
9. Such a take on the genealogy of diffraction is especially indebted to Geerts and van der Tuin’s (2021) reconstruction of the ties between Minh-ha, Haraway, and Barad.
10. Barad is careful to avoid using ‘queer’ as a metaphor or, even worse, instrumentalizing and hence depoliticizing it by employing it as just a fancy term. Rather, for Barad, ‘queer’ and ‘queerness’ express that ‘[t]he very nature of an atom’s being, its very identity, is indeterminacy itself’ (Barad 2011b, 136).
11. As I will demonstrate in what follows, Barad’s understanding of apparatuses should not be confused with instruments or experimental setups in the laboratory or elsewhere. Apparatuses are not instruments, tools, or machines for Barad. See also Barla (2019, 136–9) for a detailed genealogy of Barad’s notion of the apparatus.
12. Even though Bohr introduced the notion of complementarity as early as in his lectures in 1927, it is in his letters to Einstein that he elaborates on the phenomenon of complementarity in quantum mechanical measurements in greater detail, stressing that ‘any arrangement suited to study the exchange of energy and momentum between the electron and the photon must involve a latitude in the space-time description of the interaction sufficient for the definition of wave-number and frequency which enter into the relation’ (Bohr 1949, 210).
13. Since the talk of ‘the “new” not only ignores matter/ing’s inherent historicity but also assumes a progressive notion of time’, setting in place ‘a discontinuity from other materialisms’ (Barad and

Gandorfer 2021, 27), matter/ing and materialism cannot be understood in terms of the ‘new’ and the ‘old’. For Barad, the ‘new’ is always already the ‘old’, and vice versa. This is also why Barad has been critical of the so-called ‘founding gesture’ (Ahmed 2008) of new materialisms from the very beginning.

14. Lynch, too, seems to arrive at such a misunderstanding not only of the notion of entanglement but also of the phenomenon when he states that in his ‘understanding, the general lessons that Barad draws from Bohr about physical phenomena seem roughly in line with Husserl’s conception of phenomena or Merleau-Ponty’s account of “the intertwining”’ (Lynch 2014, 139). Leaving aside the tiresome gesture of tracing back the originality of feminist scholars to male authorities—a practice that Haraway regards as ‘one of the ways women thinkers are made to seem derivative of male philosophers’ (Haraway in Gane 2006, 156)—Barad not only explicitly states that her ‘notion of phenomenon is not that of philosophical phenomenologists’ (Barad 2007, 412n30) but also that entanglements are *not* about connections, interactions, or intertwinings for that matter.
15. Quantum mechanics indeed posits that the wave-like nature of particles extends, in theory, to all matter and thus even to the macroscopic world (Brody, 2020).
16. It was Einstein who referred to the phenomenon of quantum entanglement somewhat dismissively as ‘spooky actions at a distance’ (*Spukhafte Fernwirkungen*) in a letter to his colleague Max Born in 1947 (Einstein and Born 1971, 158). It was only in 2019, for the first time in history, that an image of quantum entanglement (or more precisely the entanglement between two photons) was captured using a sophisticated experimental setup (Moreau et al. 2019).
17. See also Giraud, who develops an ethics of exclusion ‘which pays attention to the entities, practices, and ways of being that are *foreclosed* when other entangled realities are materialized’ (Giraud 2019, 2). Drawing on Barad’s thought, Giraud highlights the need to explore the possibilities for ethical responding and/as political action in the face of the constitutive role played by exclusions in the materialization of realities.
18. Natasha Myers (2020) proposes a highly insightful notion of the anthropologist as transducer that resonates with some of my claims. Expanding on Spinoza’s understanding of bodies and affects and Erving Goffman’s idea that the ethnographer has to ‘tune’ her body ‘in’ to the field that she seeks to understand, Myers is interested in the *interactions* between affect and physical senses in both ethnographic research and artistic practices.
19. See Lather and St. Pierre (2013) for a similar take on the position and role of the researcher in post-qualitative research practices.
20. Barad draws on Levinas’ idea that responsibility is not about a relation between subjects or individuals but rather about the Other. For Levinas, it is the otherness of the Other that allows for the emergence of subjectivity and hence for ethics—or, more precisely, for the emergence of an

ethics of responding with the Other (see Barad 2007, 391–3; Barad 2012a, 216–8) For a discussion of Barad’s take on ethics in Levinas and Derrida see also de Freitas (2017), Geerts (2016), Hinton (2013), and Thiele (2014).

References

- Ahmed, S. 2008. Open forum imaginary prohibitions: Some preliminary remarks on the founding gestures of the ‘new materialism’. *European Journal of Women’s Studies* 15, no. 1: 23–39.
- Akrich, M. 1992. The description of technical objects. In *Shaping Technology / Building Society. Studies in Sociotechnical Change*, ed. W. Bijker and J. Law, 205–24. Cambridge: MIT Press.
- Barad, K. 2001. Re(con)figuring space, time, and matter. In *Feminist Locations: Global and Local: Theory and Practice*, ed. M. DeKoven, 75–109. New Brunswick: Rutgers University Press.
- Barad, K. 2003. Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs: Journal of Women in Culture and Society* 28, no. 3: 801–31.
- Barad, K. 2007. *Meeting the Universe Halfway. Quantum Physics and the Entanglement of Matter and Meaning*. Durham: Duke University Press.
- Barad, K. 2011a. Erasers and erasures: Pinch’s unfortunate ‘uncertainty principle’. *Social Studies of Science* 41, no. 3: 443–54.
- Barad, K. 2011b. Nature’s queer performativity. *Qui Parle* 19, no. 2: 121–58.
- Barad, K. 2012a. On touching. differences: *A Journal of Feminist Cultural Studies* 23, no. 3: 206–223.
- Barad, K. 2012b. *What is the Measurement of Nothingness? Infinity, Virtuality, Justice*. Ostfildern: Hatje Cantz.
- Barad, K. 2014. Diffracting diffraction: Cutting together-apart. *parallax* 20, no. 3: 168–87.
- Barad, K. 2017. Troubling time/s and ecologies of nothingness: Re-turning, re-memembering, and facing the incalculable. *new formations: a journal of culture/theory/politics* 92: 56–86.
- Barad, K. 2019. After the end of the world: Entangled nuclear colonialisms, matters of force, and the material force of justice. *Theory & Event* 22, no. 3: 524–50.
- Barad, K., and D. Gandorfer. 2021. Political desirings: Yearning for mattering (,) differently. *Theory & Event* 24, no. 1: 14–66.
- Bargetz, B., and S. Sanos. 2020. Feminist matters, critique and the future of the political. *Feminist Theory* 21, no. 4: 501–16.
- Barla, J. 2016. Technologies of failure, bodies of resistance: Science, technology, and the mechanics of materializing marked bodies. In *Mattering. Feminism, Science, and Materialism*, ed. V. Pitts-Taylor, 159–72. New York: New York University Press.
- Barla, J. 2019. *The Techno-Apparatus of Bodily Production. A New Materialist Theory of Technology and the Body*. Bielefeld: transcript.
- Bloor, D. 1991. *Knowledge and Social Imagery*. Second Edition. Chicago: University of Chicago Press.

- Bohr, N. 1949. Discussion with Einstein on epistemological problems in atomic physics. In *Albert Einstein. Philosopher Scientist*, ed. P.A. Schilpp, 200–41. New York: MFJ Books.
- Bozalek, V., V. Mitchell, A. Dison, and M. Alperstein. 2016. A diffractive reading of dialogical feedback through the political ethics of care. *Teaching in Higher Education* 21, no. 7: 825–38.
- Bozalek, V., and M. Zembylas. 2017. Diffraction or reflection? Sketching the contours of two methodologies in educational research. *International Journal of Qualitative Studies in Education* 30, no. 2: 111–27.
- Brody, J. 2020. *Quantum Entanglement*. Cambridge: MIT Press.
- Bühlmann, V., F. Colman, and I. van der Tuin. 2017. Introduction to new materialist genealogies: New materialisms, novel mentalities, quantum literacy. *Minnesota Review* 88: 47–58.
- Callon, M. 1986. Some elements for a sociology of translation: Domestication of the scallops and the fishermen of St Brieuc Bay. In *Power, Action and Belief. A New Sociology of Knowledge?*, ed. J. Law, 196–229. London: Routledge.
- Cassidy, D.C. 2009. *Beyond Uncertainty: Heisenberg, Quantum Physics, and the Bomb*. New York: Bellevue Literary Press.
- de Freitas, E. 2017. Karen Barad’s quantum ontology and posthuman ethics: Rethinking the concept of relationality. *Qualitative Inquiry* 23, no. 9: 741–48.
- Einstein, A. and M. Born. 1971. *The Born-Einstein Letters: Correspondence Between Albert Einstein and Max and Hedwig Born from 1916 to 1955, with commentaries by Max Born*. London: Macmillan.
- Finlay, L., and B. Gough. (eds). 2003. *Reflexivity. A Practical Guide for Researchers in Health and Social Science*. Oxford: Blackwell.
- Fortun, K. 2001. *Advocacy after Bhopal. Environmentalism, Disaster, New Global Orders*. Chicago: University of Chicago Press.
- Gane, N. 2006. When we have never been human, what is to be done? Interview with Donna Haraway. *Theory, Culture & Society* 23, no. 7–8: 135–58.
- Geerts, E. 2016. Ethico-onto-epistem-ology. In *New Materialism Almanac*, ed. D. Gauthier and Sam Skinner, <https://newmaterialism.eu/almanac/e/ethico-onto-epistem-ology.html>, last access: 25.03.2021.
- Geerts, E., and D. Carstens. 2021. Pedagogies in the wild—Entanglements between Deleuzoguattarian philosophy and the new materialisms: Editorial. *Matter: Journal for New Materialist Research* 2, no. 1: I–XIV.
- Geerts, E., and I. van der Tuin. 2016. The feminist futures of reading diffractively: How Barad’s methodology replaces conflict-based readings of Beauvoir and Irigaray. *Rhizomes* 30: <https://doi.org/10.20415/rhiz/030.e02>.
- Geerts, E., and I. van der Tuin. 2021. Diffraction & reading diffractively. *Matter. A Journal of New Materialist Research* 2, no. 1: 173–77.

- Giraud, E.H. 2019. *What Comes After Entanglement? Activism, Anthropocentrism, and the Ethics of Exclusion*. Durham: Duke University Press.
- Haraway, D. 1987. A Manifesto for cyborgs: Science, technology, and socialist feminism in the 1980s. *Australian Feminist Studies* 2, no. 4: 1–42.
- Haraway, D. 1988. Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies* 14, no. 3: 575–99.
- Haraway, D. 1992. The promises of monsters: A regenerative politics for inappropriate/d others. In *Cultural Studies*, ed. L. Grossberg, C. Nelson, and P.A. Treichler, 295–337. New York: Routledge.
- Haraway, D. 1997. *Modest_Witness@Second_Millennium.FemaleMan©_Meets_Onco_Mouse™. Feminism and Technoscience*. New York: Routledge.
- Haraway, D. 2000. *How Like a Life. An Interview with Thyrsa Nichols Goodeve*. New York: Routledge.
- Harding, S. 1993. Rethinking standpoint epistemology: What is ‘strong objectivity’? In *Feminist Epistemologies*, ed. L. Alcoff and E. Potter, 49–82. New York: Routledge.
- Heisenberg, W. 1927. Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik. *Zeitschrift für Physik* 43, no. 3–4: 172–98.
- Hickey-Moody, A., H. Palmer, and E. Sayers. 2016. Diffractive pedagogies: dancing across new materialist imaginaries. *Gender and Education* 28, no. 2: 213–29.
- Hinton, P. 2013. The quantum dance and the world’s ‘extraordinary liveliness’: Refiguring corporeal ethics in Karen Barad’s agential realism. *Somatechnics* 3, no. 1: 169–89.
- Hollin, G., I. Forsyth, E. Giraud, and T. Potts. 2017. (Dis)Entangling Barad: Materialisms and ethics. *Social Studies of Science* 47, no. 6: 918–41.
- Hoppe, K. 2017. Politik der Antwort. Zum Verhältnis von Ethik und Politik in Neuen Materialismen. *Behemoth – A Journal on Civilisation* 10, no. 1: 10–28.
- Hoppe, K. 2020. Responding as composing: Towards a postanthropocentric, feminist ethics for the Anthropocene. *Distinktion: Journal of Social Theory* 21, no. 2: 125–42.
- Lather, P., and A. St. Pierre. 2013. Post-qualitative research. *International Journal of Qualitative Studies in Education* 26, no. 6: 629–33.
- Latour, B. 1991. *We Have Never Been Modern*. Cambridge: Harvard University Press.
- Latour, B. 2004. *Politics of Nature: How to bring the Sciences into Democracy*. Cambridge: Harvard University Press.
- Latour, B. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.
- Law, J. 2004. *After Method: Mess in Social Science Research*. London: Routledge.
- Law, J. 2009. Actor-network theory and material semiotics. In *The New Blackwell Companion to Social Theory*, S.T. Bryan, 141–58. Chichester: Wiley-Blackwell.
- Law, J., and M.E. Lien. 2018. Denaturalizing nature. In *A World of Many Worlds*, ed. M. de la Cadena and M. Blaser, 131–71. Durham: Duke University Press.

- Lemke, T. 2015. New Materialisms: Foucault and the ‘Government of Things’. *Theory, Culture & Society* 32, no. 4: 3–25.
- Lorenz-Meyer, D. 2014. Reassembling gender: on the immanent politics of gendering apparatuses of bodily production in science. *Women: A Cultural Review* 25, no. 1: 78–98.
- Lumsden, K. 2019. *Reflexivity. Theory, Method, and Practice*. London: Routledge.
- Lynch, M. 2014. Matters of fact, and the fact of matter. *Human Studies* 37, no. 1: 139–45.
- Mauthner, N. 2019. Toward a posthumanist ethics of qualitative research in a big data era. *American Behavioral Scientist* 63, no. 6: 669–98.
- Merten, K. (ed). 2020. *Diffraction Reading. New Materialism, Theory and Critique*. Lanham: Rowman & Littlefield.
- Mol, A. 2002. *The Body Multiple. Ontology in Medical Practice*. Durham: Duke University Press.
- Mol, A., I. Moser, and J. Pols. (eds). 2010. *Care in Practice. Tinkering in Clinics, Homes and Farms*. Bielefeld: transcript.
- Moreau, P.A. et al. 2019. Imaging bell-type nonlocal behavior. *Science Advances* 5, no. 7. Online source: <https://advances.sciencemag.org/content/5/7/eaaw2563/>, last access 25.11.2020.
- Morris, K., and V. Bozalek. 2019. Diffracting diffractive readings of texts as methodology: Some proposition. *Educational Philosophy and Theory* 51, no. 14: 1504–17.
- Myers, N. 2020. Anthropologist as transducer in a field of affects. In *Knowing Knots. Methodologies and Ecologies in Research-Creation*, ed. N. Loveless, 97–125. Edmonton: University of Alberta Press.
- Pickering, A. 1995. *The Mangle of Practice. Time, Agency, and Science*. Chicago: University of Chicago Press.
- Pinch, T. 2011. Review essay: Karen Bard, quantum mechanics, and the paradox of mutual exclusivity. *Social Studies of Science* 41, no. 3: 431–41.
- Pinch, T., and W.E. Bijker. 1984. The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science* 14, no. 3: 399–441.
- Rouse, J. 1996. *Engaging Science: How to Understand Its Practices Philosophically*. Ithaca: Cornell University Press.
- Rouse, J. 2002. *How Scientific Practices Matter. Reclaiming Philosophical Naturalism*. Chicago: University of Chicago Press.
- Schatzki, T., K. Knorr-Cetina, and E. von Savigny. (eds). 2000. *The Practice Turn in Contemporary Theory*. London: Routledge.
- Schmitz, S. 2014. Karen Barad: Agentieller Realismus als Rahmenwerk für die Science & Technology Studies. In *Schlüsselwerke der Science & Technology Studies*, ed. D. Lengersdorf and M. Wieser, 279–91, Wiesbaden: Springer.

- Sellberg, K., and P. Hinton. 2015. Introduction: The possibilities of feminist quantum thinking. *rhizomes* 30. Online source: <http://www.rhizomes.net/issue30/intro.html/>, last access. 14.11.2020.
- Seth, S. 2013. Quantum physics. In *The Oxford Handbook of the History of Physics*, ed. J. Buchwald and R. Fox, 814–859. Oxford: Oxford University Press.
- Thiele, K. 2014. Ethos of diffraction: New paradigms for a (post)humanist ethics. *Parallax* 20, no. 3: 202–16.
- Treusch, P. 2020. *Robotic Knitting. Re-Crafting Human-Robot Collaboration Through Careful Coboting*. Bielefeld: transcript.
- Trinh, T.M. 1988. Not you/like you: Post-colonial women and the interlocking questions of identity and difference. In *Dangerous Liaisons: Gender, Nation, and Postcolonial Perspectives*, ed. A. McClintock, A. Mufti, and E. Shohat, 415–19. Minneapolis: University of Minnesota Press.
- van der Tuin, I. 2011. A different starting point, a different metaphysics: Reading Bergson and Barad diffractively. *Hypatia* 26, no. 1: 22–42.
- van der Tuin, I. 2014. Diffraction as a methodology for feminist onto-epistemology: On encountering Chantal Chawaf and posthuman interpellation. *parallax* 20, no. 3: 231–44.
- van der Tuin, I. 2019. Deleuze and Diffraction. In *Posthuman Ecologies. Complexity and Process after Deleuze*, ed. R. Braidotti and S. Bignall, 17–40. New York: Rowman & Littlefield.
- Verran, H. 2014. Anthropology as ontology is comparison as ontology. Theorizing the contemporary, *Fieldsights*. Online source: <https://culanth.org/fieldsights/anthropology-as-ontology-is-comparison-as-ontology/>, last access 20.11.2020.
- Viveiros de Castro, E. 2014. *Cannibal Metaphysics*. Minneapolis: Minnesota University Press.
- Whitaker, E., and P. Atkinson. 2019. Reflexivity. In *SAGE Research Methods Foundations*, ed. P. Atkinson, S. Delamont, A. Cernat, J.W. Sakshaug, and R.A. Williams, <https://www.doi.org/10.4135/9781526421036819785>, last access 25.03.2021.
- Winner, L. 1980. Do artifacts have politics? *Daedalus* 109, no. 1: 121–36.
- Woolgar, S. 1986. On the alleged distinction between discourse and praxis. *Social Studies of Science* 16, no. 2: 309–17.
- Zienkowski, J. 2017. Reflexivity in the transdisciplinary field of critical discourse studies. *Palgrave Communications* 3, no. 17007, <https://doi.org/10.1057/palcomms.2017.7>, last access 25.03.2021.

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