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Entropy and Entropic Differences in the Work of Michel Serres

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Abstract
Michel Serres's philosophy of entropy takes what he famously calls the 'Northwest Passage' between the sciences and the humanities. By contextualizing his approach to entropy and affirming the role of a philosophy of difference, this paper explores Serres's approach by means of 'entropic differences'. It claims that entropy – or rather, entropies – provide Serres with a paradigmatic case for critical translations between different domains of knowledge. From his early *Hermès* series, through to *The Birth of Physics* and later writings on social and ethical themes, he keeps thermodynamical and informational – or 'hard' and 'soft' – understandings of entropy apart, while simultaneously exploring their relation. By focusing on the systematic significance of Serres's 'entropic difference', this paper shows how it unfolds not necessarily as an ontological difference but as an operative function between the history and philosophy of science, epistemology, and a theory of negentropic (inter)subjectivity.

Keywords
difference, entropy, naturalism, philosophy, scale, Serres, translation

Introduction: Serres and the Translations of Entropy

It is hard to open a book by Serres which does not revolve, in one way or another, around questions of entropy, the role of thermodynamics and information, or what he calls the 'hard' and the 'soft'. The particular relationship of 'hard' and 'soft' is the crucial interest of Serres's philosophy (Bensaude-Vincent, 2020; Bühlmann, 2020; Connor, 2009; et al.). It is one of the most significant cases of how transdisciplinary translation appears in Serres as historically heterogenous relations between philosophy and science (Kim-Chi Mercier, 2015: 38; Serres, 2015: 41–3). This paper draws

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attention to the systematic significance of a model of difference oriented by 'entropies' within Serres's thought, that, even though he does not speak of 'entropic difference' himself, I regard as a highly fruitful operator to approach his work. In a nutshell, the 'entropic difference' aims to describe a deviant differentiation and processual distribution of chaos and order as codependent categories. Chaos and order do not appear as two distinct principles but form part of the same difference. The 'entropic difference' in Serres grasps the relation of entropy to both decay and the emergence of order. It gives a non-anthropocentric idea of differentiation at hand, one that distinguishes between degrees of entropy with sensitivity to their scale, or what Serres calls 'soft' and 'hard' entropies. This paper will ask questions in the orbit of: what impact does entropy have in Serres's thinking? What specific role does the 'entropic difference' play as a non-ontological operator? How does it differ from other philosophies of entropy and difference?

Since the concept of 'entropy' emerged, its relevance for philosophy and social theory has been widely explored. Entropy as a label for the manner in which energy is stored, and an explanation of spontaneous change, has been interpreted as 'perhaps the most awe-aspiring thermodynamic property of all' (Atkins, 1984: 30–8). It describes the evolution of a system or set of particles towards 'disorder' over time. With its etymological roots in the Greek for 'transformation', entropy was introduced by Clausius in the 19th century as a thermodynamic property, in the mid-20th century by Shannon into information theory, and has since then been transferred to many other contexts, such as the life sciences, economics, social theory, and art theory, as a paradigmatic case for divergent itineraries and complex processes of 'translations' (Daggett, 2019; Hayles, 1990; Smithson, 1996; Walker, 2020). The meaning of 'entropy' is itself far from homogeneous: the distinct early formulations of the second law of thermodynamics by Kelvin and Clausius; the work of Maxwell, Boltzmann and Schrödinger; and 20th century work in far-from-equilibrium physics are all indicators of complex developments and diverging approaches to the scientific implications of 'entropy'. The usage of the term in information theory as a measurement for the average level of information or uncertainty has further led to different positions with regard to whether 'entropy' carries the same meaning as in thermodynamics. Jeffrey Wicken, for instance, stresses that the 'uncertainties are of a dissimilar nature', and notes that while the Shannon and Boltzmann equations are 'symbolically isomorphic', the 'meanings of the symbols' would bear little in common. The many differences between the informational and thermodynamic concept of entropy concern the different meanings they ascribe to 'uncertainties' and 'states': 'whereas the Boltzmann entropy is based on the variety of alternative microstates among which the system moves, Shannon's entropy is based on states as events deriving from choice' (Wicken, 1987: 183).[1] While the discussion of informational entropy in the context of thermodynamics is 'deliberatively omitted' by some (Atkins, 1984: viii), others seek to clarify the connection between the informational and thermodynamic use of the term despite their conceptual differences (Brillouin, 1962; Deacon, 2007; Wicken, 1987). Michel Serres can count as engaged in this latter endeavour, insofar as he thoroughly distinguishes between the 'entropy' of thermodynamics and information theory ('hard' and 'soft' entropy) while at the same time exploring their relation.

Following Serres's 'entropic difference' involves an investigation of intellectual influences contributing to his understanding of entropy. In many ways close to the cosmological vision of an entropic universe in Prigogine and Stengers's (1984) *Order Out of Chaos*, Serres is interested in the complex impact of how 'order' has been conceived in the history of physics and especially thermodynamics, without implicating himself in a one-dimensional picture of the world's heat death. Serres's approach is in several ways compatible with the thinking of Prigogine and Stengers here: their key motifs such as self-organization, the emergence of order out of chaos, and a renewed understanding of 'nature' occur in Serres's writings in a very similar manner. The points of contact between the authors are manifold: Serres (1974) directly refers to Prigogine's 'dissipative structures' (p. 48), and he wrote a review of *Order Out of Chaos* for *Le Monde* in 1980; conversely, Prigogine and Stengers refer to Serres in their book several times (Prigogine and Stengers, 1984: 141; 303–5) – interestingly, they mention Serres (Stengers and Prigogine, 1979) even more frequently and with more detail in the French version of *Order Out of Chaos*, originally titled *La nouvelle alliance*.[2] Furthermore, Serres was part of the intellectual circles in which Ilya Prigogine, René Girard, Jean-Pierre Depuy, Henri Atlan, Jacques Monod, and many others discussed order and disorder as an interdisciplinary question. Serres defended Monod's work in molecular biology – for which he won the Nobel Prize in 1962, together with François Jacob and André Lwoff – against criticisms at the Collège de France (Serres and Latour, 1995; Simons, 2022: 41–4), and maintained a fascination with Monod's work as the epitome of a 'new new biological spirit' and an inherent 'natural philosophy' within a scientific practice (Serres, 1974: 43, 1992 [1972]: 60; Simons, 2022: 42). What I call Serres's 'entropic difference' is closely entangled with the 'new naturalism' or 'new synthesis' that is described in *Order Out of Chaos* (Prigogine and Stengers, 1984: 22–3), in which, as Alvin Toeffler notes, chance and necessity do not appear 'as irreconcilable opposites, but each playing its role as a partner in destiny' (Toeffler in Prigogine and Stengers, 1984: xxiii; 14). What follows will emphasize the impact entropies have on Serres's thinking at large and argue that Serres's approach to entropy grounds an entropic naturalism that, far from anchoring a determinism, accentuates co-implications of order and disorder.

Serres's Myriad Ways of Mobilizing Entropy

From his early works, such as the *Hermès* series, up until his later writings on a theory of the contract and sociality, or even his understanding of religion (Serres, 2022), Serres integrates entropy in myriad ways, and, with this, expounds on what he means by 'translation'. One way to read the fundamental character of the 'entropic difference' in Serres's thinking would be to read it as an ontology or an ontological difference. My point is, however, to show that it resists a difference of ontological kind through its translationally relational nature. It conceives a difference of information and matter without grounding a dualism on the level of being. I will start by offering some examples of the presence and mobilizations of entropy in Serres's writings between the history and philosophy of science, aesthetics, and social theory, and from there on, concretize and contextualize how the 'entropic difference' translates between different areas of knowledge.

Most famous is probably Serres's text on the so-called 'translation' (or anticipation) of thermodynamics in the paintings of J.M.W. Turner. For Serres, Turner presents a world in which the 'cosmos is a steam engine, and inversely' (Serres, 1982: 59). These paradigmatically new painterly boundaries are especially evident in the transformation of the role of the line, depicting matter and limits though the separation between the hot and the cold, that is, through spherical divisions rather than outlines that can be drawn. Serres speaks of Turner's 'pyrotechnical canvases' (Serres, 1997: 2) and the absence of an outside or representational function, culminating in the statement that the painting becomes 'the very furnace itself'. This all feeds into Serres's claim that Turner appears to be the 'first true genius in thermodynamics' (Serres, 1982: 57). We can add to Serres's explorations of aesthetic 'anticipations' of an 'entropic world view' his writings on Émile Zola, Jules Verne, or Virginia Woolf. For example, Serres interprets Émile Zola's *Rougon-Macquart* as an 'epic of entropy'. According to Serres, at the core of the *Rougon-Macquart*'s genealogical and genetic perspective is the model of a 'thermodynamic grill' that can be explained through two sources (the hot and cold), which makes Zola's treatise a 'materialization of a cosmology of heat – a steam engine' (Serres, 1982: xviii; 40; 1984 [1975]: 40). Three decades after his text on Zola, Serres returns to the theme of literature and entropy, reading Woolf's *To the Lighthouse* as an example of how perception can equal 'negentropy'. Serres explores negentropic processes as a motif in Woolf's depiction of, for example, the female characters or the house in *To the Lighthouse* and argues that the novel suggests that perception can introduce oppositions to entropy in forms of 'soft' negentropy (Serres, 2008: 122). Whereas both Zola and Turner furnish Serres with an understanding of the entropic world from the viewpoint of the 'hard', Woolf's novel gives Serres an opportunity to consider negentropic resistances through the 'soft'.

The terminology of 'soft' and 'hard' turns out to be key to Serres's thinking. The differentiation is less a factor of *division* than of *combination*. With the 'hard', he refers to the thermodynamic understanding of entropy, and with the 'soft', to the meaning of entropy in information theory. The alliance between information and negentropy follows up on Brillouin's, rather than Shannon's understanding of entropy, which makes his 'passages' between informational and thermodynamic entropy understandable.[3] Serres investigates interconnections between these two entropies, while at the same time keeping the distinction between the 'soft' and the 'hard' alive. According to Serres, it is 'the greatest discovery of history that entropy and information are connected, in epistemology as well as in the theory of matter. Here, chance and necessity are rigorously connected. And we have a philosophy of nature, which is formulated by information theory' (Serres, 1974: 71). For Steven Connor, the distinction between the 'hard' and the 'soft' not only defines considerably different (albeit relatable) scales, as well as the distinctions between hardware/software, but also makes accessible Serres's broader thinking and other oppositional metaphors such as the 'finite'/'indefinite' or the 'polychrome'/'white' (Connor, 2009). According to Bensaude-Vincent, the distinction between the 'hard' and the 'soft' refers to a heterogeneity of topics in Serres's work; she calls it 'a mesh of interwoven meanings' (Bensaude-Vincent, 2020: 13). She regards the oppositions between softness and hardness as in manual and digital, or entropic and informational scales, as 'by no means' a 'dualism between nature and culture' or 'inert matter' and 'code' as divided spheres. Instead, she affirms 'quite the contrary': 'There is no ontological difference

between the material world and the immaterial codes and signs but a difference of intensity between the hard and the soft. As they refer to two domains in a continuum, they are commensurable, interchangeable in spite of a huge gap of 10^{16} zeros between them' (Bensaude-Vincent, 2020: 13). Bühlmann comes to similar conclusions, arguing that the role of entropy in Serres's thinking is not negotiated on *ontological* grounds: she reads Serres's entropy and negentropy as related to 'thought' and 'communication' rather than to 'metabolism' and 'ontology' (Bühlmann, 2020: 34). I strongly concur with their observation that Serres's philosophy of the 'soft' and the 'hard' does not necessarily lead to an ontological difference, but rather a fundamental recognition of differences in scale and respective relations between them.

Let us continue to look at how Serres makes use of entropy in other contexts. In addition to his writings on literature and painting, entropy is also of critical importance in his understanding of becoming and decay, as well as that of knowledge and (inter)subjectivity. Serres deliberately describes his philosophy of distribution in *Hermès IV* with what he himself calls 'naïve' images, such as 'disorder, cloud, storm, stream, brook' (Serres, 1981 [1977]: 13). The story Serres tells in *Genesis*, a book concerned with noise, chaos and emerging forms on multiple levels, similarly defines a distribution on the grounds of negentropy and entropy, which he captures in images like 'archipelagos' within the 'sea', 'hard nuclei' in 'high clouds', 'messages' in 'noise', 'islands' within a 'jigsaw puzzle', 'islets of order or negentropy in a fractal sea of commotion, lakes of noise in a formerly glacial soil', a 'bathing' that 'is not endowed with regularity' (Serres, 1995a [1982]: 129–30). Serres makes it unmistakably clear that he sees order and the rational as the exception, not the rule, and thus resists what he diagnoses as a 'reversal'. This sense of order as an exceptional phenomenon in the midst of a 'pompous disorder' stated as 'reality' makes him speak of those 'islands' of law, rule, order as 'ultrastructures' and a 'hermetic' 'infra-distribution' (Serres, 1981 [1977]: 10–15). The 'entropic difference', as I suggest denoting it, describes a distribution of order and disorder as a distributive difference configured through a vortex. It is a negentropic island in deviant differentiation from a global entropic stream. With the operative function 'entropic difference', Serres describes a processual distribution that thinks chaos and order beyond its dichotomization – it is an emergence of order from chaos, rather than anything above or beyond it, and without any point of categorial distinction between them. This combines both 'soft' and 'hard' entropy while, at the same time, keeping them apart in their matter of scale. The 'entropic difference' can be decisively elucidated, through 'infra-distribution', as a form of differentiation that manifests through a self-reproductive law involving local and temporary forms of difference. What emerges from 'chaos', the 'prebiotic primordial soup' and 'noise' are formations that Serres (1981 [1977]: 10, 33) understands not only as 'structures' but as 'ultrastructures' (or also 'interstructures').

Entropy and entropic differences are also presented in the different ways machines function. Every motor, Serres claims, functions through difference (Serres, 1981 [1977]: 60). Before differentiation or circulation can begin, Serres appeals to reservoirs as 'the beginning of the chain, the precondition and the priority' (Serres, 1981 [1977]: 59) in order to set in motion those 'engines' that, as he says, should also radically change the relationship to the planet and resources. With the catalogue of questions that Serres compiles in relation to 'reservoirs', we can see how he takes the connection circulation

– reservoir–difference – to be an economic problem. He describes the activity of oppositeness or differentiation as an engine that functions via temperature difference, on the one hand, and information, on the other. According to Serres, the reservoir functions 'universally in its singular realisations' (Serres, 1981 [1977]: 47–58). Although Serres sees a connection between the so-called 'transformation' and 'information engines', in that they both produce a definition of energy related to entropy, he keeps them strictly apart; indeed, he considers the confusion between these two forms of motor to be the great error of the 19th century, one with far-reaching consequences (Serres, 1981 [1977]: 163–71). The primacy of reservoirs as an indispensable precondition distinguishes Serres's approach, in important aspects, as I will argue later, from approaches such as those of Gilles Deleuze or Bernard Stiegler.

In Serres's usage, the concept of entropy contains a twist, insofar as he not only describes it as a historically-developed idea but goes further in relating it to the genesis of knowledge and the history of science itself (Serres, 2018a [1977]: 179). This culminates, for example, in claims that '[w]riting is negentropic' (Serres, 2018a [1977]: 178). Serres's philosophical project is dedicated to the idea that the 'conditions of the possibility of historical knowledge' are not different from the 'conditions of the possibility of physical knowledge' (Serres, 1981 [1977]: 33). This is a crucial part of Serres's naturalism. 'The laws of nature are not federal as imitations or projections of our own laws, but the reverse. Our writings, our memory, our histories and our times are negentropic; they go back to the initial conditions, preserve them and maintain them, as nature has shown them to us. History is a physics, and not the other way around' (Serres, 2018a [1977]: 179). With Brillouin, one of his main references in regard to informational entropy, this leads Serres to an entropic-economic theory of knowledge, one that manifests the 'price' of its clarity: exactness can only be achieved at the 'price of an infinite negentropy'.[4] In many instances, Serres (2009 [1985]: 116–17) clarifies that the 'soft' has its price as well, which – as Bühlmann (2020: 41) defends – is not merely an abstract idea. Rather, it applies the 'law of entropy' to the genesis of knowledge itself, and to the consequent need for knowledge to do negentropic work – that is, to resist mixing, dilution, loss, and noise. Knowledge itself is subject to 'shrinkage in information content' and is neither timeless nor immune to decay (Serres, 1969: 28–31).

We can furthermore see the wide range of entropic differences as an operative function in Serres's work extending to his characterization of subjectivity. Serres builds bridges between entropy's locality and globality that arguably define his incisive understanding of subjectivity as a 'negentropic island'. In contrast to readings of Serres's philosophy as trying 'to create a universal theory of local difference' (Hayles, 1990: 204), the 'entropic difference' presents itself as a local difference with global implications, yet without universal validity (Serres, 1974: 61–3, 2018a [1977]: 98–102, 150). In describing the relationship between the stable flow and the eventual islands of order, Serres also uses the terms 'homeorrhesis'[5] and 'homeostasis' as yet another version of describing the global entropic stream being counteracted by local exceptions (Serres, 1981 [1977]: 81–2, 261–71, 2018a [1977]: 83, 97, 99–100). 'What am I?', he asks, replying '[a]n island of negentropy in the sea of entropy' – an answer that he repeatedly returns to (Serres, 1981 [1977]: 263, 1992 [1972]: 98, 110). The description of the negentropic subject shifts, as is characteristic in Serres's writings, between figuration and

different levels of abstraction. It meanders between vortices in the sea of an Aphroditean physics, islands adrift, and the mythical figure of Sisyphus (Serres, 1981 [1977]: 219–25, 2018a [1977]: 202–4). It takes the flow of irreversible time as global and entropic, and the points of order or reversible time as local and singular events. In *The Incandescent*, Serres equates subjectivity with a 'pocket of information or an island of negentropy': 'We live, exist and think like such pockets, manifestly perforated, like eddies that hold back, a little, time. Life and the subject appear the way direction and things do' (Serres, 2018b [2003]: 177). On the one hand, the 'entropic difference' offers him a time-based approach to the living, which culminates in his formulation of the living being as a 'bouquet of times' (Serres, 1981 [1977]: 263). On the other hand, he acknowledges the point of view of subjectivity, and the possibility of perception acting as a 'black box'. The crucial argument is, however, that this black box – elaborated on more extensively in *The Five Senses* (Serres, 2009 [1985]: 112–15) – is not a placeholder for a Cartesian or Kantian transcendental 'ego'. Without undermining the impenetrability or opacity of the subjective 'black box', Serres maintains that this is itself based on an objective difference between noise and information (Serres, 1981 [1977]: 270–71).

Especially in Serres's later writings, there appears to be a commitment to a 'new universal humanism' encompassing non-human life and the 'whole universe' (Watkin, 2016: 141–2). This aspect is one of the many ways in which Latour has been arguably influenced by Serres. Serres emphasizes the quantitative as opposed to the qualitative difference between humans and animal, plants, crystals, etc., and 'renders redundant the subject/object dichotomy by establishing a biosemiotic continuity across the nature/culture divide' (Watkin, 2016: 145). 'Plunged into objective flows', Serres writes, it is not the perception of the subject which marks its position but rather its being primarily an object, a 'soul' as a 'material body', or 'physiology or psychology [. . .] just physics' (Serres, 2018a [1977]: 70). In *Hermès IV*, Serres similarly surmises that there might not be a huge difference between what we call a subject and an object (Serres, 1981 [1977]: 271), resonating with a thought he develops in *Genesis* – namely that 'I am anyone, animal, element, stone or wind, number, you and him, us' (Serres, 1995a [1982]: 35). 'Liveliness' appears here to be a quasi-stable vortex or a bound island of time within an entropic world, from which it saves itself in a process of differential deviation (Serres, 2018a [1977]: 194–5). In a process that is always local, and never universal, the vortex makes it possible to perceive a 'now' in a complex interplay between reversible and irreversible times (Dicks, 2019: 172).

'The world', Serres writes, 'objects, bodies, my very soul are, from the time of their birth, adrift' (Serres, 2018a [1977]: 54). Subjectivity is constituted by nothing other than a multi-level battle against disorder (Serres, 2018a [1977]: 115), and therefore co-emerges alongside entropic differentiation. The situation of this negentropic subjectivity in a 'vortex' also reaches, through what Serres calls 'loops', the scale of the social. Distinct from approaches that 'naturalize' science for a theory of the social, Serres is interested in the feedback loops between 'soft' and 'hard' entropies in a cyborgian understanding of the human condition (Serres, 2019 [2001]: 35). To understand how he conceives subjectivities, we need to follow the natural-cultural vortices that constitute and connect them. He develops an understanding of the *human* on the basis of entropic and negentropic processes on multiple scales, which, in their co-genesis with technologies,

'quasi-objects' and 'world-objects', create 'loops' that form intersubjectivity and 'society' (Serres, 2019 [2001]: 215–16). What is at stake in theorizing (neg)entropic processes through different domains beyond physics is, crucially, a matter of scale and translation. In Serres's picture, living bodies and co-domestic companionships are not to be translated *directly* into a theory of society as 'entropic' but instead into a theory of historically heterogenous loops and scales of societal formation. In this vein, the connection between entropies help Serres theorize intersubjective relations without summing it up to a general picture of how societal systems work. 'Hominization' explores (neg)entropic processes between cells, 'new bodies', 'new houses' and 'new globalities' by means of a structural analysis of non-linear relationships (Serres, 2019 [2001]: 45–6, 196). For Serres, the social field, as it were, is not governed by laws distinct from those of the physical world, insofar as 'we are slices of the world' (Serres, 2010: 212). In Serres's critically translative way, entropy can explain multiple themes of the 'human' and 'social', which also grounds a normative dimension. In *The Natural Contract*, he writes that 'we are not conceiving, constructing, or putting into operation a new global equilibrium between the two sets of equilibria' (Serres, 1995b [1990]: 37). In his late text on Woolf, he goes even further, relating entropy to another contractual form. The mixing together of 'soft' and 'hard' entropies requires for Serres not only an idea of integrated nature and culture – the similar differentiation and integration of which is indicated by the 'entropic difference' – but also a contractual consciousness that follows from that. Humans are 'integral to the world' and will not be able to save themselves 'without it' (Serres, 2008: 126–7).

Serres's 'Entropic Difference' in Context

Having investigated these notions of entropy, how can we now understand the role of the 'entropic difference' in Serres's thinking at large? How can it be contextualized? I conceive of it as a key operator in Serres's thought describing a processual distribution that thinks chaos and order beyond their dichotomization and without indicating a categorial distinction; it is the emergence of order from chaos. In this sense, chaos and order are not two distinct principles but both integrated and engendered by the 'entropic difference'. It therefore presents neither a categorical distinction between order and chaos nor a melting pot for different entropies, nor does it operate through an understanding of entropy that describes only the tendency towards equilibrium. Serres's thinking here is inspired by far-from-equilibrium thermodynamics and the idea that chaos is the potential ground for order. The 'entropic difference' voices his understanding of a deviant differential that grasps order and chaos in a 'hyperlocal' emerging. It describes the emergence of such a differential on the basis of generally undistinguishable and codependent categories of order and chaos, which form local distributive distinctions. Serres's 'entropic difference' furthermore attempts to grasp a form of difference that combines both 'soft' and 'hard' entropy while at the same time distinguishing the scales of both, such that the difference combines heterogenous 'entropies' without merging them. In many respects, Serres's thinking diverges from similarly motivated attempts to introduce 'entropy' into philosophical thought.

To sharpen our understanding of Serres's particular approach, it may be useful to compare this to Deleuze's and Stiegler's thermodynamics, entropy, and respective conceptions of difference. Serres's (the entropic) difference is, first of all, neither treated as a problem of (non-) identity in the first place[6] nor generally discussed as an ontological problem – as is the case with Deleuze, who's clearest discussion of difference in relation to thermodynamics is in the fifth chapter of *Difference and Repetition.* There, he states, 'difference is not diversity', but rather acts as the motor or 'sufficient reason' through which diversity is provided as a given (Deleuze, 1994: 222–3). Deleuze (1994) ascribes a primariness to the differentiation of difference itself, one which refrains from assuming any sort of 'ground' (p. 229). Serres's approach is in no way opposed to this, in the sense of proposing a metaphysical foundationalism, but in regard to thermodynamics Serres sticks to the primariness of the 'reservoir' (Serres, 1981 [1977]: 58–62). This implicates a conceptualization of difference that is oriented by different historical developments in thermodynamics and information theory. Rather than presenting itself as an ontological difference, the 'entropic difference' conceives a difference without fundamental distinction in kind. It leans towards what Serres himself has called 'transcendental objectivity' (Serres, 1981 [1977]: 58) and not, as Deleuze suggests, 'transcendental illusion'. Deleuze identifies the thermodynamic idea of vanishing difference as a 'transcendental illusion' and a 'good sense' of the 'middle classes' (Deleuze, 1994: 225–8). He seeks to oppose the thermodynamic 'transcendental illusion' of the vanishing sources of difference with the 'paradox of entropy' and an 'intensity' which provides a transcendental alternative to the necessity of the heat death scenario. Deleuze's formulation of intensity, therefore, seems to be a literally transcendental principle constituting a reality that one might not be able to perceive in the first place (Clisby, 2017: 250–51). With this, Deleuze endeavours to think difference as the 'unthinkable' in the course of 'sensing' something different to the 'laws of nature' and 'the principles of thought' (Deleuze, 1994: 227). In other words, the thermodynamic logic has to be philosophically overcome in Deleuze.

Serres, on the other hand, does not posit the unthinkable, nor even assume there to be a constitutive outside of thought (which diverges from the Blanchotianism in Deleuze). Serres models difference on the basis of a 'transcendental objective' and a reality that Deleuze notably mistrusts as an illusory vanishing of difference, which thought must oppose. Deleuze's application of the distinction between 'extensive' and 'intensive' (Deleuze, 1994: 223) is relevant to follow his thinking of 'intensity' and, for instance, the possibility of the new, but is more problematic when attempting to meaningfully get a grasp on entropy – which appears to be clearer in the application to mass and force (Clisby, 2017: 247). In a way, Serres looks for something strikingly similar – the origins of order, an alternative to the necessity of heat death, and a simplification of the tendency towards equilibrium. However, in ways arguably different from Deleuze's take on entropy and its relationship with science (Clisby, 2017: 241), Serres finds these in the philosophy of science and the 'nature of nature' itself, and, alongside Prigogine and Stengers, precisely in the philosophical implications of the 'order out of chaos' scenario. Whereas Deleuze sees entropy as a one-dimensional lawfulness of the vanishing of differences and decay, which he then opposes with a creative and productive difference, Serres takes into account the differentiative

potentials of entropy itself, and paradoxically arrives at a more immanent philosophy of difference – one that enters the stage of a 'new new scientific spirit' (Serres, 1969, 1974, 1992 [1972]; Simons, 2022: 21–7).

As discussed earlier, Serres applies entropy and negentropy to a theory of knowledge itself (Serres, 1969: 28–31). Similar notions of 'entropy' as reflected in terms of a theory of knowledge can be found in Bernard Stiegler's approach, yet with some important differences. Stiegler (2018) implements the concept of 'negentropy' into a critique under the banner of the 'neganthropocene'. While experimentation with the concept of entropy is already present in his earlier writings, it is in *The Neganthropocene* that Stiegler elaborates his psycho-social critique in interrelation to 'entropy' most extensively. The work of Serres and Stiegler shows a notable divergence in explorative and translational approaches to the term. Whereas Serres's main interlocutors are Lucretius, Prigogine, Monod, and Brillouin, Stiegler's references are mainly Schrödinger, Georgescu-Roegen, Giuseppe Longo, Francis Bailly, and Claude Lévi-Strauss (Stiegler, 2018: 54–8, 77–105). Stiegler's interest concerns the applicability of 'negentropy' to other realms such as economic (namely capitalist) and anthropological domains, and he identifies an 'entropic' toxicity as a diagnosis that does not only concern human perception but also and especially the epoch of the so-called 'Anthropocene'. The 'Neganthropocene' is the banner for a 'new curative and care-ful epoch' (Stiegler, 2018: 45). Stiegler worries about the toxic and destructive effects of 'entropy' on knowledge and individuation. He diagnoses the 'short-circuiting' of 'protentional projections of psychic and collective noetic individuals' and connects the increase of 'entropy' to 'hyper-proletarianization and a generalized form of automatic piloting' as well as a 'structural insolvency'. In the face of this, Stiegler urges reflection on the 'production of negentropic bifurcation' and 'how to re-establish a true process of transindividuation with digital, reticulated tertiary retentions and to bring about a digital age of psychic and collective individuation' (Stiegler, 2018: 49–51). It is striking how his 'organological naturalism' (James, 2019: 212) treats entropy and negentropy not only from the perspective of departing from the scientific use of the term towards a 'psycho-social or political cultural sense' (James, 2019: 203), but also as a question of 'value' (James, 2019: 209–10; Stiegler, 2018: 39) and 'work' (Stiegler, 2010: 46).

There is a normative dimension and categorizing perspective connected to this, which makes Stiegler identify a contemporary crisis of knowledge and individuation and articulate a critique that resembles an almost activist invocation of negentropy. In both of these aspects, I argue, Stiegler differs from Serres. While Serres too lets 'entropy' and 'negentropy' be reflected into realms beyond rigorous scientific meaning, his 'criticality' and his naturalist approach to translating between the sciences, the arts, and the humanities is approached differently. Serres's use of these terms maintains a close contact with thermodynamics and information theory, especially in relation to epistemological questions. The critical approach towards entropy in Serres's work consists of a strategy of 'translation' that searches for isomorphic structures of entropy in, for example, art, literature, and social theory. For Serres, as I have tried to show, entropy has an epistemological dimension in the sense that information has its 'price', and that the exactness of knowledge must be regarded under this premise. The economic side of entropy also provokes heterogenous forms of thought across the work of both authors. In Stiegler's

contemporary scenario of a proletarianization in computational capitalism (Stiegler, 2018: 44–5), he adapts Georgescu-Roegen's (1971) *The Entropy Law and the Economic Process* to underpin the idea of 'exosomatiosation' at the base of the economy (Stiegler, 2018: 98–9, 104). This, again, is somewhat different from Serres's understanding, which also touches on the history of the economy since the industrial revolution but which further takes into account the economic dimension of the complex continuity between thermodynamics and information theory (with reference to Brillouin).

By having looked at Serres's approach to entropy from a comparative point of view, with Deleuze's understanding of entropy as an illusional motive of vanishing differences and Stiegler's cultural critique of a 'hyper-proletarianization', it seems that Serres develops a particular naturalist argument. We must underscore that the 'entropic difference' is not inscribed in a dominantly apocalyptic narrative of general decay but is rather a reflection on the emergence of structures and complexity as ways of resisting entropy that arises from the system itself. Evidence of this is clear in Serres's reference to 'dissipative structures in the sense of Prigogine' (Serres, 1974: 48) and, as mentioned earlier, the close connection between Serres and the work of Monod as well as Stengers and Prigogine's approach in *Order Out of Chaos*. What kind of naturalism is it that the 'entropic difference' relates to? There is a physicalism to be found in Serres's approach, yet clearly without coming down to a reductionist or determinist stance. Nature, in Serres, is taken from its literal meaning and closely related to his reading of Lucretius' physics, appearing as 'what is being born' (Serres, 2018a), and not as a 'given' from which one could derive stable and normative laws. The label 'naturalism' has many more meanings to which Serres's 'entropic difference' is in various ways allied. A fascination with the literary movement of naturalism, for example, lurks in Serres's engagement with Zola and thermodynamics (Serres, 1984 [1975]). More explicitly, Serres takes up one of these alternative meanings with reference to the anthropologist Philippe Descola, who distinguishes between animism, totemism, naturalism and analogism and contextualizes them in cultural narratives (Descola, 2013). Serres uses these distinctions to both classify his own work and to self-criticize it in terms of Western ethnocentric biases (Serres, 2008: 125–30). This marks an important point in the development of Serres's thought: whereas *The Natural Contract* showed a tendency to strategically essentialize 'nature' for the sake of its inclusion into law, in his later thought Serres will develop an entropic naturalism which does not require any opposition to culture or law, leading him to fundamental reconsiderations of legal relationships (Serres, 2008: 125–7).

Apart from 'naturalism' being an important keyword from an anthropological and legal perspective, Serres also conceives of a naturalism that emerges from his understanding of the relationship between philosophy, nature, and science. His 'naturalism', as Posthumus has shown (Posthumus, 2011), is deeply concerned with 'nature' but refrains from ideological ecologism. In respect to the relationship between philosophy and science, his work can be read as a form of 'post-continental naturalism' – a term introduced by Mullarkey, and insightfully elaborated on by Ian James, to describe a tendency to find novel forms of engagement between philosophy and science (in the work of Stiegler, Nancy, Laruelle, and Malabou). Serres's approach with its orientation according to a 'transcendental objective' might not be fully in line with what James describes as 'an experience of thought itself rather than a reference to the scientific experience or picture

of reality' (James, 2019: 10). Serres could, however, in several aspects be considered as adaptable to 'post-continental naturalisms', insofar as his thinking explores idiosyncratic continuities between philosophy and science and fits into a framework that 'attempts to articulate a fundamental structure of philosophical thought as such' and 'gives way to a horizon of multiplicity, disunity, and incompleteness' that is distinct from both reductivist physicalism and Deleuzian ontology (James, 2019: 10–14).

Serres's 'entropic difference' makes conceivable a continuity between scientific and philosophical concepts in a historically specific encounter, without this necessarily entailing a *generalized* idea of transdisciplinary interference. He shows that studying the interpenetrations between different domains profits from moving freely between conceptual, scientific and aesthetic aspects to get a grip on isomorphic patterns. The 'entropic difference' is paradigmatic of how Serres harnesses a scientific concept in relation to a 'world view' across different domains, by means of an investigation that attempts to do justice both to its *historical genesis* and its *philosophical impact*.

Conclusion: Serres's Entropic Naturalism

This paper has argued that the operative function of the 'entropic difference' is a key line running through Serres's work, making a case for an entropic naturalism. There has been a focus on understanding the *work* that entropic differences do and how that can be translated into different domains. The 'entropic difference' brings together several of Serres's aims, in terms of turning the 'Northwest Passage' between the natural sciences and humanities towards a philosophy of limits and differentiation. Inspired by 'energy reservoirs according to Brillouin', 'differences in the sense of Carnot', and 'Prigogine's dissipative structures', Serres arrives at a deeply temporalized understanding of difference that sees thermodynamics, information, and life not as equivalent but as crossing paths with one another. I take Serres's approach as revelatory regarding an integrative philosophy of nature and science, and as overlooked in developing a distinguished philosophy of difference.

By sketching Serres's position within possible philosophical approaches to entropy, it becomes evident that his writings thoroughly keep thermodynamical and informational, or 'hard' and 'soft', understandings of entropy apart, and similarly attempt to concretise their relation. He repeatedly returns to the idea that order is an exception to disorder and that the relationship between these terms can be modelled as archipelagos in the sea (Serres, 1981 [1977]: 9–13, 1986: 24, 1995a [1982]: 129–30, 2018a [1977]: 120, 2018b [2003]: 225). This line of thought runs through his early *Hermès* series, *The Birth of Physics, The Five Senses*, and *Genesis*, as well as his writings on social and contract theory, religion, literature, and art, in which the 'entropic difference' acts as a 'translator'. In close contact with far-from-equilibrium thermodynamics, the 'entropic difference' is about understanding a difference that is not ontological in kind but that seeks to grasp the relation of entropy to both decay and the emergence of order.

The 'entropic difference' combines heterogenous entropies and grounds a differentiation of chaos and order beyond its dichotomization, with a focus on harnessing heterogenous scales and intensities. Especially the sensitivity for scales in Serres's thought proves to be highly fruitful to ground a form of transdisciplinary theorizing without losing touch with the phenomena in question. This is complemented by his insistence on refraining

from the tendency for philosophy to become 'a-cosmic'. As a deviant differential, the 'entropic difference' describes the emergence of order in a 'hyperlocal' way: as a non-universalist difference which, at the same time, entails a generative and 'worlding' character. With his approach to entropy, Serres integrates history and philosophy: on the one hand, he *historicizes* entropy and entropic world visions; on the other hand, he draws on the history of science to *develop* conceptions of 'time', 'system', 'subject', 'object' and 'world', under the premise of a interplay between methodology and subject matter.

Exploring Serres's intellectual alliances, as well as contrasts to other philosophical approaches to entropy, helps us to identify important aspects of the 'entropic difference'. This supports the emphatically temporalized and materialized function of difference as an 'ultrastructuralism' and 'infra-distribution'. Order, organization, life, and subjectivity are understood through entropic differentiation, or as quasi-stable 'negentropic islands'. Negentropic subjectivity breaks with anthropocentrism, insofar as it undermines a nature/culture divide by introducing a quantitative divide – namely that of entropic differences. This productively connects Serres to the environmental humanities in many ways. Stressing aspects of contingency and indeterminacy, both in his understanding of 'nature' as well as of (inter)subjectivity (Serres, 2018a [1977]: 22), does not, however, rule out lawfulness or an ethical stance. The legal dimension remains part of Serres's consideration of his understanding of 'nature' and of a principle of difference that is itself grounded in indeterminacy. He thinks subjects, contracts, and societies as a multiplicity of 'negentropic islands' and through different 'loops' of 'soft' and 'hard' entropies.

Entropic differentiation engenders a naturalism that is characteristic of Serres's work. His framework is in ways similar to Bachelard's approach, characterized by 'a typical combination of philosophy and history of science', and, in response to Bachelard, an attempt to think a 'new new scientific spirit' (Serres, 1969, 1974, 1992 [1972]; Simons, 2022: 19–27). I have shown that, distinct from scienticism, ecologism, or reductive physicalism, responsive to the anthropological approach of Descola (2013; Serres, 2008), relatable to Prigogine and Stenger's 'new naturalism' (Prigogine and Stengers, 1984: 22), or 'post-continental naturalisms' (James, 2019: 10–14), Serres's 'entropic difference' provides an account of an operative function. He harnesses the 'hard' and 'soft' forms of entropy for a theory of infra-distributive becoming, of knowledge, of subjectivity, and of society, with a physicalism that remains enchanted.

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Notes

1. Although Wicken counsels caution around systematic perspectives that would connect the different entropies, given the interrelation with 'complexity' as well as informational entropy being 'autonomous', he nevertheless concedes that 'information theory and thermodynamics ought to work cooperatively in making sense of life's emergence, evolution, and operation' (Wicken, 1987: 188).
2. The references to Serres in the original French version *La nouvelle alliance* are notably more frequent (Stengers and Prigogine, 1979: 44, 89, 98, 119, 122, 127–8, 154, 285, 291, 294, 296).

3. Whereas for Brillouin information and entropy are opposites, Shannon 'devised a probability function that he identified with information' and 'chose to call the quantity calculated by the function of the "entropy" of a message' (Hayles, 1990: 48–9). See also Bühlmann for the impact of Brillouin on Serres (Bühlmann, 2020: 34–42).
4. Serres refers to Brillouin's theorem and his related critique of determinism. In *Science and Information Theory*, Brillouin writes: 'A very large amount of information shall cost a very high price, in negentropy. An infinite amount of information is unattainable. An infinitely short distance cannot be measured, and a physical continuum in space and time is impossible to define physically' (Brillouin, 1962: 303).
5. In a footnote, it is clarified that 'Homeorrhesis is a term relating to dynamical systems whose equilibrium is defined by a path or flow, rather than a state' (Serres, 2018a [1977]: 88).
6. Watkin states: 'Serres does not refuse the primacy of identity by subordinating it to difference as Derrida and Deleuze do, but he insists that identity and difference, variation and invariance, be understood as mutually complementary and equiprimordial' (Watkin, 2020: 62).

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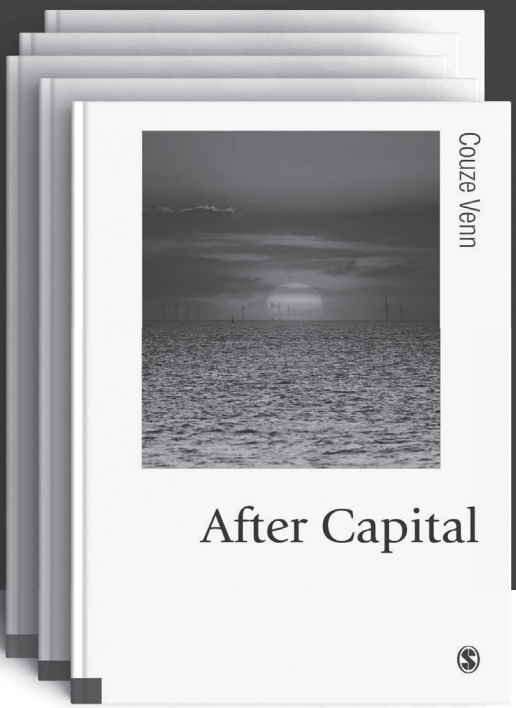

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