Colloque « L'émergence dans les sciences »
Université Paris-Sorbonne
11 décembre 2012

Sorbonne, 56 rue Saint Jacques, Galerie Gerson,
Escalier G, 3ème étage, salle J636

Argument scientifique

La notion de propriété émergente prend sa source dans l'idée qu'un système physique exclusivement composé de parties matérielles, lorsque son organisation structurelle atteint un certain degré de complexité, peut manifester des propriétés entièrement nouvelles qui ne sont pas présentes dans ses parties constituantes. L'émergence est alors conçue comme la relation existant entre des phénomènes complexes et des phénomènes ou des entités physiques plus simples, lorsque les premiers dépendent ontologiquement des seconds (ou surviennent sur ceux-ci) mais ne peuvent néanmoins pas se réduire à eux. Les débats autour de la notion d'émergence ont été ravivés à partir des années 1970 par les critiques adressées au physicalisme réductionniste (l'idée que toute science est théoriquement réductible in fine à la physique et à ses lois fondamentales) au sujet des propriétés mentales. En effet les phénomènes mentaux (notamment les propriétés phénoménales de la conscience) semblent constituer des cas exemplaires de phénomènes émergents dans la mesure où, bien qu'il existe une dépendance ontologique des propriétés mentales par rapport aux propriétés physiques (du système nerveux central, notamment), les premières sont généralement conçues comme irréductibles aux secondes.

L'émergentisme est donc une thèse ontologico-épistémologique affirmant: 1) que le phénomène émergent possède une nature matérielle et ne relève donc pas d'un type de substance radicalement différent des substances physico-chimiques (en ce sens il s'oppose à tout dualisme substantiel), 2) que le phénomène émergent exhibe des propriétés irréductibles aux phénomènes physico-chimiques qui lui sont sous-jacents (il est une forme d'anti-réductionnisme).

À ce titre la notion d'émergence se trouve au coeur des débats théoriques fondamentaux actuels relatifs à la pertinence du réductionnisme physicaliste :

1. En philosophie de l'esprit (notamment autour de l'interprétation de l'émergence en termes de survenance qui a été récemment critiquée du fait de l'incapacité dans laquelle elle nous place pour rendre compte de la causalité psycho-physique)

2. En philosophie de la biologie (à la fois dans une dimension diachronique au sujet des « transitions entre niveaux d'individualité » ou des origines de la vie elle-même et dans une dimension synchronique au sujet du caractère émergent des propriétés des organismes pluricellulaires vis-à-vis des propriétés de ses cellules individuelles)

3. En philosophie des neurosciences (en particulier autour des difficultés théoriques qu'elles rencontrent pour franchir le « gouffre explicatif » subsistant entre les propriétés phénoménales de l'expérience vécue et les propositions théoriques réductionnistes les plus solides).

4. En philosophie des sciences sociales (par exemple en ressaisissant certains éléments du débat classique entre les partisans de l'individualisme méthodologique et les ceux du holisme méthodologique).

5. Enfin, l'histoire même du concept d'émergence (et, plus largement, du type de relation qu'il décrit) est restée jusqu'à présent essentiellement cantonnée à l'émergentisme britannique du début du XXe siècle et mérite un examen plus approfondi de ses liens avec la philosophie naturelle mécaniste et corpusculariste du XVIIe siècle (Boyle, Locke).

Cette réflexion sur l'émergence est menée conjointement par le département de philosophie de l'Université de Bordeaux 3 et l'EA Rationalités contemporaines de l'Université Paris-Sorbonne. Une première journée d'étude a eu lieu à Bordeaux à l'automne 2011 et a rencontré un vif succès, notamment auprès des étudiants. Le deuxième volet de ce colloque, qui impliquera des spécialistes internationaux du domaine de l'émergence, permettra de parvenir à des conclusions quant à la signification du terme « émergence » dans les sciences contemporaines et quant aux conditions de validité de son utilisation.

Programme

9h30-10h15, Daniel Andler, Professeur de philosophie à l'Université Paris IV Paris-Sorbonne, EA Rationalités contemporaines
"A relaxed take on emergence"

10h15-11h, Anouk Barberousse, Professeure de philosophie à l'Université de Lille 1 & Julie Jebeile, Doctorante en philosophie à l'Institut d'histoire et de philosophie des sciences et des techniques (UMR8590) et monitrice à l'Université Pierre et Marie Curie
"Emergence and the computational turn"

11h-11h15, Pause

11h15-12h, Hervé Zwirn, Professeur associé à l'Université Paris 7, Directeur de recherche associé au Centre de mathématiques et de leurs applications (ENS Cachan)
"Emergence and computational irreducibility"

12h-14h, Pause déjeuner

14h-14h45, Mark Bedau, Professor of Philosophy and Humanities, Reed College, USA
"A defense of pluralism about emergence"

14h45-15h30, Hugues Bersini, Professeur, Université libre de Bruxelles
"Emergent phenomena only belong to biology"

15h30-16h15, Stéphane Chauvier, Professeur de philosophie à l'Université Paris IV Paris-Sorbonne, EA Rationalités contemporaines
"Emergence and transubstantiation"

16h15-16h30, Pause

16h30-17h15, Philippe Huneman, Chargé de recherches en philosophie, Institut d'histoire et de philosophie des sciences et des techniques (UMR8590)
"Making sense of emergence through simulations: predictability, causation and transitions"

17h15-18h, Anaïs Soubeyran, Doctorante en philosophie à l'Université Paris IV Paris-Sorbonne
"Emergent phenomena: from computational irreductibility to functional irreducibility"

Résumés

Daniel Andler, A relaxed take on emergence
Since emergence re-emerged as a central issue in philosophy of science and philosophy of mind, the issue has been whether emergence *really* exists and if so, what makes it *truly* different from other ontological or epistemic relations in science. In other words, we have been seeking to circumscribe the vexing phenomenon as *stringently* as possible. While this is undoubtedly the major issue on the agenda, one that will be discussed at length by other speakers, I propose to go, so to speak, the other way, and to see emergence in as *broad* a perspective as possible. Seen in this way, it is merely a useful, though gross way of singling out a wide variety of situations encountered in science. The bulk of the talk will be devoted to an example, that of so-called 'collective intelligence', from which I will attempt to extract a characterization of the family of situations in which this loose sense of emergence may be of use.

Anouk Barberousse & Julie Jebeile, Emergence and novelty
According to Mark Bedau's definition of emergence, "macrostate P of [a system] S with microdynamic D is weakly emergent iff P can be derived from D and S's external conditions but only by simulation." (Bedau, 1997, p. 378). At first sight, this definition is surprising because emergence of a property (or macrostate) is often associated with its being not derivable from the underlying microscopic properties. However, when considering examples of complex systems as investigated through computer simulations, like bird flocks, Bedau's definition seems to capture an important feature of our reactions to such simulations: even though the micro-dynamics is known thoroughly, the resulting macroscopic arrangements are often unexpected.
In this paper, we analyze the relationships between Bedau's definition and the notion of novelty that is contained in the concept of emergence. On the one hand, the derivability requirement seems to prevent any new element to occur at the macro-level. On the other, the simulation requirement points to possibly new elements in the sense that they cannot be reached by unaided human agents. The upshot of our discussion is that the analysis of the emergence concept, as applied in a computational context, had better take human expectations into account.

Mark Bedau, A defense of pluralism about emergence
Much of the philosophical debate about emergence aims to determine what emergence is and whether it exists. Behind much of this debate is an unarticulated monistic presupposition that there is one right way to understand emergence. In this talk I defend a pluralistic alternative, according to which a number of quite different conceptions of emergence each play important roles in our best scientific explanation of the natural world. This pluralism about emergence follows from two premises. The first is that any conception of emergence involves some interpretation of the twin hallmarks of emergence: the properties of certain wholes both depend on, and are autonomous from, the properties of their parts. The second premise is that a number of different conceptions of emergence are key players in our best scientific understanding of

certain complex wholes. I will illustrate these premises with what I have elsewhere called "nominal" and "weak" emergence.

Hugues Bersini, Emergent phenomena only belong to biology
In this talk, I will discuss and illustrate the necessary three ingredients that together could allow a collective phenomenon to be labelled as “emergent.” First, the phenomenon, as usual, requires a group of natural objects entering in a non-linear relationship and potentially entailing the existence of various semantic descriptions depending on the human scale of observation. Second, this phenomenon has to be observed by a "mechanical" observer instead of a human one, which has the natural capacity for temporal or spatial integration, or both. Finally, for this natural observer to detect and select the collective phenomenon, it needs to do so on account of the adaptive advantage this phenomenon is responsible for. The necessity for such a teleological characterization and the presence of natural selection drive us to defend, with many authors (Kauffman, Goodwin, Corning, Maynard-Smith), the idea that emergent phenomena should belong only to biology. Following a brief philosophical plea, I'll present a simple and illustrative computer experiment in which a society of agents evolves a stigmergic collective behavior as an outcome of its greater adaptive value.
The three ingredients will be illustrated and discussed within this experimental context. Such an inclusion of the mechanical observer and the natural selection to which this phenomenon is submitted should underlie the necessary de-subjectivation that strengthens any scientific endeavor. I shall finally show why the short paths taken by ant colonies, the collective flying of birds and the maximum consumption of nutrients by a cellular metabolism are strongly emergent whereas water liquidity, supraconductivity, cellular automata gliders and gaz are certainly not.

Stéphane Chauvier, Emergence and transubstantiation
The philosophical debate about emergence is mainly a debate about the emergence of properties. But no property is a genuine entity or an *ens per se*. Any property F needs an ontological bearer that is an F-thing or that is modified by the F-property. In this paper, I would like to investigate the bearer-side of emergence. I propose to contrast three ways, for an emergent property, to modify its bearer(s): 1) by simply adding new peripheral causal powers to substances of a certain kind; 2) by introducing stable well funded phenomena at the surface of aggregated substances; 3) by operating a natural transubstantiation of primitive substances or by altering their sortal identity. I will argue that it is only if we can give sense and reference to *transubstantiative emergence* that emergentism can represent a real novelty in the history of metaphysics.

Philippe Huneman, Making sense of emergence through simulations: predictability, causation and transitions
Talking of emergence means trying to conciliate a commitment to some ontological monism, with the acknowledgement of some novelty. The word “emergence” is pervasive across sciences; it has been highly challenged in the philosophy of mind, especially with Kim’s famous arguments against non

reductive physicalism. The present talk contributes to the project of elaborating a concept of emergence, a project aiming ultimately at assessing the prospects of the attempt encapsulated in the use of the word. The question of whether some things in this world fall under such concept is different from (and comes after) the question of elaborating a consistent, non trivial and scientifically adequate concept of emergence, which will be the main focus of my contribution.

Emergence in general is supposed to encompass four characteristics: unpredictability irreducibility, conceptual novelty (some novel order is there), and downward causation (sometimes). Many accounts of emergence start by accounting for the characteristic of a novel order - especially, views that formulate the idea of "properties of the while being more than properties of the parts". The present paper opposes to these views, termed "combinatorial", a view that starts from capturing unpredictability. It is done in computational terms.

I will argue that the computational view is more likely than the combinatorial view to satisfy the requisite of being non-trivial. I will also show that it provides objective or non-epistemic criteria for determining emergent properties or processes. I will then argue that the computational emergence can be also framed in terms of causal specificities, which means that it is not only a formal property in simulations, but it is likely to get an ontological meaning.

The last part of the talk attempts to see that in this perspective the other characteristics of emergence can be captured if one adds to the computational criterion some other criteria concerning coarse-grain patterns proper to transient regimes. Taking all criteria together defines a concept of "robust emergence" that will match many of the scientific uses of the word "emergence", while providing a way to disqualify some of these uses. I will end by showing that the concepts of predictability and unpredictability, as well as compressibility and incompressibility, receive different meanings, articulated together, at various grains of description and space and time scales. The recent biological problem of evolutionary transitions in individuality will be a test case.

Anaïs Soubeyran, Emergent phenomena: from computational irreductibility to functional irreducibility

In the classical emergentist position and its re-interpretation within the early cognitive sciences, the notion of emergence transposes only an anti-reductionist consensus and does not contain any pertinent explicative value. Yet today, as a consequence of the multi-agent systems in informatics along with dynamic non-linear theories in both physics and biology, the formerly dubious notion of emergence has become a relevant and informative concept. Emergence was defined as magic supervenience of ontologically irreducible properties. Today in contrast, one views the notion of emergence in terms of dynamic bifurcations to a robust macroscopic organization computationally irreducible.

Computational irreducibility can be defined in terms of explanatory incompressibility: it is not possible to find some global rules that connect microphysical properties and macroscopic mechanism. Thereby macroscopic organisation, its spatio-temporal regularities cannot be apprehended at the microscopic level. Emergent properties exist if and only if they are functional for a higher level of detection. Furthermore, as a consequence of computational

irreducibility of emergent systems, emergent properties cannot be conceptually derived from the microscopic properties, macroscopic mechanisms can not be expressed in terms of the causal roles of its components. So, emergent properties are functionally irreducible although micro-explainable. For a high-level sytem of detection, the functional role of an emergent property will consist in global aspects independent of the identity of the lower-level components and their specific causal powers.
This means that functional irreducibility is not an argument against physicalism, nor is it possible to state that a certain property is not functional simply because we are unable to give it a functional interpretation, for it might signify that one is not situated within the correct level for its detection. The functional irreducibility of some phenomenal properties will not therefore be a sufficient argument to exclude them from the physical realm.

Hervé Zwirn, Emergence and computational irreducibility
The concept of emergence is often associated with different qualifiers such as weak, strong, objective, subjective, or is thought to have close links with concepts like supervenience or downward causation. I'll start by briefly examining the meaning of these different ways to qualify emergence and will argue in favor or against some of them. It is widely recognized that a salient feature of an emergent state or property is that it is difficult to predict its appearing. That is often translated under the form "it can be derived only by simulation". This fuzzy way of speaking is trying to point toward a property that can be called computational irreducibility. I will then focus my talk on an attempt to define rigorously what computational irreducibility is.

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Ces journées sur l'émergence ont pu être organisées grâce au soutien financier de l'EA Rationalités contemporaines et de l'ED Concepts et Langages de l'Université Paris-Sorbonne, le Centre Sciences, Philosophie, Humanités (Universités Bordeaux 1 et 3), et la chaire junior de l'Institut universitaire de France de T. Pradeu.