Information as matter: a diagrammatic reading between Simondon and Stengers.

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1. Introduction

This paper is inspired by Isabelle Stengers' critical position in relation to Simondon's thought, with particular regard to her 2002 essay "Pour une mise a l´aventure de la transduction".
The focus of the present investigation concerns a specific issue of Stengers' critique. It examines a "break" which, following the Belgian theorist, would occur in the development of Simondon's treatise "Líndividu et sa genese physico-biologique". Specifically, this textual fracture would be located at the end of the second chapter, entitled "Forme et Energie"[1].
According to Stengers, this passage demarcates an abrupt change in the way Simondon conceives and describes microphysical reality, one of the of the components at the basis of his conception of individual. At the beginning of the book, she argues, Simondon's argumentation gets inspired by the interpretation of Quantum Mechanics proposed by Louis De Broglie. The physicist is known for the development of a complex probabilistic formalism which explains the uncertainty (indeterminism) deriving from Planck's quantum of action in terms of external observation.
On the other side, the microdynamic field of forces at the end of the second chapter of "l`Individu" is characterized by a sudden change in perspective. Simondon comes closer to another interpretation of Quantum Mechanics, in many ways antithetic to that of de Broglie's, which is the position hold by the experimentalist Niels Bohr. From this point of view indeterminism is not anymore connected to a question of measurement, but is presented as being intimately related to physical reality itself.

Although this research topic is very detailed, both because the inquiry is limited only onto a small passage of Simondon's undertaking, and is developed along the lines of a problem complex derived from quantum mechanics, it contains nonetheless wider implications.
Simondon's thought develops from the strict refusal of conceptual dichotomies such as matter and form (Toscano, 139). The science theorist argues that this dichotomy was not defined aprioristically in terms of laws of general Physics, but has arisen through sociological conditions, as a symptom of industrial age and its rules of division of labor (2009, 20). By means of the clinical analysis of Simondon's text presented here, I intend to investigate some aspects of the strategical reconnection

between the abstract level of formal principles and the physical dimension of material and energetic components.

In the following paragraph I introduce the argument by exploring the microphysical reality in question. My approach will develop by taking into account the concept of indeterminism and information. These concepts are interrelated: indeterminism denotes a functional condition, the condition of necessity for information to be transferred. By means of the interplay between information and quantum mechanical laws, the question becomes to what degree indeterminism gets to express a material condition as well.

2. Indeterminism between observation and matter

In the introduction of "l'individu", Simondon gives a definition of indeterminism which is concomitant to the quantum mechanical conception of de Broglie. Indeterminism depicts a state characterized by the possibility of a dualistic manifestation either in terms of wave or of corpuscle. However, in the fourth section of the second chapter, named "Topologie, chronologie et ordre de grandeur de l´individuation physique" the panorama changes: Simondon presents indeterminism as a quantity *intrinsic* to physical reality itself. "Indeterminism is not solely bound to measurement; its presence is also due to the fact that physical reality entails different degrees of magnitude which overlap each other, both topologically and chronologically, each of them being bound to its own specific becoming" (1964, 125, my emphasis). In the moment in which indeterminism assumes a constitutive role to matter, matter itself gets complexified into an entity entailing a progressive variety of levels. Indeterminism is thus no longer bound as in the previous case, to a phenomenological question, to the possibility of a subsequent apparition of either one state or an other, but instead, it assumes the operational role of relation between the microscopic and macroscopic layers of a particular physical system.

It is relevant to note that the change of point of view is problematized by Stengers' reading, but not by Simondon himself. Stengers individuates the reason of this 'oblivion' in terms of the approach of transduction, which Stengers understands in terms of speculation: transduction allows "to think [...] [the inorganic formations of] cristallization and human processes of individuation and individualization" on parallel levels (Stengers 2003, 276). It is true that Simondon starts his investigations out of a detailed and insightful analysis of concrete problems, deriving from specific examples of physics and information theory. But on a subsequent step, Stengers argues, a series of

images and conditions are extracted from the experimental practice and developed onto an abstract level not anymore in connection with any specific reality. From this position of 'above', Simondon would link, in terms of speculative "jumps", sets of problems arising from research settings completely different than the original ones. This way of proceeding would demarcate on one side Simondon's originality, as the epistemological connections which he draws, are not in line with any school of thought. On the other hand, speculative jumps would tend to reduce the differences of concurring scientific traditions. As a consequence, the singular scientific example would not be grasped and valued by means of its own specificity, but would be somehow subsumed to the status of a demonstrative "tool" for the thesis Simondon is intending to carry along.

However, as Sarah Margairaz (2010) points out, Simondon himself does not describe transduction in terms of speculation, as Stengers would suggest, but by means of the concept of intuition. Intuition is understood as a modality of thought which "can be applied to any domain transversed by a genetic operation, because it follows the *genesis* of beings, taking in this way every being at its level of unity." (236, my emphasis). This means that the production of analogies between heterogeneous domains, can be thought only in terms of conceiving genetic relations between different processes of individuation and not in terms of establishing connections amongst pre-given structures (see Margairaz 2010, 9). Because of this strong relation to an ontological dimension of becoming, Simondon's idea of intuition maintains de facto a connection with substance, and entails moreover a constraint accounting on one side for the creation of constitutive genetic relations, but establishing also a precise limit to the "general spreading" of linkages previously denounced by Stengers. Transduction comes to describe a procedure that "while it may be applied to ontogenesis, it is also ontogenesis itself" (Margairaz quotes Simondon in 2010, 7).
While thought follows the genesis of the objects of knowledge, it is accompanied by the genesis of a mental image defining the individuation of thought itself.

In the following sections I propose an analysis of the concept of indeterminism along the coordinates of the method of transduction. I relate the different facets of how indeterminism gets conceived along "l'individu" to their original physical theories. I will start with an investigation of the basic conceptual differences between the atom of Bohr and de Broglie, by taking into specific account of the question of the difference in the degree of materiality between the two physical conceptions.

3. Materialism in the Bohr vs the De Broglie atom.

In his theoretical survey of quantum theory, “The revolution in Physics”, de Broglie affirms that the development of quantum theory can be demarcated by two different stages.

The first period comprehends the development of Max Planck´s theory of black body radiation, demarcating the fundamental break from the point of view hold by classical mechanics.
Plank discovered in 1900 that under specific conditions energy is not absorbed in a continuous way, but in form of discontinuous levels, differentiated by the rule of the “quantum of action”. In 1913, Niels Bohr made a subsequent important contribution, by managing to implement Planck´s principle in his study of the constitution of the atom. His fundamental idea lies in the recognition that all atoms are characterized by a series of stable quantized states, or *stationary states.* These states provide for a quantitative description of the overall atomic behavior, as they demarcate the specificity of each experimental condition. (De Broglie 1954, 128)

The second moment of quantum mechanics arises with the development of wave mechanics and the consequent assessment of *probability interpretation.* Here, the main focus is devoted towards exploring the distinction between the different statuses of corpuscle and wave each particle is found able to assume, and of understanding their connection in terms of the uncertainty relation. One essential assumption of this approach is that only in exceptional cases the state of an atom at a given moment of its development, can be reduced to a *single* stationary state; in general it is described by the superimposition of *certain number* of stationary states (168). By following this perspective, Schrödinger came to define the wave function Ψ, as a function which is not intrinsically associated to a specific physical state, but is relative to a general *indetermination* of the system: its square measures the probability that the associated corpuscle will be observed in a particular location and at a particular time (180). This means that it is not possible to determine the singular physical conditions relative to specific states of position and energy in a moment prior to measurement. It is only possible to define with an *aprioristic probability* the presence of a specific condition.
It is significant to point out that the theoretical postulates of Quantum Mechanics, as remarked by de Broglie himself, are not to be considered as “necessary” ones. They have, as a matter of fact, no foundation on the level of physical reality, but account for complex and precise mathematical constructions. De Broglie defends them as “the only *possible* one(s)”: they lead to the construction of a “coherent theory, compatible with all the experimental facts”. Its confutation is prevented “by the impossibility to find another system that possesses the same qualities.” (1954, 205). According to de Broglie, it is this *probabilistic formalism* conceptually defined by the idea of superposition, which demarcates the fundamental break with classical physics, as the traditional laws could not

provide a frame for the description of the contemporaneity of states.

It is furthermore interesting to note that one of the last paragraphs of de Broglie´s treatise is concerned with the discussion about the *limits* that his theory sets to individuality. I outline two aspects which are important to our discussion about Simondon.

De Broglie notices how it is the notion of *potential energy* of a system, which implies a certain weakening of the individuality relative to the constituents of the system, by means of procedural coupling (1954, 281). This aspect parallels Simondon´s conception of the preindividual, in its constitutive relation between the individual and a preindividual charge.
However, wave theory prevents identical particles to be "followed" when the respective density distributions of each particles overlap (280). This aspect shows two problems: first, it means that the possibility of individuation is completely dependent on an external observer in charge of detecting the particle; second this process has the semblance of a black box which allows only to register the initial state of total superposition of particles and the final state of total clarity, but not the generative process in its singular states. This scenario is clearly diverging from Simondon´s *becoming individual* in terms of a process of continuous metastability.

With these sets of contradictions in mind, I will proceed with a brief investigation of the position held by Niels Bohr. De Broglie assesses the work of his Danish colleague as a contribution towards the creation of the transition from classical physics to quantum mechanics, but we will see that Stengers reevaluates the work carried on by the author of the atomic model and the correspondence principle from a very different perspective. Inspired by the latter divergent appraisement, I will show how de Broglie's theory provides Simondon with an initial ground necessary to connect the notion of information with its underlying energetic levels, while the approach to Bohr's hypothesis allows him to further tighten up the relation between information and matter, and describe it in terms of a process of individuation.

In a 1927 article, Bohr investigates the consequences of Planck´s postulate in respect to atomic processes (Bohr, 53). This departure point is altogether different to that of De Broglie´s: it is not the *superposition* of different physical states that concerns the interest of the Danish physicist, but the *fundamental disconnection* between different physical quantities such as position and velocity, which determines a causal break between space and time. Bohr advocates on one side the need for a novel formalism which is able to cope with the a-causal relationship opened by the "quantum of action", but defends nonetheless the necessity to maintain the basic principles of classical

mechanics operational, as it is classical mechanics and not the theory of quanta which furnishes a description of sensible phenomena at the basis of any experimental setting. “No more is it likely that the fundamental concepts of the classical theories will ever become superfluous for the description of physical experience. The recognition of the indivisibility of the quantum of action, and the determination of its magnitude, not only depend on an analysis of measurements based on classical concepts, but it continues to be the application of these concepts alone, that makes it possible to relate the symbolism of the quantum theory to the data of experience” (16). Here Bohr proposes a description of *complementarity* which *precludes* the simultaneous use of two parallel sets of classical concepts. Although praising Schrödinger´s effort to provide a consistent description of atomic phenomena, Bohr is concerned with the problem that wave mechanics would represent a *symbolism* leading to a *denial of individual* (physical) *stationary states*, constituting the very “reality” observed in the laboratory. The interpretation of Schrödinger along with those of of Heisenberg and de Broglie, entails the risk that reality might become an illusion whose only weight lies in the illustration of resonance effects between particles (Crf. 75). In order to reaffirm the value of “physical reality” i.e. of the material atomic components which can be observed in the laboratory, Bohr constructs his theory not by setting a pre-given mathematical formalism as a hypothesis of departure as it was the case of De Broglie, but by emphasizing the central role that the dispositives of detection take within the process of experimental observation.

This means that the the concept of observation, as well as the related idea of indetermination, are not relative to a subjectivity engaging in the process by means of *external* contemplation, but are *intrinsic features* of the object itself. Both the observed object and the mechanical dispositives of observation take an active role in the production of observation as well as indetermination of physical quantities. The process of measurement is not abstractly bound to a perturbation, as De Broglie understands it, but is a question of “actualizing an observable” (Stengers 2003, 38). That is, quantum phenomena are *created by the very means of observation,* which thus become dispositives of individuation (Bohr, 68) “The actualization is put onto the sign of and...and” of dinstinctive eventualities of emergence and not anymore of “either ... or” of mutually exclusive possibilities determined a posteriori by external reference (Stengers 2003, 212).

After this digression, we might understand better the issue that Stengers points out in her critical analysis. Simondon´s *genetic* theory of the individual builds its roots onto a version of quantum mechanics, which on one side allows us to think of the preindividual in terms of a basic indetermination, but on the other limits the potential of the preindividual itself, as it functions within the scheme of a diagram which is a symbolic construction, and it necessitates an observer

external to the genetic process and the relational interplay, in order to accomplish the act of individuation.

In the next sections I will draw consequences of the present analysis to the Simondonian notion of individual, as well as to the concept of information.

4. Individuality as topo- cronological problem.

As briefly stated before, at the beginning of "L´individu", Simondon elaborates the concept of preindividuality from De Broglie´s conception of quantum mechanics. After the previous digression, I would now like to deepen the analysis of this *modus operandi*.

In the introduction of the book, Simondon derives the concept of *preindividuality* from the dualistic description of the atom, defining it as a state "beyond unity and identity, something capable of being manifest as either wave or corpuscle, matter or energy." (1992, 302) The assessment of these different configurations allows for a continuous energetic exchange, which leads the system into a state of *metastable equilibrium:* contrary to the stationary state of stable equilibrium, metastable equilibrium continuously allows for new processes of transformation to happen. This status entails the presence of a level of *potential energy* which constitutes the basis for the maintenance of metastability. Or, in Simondonian terminology, a dimension of preindividuality is always accompanying individuation, i.e. the process of constitution of the individual which is not conceived as being in the whole, but merely as one of its phases. Being is here diversified into "disparate realities" (1992, 311).
De Broglie´s inheritance allows Simondon to *introduce* preindividuality as a concept in strict relation to indeterminism. That is, it allows the concept of preindividuality to be *defined*, but not yet to be made operative in the sense that Simondon himself assigns to the concept. The epistemologist defines operation in the moment in which he takes distance from the hyleomorphic schema. He asserts that the individual is not "the *possible* term of a relation" (1964, 69 my emphasis), but "*theatre and agent* of a relation" (1964 69 my emphasis) that is, the individual is "the being *of* relation, and not the being *in* relation, as the relation is an intense operation an active center". (1964, 69)

It is only *after* the "break" pointed out by Stengers, that the concept of relation acquires the operative role that Simondon is striving for. It is by means of the assertion that indeterminism is

integral to matter, that the idea of relation acquires the capability of *communication* between different orders of magnitude. And it is at this stage, that the problem of individuation becomes truly *an-archic* and gets to depict a complex becoming of a "chrono-topological ensemble" (1964, 127). The preindividual field looses here the character of "classical potential field". This frameview had provided on one side the general setting for individuation to occur by reducing the identity of the single particles in favor of a "transindividal" interaction between them; on the other however, it constrained the preindividual onto the static image of an immutable referential plane.

In the moment in which indeterminism acquires the status of an intrinsic feature of matter, the relation between the process of individuation and the preindividual becomes no longer an issue of return to the initial conditions, but is understood as a *coupling* between different entities in continuous transformative stages. The preindividual sets the conditions for the genetic becoming of the individual, and on the other side, this very process of individuation shapes the *chrono-topological conditions of the preindividual*. A complex mechanism of subtle resonances takes the place of the one-to-one relation between the individual and the surrounding field.

5. Information as matter

It is not by chance that the concept of information emerges as crucial in the section related to the *chronology and the topology of a system,* where it acquires the status of a *singularity* creating communicative levels between different degrees of chain reactions. Information becomes a "fundamental entity of individuation, which can be conceived in a topological or chronological dimension" (1964, 127). What is the difference in how information is conceived between here and the preceding sections of the treatise?

In the introduction of the book, "L´individu et sa genese physico- biologique" Simondon defined information as "the *signification* that emerges, when a process of individuation reveals the dimension through which two separate realities together become a system." (1992, 311) Here, as well as in the preceeding treatise "Du mode d'existence des objects techniques", the perspective of de Broglie allows Simondon to rethink the cybernetic definition of information neither in terms of *pure abstract* mathematical quantities nor in an anthitetical relation with uncertainity, as it was the case for initial system theory, but in relation to differentiated *energy levels.* That is, information is reconnected to the basic atomic structure out of which it is generated. In this way, Simondon pursues a first step towards conceiving information in terms of its underlying material level.

Furthermore, by inserting the principle of quantum mechanics into the equation, Simondon makes a step towards understanding the meaning of indetermination from a broader perspective than the cybernetic point of view, which remains inherently bound to a positivist angle. The approach towards physics allows Simondon to conceive information as metastable, that is, as being *intrinsically bound* to indetermination and not in opposition to it, as it has been the case for cybernetics. While the French thinker agrees with cybernetics that information is set to carry determination to the system in question, by referring to quantum mechanics he examines information out of its own limit point: in the absence of any indetermination no new state can be brought to the system and information ceases to have its effect. However, the limit that the De Broglie's Quantum Mechanical scenario sets, is the explicit reference of indetermination as "non-previsibility" (1958, 137). Indetermination is this still dependent onto the external point of view of the receiver and is thus not a quantity strictly intrinsic to information itself.

What happens to the quantity of information after the "break"? The new frameview introduces information as well as indeterminism as both strictly interconnected to the topo-chronology of the system. More specifically, indeterminism becomes the quantity able to delineate the mutual degree of separation between space and time components. It is in this section that a concrete step towards the reconnection between information and matter gets tangible.
As a consequence of this shift in perspective, the *relational* aspect of information becomes pivotal. Relations do not appear as a secondary process, once the shape of individual is constituted, but are part of the generative process itself. "The relation to both the world outside and to the collective, is in fact a *dimension of the individuation* in which the individual participates due to its connection with the preindividual reality that undergoes gradual individuation" (Simondon 1992, 309). The construction of such a web of relations generates a flow of subtle communications between structures of different degrees, giving rise to processes of *resonance* amongst levels of different magnitude – both microscopic and macroscopic. By introducing the concept of relation and resonance, Simondon incorporates physical principles concerning the exploration of transitional laws between different orders of magnitude. This concern about transitions between micro and macrodomains demarcates the change in perspective about indeterminism. Far from being only bound to an *external* source of measurement, as it was for De Broglie's quantum mechanics, it plays the role of a pivotal key *intrinsic* to the system in question, by enabling relations between heterogeneous and structurally different macro- and microscopical levels.
It is at this stage that information acquires the status of a "*singularity*" as it gets dependent upon the specific aspects produced by the underlying indetermination (Simondon 1964, 124-130).

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[1] I refer to the 1964 edition. In the 1995 edition the chapter is renamed as “Forme et Substance.”