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SIMONDON AND BOHM BETWEEN DETERMINISM AND INDETERMINISM

ABSTRACT
The radical redefinition of the landscape of physics that followed the contributions of Niels Bohr and Werner Heisenberg at the start of the 20th century led to plethora [of] new perspectives on age-old metaphysical questions on determinism and the nature of reality. The main contention of this article is that the work of Gilbert Simondon – whose magnum opus possesses a scope uniting the most basic philosophical concerns with the (then) most recent breakthroughs in natural sciences – is highly relevant for an adequate understanding of the split between determinism and indeterminism, as well as the underlying presuppositions which have driven some influential contributions to this topic. To this end, the article shows that the more deterministic interpretation of quantum mechanics offered by David Bohm and Louis de Broglie proves to be a valuable reference point for a more precise use and understanding of Simondon's transductive logic – especially when its philosophical lapses are considered closely. Finally, following the considerations of both thinkers, we aim at a more precise reconsideration of the stakes of indeterminism in modern physics, as well as a restructuration of what is often understood as a polarization.

KEYWORDS
Simondon, Bohm, quantum mechanics, determinism, indeterminism, substance, relation, transduction

1. Introduction

The perplexity with which *A Thousand Plateaus* was met in France upon its publication in 1980 will hardly go on to perplex us today – a text of such density or, even better, of such an erratic interdisciplinary approach exhibited on almost every page was bound to hit a stonewall with the readers. The fact that we are now in possession of thousands of pages of scholarly inquiry into the subject matter(s) of the book and that the range of its sources is much clearer to us – namely: biology, psychoanalysis, geology, linguistics, literature, sociology, chemistry, etc. – cannot possibly produce a feeling of being-at-home or even familiarity; what we rather feel is a profound sense of being dislodged

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or simply lost within the invisible, meandering roads Gilles Deleuze and Félix Guattari have pointed to. However, incorporating a variety of (scientific) disciplines into a single book of philosophy was not new at the time; a similar book, albeit more combed-through, had already been published more than fifteen years before, Gilbert Simondon's *Individuation in the Light of Notions of Form and Individuation*. The reasons for an even slower reception of this work (which is still sluggish in comparison to our first example) are numerous: a long-overdue translation, an ancient and deeply metaphysical concern at its heart, the highly technical elaboration of seemingly tangential aspects which takes up a large chunk of the book are only the first which come to mind. This should not put us off, however, since there is no reason to belittle the importance of this work – which takes into consideration both primarily ancient concerns (the critique of hylomorphism, substantialism, and atomism, among others) *and* questions about emergence, life, the human-animal difference and technology from the point of view of physics, chemistry and biology with rarely matched erudition – in comparison with the work which is often hailed as a product of creative genius, or praised for its rhizomatic implications and lines of flight. From the biological line of flight, which meticulously tracks the individuation of living organisms from inert matter and observes how colonies formed by the most primitive forms of life can be juxtaposed with the collective individuation of humans (Simondon 2020: *276*, *357*, *395*), to mineralogical considerations on the development of crystals which offer insights into how pre-individual reality effects further individuation and how the latter is fueled by energetic changes and structural shifts (Simondon 2020: 70), *Individuation* lets us get a glimpse of how life and things become and how they are related to what is exterior to us.

All of the abovementioned problems have certain kinds of solutions (or, at least, attempted ones) in their corresponding scientific disciplines, and underlining the import Simondon's analyses have for grasping the ontological-problematic ground upon which these particular scientific questions are developed strikes us to be of exceeding importance at a point where he could well be mistaken to be a philosopher of technology. This is why we are going to consider the paradigm with the largest ontological potential in *Individuation* – that of physical theories and, more specifically, quantum mechanics (QM). Namely, we are interested primarily in the crossroads at which Simondon found himself in the mid-1950s: between Niels Bohr's "orthodox" interpretation and the pilot-wave interpretation represented by Louis de Broglie and David Bohm. To this end, we will examine Bohm's philosophical work on wholeness, qualitative infinities, and determinism and how this might help us understand Simondon's philosophical work outside the scope of the chapter dealing with QM. Finally (but also throughout the text) we are going to look into the two main philosophical implications which arise from the previous two points – both of which are ontological: the question of (anti)substantialism and (in)determinism – and how Simondon himself reasons through the complex relation between them. After establishing this solid comparative basis which is supposed to help

us understand the stakes of the debate between determinism and indeterminism in QM, we will turn to Léon Rosenfeld – one of Bohr's closest pupils – in hope of clearing up Simondon's philosophical choice and proposing a slightly reformed view of the debate at hand and its relation to the initial rejection of the substantialist position. The very nature of our initial remarks should have pointed the reader in the preferred direction when it comes to the object of our concern: it should be clear that we are not trying to make judgments regarding the validity of the abovementioned renderings of quantum phenomena, but rather that we are trying to unearth the philosophical impasses that might occur when one fails to pay close attention to the concepts one is employing to hastily get the desired outcome. As Rosenfeld succinctly put it, "the crucial issue is one of logic, not of physics" (Rosenfeld 1979: 476). This is why Bohm's propositions inside the domain of theoretical physics deserve to be immediately put under a spotlight that might just be strong enough to enable us to discern their *philosophical* presuppositions; it is precisely this initial pointer that we see as the *implicit* kernel to grasping the reasoning behind many of Simondon's conclusions.

2. Bohm's Double Solution

The "atypical" character of Bohm's earliest general presentation of the leading interpretation of quantum mechanics (as given in his first book, *Quantum Theory* [1951]), which took seriously the importance of a historical approach to the problematic that would forever go on to be associated with Bohr, has not been noted in vain (Jacobsen 2012: 272). Indeed, even if this approach, which favors adding historical context to the theory at hand, is dissociated from pure mathematical formalism that is commonplace in textbooks, the value of adding the former to the latter when dealing with QM is hard to overestimate. Half a decade later, in his *Causality and Chance in Modern Physics* (1957), Bohm did not fail to remember the weight of the history of ideas and philosophical presuppositions that threatens to undermine any physical, epistemic, or ontological inquiry if left unaccounted for. It is no surprise, then, that he spends the better part of the book establishing the arguments behind a predominantly philosophical disagreement – that between determinism and indeterminism. Before we recount the opposition (as seen from the point of view of Bohm), it is worth mentioning that the determinism which interests us tends to favor Spinoza's initial concern, rather than that of Leibniz.[1] Even though the work

1 It should be noted that our (perhaps facile) opposition is at odds with certain influential interpretations of Spinoza's work that appeared in the second half of the 20th century in France (Matheron 1988, among those we mention below). Whether the passage from the strictly ontological concern of the first part of the *Ethics* to the ethical/political concern of parts three to five is seen as a "conversion" or a "reorientation of its objectives" (cf. Macherey 1997: 8–9) or as showing no discontinuity (Balibar 2020: 3ff), it is certain that the overarching concern of the first part needs to be explored in order to pass onto other, social concerns. Although a discussion of the relation between

of both thinkers can be said to carry the implications of their position in (what we now know as) the determinist/indeterminist debate, their concerns are significantly different; in order to juxtapose them, we will borrow a quote from Leibniz and use it to differentiate between "*metaphysical* necessity, which leaves no place for any choice, presenting only one possible object, and *moral* necessity, which obliges the wisest to choose the best" (Adams 2004: 22). Thus, the question of contingency and necessity in the pages that follow does not pretend to address the problems of compatibilism, free will, God's choice, etc. On the contrary, we maintain that these questions cannot be sufficiently dealt with if we have somehow managed to abstract them from their fundamental problem – that of contingency and necessity (that is, causality and chance) of physical phenomena.

Notwithstanding Bohm's curious attempt to account for the intricacies of the path of determinism from Laplace's mythical formulation – mythical, not only because of its content but also because of its importance for the generations of physicists to come – to what is commonly seen as its overturning in Heisenberg's uncertainty principle and Bohr's complementarity, his position seems to be precarious enough to warrant its own stepping away from mathematical formalism. In fact, Bohm's dissatisfaction with the state of theoretical physics at the time of writing his first textbook can largely be explained by the conceptual rift caused by the accepted probabilistic rendering of quantum phenomena (to which he refers as the "*usual* interpretation") on the one hand, and the relativistic theories that consider the former to be incomplete (at first presented by the famous Einstein-Podolsky-Rosen paradox) and offer a hidden-variable solution to "resolve" this incompleteness, on the other. However, the latter part of this 20th-century split can largely be understood as

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ontology and politics – a discussion which Balibar flattens, as it were, despite his efforts to make the two coextensive and mutually implicative – goes beyond the scope of this article, it is doubtful that the problematic can be done away with easily, especially in light of Balibar's comments regarding Simondon's transindividuality and its relation to Spinoza and political thinking (Balibar 2020: 45, 139). In these comments, we see again (the only difference being that the work at hand is now Simondon's), an intersection of ontological and political efforts being turned into a single road. The result, however, is a patent criticism of Simondon and his supposed unwillingness to integrate politics within ontology and to think the two as if they were one. In a recent enquiry, Daniela Voss (2018) has shown that such a move is impossible for Simondon in that it misappropriates the tenets of latter's ontology: namely, non-linear and problematic differentiation which, in fact, "*can* accommodate politics", albeit without reducing the import of ontology. A similar conclusion, more aligned with our implicit understanding of the Simondon/Spinoza convergence, was presented by David Scott who argues that Simondon completes Spinoza's project qua "*ontologisation* of ethics, where ethics is expressive of the constitutive ontology of individuation" (Scott 2017: 569). As such, parts of this essay can be seen as seeking to rectify an all-too primarily political image of Spinoza through the mediation of Simondon's work and its ability to institute the New in an immanent, ontological way, that is, without having recourse to historical/political events. Criticizing Bohm's understanding of qualitative infinity and showing that its completion is to be found in indeterminism is only one way of doing this.

a reemergence of a previously well-established effort: in other words, the deterministic endeavor of EPR that tends to favor an understanding which sees reality as fundamentally complete and which envisions the possibility of at least a hypothetical "final theory" (whether or not it thinks this final theory as *actually* obtainable should not concern us, according to them [Bohm 2016: 68, 91]), is a modern-day call for a reality which is devoid of any frames of reference, a "nostalgia for that blissful situation where reality itself seems to dictate the categories of its definition" (Stengers 2012: 42). It is no secret that Bohm was, at least in the early days of his theoretical work, one of the most promising additions to the theoretical conjunction which wanted to oppose the "orthodox" interpretation by offering a "causal [and deterministic] reinterpretation of quantum mechanics," as de Broglie put it in his preface to Bohm's *Causality and Chance* (Bohm 2016: xi). Should we see Bohm as a simple advocate of a determinist view, then? The image is not so clear, however, because the interest in Bohm's work and its dual aspect (that will become clear as we consider his mature work) would not be nearly as strong if his position were reducible to a simple binary choice between Bohr and Einstein.

A closer reading of the debate that he positions at the heart of 18th and 19th-century physics shows that this debate is no more binary than that which we saw unfold in more recent times: reducing every attempt at a causally deterministic conception of the world to a mythical elaboration which is grounded in a supposed metalinguistic intellect (à la Laplace), as well as reducing every attempt at privileging chance over "hard", causal necessity to an "absolute arbitrariness and lawlessness in the detailed behavior of individual phenomena" (Bohm 2016: 42) is certainly an irresponsible philosophical reading which borders on reductionism. It is in the sense of constantly trying to move away from both of these options – he equally rejects "*perfect* one-to-one causal relationships that could in principle make possible predictions of *unlimited* precision" (Bohm 2016: 13) as well as absolute contingencies with no possibility of prediction – that Bohm falls into an analogous reductionist trap necessitated by making possible a delineation of his own position. In order to nuance his own contribution, he makes a rigid opposition between *deterministic mechanism* – pertaining to classical physics from Laplace to Bohr – and *indeterministic mechanism* which is simply the former's reverse and which remains caught in the trap of mechanism. Bohm then argues that the usual interpretation of QM makes virtually no progress in relation to its mechanistic predecessor: "The assumption of the absolute and final validity of the *indeterminacy principle, which implies that the details of quantum fluctuations have no causes at all*, evidently resembles very much that [assumption] underlying the philosophy of indeterministic mechanism" (Bohm 2016: 68). It is at the cost of the reduction of the former to the latter that Bohm manages to revive de Broglie's envisioned alternative to QM which was rejected at the Solvay conference (Simondon 2020: 140) and which supposedly lay dormant under the boot of the oppressor – the so-called indeterministic mechanism.

Even though Bohm never refers to de Broglie's theory as the "double solution" (which is the name de Broglie uses for his reinterpretation), it is clear that a proposal of this kind fuels both his own position regarding the determinist/indeterminist debate – he warns that "the causal laws and the laws of chance *together* are what bring about the actual development of things, so that *either of them alone is at best a partial* and approximate representation of reality, which eventually has to be corrected with the aid of the other" (Bohm 2016: 19) – and his rejection of the principle of complementarity – "it is evidently possible that in any given process, *both wave and particle could be present together in some kind of interconnection*" (Bohm 2016: 76). Thus, Bohm is primarily attacking the (epistemo)logical tenets of Bohr's idea of complementarity in hope of striking at the roots of the usual interpretation itself and allowing himself to introduce two concepts which are supposed to persuade anyone out of still thinking in terms of probabilistic calculations and their absoluteness. These two ideas include (1) the supposition of a sub-quantum level (which is the most profound expression of EPR's idea of hidden variables in Bohm's theory) and, as a direct correlate of the principle which allows Bohm to even propose such a level, (2) the conception of reality as a product of a *qualitative infinity* of phenomena and potentials. The former of the two, the supposition of a sub-quantum level, is a modification of the hidden variable supposition which had been presented as a solution to the incompleteness of the Copenhagen interpretation: Bohm contends that we might be able to escape thinking reality as incomplete if we put forward a hypothesis which would allow a furthering of our physical inquiries into the nature of reality, a hypothesis which would postulate the existence of a further layer that is accessible to us, probably below the dimensional order of 10^{-13}. Discussing whether or not this idea is "defensible" or simply impossible (de Broglie 1958) will be left for later, since we are now primarily interested in the philosophical implications and causes of such a postulation: namely, the rejection of any kind of finality and absoluteness when it comes to definable theories and a self-perpetuating infinity of qualitative phenomena observable (or thinkable)[2] in nature. As we said earlier, an openness to infinity which is always able to find and think

2 Bohm writes that the "thesis [that we should not postulate the existence of entities which cannot be observed by methods that are already available] stems from a general philosophical point of view containing various branches such as 'positivism', 'operationalism', 'empiricism', and others, which began to attain a widespread popularity among physicists during the twentieth century. Since we do not yet know how to detect the new entities that might exist in the sub-quantum mechanical level, the point of described above leads us to refrain from even raising the question as to whether such a level exists. [...] As an alternative to the positivist procedure of assigning reality only to that which we now know how to observe, we are adopting in this book a point of view [...] which we believe corresponds more closely to the conclusions that can be drawn from general experience in actual scientific research. In this point of view, we assume that the world as a whole is objectively real, and that, as far as we know, it has a precisely describable and analyzable structure of unlimited complexity" (Bohm 2016: 66–67, added emphasis).

phenomena that are unaccounted for in the current theory, as well as change the context or the conditions under which certain phenomena can be found (thereby causing a chain-reaction of possible reformulation of our theories given even the slightest change of conditions) seems to be the leitmotiv of Bohm's early work on his own interpretation of QM. To be sure, he is not speaking of complementarity between a qualitative infinity and the sub-quantum level; rather, he is offering a double solution that hinges on both of these *existing harmoniously at the same time*, and which presupposes a mutual dependency of the two: *there is no sub-quantum level without the possibility of thinking a physical infinity, and the physical infinity does not exist if we do not envision going further and further*.

To say that this reinterpretation is final goes against both the methodological imperative of avoiding absolutization and Bohm's explicit proclamations regarding the possible downsides that the reinterpretation brings; however, the fact that Bohm is quick to disregard even the criticism which belongs to physics since he considers "these theories [only] as something definite *from which it may be helpful to start*" (Bohm 2016: 87, added emphasis) shows a deep-seated disregard even for the philosophical contentions that could be raised against his theory. Saving the obvious criticism of the sub-quantum level being only a "seductive construction" (Rosenfeld 1979: 475) for later, and further disregarding the equally possible outcome that the sub-quantum level could lead to even more indeterminism if left in this insufficiently defined state, we find it urgent to raise the question of infinite regress that is almost guaranteed when a nostalgic search for more rigidly deterministic laws is charged by a qualitative infinity – and a qualitative infinity which is supposed to function only in the bounds which suit our objective, at that. Such a question is urgent not only because of the fact that it is the only one that Bohm explicitly raises in considering the possible reproaches to his theory, but also because it seems to us that the possibility of infinite regress follows Bohm into a major (albeit silent) reconsideration of the double solution which has the power to completely change his current thoughts on the determinist/indeterminist debate. Indeed, as we have stated, Bohm explicitly rejects any criticism of his system of scientific inquiry being infinitely regressive (Bohm 2016: 95), but even his rejection is built on either an arbitrary reduction – infinite regress only functions if the same pattern is identifiable on every level – or a further hypothetical which bets on the possibility that the general pattern which was observable in nature (that of layers which are found beneath other layers) would be exchanged for some other pattern at some point. The obvious vagueness of the latter point is similar to the one which can be observed when the existence of the pre-quantum domain is supposed, and the former simply invents the condition of following the same pattern which does not apply to the general definition of what regress is – "a series of appropriately related elements with a first member but no last member, where each element leads to or generates the next in some sense" (Cameron 2018). Thus, whether or not the same pattern is followed from the 1st to the nth layer and whether the general pattern of

layering is followed is irrelevant for arguing against the reproach that Bohm mounted against himself.

His arguments notwithstanding, it seems that the necessity of establishing a more deterministic outlook which called for contriving two interconnected concepts – the sub-quantum layer and qualitative infinity – brought Bohm to an internal impasse: on the one hand, conceiving of reality as a qualitative infinity was the only way of establishing a sub-quantum level, while, on the other hand, this same qualitative infinity proved infinitely regressive and dangerous for the very concept it helped introduce (dangerous both logically and substantially). The statistical game (played by Laplace) which proved to be one step closer to seeing its downfall with every further fragmentation of knowledge (in science generally and physics particularly) is once again accepted by Bohm's infinitely regressive method, and finds itself once again on the wrong side of history. If the double solution, which saw itself somewhere in between determinism and indeterminism, has been tolerable, it now proves unbearable in so far as the full implication of the notion of qualitative infinity has been understood. Something in Bohm's theory needed to change – it was either going back to indeterminism or conceptually renouncing qualitative infinity.

3. Bohm's Substantialist Spinozism

The concept which takes center stage in *Wholeness and the Implicate Order* (which can be seen as Bohm's anthology) is that of wholeness. As this holistic approach has been assimilated to the philosophies of Spinoza (cf. Rocha, Ponczek 2018) and Deleuze (cf. Gualandi 2017; Murphy 1998) in quite a similar way, we will proceed towards finding an answer to our last problem by questioning the validity of both comparisons. The main thesis Bohm presents in relation to his holistic rendering of reality is apparently simple: divisions, categories, and dichotomies – whether social or scientific – which are ever-present in our day-to-day reality are false representations of this same reality in so far as it equates *categories that are necessary for thinking* with *the nature of the world itself*. In other words, Bohm distinguishes epistemic categories from ontological ones by distinguishing "the content of our thought [from] 'a description of the world as it is'". Rather than making this mistake, he continues, we should make an effort to understand the world as "an undivided whole in flowing movement", a whole which is "real, and that fragmentation is the response of this whole to man's action, guided by illusory perception, which is shaped by fragmentary thought" (Bohm 2013: 9, 14). Mapping such a conception of the world to Spinoza's unique and indivisible substance presents no problem, if the whole is immediately understood as Spinoza's substance, the infinite possible fragmentations as infinite attributes (cf. D6 of the first part of *Ethics*, which also matches Bohm's later conception of the implicate order) and Bohm's earlier "return of the lost determinism to the microscopic world" finds its correlate in Spinoza, "for whom there is no contingency in nature" (Rocha, Ponczek 2018: 15–16). However, curiously enough, Spinoza seems to think that determinism

is ultimately compatible with a qualitative infinity *of one substance*. To us, this seems like an untenable position given our discussion of the fundamental impasse that one arrives at when one takes the route of qualitative infinity in order to get to determinism. To be sure, we have emphasized that Spinoza's qualitative infinity is that of (one) substance due to the fact that one of the tenets of Spinoza's philosophy is precisely this infinite explication of *the* substance, and not an infinite qualitative explication in general, which would imply a pluralism with a Spinozist/expressionist twist. As Deleuze puts it: "*The One remains involved in what expresses it*, imprinted in what unfolds it, immanent in whatever manifests it: expression is in this respect an involvement" (Deleuze 2013: 16). The involvement of the One in the infinity of its expressions is nowhere to be found in *Causality and Chance* since the double solution (which nonetheless renounced complementarity) gives no pointers to what its underlying ontological structure is like – what's more, it could probably be postulated that it is much closer to a (wave-particle) *dualism* than a dual-aspect monism of the later work. An attentive reader of Bohm would have noticed that his *Causality and Chance* mentions wholeness only in the preface which was written with a delay of almost thirty years, while his supposed anthology makes abundant use of the concept *even when it speaks of incorporating newness in the existing, all-encompassing whole*, i.e. when it speaks of veritable qualitative infinity (Bohm 2013: 198). The difference between the two Bohms is, of course, the fact that the previously utilized concept of qualitative infinity cannot be grasped in its full implication (which, we remember, involved the very real danger of infinite regress) when it is subjected to the Spinozist undivided whole. Thus, Bohm reduces the infinite potential of a veritably boundless infinity – which had threatened to undermine determinism through its flirtations with infinite regress – to an infinite potential under the surveillance of One substance or wholeness. The fact that this wholeness is still labeled as boundless and infinite is only a ruse, in so far as a primarily determinist and substantialist conception of the world precludes a veritable infinity or multiplicity.

In light of these convincing parallels between Bohm's holistic approach and Spinoza's philosophy *and* Spinoza's profound influence on Deleuze, one could naturally wonder – and some did – what possible parallels would arise when the works of Bohm and Deleuze were to be juxtaposed. Following this line of inquiry, Alberto Gualandi writes that "with Bohm, as well as with Deleuze, the privileged metaphor is the Heraclitean one of an incessant flux of being, where *everything that is* becomes" (Gualandi 2017: 298); moreover, earlier in the same paper, he equates the previously mentioned *undivided whole in flowing movement* with *univocal being in becoming* (Gualandi 2017: 284). However, these two parallels are by no means the same, and the fact that Heraclitus serves as a conceptual stepping stone for both thinkers' conceptions of reality as fundamentally becoming (Bohm 2013: 61)[3] cannot lead to eschewing the

3 Also cf. Gilles Deleuze, *Leibniz and the Baroque*, lectures 12–15 (March 10 – April 28, 1987).

pains Deleuze took to differentiate univocity from simple holistic monism that is found in Bohm. It is our contention that this opposition underlies the one we pointed to above: namely, between an expressionist view that subordinates the substance to the modes and the Bohmian account that privileges the unity of substance. This differentiation points to the fact that, as Daniel W. Smith notes, "it is precisely the 'immanence' of the concept of Being (univocity) that prevents any conception of Being as a totality" (Smith 2012: 305). In fact, if we are to follow Deleuze's reading of Spinoza that undoubtedly informed his concept of difference in *Difference and Repetition*, we quickly realize that the short quote from *Expressionism in Philosophy* takes on a double sense: the one we have given above, the one which informed the perhaps facile connection Ponczek and Rocha established, is the reading that pays no attention to the conceptual shifts inherent in Deleuze's account, while the one we are about to give follows Deleuze's own formulation of Spinoza and grasps the One in a univocal *manner*.

With these distinctions in mind, whether or not we accept Deleuze's reading of univocity – "not that Being is said in a single and same sense, but that it is said, in a single and same sense, *of* all its individuating differences or intrinsic modalities [, that B]eing is the same for all these modalities, *but* [*that*] *these modalities are not the same*." (Deleuze 1994: 36, emphasis added) – has the power to determine completely whether or not Bohm is a Spinozist or, even better, whether or not Deleuze can be taken to be one. Even though it might seem that Deleuze's definition of univocity is dependent on the result of the expression of Being – i.e. that the only difference is in the finite modalities which result from this expression – this reading only serves to bring the abjured reading of difference through the back door; rather than focusing strictly on the finite modes, Deleuze's univocity considers the very sense of expression and goes toward reformulating the presupposition – the question of what the One really *is* (or, to be more precise, *that* it *is not*). Thus, Deleuze ends up formulating a "Spinozism minus substance", as Smith masterfully called it: the One loses the substantiality it had in the commonsensical reading and "the single *sense* of Being frees *a charge of difference* throughout all that is [i.e. throughout all the finite modes and their intensive variations – AJ]" (Smith and Protevi 2020). The sketch for a threefold history of the concept of univocity given in *Difference and Repetition* (Deleuze 1994: 39–42) shows this in that the modification effectuated between the second and the third moment (i.e. between Spinoza and Nietzsche) concerns turning substance around the modes, and solely around the modes – a procedure that brings an undoing of substance in its usual sense and the advent of a differential substance, an accidental namesake of the former. It is precisely because of this change whose importance cannot be overstated that Deleuze could go on to remark, twenty years after the publication of *Expressionism in Philosophy*, that "what interested [him] most in Spinoza wasn't his Substance, but the [process of] *composition* of finite modes" (Deleuze 2013: 11).

There now seem to be two contradictory Spinozas: one whose One is a substance that is expressed (and, as Bohm would say, implicated) in each finite

mode (but that does *not* around these modes), and the other whose One is a *sense* (or manner) of Being, an expression which can only be understood as a self-differentiating process whose (un)folding does not imply (substantial) wholeness, as it is understood in Bohm (Bohm 2013: 186). In short, it is a question of a more traditional and an upside-down Spinoza; however, the difference between them is not reducible to mere reversal (it is not simply a matter of seeing what comes first, and what second: the substance or the modes), but implies a broader theoretical choice between substantialism and an outlook that seeks to pull the carpet under substantialism and see what is beneath it. Evaluating the validity of both of these readings (for the sake of Spinoza himself) is beyond the scope of this article which is only now beginning to reach its real concern: namely, the relation of Simondon's radical anti-substantialism (which does not claim to be Spinozist) to his choice in the debate regarding the nature of physical reality with which we started. Additionally, it is crucial to keep Simondon's philosophical context in mind and present the debate as it would have appeared to him. In order to do this, we are going to need to consider our initial question from the reverse side, that is, see how Simondon opposes substance first in order to arrive at his own conclusions regarding the determinist/indeterminist debate.

4. Simondon's Theoretical Choice

The fact that we purposefully chose to emphasize that Simondon chooses to go on an anti-substantialist path *without* Spinoza (something which might seem very hard to do when we have fully understood the importance of univocity for thinking difference) has a double significance: first, it wants to show that Simondon's concern – establishing a philosophy which manages to think the process of individuation, rather than an already constituted individual, that is, ontogenesis and not being which is static and stable – is initially different from that of Deleuze;[4] secondly, it allows us to immediately enter into the heart of Simondon's problematic precisely by using as an example that which he opposes. Although Spinoza is not one of the philosophers with which Simondon is in constant conversation in *Individuation*, the latter is sure to denounce the former's "substantialist monism" because it "comes against a great difficulty when it is a question of accounting for the individual being" (Simondon 2020: 368). For Simondon, thinking the ontogenesis of an individual being and avoiding conceiving of the individual as already constituted means "*to know the individual through individuation rather than individuation starting from*

4 Deleuze, for his part, appropriates Simondon's path and method during his discussions of individuation and dramatization (cf. Deleuze 1994: 246; Deleuze 1990: 104, 344), the two processes which prefigure the advent of actually constituted terms (Deleuze 1994: 251) and which are wholly dependent on modal and formal distinctions (Deleuze 1994: 39) introduced by univocal thinking (the constellation of Duns Scotus, Spinoza and Nietzsche).

the individual [... For him,] it is necessary to reverse the search for the principle of individuation by considering the operation of individuation as primordial, on the basis of which the individual comes to exist" (Simondon 2020: 3). In providing an alternative to substantialist atomism as well as Aristotelian hylomorphism, Simondon refers to the logic of transduction in hope of successfully thinking without the constraints of stability, eternity, unneeded abstractions and, most of all, loaded ontological notions which fail to consider ontological processes. Transductive logic – "a process whereby a disparity or a difference is topologically and temporally restructured across some interface" (Mackenzie 2002: 25) *without its inherent antinomy being diminished through this restructuration* – which can also be understood as Simondon's own way of reformulating what a *synthesis* should be (Simondon 2020: 111), introduces a veritable alternative to every concept which has plagued philosophy since its ancient beginnings. This alternative concept is that of *relation*. Indeed, since no being which is necessarily becoming has a static presence, it must exist both through relating to things in its milieu (or its exteriority) and its own self; this is how Simondon postulates that relation has "the value of being" (Simondon 2020: 76).

Although Simondon's concern is almost entirely philosophical when its initial postulates and goals are set in this way, it is no secret that the implications of such ideas are both carried from and applicable to various endeavors of modern science. For example, an anti-substantialist position such as Simondon's would have certainly been (physically) untenable and, what's more, philosophically idealistic for a long time; when Simondon reproaches substantialist materialisms such as those represented by the hylomorphic schema and *atomism*, he is not going against the still-predominant materialist grain and opting for an idealism of sorts.[5] Rather, as we have tried to show by highlighting his trans-disciplinary approach in the introduction, his ideas are heavily informed by the most recent breakthroughs in science (at the time) and especially by physics. Simondon himself was perfectly aware of the debt he had towards physics and the paradigm shift which allowed him to definitively move away from substantialist systems by proposing a positive alternative (that of relation); he writes that "the notion of discontinuity [which came with nineteenth-century physics and which enriched the particle with relations] must become essential to the representation of phenomena in order for a theory of relation to be possible" (Simondon 2020: 98). Indeed, now it is the atomist conceptions that are idealist, in so far as they, as Jacques Garelli put it in his foreword, fail to consider the "caveats of Bohr and Heisenberg" when they "continue to conceive of quantum particles as infinitesimal first substances with an autonomous reality" (Simondon 2020: xix). Furthermore, Garelli's astounding perceptiveness which led him to posit the quantum problematic as one of the few leading concerns in Simondon's entire oeuvre – something

5 We are here referring to idealism as it might have been conceived by a positivist or an empiricist.

which other commentators (e.g. Scott 2014; Combes 2013) have failed to do,[6] causing damage to our understanding of Simondon's work – reassures our initial postulation that examining the physical paradigm might be more beneficial than examining the others. As such, we can identify that the concern which we deemed "entirely philosophical" might also be able to give its fair share of contributions to the realm of theoretical physics and the subversive logic which fuels its 20th-century postulations. In light of this renewed bond between philosophy and physics, we could postulate that the principle of complementarity should be extended even to this bond, in so far as complementarity is not to be understood as only a borrowed analogy, but rather as a "more flexible framework which [it] offers for possible syntheses" (Rosenfeld 1979: 481). Thus, we have arrived at a point that can be seen as the central mediator between QM and Simondon's own philosophy: the methodological commensurability between the synthetic logic of transduction and the equally synthetic view which is able to see complementarity where up to then only discordance was found. It is in this sense that Simondon is led to write that "only a transductive logic has made the development of the physical sciences possible [...]. [There, wave and particle are] not truly synthesized, like those of thesis and antithesis at the end of dialectical movement, but instead are put into relation due to a transductive moment of thought" (Simondon 2020: 111). At this point, Simondon is still sticking to the "orthodox" interpretation of QM, since the interconnectedness of the double solution of de Broglie and Bohm does not adhere to the relational aspect of Bohr's transductive complementarity.

Staying faithful to his own transductive methodology carries with it an exigency of considering the other breakthrough which also fundamentally changed the horizon of modern physics – relativity theory (RT). For Simondon, the theory of relativity seems to come from the same paradigm shift which allowed physics to think in non-atomistic, anti-substantial terms we mentioned above, but he also states that relativity theory manages to – apart from "merely" introducing discontinuity – "find this *beginning* of a discovery of compatibility between [...] the representation of the continuous *and that of the discontinuous*" (Simondon 2020: 128). This leads him, once again, to express the impossibility

6 In their remarkable article that seems to be the rare exception to this trend in scholarship, De Ronde and Bontems investigate the affinity between the Simondonian metaphysical schema of potentiality and one possible interpretation of QM (De Ronde, Bontems 2019). As they argue, Simondon's transductive hypothesis, in its aim to consider the process of individuation as being irreducible to well-constituted, formed individuals, must abandon the ontology of substantialism and move toward a different schema of potentiality that is irreducible to entities. They claim, in confluence with our conclusions, that Simondon's intuition regarding his realistic non-substantialist interpretation of QM was basically correct, but that his presentation is misguided in so far as it analyzes de Broglie and Bohr the most. In the remainder of our article, we intend to show that Simondon's conclusions are correct *despite* his misguided presentation and that it is the misguided presentation that helps us see its own insufficiency compared to Simondon's metaphysical schema.

of isolating an atom from the effects of other atoms, as well as further proof for the essentially relational existence of an individual:

> The mutual isolation of atoms, which for ancient atomists was a guarantee of substantiality, cannot be considered absolute [...]. In this substantialist atomism, shock can modify the state of an atom's movement or rest but not its own characteristics, like mass; however, if mass varies with speed, a shock can modify the mass of a particle by modifying its speed; *the accidental, totally fortuitous encounter affects substance*. (Simondon 2020: 131)

It is in this difference between QM and RT – which Simondon identifies by a slight conceptual change between complementarity and compatibility (the latter of which, as we will see, leads to a double solution, à la de Broglie) and by introducing the repressed continuity in the same breath as discontinuity – that Simondon finds a way of making plausible (at least for now) *anti-substantialism and determinism* in a single theory. The subtlety of the argument (and its goal) presented in this chapter of the work is certainly bound to confuse the reader, not least of all because of the unusual chronology that is employed throughout the presentation; the importance of reintroducing continuity – which we identified as hitherto repressed in QM – becomes clear, however, when Simondon states (only a few pages later), that "this relativistic doctrine [...] is realist without being substantialist" (Simondon 2020: 133). Thus, even though he categorically goes against Bohm's later prohibition of fragmentation (or, at least, against its "relegation" from ontological categories to those of epistemology) by affirming discontinuity, Simondon is found by and large to be in front of a similar rift between Bohr's probabilistic interpretation of QM and EPR's impetus to find a more deterministic explanation (the difference being, of course, that Bohm is thinking from a standpoint which is more prone to determinism and EPR's suggestion, and Simondon's concern is primarily that of not giving up anti-substantialism, that is, of not giving up relational ontogenesis). The return to quantum mechanics (Simondon 2020: 149) that Simondon makes after considering both the "orthodox" interpretation and relativistic theory is led strictly by a wish to conceive of reality more "realistically" – while maintaining anti-substantialism, no less – and his path is lit solely by the rift described above – a rift between an insufficient quantum theory and an example given by relativity (that thinking can be done both in terms of anti-substantialism and determinism). This return is not necessarily envisioned as an excavation of a sub-quantum level, but a consideration of de Broglie's double solution.

The unusual speed with which Simondon passes *from* praising the transductive properties of Bohr's complementarity and the remarkable conception of discontinuity in the Copenhagen interpretation *to* a general disdain for theories of Bohr and Heisenberg must be noted; the fleeting appearance of particles, which he identifies as the main upshot of complementarity and Heisenberg's uncertainty principle, is dismissed along with what is now *explicitly* labeled

"an indeterministic and probabilistic theory" (Simondon 2020: 150).[7] The reversal through which complementarity loses the fruitfulness needed to maintain its "fidelity to the real" is only the beginning of a chain-reaction that soon follows: the (relational) dependence of the measured object on the measuring instrument is dismissed, and so is the anti-substantialism of the "orthodox" interpretation ("*In the indeterministic and probabilistic theory, a certain static substantialism of the physical individual remains in the subject*"); finally, relation is understood to *lack* the value of being in so far as it is "independent of terms" (Simondon 2020: 151). The strict dichotomization that Simondon's careful and subtle reading of (at the time very recent) 20th-century physics avoided up to this point is brought back despite its previous prohibitions (which were implemented following the logic of transduction): the fundamentally relational property of atoms that was fostered by both QM and RT is only one of the several joined characteristics which now suddenly found itself in need of picking sides. Due to an addition made by de Broglie that consisted of denying claims to objectivity to any theory which found its (probabilistic) results contingent on measurement and the measuring device itself, the relational property (following the need for staying objective, realistic, etc.) "chose" (in Simondon's eyes) determinism, thereby also bringing with itself anti-substantialism. It is our contention to prove, however, that beyond the obvious criticism that can be erected here – that Simondon's (or de Broglie's) rigid dichotomy is a grand injustice to the methodological principle underlining the entire book – Simondon's approach can also be criticized for failing to take into account the true *relational* nature of the measurement process in quantum mechanics, as well as the underlying supposition of every scientific anti-substantialism. Furthermore, in addition to explaining this second criticism in the third section of the text, we are also going to try to show how Simondon implicitly stays loyal to his method in that he does not accept the strict dichotomy as the final solution, while also showing that both Bohm's detrimental choice and Simondon's non-confrontational choice were needed for understanding the full extent of the application of complementarity to ontological questions of indeterminism and determinism.

As we noted at the end of the previous paragraph, the conclusion that followed a complete reversal of Simondon's views on the split between indeterminism and determinism (which he mapped on the one between QM and RT almost point-by-point) hardly reflected these views themselves; this is why we chose to be careful when ascribing them to him, rather than to de Broglie himself. Nevertheless, as with many borderline cases [*cas limites*] throughout the book – interiority and exteriority, stability and instability, etc. – Simondon chose to apply the logic of transduction in affirming that these borderline cases are untenable in actuality precisely in so far as they are found on the utmost

7 We are quoting Simondon not because these theories should not be considered indeterministic or probabilistic, but rather due to the fact that he has avoided labeling them in this way until this point

points of a pole, that is, precisely in so far as they are idealizations of how far a pole can possibly extend itself. Thus, "determinism and indeterminism [are only] borderline cases", and place should be made for "a new representation of the real that encompasses these two as particular cases [which] should be called the theory of transductive time or the theory of the phases of being" (Simondon 2020: 154). No matter the name, it should be absolutely clear that reflexive transduction calls for a polarization of these terms that is ultimately supposed to lead to a new solution through abstaining from immediate, premature choice. In sum, when confronted with the choice between a substantialist position which promised to lead to a more controllable, predictable outcome in physical calculations, *and* qualitative infinity which precludes the possibility of substantialism, Bohm chose the former; when, led by his anti-substantialist presupposition and a flawed equivalence between this position and determinism (that is, substantialist anti-relationism and probabilism), Simondon had to make a similar choice, he chose *neither*. Our main contention is that a third choice exists and that this choice is precisely that of the transductive method when carried to its conclusions.

5. Relations, Complementarity and the Absence of Polarization

Hardly has there been a concept in the "orthodox" interpretation of QM which caused more strife than that of measurement. The pains that classical physics took to dissociate the observer from the observed in trying to reach objectiveness and definiteness at the same time is almost completely thrown out of the window with the advent of quantum considerations: "a disparity arises between the atomic system we want to observe and the means of observation". Rosenfeld further explains the problematic in this way:

> Now, at this point the human observer, whom we have been at pains to keep out of the picture, seems irresistibly to intrude into it, since after all the macroscopic character of the measuring apparatus is imposed by the macroscopic structure of the sense organs and the brain. It thus looks as if the mode of description of quantum theory would indeed fall short of ideal perfection to the extent that it is cut to the measure of man. (Rosenfeld 1979: 539)

It is on this same stumbling block that Simondon tries to raise his criticism of the "orthodox" interpretation, which can neither be reduced to a Bohmian perspective – the subject-object distinction essential to the process is only a false and fragmentary epistemic category – nor to a mechanistic determinism – measurement only introduces confusion and subjectivism in scientific calculations. His criticism encapsulates both, in a way, and goes further still in that it purports to find a deep-seated connection between the formalism of quantum mechanics and its lifeless, non-relational substantialism. As we have stated above, in Simondon's eyes de Broglie's double solution stays veritably anti-substantial and realist at the same time, affirming once again that it is for *his* conception that "relation has the value of being", and not for probabilism

which must maintain that "the relation is independent of the terms". For Simondon, the fact that the result of measurement in QM is contingent on the very act of measurement is the prime expression of the non-essentiality of relation; in other words, if the relation of measurement is what *externally* determines the probability which is the outcome, the different probabilities which can be obtained in different instances of measuring do not reflect the "thing in-itself", but rather only these *external* relations, and only in formal ways. Thus, no matter how many instances of measurement are numbered, none of them manage to get at the "relationality" which is "essential" to what is being measured. Such a reading which manages to equate the externality of a relation – a relation of measurement or any other for that matter – with pure independence and dissociation is the same mistaken reading which is employed by Arjen Kleinherenbrink in his *Against Continuity*; if we stick to it, we will easily be able to conclude that "entities must therefore have a private, internal reality [... and that they] never fully touch" (Kleinherenbrink 2019: 51).[8] Is this not precisely the definition of metaphysical atomism that disregards every physical breakthrough of the 19th century?

If, for Simondon, the relational properties of being are the ultimate philosophical goal that enables individuation, equating externality and dissociation is a categorically untenable position. But Kleinherenbrink's philosophical rejection of continuity which draped itself in Deleuzian cloth was not essential for grasping the inadequacy of Simondon's reading which, we remember, stems from a rigid dichotomization that necessitated choosing sides. In fact, this inadequacy can also be grasped if we consider the real implications that the revolution of measurement in QM has on questions of objectivity, the externality of relations and formalism in general. Thus, we are first of all led to rectify the situation when it comes to external relations of measurement: the fact that this relation appears unnecessarily external, formalist and artificial to the classical position which accustomed itself to claiming complete dissociation is neither an expression of subjectivity – which would entail the subject/measuring object being the *sole influence* on the properties of the measured object – nor of complete abstraction from the realist position – which is often seen as an exercise of mathematical formalism with no bearing on reality. Slavoj Žižek is quite right in claiming that "whenever we repeat the same act of measurement under the same conditions (the same entanglement of object and apparatus), we will obtain the same result" (Žižek 2013: 932). This claim to objectivity that is often mistakenly denied to quantum mechanics is corroborated by Rosenfeld's seminal essay *Strife about Complementarity*. The realization – quite deadly for a classical conception – that *objectivity* is not the same as *invariance* is essential here: "the two [or *n*] possible interventions of the observer define two [or *n*] different phenomena; to each of these phenomena there

8 It is also worth mentioning that Simondon himself is one of the only thinkers that Graham Harman mentions in the foreword to Kleinherenbrink's book, of course in order to draw a sharp distinction between their thought.

corresponds a well-defined and perfectly objective set of possible predictions" (Rosenfeld 1979: 479). The mythical reading which wanted to claim that no realism or objectivity is possible from a probabilistic perspective is therefore shaken at its most fundamental, classical presupposition; the postulation that a (measurement based on) relation – that is, the linchpin of every anti-substantialist position – bore no significance for the supposed isolated object which is being observed falls with the previous error. If contrary to Simondon (or de Broglie), we understand Rosenfeld's postulate fully, it will become clear to us that quantum mechanics in its "orthodox" interpretation offers the more anti-substantialist interpretation of the two we have been considering in this text.

This becomes painfully clear when we look at one of the discussions in which J.P. Vigier – another proponent of the deterministic interpretation – and Rosenfeld return to their "old quarrel again: does the scientific statement have a meaning outside observers?" In short, the position defended by the former – that which Rosenfeld calls classical (in its beliefs, primarily) – corresponds to that which cannot accept speaking about probabilism and objectivity in the same breath, while the position of the latter understands the importance of a reference point for which the observed object has *meaning*. As Rosenfeld states later: "All the statements we make about the world are necessarily *descriptions of a state of affairs, of mind, of material, that an observer might perceive* if he were placed in those particular circumstances" (Feyerabend, Gattei, Agassi 2016: 289, 293). The implications of this are, as we have been trying to show, *nothing short of anti-substantialist* in so far as the position privileges relations (which are now a *veritable*, objective part of the measured object) as fundamental for calculations, rather than seeing them as static parts of *being*s understood in the abjured ontological sense. Without stating the affair, there is no *meaningful objectivity* (Stengers 2011: 55).

The short-lived disregard for the principles of transduction and a lack of understanding of what Bohr's reformulation of measurement truly entails (something which is apparent now, but must have been less clear for many years, thereby resulting in a necessity of both popular and field-specific rectification we saw in Žižek and Rosenfeld) led to both a dichotomy which from the beginning favored determinism and to a mistaken categorization of notions associated with determinism/indeterminism.[9] From the previous two paragraphs, one can easily conclude that Simondon's main failure in his conceptual recounting of modern physics consisted of failing to think *the correlation between anti-substantialism and indeterminacy*, that is, between substantialism and determinism. The reason for distinguishing Deleuze's ontological concern in *Difference and Repetition* from Simondon's in *Individuation* receives its broader significance at this point: whereas Deleuze virtually based his inquiry towards *difference-in-itself* on a rereading of Spinoza in the key of

9 The dichotomy established by Simondon follows these lines: indeterminism, substantialism and staticity on the one hand, and determinism, anti-substantialism and relationality on the other.

desubstantialization, thereby managing to arrive at both an anti-substantialist position *and* one of relational indeterminism, Simondon meandered through modern physics and ultimately erected a false dichotomy. The more deterministic interpretation he seemed to privilege hit a brick wall at around the same time that he defended his thesis (1957–1958), and it only managed to find its way out (through opting for a substantialist determinism) in a long period of 25 years that followed. Understanding where Bohm failed and went against Simondon's starting thesis was essential for grasping the latter's mistake; however, Simondon's conclusion of integrating both determinism and indeterminism in an ontogenetic "topology" (which still retains traces of *compatibility*) is a felicitous leftover of his general methodology and not due to a closer consideration of the complementarity between the two. This complementarity, however, arises only if we have successfully managed to think the correlation between anti-substantialism and the inclusion of indeterminacy – Simondon's failure is to be measured against this pivotal exigency that is as crucial for our thesis as much as the exigency of anti-substantialism is for Simondon. Only a veritable transductive synthesis, which takes into account both the takeaways of correctly understanding the role of measurement and the notion of complementarity, will be able to show how indeterminism and determinism are really *complementary* notions that flow above the undercurrent of a disparity between substantialism and relationism.

The strict distinction between complementarity – i.e. a coexistence of two things which emphasizes mutual relation, but retains every contradiction between them – and compatibility – i.e. a coexistence which leads to an interpenetration of entities that seeks to overcome and integrate the difference between them – may seem tedious and unnecessary if it were not for the emphasis we previously put on a transductive dialectic which retains the antinomies and uses them in the entities' further becoming. Having broadened Bohr's definition of complementarity from its application to waves and particles to a dialectical relation between the two major currents in the history of physics – the classical and the quantum – Rosenfeld confirms "the *logical* feature common to [...] the occurrence of a relation of complementarity [that is] intimately associated with an essential use of the idea of probability" (Rosenfeld 1979: 470). Indeed, from his point of view, the one cannot occur or continue to exist without the other: the principle of complementarity could not have been envisioned if some of the earlier principles of probabilistic physics were missing, but, similarly, probabilistic calculations of the quantum of action could not have posed such a valuable addition to physics were it not for the intuition about the complementarity of certain phenomena. Thus, being able to suddenly think in terms of complementary relations is not only a formalist addition to a scientific discipline but *a* veritable *shock to thought*, an event that has the power to change our entire perception of phenomena. This shock is exactly what is transmitted through our minds: what was previously a non-essential relation between isolated atoms becomes a possibility of thinking in probabilistic terms and, therefore, a chance to consider complementarity as a

veritable expression of reality; we move from a substantialist determinism of classical physics to a relational probabilism.

However, whereas the critics of the orthodox interpretation of QM usually stop here in order to accuse this interpretation of an absolutization of its own principles (Bohm 2016: 47, 57), we must understand – once and for all – that probabilism envisions itself as being applicable only to a certain physical domain. It is only because of this that Rosenfeld can write that "in generalizing determinism, complementarity does not destroy it; it rather makes it more fruitful and firmer by assigning it its proper limits. Likewise the future theory will *reinforce complementarity by fixing its place within a still wider synthesis*" (Rosenfeld 1979: 481–482). Vigier's ideal of going beyond Laplace and extending him to a physics that manages to think qualitative infinity is mistaken precisely in so far as it does not understand that one can only extend determinism by seeing to what additional ideas it leads. Complementarity which arises from probabilistic relationism, and relationism which occurs due to complementarity, are only worthy of their names if they dare to curb the applicability of their own radicalism, both in relation to classical ideas and those ideas which are yet to come. This method would be worth nothing, and would really be reducible to Bohm's criticism of indeterministic mechanism if it confined itself to thinking *only* indeterminism, in the same way that substantialism confined itself to thinking *only* determinism; on the other hand, when it applies determinism and indeterminism to *different layers of reality* and thinks of them as complementary – that is, *as informing one another and seeking to devour the other at the same time* – then we truly find ourselves to be embracing the shock and letting it lead us to even more shocking findings in the future. As we hinted at earlier, this insight which was brought to us through probabilism is not the same as Simondon's topology, in that he does not seem to have grasped how exactly determinism and indeterminism are related: *not as borderline cases of one pole, but rather as middle points of their respective planes which invite a coalescing of determinist and indeterminist calculations of varying intensity*. As we said above, and as we tried to insist throughout the article, the phenomena interpreted as determinist or indeterminist have their respective conditioning bases in substantialism and relationist anti-substantialism (or, as Deleuze would have written it, ?-substantialism). To be sure, Simondon *did* understand transduction, but he failed when it came to fully putting to use the transductive properties probabilism facilitated in physics; the topology he intuitively proposed at the end becomes fully probabilistic in so far as it is understood with the help of a reformed triad consisting of relation, complementarity and anti-substantialism.

6. Conclusion

Recent inquiries (cf. Torza 2020) into the nature of metaphysical indeterminacy continue to show the complexity of the issue even if we disregard the determinist/indeterminist debate. The facile distinction – erected by Bohm – between

those who consider probabilistic incompleteness to be final and those who are able to imagine a sub-quantum layer is artificial; rather, the horizon of the question of indeterminism and determinism and their respective positions in physical considerations bring with them a complexity which must not be circumvented in philosophy. It is in light of this necessity – and also that which is posed by a lack of scholarly interest in Simondon and especially his work in the philosophy of physics – that we tried to find the intersections between his main inquiry (and its transductive methodology) and a debate which has lost none of its importance. It is our contention, after moving through both Simondon and Bohm, that this debate cannot be understood if indeterminism is strictly opposed to determinism, i.e., if we fail to understand the philosophical suppositions of an indeterminist position. Such are the stakes of understanding complementarity and anti-substantialism, something which – at least according to us – could not have been done were it not for transduction (or, the hypothesis of individuation) and Rosenfeld's trans-disciplinary perspective on the most intimate questions of physics. The growth of scientific thought is complementary to that of philosophy – understanding the principles of the former necessitates considering the depth which the latter adds, while the very depth that is added by the latter is often facilitated by the former.

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Andrej Jovićević

Simondon i Bom između determinizma i indeterminizma

Apstrakt

Temeljno redefinisanje polja fizike usled doprinosa Nilsa Bora i Vernera Hajzenberga na početku 20. veka dovelo je do mnoštva novih pogleda na vekovna metafizička pitanja u vezi sa determinizmom i prirodom stvarnosti. Glavna tvrdnja ovog članka je da je rad Žilbera Simondona, čiji magnum opus objedinjuje najosnovnija filozofska pitanja sa (tada) najnovijim otkrićima u prirodnim naukama, relevantan za adekvatno razumevanje podele između determinizma i indeterminizma, kao i osnovnih pretpostavki koje su značajno uticale na ovu temu. U okviru ovog cilja, tvrdimo da je tumačenje kvantne mehanike naklonjeno determinizmu,

koje nude Dejvid Bom i Luj de Broj, vredna referentna tačka za precizniju upotrebu Simondonove transduktivne logike — posebno kada se pažljivo razmotre njeni filozofski propusti. Konačno, prateći razmatranja oba mislioca, ciljamo na preciznije preispitivanje uloge indeterminizma u savremenoj fizici, kao i na ponovno strukturiranje onoga što je često shvaćeno kao polarizacija.

Ključne reči: Simondon, Bom, kvantna mehanika, determinizam, indeterminizam, supstanca, relacija, transdukcija