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Mechanism, Occasionalism and Final Causes in Johann Christoph Sturm's Physics

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Abstract

This paper argues that mechanism, occasionalism and finality (the acceptance of final causes) can be and were *de facto* integrated into a coherent system of natural philosophy by Johann Christoph Sturm (1635–1703). Previous scholarship has left the relation between these three elements understudied. According to Sturm, mechanism, occasionalism and finality can count as explanatorily useful elements of natural philosophy, and they might go some way to dealing with the problem of living beings. Occasionalism, in particular, serves a unifying ground: It will be shown that occasionalism can account for the problems of the source and transmission of motion that mechanism faces, while at the same time explaining the finality of non-rational living beings as designed by God.

Keywords

Johann Christoph Sturm – occasionalism – mechanism – final causes – life

Introduction

The seventeenth century saw the rise of mechanism, the re-emergence of occasionalism and controversial debates about the role of final causes in natural philosophy. In its most comprehensive form, occasionalism maintains that finite substances, both minds and bodies, have no causal power and that God

is the first as well as the only truly efficient cause acting in nature.[1] Separately, mechanism, occasionalism and (the acceptance of) final causes or finality (as a shorthand) are commonly discussed elements of early modern natural philosophy. Nevertheless, historical research has yet to show how these three important elements relate to one another, whether they could in principle be combined, and if so, how. Studies on the early modern philosophical landscape have shown that (Cartesian) mechanism, occasionalism and finality were either adopted *independently*, or sometimes two out of these three elements have been endorsed, but not that they have been embraced *all together*.[2] This might be so, since *prima facie* there is philosophical tension among these three elements. Especially mechanism and finality seem to be strange bedfellows. Mechanism reduces the physical world to matter in motion. Efficient causation is taken to be sufficient to explain all natural phenomena. There is no need and no place for final causes.[3] Insofar as occasionalism usually retains only efficient causation, it does not seem to harmonise with finality, either. After all, in the physical world God is usually thought to act by means of efficient causation. In addition, since occasionalism has oftentimes been seen as a branch of – or following from – Cartesianism, scholars seem to have taken for granted the Cartesian rejection of final causes when it comes to occasionalism. There is a lacuna in scholarly literature treating of the relation between final causes and occasionalism. Although mechanism was the celebrated new philosophy of the seventeenth century, it soon came under pressure, because it rejected uncompromisingly the purposiveness of nature that still seemed obvious for the majority of philosophers at the time, in particular, those of

1 See Steven Nadler, *Occasionalism: Causation Among the Cartesians* (Oxford, 2011), 1, 34. Nadler points out that there are "different degrees of occasionalism" (ibid., 5), that is to say, while some occasionalist authors commit themselves to occasionalism across the board (for all causal dimensions), others only commit themselves to occasionalism to account for certain causal dimensions, say, body-body causation or mind-body causation. As will become clear later, I am first and foremost concerned with Sturm's physical (or body-body) occasionalism. Moreover, I am not claiming that Sturm holds an occasionalist position for every causal dimension, that is, he is not what Nadler calls a 'thoroughgoing' occasionalist.

2 Scholars have investigated the relation between mechanism and final causes (e.g., Dennis Des Chene, *Spirits and Clocks: Machine and Organism in Descartes* (Ithaca, NY, 2001); Margaret Osler, "Whose Ends? Teleology in Early Modern Natural Philosophy," *Osiris*, 16 (2001), 151–168), as well as mechanism and occasionalism (e.g., Lisa Downing, "Occasionalism and Strict Mechanism: Malebranche, Berkeley, Fontenelle," in *Early Modern Philosophy: Mind, Matter, and Metaphysics*, ed. Christia Mercer and Eileen O'Neill (Oxford, 2005), 206–226; Tad M. Schmaltz, "Occasionalism and Mechanism: Fontenelle's Objections to Malebranche," *British Journal for the History of Philosophy*, 16 (2008): 293–313).

3 For instance, in the *Principles of Philosophy* (I, §28), Descartes prominently attests to the discrepancy between mechanism and finality.

Aristotelian-Scholastic origin.[4] Mechanical philosophy by itself seemed not to provide very convincing answers to the problem of life and the generation of living beings.[5]

In this paper, I will show why and how Johann Christoph Sturm (1635–1703) integrates (Cartesian) mechanism, occasionalism and finality into a coherent system. It will become clear that occasionalism will provide a sufficient ground to connect mechanism and finality. The problem of life will serve as a promising test run of Sturm's theoretical physics.

Sturm was a professor of physics and mathematics at the University of Altdorf in Germany. He published three works on physics – the *Physica conciliatrix* (1684), the *Physica electiva sive hypothetica* (1697/1722) and the *Physicae modernae sanioris compendium* (1704).[6] He was a well-known figure during his lifetime, and engaged in discussions with Henry More (1614–1687), Robert Boyle (1627–1691) and Gottfried Wilhelm Leibniz (1646–1716).[7] However, Sturm has been neglected by scholars of early modern philosophy. In the introduction to their translation of Leibniz's (1698) *De ipsa natura*, Ariew and Garber

4 Des Chene points out that "[d]oubts about the existence of ends in nature came largely from outside Aristotelianism. With few exceptions, Aristotelians agreed that the actions of rational and irrational agents had ends" (Dennis Des Chene, *Physiologia: Natural Philosophy in Late Aristotelian and Cartesian Thought* (Ithaca, NY, 1996), 188).

5 See Des Chene, *Spirits and Clocks*, and Andrew Pyle, "Animal Generation and the Mechanical Philosophy: Some Light on the Role of Biology in the Scientific Revolution," *History and Philosophy of the Life Sciences*, 9 (1987), 225–254, as well as idem, "Malebranche on Animal Generation: Preexistence and the Microscope," in *The Problem of Animal Generation in Early Modern Philosophy*, ed. Justin E. Smith (Cambridge, 2006), 194–214.

6 Abbreviations for Sturm's works are as follows: *Physica electiva sive hypothetica. Tomus primus* (Nuremberg, 1697), in Christian Wolff. *Gesammelte Werke, Materialien und Dokumente*, vol. 97.1.1 = PE I.1, and vol. 97.1.2 = PE I.2, eds. J. Ecole, H.W. Arndt, R. Theis, W. Schneiders and S. Carboncini-Gavanelli (Hildesheim et al., 2006); *Physica electiva sive hypothetica. Tomus secundus* (Nuremberg, 1722), in Christian Wolff. *Gesammelte Werke, Materialien und Dokumente*, vol. 97.2.1, eds., J. Ecole, H.W. Arndt, R. Theis, W. Schneiders and S. Carboncini-Gavanelli (Hildesheim et al., 2006) = PE II.1; *Physicae modernae sanioris compendium erotematicum in tironibus gratiam* (Nuremberg, 1704) = CPMS; *Physica conciliatrix per generalem pariter ac specialem partem conamina*, 2nd edition (Nuremberg, 1687) = PC. I will focus on Sturm's flagship writing, the PE, drawing on his other works in physics when they add to or clarify the discussion.

7 On Sturm's discussion about nature with Leibniz, see Roberto Palaia, "Naturbegriff und Kraftbegriff im Briefwechsel zwischen Leibniz und Sturm," *Studia Leibnitiana Supplementa*, XXVII (1990), 157–172; Heribert M. Nobis, "Die Bedeutung der Leibnizschrift 'De ipsa natura' im Lichte ihrer begriffsgeschichtlichen Voraussetzungen," *Zeitschrift für philosophische Forschung*, 20 (1966), 525–538; and Myriam Dennehy, "Leibniz et Sturm, Lecteurs de Boyle," in *La Philosophie naturelle de Robert Boyle*, ed. Myriam Dennehy and Charles Raimond (Paris, 2009), 331–359. For an overview of Sturm's life, philosophy and his reception, see Andrea Sangiacomo and Christian Henkel, "Johann Sturm," in *Stanford Encyclopedia of Philosophy*, <https://plato.stanford.edu/entries/johann-sturm>.

reduce Sturm to "a minor figure in the history of physics and a correspondent of Leibniz's."[8] One reason for this dismissive treatment of Sturm might be the fact that Sturm *prima facie* speaks the language of the schoolmen, and this makes scholars inclined to take him for yet another one of their number. Nonetheless, one should keep in mind that the institutional constraints of being a university professor required Sturm to hold on to some of the scholastic terminology. In fact, Sturm reworked (i.e., mechanised) an Aristotelian-Scholastic natural philosophy. He carefully negotiated common ground between the philosophy of the schools, and the new mechanical philosophy.[9]

Scholars paying some attention to Sturm have focused mostly on aspects other than natural philosophy, in particular, on his eclectic approach to philosophising.[10] His occasionalism has been discussed, only superficially, by

8 Roger Ariew and Daniel Garber, "Introduction," in Gottfried W. Leibniz, *Philosophical Essays*, ed. and trans. Ariew and Garber (Indianapolis, IN – Cambridge, 1989), 155. In his *De ipsa natura*, Leibniz attacks Sturm's *De idolo naturae* (1692). Gunter Lind, in *Physik im Lehrbuch 1700–1850: Zur Geschichte der Physik und ihrer Didaktik in Deutschland* (Berlin et al., 1992), shows the exact opposite, i.e., that Sturm was one of the most important physicists in Germany of his time. Sturm was probably the first person to give (private) lectures in experimental physics (Lind, *Physik im Lehrbuch*, 92; see also Fritz Krafft, "Der Weg von den Physiken zur Physik an den deutschen Universitäten," *Berichte zur Wissenschaftsgeschichte*, 1 (1978): 123–162, at 136; Hans Schimank, "Die Wandlung des Begriffs 'Physik' während der ersten Hälfte des 18. Jahrhunderts," in *Wissenschaft, Wirtschaft und Technik. Studien zur Geschichte*, ed. Karl-Heinz Manegold (Munich, 1969), part VI, 454–468, at 456). Mechanist physics textbooks after Sturm followed him closely (Lind, *Physik im Lehrbuch*, 71). Moreover, Sturm was an influential source of inspiration for Christian Wolff's (1679–1754) experimental physics (ibid., 96, 102).

9 In this respect, Lind notes that "a consequent mechanist system" had neither been provided by Descartes as the iconic figure of mechanical philosophy nor was it immediately possible to treat of all phenomena of physics in a strict mechanical fashion. However, since a comprehensive systematic framework was needed to teach physics, mechanist academic philosophers kept the old Aristotelian framework, retaining but reinterpreting the handed down scholastic notions (Lind, *Physik im Lehrbuch*, 83–84).

10 Michael Albrecht, *Eklektik: Eine Begriffsgeschichte mit Hinweisen auf die Philosophie- und Wissenschaftsgeschichte* (Stuttgart-Bad Cannstatt, 1994), 309–357; idem, "Johann Christoph Sturm," in *Friedrich Ueberwegs Grundriss der Geschichte der Philosophie. Die Philosophie des 17. Jahrhunderts. Das Heilige Römische Reich Deutscher Nation, Nord- und Ostmitteleuropa*, vol. 4.2, ed. Helmut Holzhey, and Wilhelm Schmidt-Biggemann (Basel, 2001), 942–947; Thomas Ahnert, "'Nullius in verba': Autorität und Experiment in der Frühen Neuzeit. Das Beispiel Johann Christoph Sturms (1635–1703)," *Zeitsprünge*, 7 (2003), 604–618; Constance W.T. Blackwell, "The Case of Honoré Fabri and the Historiography of Sixteenth and Seventeenth Century Jesuit Aristotelianism in Protestant History of Philosophy: Sturm, Morhof and Brucker," *Nouvelles de la Republique des Lettres*, 1 (1995), 49–78; eadem, "Sturm, Morhof and Brucker *vs.* Aristotle: Three Eclectic Natural Philosophers View the Aristotelian Method," in *Method and Order in Renaissance Philosophy of Nature: The Aristotle Commentary Tradition*, ed. Daniel A. Di Liscia and Eckhard Kessler (Aldershot et al., 1997), 381–407; and (to some extent) Josef Bohatec, *Die*

Leinsle.[11] Specht and Sangiacomo, however, are notable exceptions. Specht places Sturm in the yet to be written history of the German reception of occasionalism.[12] Sangiacomo investigates Sturm's natural philosophy in general, and shows how his occasionalism emerges from a rethinking of scholastic metaphysics.[13] In particular, he discusses Sturm's treatment of gravity. In contrast to Sangiacomo, I will make a comprehensive case for how mechanism, occasionalism, and finality go together in Sturm's philosophy. Moreover, I will analyse the question of life and living beings as an application of Sturm's theoretical natural philosophy to a more practical problem. In this way, my paper aims to contribute to a better understanding of how mechanism, occasionalism, and final causes can be and were *de facto* integrated.

The structure of this paper follows Sturm's own presentation in the theoretical part of his *Physica electiva*. Accordingly, I will first present Sturm's mechanist natural philosophy (§1). I will then focus on physical occasionalism, as this is both what Sturm as a physics professor was most concerned with, and what is mostly at stake given the purposes of this paper. In particular I will analyse Sturm's argument from spatio-temporal grounding (§2). Next, I will investigate the role final causes play (§3). Finally, Sturm's account of the phenomenon of life will make us comprehend to what use his theoretical physics was put (§4). It will become clear how mechanism, occasionalism, and finality are interconnected and mutually support one another.

1 Mechanism

As is well known, Cartesian mechanical philosophy reduces everything in nature to matter in motion. Natural phenomena are explained by the size, shape, and the states of motion or rest of bodies interacting, that is, pushing,

cartesianische Scholastik in der Philosophie und reformierten Dogmatik des 17. Jahrhunderts. I. Teil: *Entstehung, Eigenart, Geschichte und philosophische Ausprägung der cartesianischen Scholastik* (Leipzig, 1912).

11 Ulrich Leinsle, "Universalmathematik und Metaphysik bei Johann Christoph Sturm," in *Johann Christoph Sturm (1635–1703)*, ed. Hans Gaab, Pierre Leich and Günter Löffladt (Frankfurt am Main, 2004), 153–183.

12 See his "Occasionalismo in Germania nell'Età dei Lumi," *Giornale Critico della Filosofia Italiana*, sesta serie, vol. V, anno LXIV, fascicolo II (May–August 1985), 189–214 (esp. 192–193).

13 See his "Johann Christoph Sturm's Natural Philosophy: Passive Forms, Occasionalism and Scientific Explanations," *Journal of the History of Philosophy*, 58 (2020), 493–520, and "Teleology and the Evolution of Natural Philosophy: The Case of Johann Christoph Sturm and Petrus van Musschenbroek," *Studia Leibniziana*, 50 (2018), 41–56.

pulling, colliding, and so on. The principle of motion is extrinsic to the moving body, which is to say that self-motion is rejected. The only kind of action in the physical realm is contact action. There is no action at a distance, and the focus lies on efficient causes. As such Cartesian mechanical philosophy avoids invoking scholastic occult qualities, virtues, powers as well as sympathy and antipathy. By following these criteria in general, and by reducing substantial forms to merely passive modifications and dispositions of matter produced by motion in particular, Sturm's natural philosophy qualifies as mechanical in a Cartesian sense.[14]

Taking up the Aristotelian-Scholastic tradition, Sturm identifies matter and form as the internal principles of natural bodies.[15] While this seems to raise immediate doubts about the consistency of Sturm's mechanist approach to philosophy, Sturm's understanding of form in particular diverges significantly from the scholastic one. Bodies are modified or 'formed' matter. We will see, however, that forms are dependent upon matter and come about by local motion. Sturm might therefore be understood as 'Cartesianising' the scholastic notion of form. It remains true that Sturm avails himself of the scholastic framework in order to present his physics – probably because a thoroughly mechanist way of presenting natural philosophy in the universities was still to be developed in the years to come.[16] The actual content of Sturm's physics should not, however, be confused with its presentation.

Let us first turn to matter. According to Sturm, it is an uncontroversial principle of physics, that is, natural philosophers accept the existence of matter constituting physical reality. Accordingly, debates among philosophers have mostly focused on the nature of matter (prime matter, atoms, etc.), but not on whether matter exists or not. As to the nature of matter itself, Sturm supports the idea that (prime) matter is the same in all, even imperceptible bodies. Matter in itself is completely homogenous.[17] The essence of matter consists solely in extension.[18]

14 I am indebted to an anonymous reviewer for pointing out to me that one needs to distinguish different kinds of mechanical philosophy, and that the one to which Sturm will be shown to ascribe is of Cartesian origin.

15 PE I.1, 3f; CPMS, 11. For the sake of simplicity, I bypass the discussion of privation. It does have a place in Sturm's physics – i.e., that of a mode of form (PE I.1, 10), the latter itself being a mode of matter – but it does not play an important role as far as I can see.

16 Lind has convincingly made this point in his *Physik im Lehrbuch*, 82–85. See note 9 above.

17 PE I.1, 67.

18 PE I.1, 234.

Sturm argues in favour of the existence of prime matter by showing that otherwise the physical world cannot be conceived.[19] We know that material objects, say houses, are made out of other chunks of matter; bricks, mortar, wood, etc. Bricks, in turn, are made out of sand, clay, lime, iron oxide, and magnesia. If we continue this analytic procedure, we either need to say that it is infinite, or we need to posit some ultimate foundation of physical reality called prime matter. Since a bottomless reality is absurd, prime matter needs to exist as a ground to the physical world.[20]

However, matter cannot be the principle of individuation of natural bodies, since all natural bodies are alike in this regard, i.e., they are all made up of corpuscles whose essence is extension. Sturm hints at form being the principle of individuation of bodies:

> They [all bodies] nevertheless [despite the fact that they are ultimately made out of the same homogenous matter] differ among one another in various ways and, according to these observed differences, they are distinguished into different orders and classes by the human judgement, not blindly and merely seemingly, but on the basis of certain reasons and a consideration of the things themselves (although it may not everywhere be sufficiently circumspect and accurate). And they have designated these differences by the name of *Forms*.[21]

Sturm is here citing a philosophical position on forms that can reasonably be ascribed to most late Aristotelian-Scholastic philosophers, although he does so with a certain nominalist emphasis. Still, Sturm himself is *de facto* also convinced that forms serve to individuate bodies constituted of otherwise homogeneous prime matter. After all, within the framework of a matter-form model of whatever kind, nothing else could do the job: "As matter is common to all

19 CPMS, 12–14.

20 The example is my own.

21 "[…] multimodis tamen inter se differunt [omnia corpora] & secundùm observatas istas differentias in varios ordines classesq.; distincta sunt hominũ arbitrio, non temerario tamen & merè-tali, sed certis rationibus ac rerum ipsarum consideratione (tametsi non ubique fortasse satis circumspectâ & accuratâ) adducto. Has differentias autem *Formarum* nomine insigniverunt" (PE I.1, 67–68). All translations from the Latin original are mine. All capitalisation and emphases are in the original. Sturm does not say who "they" are, who use the term 'form' in this way. I take it that he talks about scholastic philosophers, especially since for them form was (among other things) the principle of individuation of bodies. For form in (late) Aristotelian-Scholastic philosophy, see Des Chene, *Physiologia*, ch. 3, "Form, Privation and Substance," 53–80; and Robert Pasnau, *Metaphysical Themes 1274–1671* (Oxford, 2011), ch. 24, "Substantial Form," 549–573.

genera and *species* of natural bodies, so forms are different for individual ones, because they give them substance and [their] essential difference."[22] Sturm is here somehow appropriating an Aristotelian-Scholastic conception of the role of form. It does seem problematic for a mechanist like Sturm to attribute to form the role of a principle and of "giving substance and essential difference" to bodies.[23] As he was reworking scholastic natural philosophy, Sturm's different takes on form might not immediately square with one another. While this tension might not be fully eliminable, we should bear in mind that modes of matter might to some extent characterise an individual body in the way merely homogenous matter as such does not. What makes the body the very body it is can only be its purely geometrical limitations.[24] In any case, it is clear that form has no place *qua* incomplete substance, and in this Sturm clearly deviates from a classical (late) Aristotelian-Scholastic stance. Ultimately, form is reworked into being merely a mode of matter: "[F]orms are more strictly and unrestrictedly speaking not substances or some absolute entities having an own and proper subsistence, but modifications of inert and merely passive matter."[25] The notion of form is hence mechanised following a Cartesian approach. Forms as modes of matter come about by subdividing and arranging matter: "[T]he production of all forms [...] involves nothing other than the variegated disposition, coordination of matter differently divided, etc. and the peculiar union and correspondence [of matter] so ordered."[26] Sturm probably

22 "Uti materia communis est omnibus corporum naturalium generibus ac speciebus; ita formæ singulis [sic] diversæ sunt, utpote quæ hisce substantiam & essentiale discrimen largiuntur" (PC, 30).

23 However, Norma Emerton, focusing on the geometrical-mechanical or corpuscularian reinterpretation of form (*The Scientific Reinterpretation of Form* (Ithaca, NY – London, 1984), 126–153), gives an example from *A Physico-Chemical Essay* by Boyle – whose mechanist attitude to nature seems fairly well-established, and whose philosophy Sturm appreciated – speaking of forms as that "which gives it [a concrete entity] its being and denomination" prior to making it clear that they are only modifications and dispositions, i.e., arrangements, of matter (144).

24 In his *De ipsa natura*, arguing against Sturm's *De idolo naturae*, Leibniz will later point out to Sturm that individuating bodies in virtue of mere 'extrinsic denominations' such as motion or shape is insufficient. According to Leibniz, things must be individuated by an intrinsic principle, that is, an active force belonging to them essentially (Leibniz, *Philosophical Essays*, 163–166).

25 "Formæ strictiùs & illimitatiùs sic dictæ non sint Substantiæ aut entitates quædam absolutæ, veram aliquam & propriam subsistentiam habentes, sed materiæ [...] inertis merèque passivæ modificationes" (PE I.1, 115–116).

26 "[...] formarum omnium productio [...] nihil aliud involvat, quàm materiæ varie divisæ, variam dispositionem, coordinationem &c. & sic ordinatæ [...] peculiarem unionem & correspondentiam" (PE I.1, 118). I take 'disposition' in Sturm to designate nothing other than the organisation or arrangement of certain parts of matter. Indeed, Des Chene

took his cue from Descartes, who wrote that "we do not perceive at all in any way that […] their qualities [those of objects] […] and also what we call their substantial forms are in them [objects] something other than their diverse shapes, locations, sizes, and movements of their particles."[27] For Descartes, shapes, sizes, etc. are, of course, nothing but modes of matter.[28] They do not exist independently of matter, i.e., they are not substances.[29]

Sturm is clear that what divides and arranges matter so as to create forms *qua* modes of matter is motion. Different forms are produced by matter differently moved: "The production of all forms […] and indeed that division of matter and every motion cannot happen without the motion of the parts."[30] Sturm insists that matter is itself "a merely passive Substance, which undergoes many things, but can bring about nothing."[31] The passivity of matter, its inability to actively move something applies to its parts as well as to the whole.[32] Since forms are merely modes or accidents of matter, their ontological status cannot be any different from that of matter itself.[33] That is to say, forms are passive, too. Since matter is passive, it cannot produce motion. It is not able to receive

(*Physiologia*, 127) notes: "Form identified as organisation or disposition, or as activity or power, must be realised in a material subject. In Aristotelian terms, that is to make form a mode of matter, as Descartes did." This strikes me as precisely what Sturm did, too (see also Leinsle, "Universalmathematik und Metaphysik," 175). Despite the fact that Sturm's view is close to that of Descartes, Sturm neither cites nor mentions him or anyone else in this passage, nor the one cited earlier.

27 "[…] nous n'apperceuons point aussi en aucune façon que leurs […] qualitez [dans les objects] & aussi ce que nous appellons leurs formes substantielles soit en eux autre chose que les diuerses figures, situations, grandeurs & mouuemens de leurs parties" (*Les Principes de la philosophie* (Paris, 1647), 472f). I took the cue to look at the corresponding passage from Emerton (*Scientific Reinterpretation of Form*, 128–129). The translation from the French is my own.

28 *Principles of Philosophy* I, §§65, 69, in *The Philosophical Writings of Descartes*, 2 vols., eds. and trans., John Cottingham, Robert Stoothoff, and Dugald Murdoch (Cambridge, 2008–9) (hereafter: CSM I, II), vol. I, 216–217.

29 Retaining the notion of form while working (mechanising) it into a mere passive mode of matter is not unique to Sturm; it can be found, e.g., in Régis' physics as well (Walter Ott, "Régis's scholastic mechanism," *Studies in History and Philosophy of Science*, 39 (2008), 2–14, 11), but also in English authors, such as Boyle, Charleton and Grew, as Emerton shows (*Scientific Reinterpretation of Form*, 126–153).

30 "[…] formarum omnium productio […] & verò ista materiæ divisio, motioque, quæque sine motione partium fieri non potest" (PE I.1, 118).

31 "Primam istam sive communem omnium corporum naturalium materiam esse Substantiam merè-passivam, quæ pati multa, agere nihil possit" (PE I.1, 65); see also PE I.1, 117, 158, 231–232; CPMS, 20.

32 PE I.1, 67.

33 In contrast to (late) Aristotelian-Scholastic thinkers, but in line with the Cartesians (Des Chene, *Physiologia*, 132), Sturm equates modes with accidents.

or communicate any form of activity.[34] Since Sturm's passive forms are brought about by motion, understanding motion is the next step in understanding nature. Importantly, Sturm distinguishes two different *designata* of the term. 'Motion' either designates the mover or the thing moved:

> The term Motion usually indicates two very different things, the first of which is conceived in the thing moved and is the received impetus itself, by means of whose force that [body] is transferred from the vicinity of some bodies to the vicinity of others, which in turn are at rest or less moved; the second is conceived in the mover as some force, as it were, which produces that impetus in the thing to be moved; so that in this way cause and effect, very different things, come under the same name of motion.[35]

Since the cause and the effect of motion are distinct, matter, i.e., corporeal substance, being moved does not cause its own motion. What is hence ruled out is self-moving matter. The origin of motion must be extrinsic to matter. Setting aside for the time being the case of human and other finite minds, such as those of angels, which are located halfway between purely passive matter and God, who is purely active, there are only these two extremely contrary substances (passive matter, and God) left to explain motion.[36] It is plain, for Sturm, that a purely passive substance cannot cause anything. Hence, only the one, most powerful substance acts and causes motion in the world.

The ontological status of motion is that of a mode of existence of matter. Insofar as matter is successively in different places relatively defined, it moves. However, the principle of sufficient reason – to which we will return – requires that a ground be given for matter's existence in every place – and there are infinitely many places in space – not to mention a cause bringing about the successive passing of matter through various places:

> Motion is not some separate thing, but only a mode of existence of things moved; just as to be moved is nothing other than to exist not in one, but different places successively. This mode of existence depends no less than any thing's very existence only on the divine, merely discretionary

34 PE I.1, 66.

35 "Vocabulo Motûs communiter indigitari duas res distinctissimas, quarum altera concipitur in re mota, & est ipse impetus receptus, vi cujus ista ex vicinia unorum corporum in viciniam aliorum, interea quiescentium aut minùs motorum, transfertur; altera concipitur in movente, tanquam vis aliqua, quæ impetum istum in re movenda producat; ut hoc pacto causa & effectus, res diversissimæ, eodem motûs nomine veniant" (PE I.1, 231).

36 PE I.1, 67.

> power, because to exist successively in multiple places is in a way more than to exist *simpliciter*. Likewise, to exist successively in multiple vicinities or the continuation of existence are more than to exist once and *simpliciter*. Indeed, the conservation of things does not depend any less, but even more, on the most powerful Will of God than their very existence.[37]

The existence of matter's need of a ground foreshadows Sturm's argument from spatio-temporal grounding, which I will analyse in the next section. For the moment, it suffices to notice that the passivity of matter, the grounding argument, as well as the causal impotency of all finite minds, together point towards God as the first and continuous mover of all things moved.

God is the substance defined by pure activity, and He is the only truly efficient cause of all motion in the world:

> Only God's most efficacious volition is that truly acting power, which moves while not being moved, which most rigorously speaking moves, [which] moves one body by means of another, and which moves the whole corporeal world, its parts, some by means of others, and in this way, He brings about every one of the natural effects that happens in even the most remote corners of the Universe by means of His sole immediate power.[38]

We can conclude that bodies consist of matter and its modifications, or passive forms, in Sturm's terminology. However, forms are derivative upon matter. Matter itself is defined as purely passive. As such, it cannot bring about its own variegated modifications, since their production hangs on motion, and the production of motion is an activity. The only truly efficient cause of motion is God.

37 "Non est motus res aliqua peculiaris, sed rerum motarum existendi modus tantùm, sicut moveri nihil aliud quam existere non in uno, sed in aliis aliisque successivè locis; qui modus existendi non minus quàm ipsa cujusq; rei existentia à virtute divina mere arbitraria unicè dependet, siquidem existere in pluribus successivè locis, quodammodo plus est quàm existere simpliciter: quemadmodum plus est existere pluribus successivè vicibus, sive existentiæ continuatio, quàm existere semel & simpliciter, adeoque rerum conservatio non minus, sed magis etiam, à Voluntate Dei potentissima dependet, quam ipsa earum existentia" (CPMS, 262).

38 "Solam Dei voluntatem efficacissimam esse virtutem illam verè agentem, quæ non-mota moveat, propriissimè loquendo moveat, unum corpus per alterum moveat, totum hunc mundum corporeum, partesque ejus unas per alteras moveat, & hoc pacto quicquid fit effectuum naturalium in omnibus etiam reconditissimis Universi angulis, suâ solius immediatâ virtute efficiat" (PE I.1, 164).

Despite this reductionist programme with its nominalist overtones, in which forms are nothing but modes of motion caused directly by God, we find Sturm employing a somewhat more robust, scholastic notion of form. In those moments, he explains that since bodies do not differ with regard to the (prime) matter of which they are ultimately composed, what renders a thing fit to 'perform' certain functions cannot be matter in itself. What makes the thing the very thing it is, are its passive forms. Accordingly, Sturm has it that form "is that by means of which the thing is what it is, by means of whose aid it carries out its ordinary function, according to that commonplace, *Form gives the being and acting of the thing*."[39] He continues: a thing's form is that which "insofar as it is posited, the thing itself and its faculty to act are posited at the same time."[40] Here, Sturm is once more leaning heavily on the scholastic tradition. In passages such as these, he seems to overstretch what can be comprised in one consistent natural philosophy. After all, how could a passive form account for a faculty to act? Moreover, matter – passive in itself – has no such faculty. It can only be that things can be said to 'act' because God acts through them. In this respect, the allusion to a *facultas operandi* of things could only be taken as a shorthand for God's actions. We find Sturm struggling in his reinterpretation of the scholastic vocabulary, trying to negotiate a compromise between the new and the old physics.

One last issue we need to look at before moving on to Sturm's occasionalism is his distinction between artificial and natural beings, as this will be important for the problem of life and living beings to be studied later. Unlike scholastic authors, Sturm would attest to both natural and artificial beings (humans apart) having only a dispositional and functional, but not a substantial unity, precisely because passive forms for Sturm are merely modes of matter (in motion). Taking into consideration the scholastic heritage of early modern mechanist philosophy, it is clear that the problem of unity and that of agency remain intimately connected. It is in virtue of being a unified entity that both artificial and even more so natural machines are able to act in a certain way, and produce meaningful (behavioural) output. Des Chene has shown that the kind of unity that occupies centre stage in mechanical philosophy is dispositional unity, which is "the unity of something whose parts are said to be 'disposed' or arranged in such a way that the whole has some designated effect."[41] In particular, "the unity of the mechanism consists in the joint influence of its

39 "[…] forma sit rei formatæ forma, atque id per quod res est id quod est, & cujus ope suo defungitur officio ordinario, juxta tritum illud, *Forma dat esse rei & operari*" (CPMS, 21); see also, PE I.1, 94. The commonplace is a reference to Aquinas.

40 "[…] quo posito res ipsa simul ejusque facultas operandi ponitur" (CPMS, 21).

41 Des Chene, *Spirits and Clocks*, 116.

parts on one another, an influence analysable into the transmission of force by contact from one link to the next."[42] While Descartes himself tries to confine the unity of machines to dispositional unity, Des Chene has shown that this is to no avail.[43] The very effects and functions machines are intended to carry out inevitably lead to the idea of ends and a designer – either human beings as in the case of artificial machines, or God as in the case of infinitely complex natural machines.

According to Sturm, natural and artificial bodies alike take their operations from their internal "principles."[44] The constitution or nature of a thing defines what a thing is able to do or undergo. While this again seems somewhat scholastic, Sturm, however, makes it clear that a thing's 'nature' in turn is its internal set-up: "The intrinsic nature of every natural body is nothing other than its form itself or its internal fabric or its disposition and particular and proper texture."[45] In light of the absolute sameness and homogeneity of (prime) matter, only passive forms, i.e., matter's proper modifications, can explain the characteristic 'operations' of a thing.[46] Ever more complex structures of modes of matter lead to the 'performance' of ever more complex and demanding functions.

If the whole of nature is reducible to passive matter, and its modifications and mechanical dispositions are brought about by motion, questions about the cause of its motions as well as the ground of matter's existence naturally arise. Hence, following Sturm's own presentation, the next section will analyse the issue of efficient causation, i.e., occasionalism.

2 Occasionalism: The Argument from Spatio-Temporal Grounding

As I already hinted in the previous section, Sturm rejects the existence of truly efficacious secondary (natural) causes, opting instead for occasionalism. In this section, I will focus in detail on one of Sturm's strategies for

42 Ibid., 131.

43 See ibid., 132–140.

44 CPMS, 37.

45 "Naturam cujusque corporis naturalis intrinsecam, nihil aliud esse quàm ipsam ejus formam sive fabricam internam sive dispositionem ac texturam particularem & propriam" (CPMS, 35f). Emerton (*Scientific Reinterpretation of Form*, 143–146) has pointed out that for someone like Boyle texture is tantamount to internal structure, and that this is consistent with Boyle's geometrical, or mechanical reconceptualisation of form not only as a mode of matter but – in extending Descartes' use and building in turn on Gassendi – in seeing forms as structures of matter.

46 Strictly speaking, of course, things – insofar as they do not cause anything – cannot be said to act.

establishing occasionalism, that is, what I will call the argument from spatio-temporal grounding. This argument concentrates on physical occasionalism in particular.

The argument is based on what I take to be three separate principles: (1) the infinity of time and space; (2) the principle of sufficient reason; and (3) the causal containment axiom standardly held by early modern philosophers. Sturm is not very outspoken on any of these principles. It seems to me, however, that he must have accepted these principles for the argument to work. Let me first introduce each of them in turn:

(1) *The infinity of time and space*: The infinity of time consists in the idea that an infinity of moments of time existed up until this point, i.e., the present, and – until God chooses to annihilate the world – it seems reasonable to believe that an infinity of moments of time will follow in the future. The infinity of space consists in the idea that there is an infinity of points of space. Concerning space, it is worth noting that Sturm endorses Aristotle's and Descartes' plenism: the world is full of bodies. Empty space is not more than an abstraction, as it were, an *ens rationis* produced by the mind.[47] Since the essence of bodies is extension, and there is no empty space, space and extension (three-dimensionality) are coextensive.

(2) *The principle of sufficient reason*: For every x, if x exists, there will be a sufficient reason why x exists in general and in particular why it exists in the way it does. By 'in general', I understand that there be a sufficient reason for why x exists *rather than* not exist. By 'in particular', I understand that there be a sufficient reason for why x exists in the way it does rather than in any other way. In particular, why x exists at t_1 rather than at t_2, or continuously at times $T = \{t_1, t_2, t_3, \ldots t_n\}$ and why x exists, say, at $\{x = 1; y = 2; z = 3\}$ rather than, say, at $\{x = 0; y = 1; z = 2\}$ in space.

(3) *The causal containment axiom*: For any effect *b* of a given cause *a*, it has to be the case that *a* has more, or at least the same degree of, reality or ontological perfection as its effect *b*. This is to say that whatever is contained in an effect *b*, has to have been contained in its producing cause *a*. The motivation for this axiom comes from the absurdity associated with a world where the inverse were to obtain, i.e., where the effect *b* contained more than was contained in its cause *a*. If the effect *b* exceeded its cause *a* in ontological reality or perfection, then in (some) acts of causation something could be produced that was not somehow or other present before. This would amount to allowing creations *ex nihilo* into the realm

47 See PE I.1, 64.

> of natural causation, which is absurd, or utterly unintelligible for most early modern philosophers.[48]

The basic idea of the argument from spatio-temporal grounding is this: setting aside the possibility that matter could be annihilated by God's absolute will, matter or some part of it continues to exist through an infinity of moments of time and through an infinity of points of space. A sufficient reason or ground needs to be given both for matter's existence rather than its non-existence, and for its particular persistent existence throughout an infinity of moments of time and points of space rather than any other particular persistent existence.[49] Grounding matter's existence is especially pressing since, insofar as it is passive, matter seems unlikely to be the kind of thing that could ground itself, occluding the question of whether genuine cases of self-grounding obtain in nature. However, the persistent existence throughout an infinity of moments of time and points of space requires a ground that has at least the same degree of ontological reality as the existence to be grounded. The ground of something existing infinitely in time and space needs to be infinite itself. That is, only a ground that is itself infinite will be able to underpin the existence of matter which spans over infinitely many points of time and space. This ground could only be God who is eternal, omnipresent, and infinitely powerful. Only He is able to sustain matter's existence, and prevent its fall into nothingness. Sturm himself puts it like this:

> Indeed, no one can have any doubt that the same matter existed constantly through infinite moments of time past, and continues to exist today and also in innumerable moments of time (as is plausible) to come; indeed, this mode of existence with regard to different and infinite points in time can at least also not be ascribed to a minor power, because to exist infinitely and to make something else exist infinitely, is something infinitely greater than to exist once, or to make something exist once or at an instant. Hence, why do we not acknowledge that this other mode of existence by means of which matter or some parts of matter exist

48 Descartes formulates the causal containment axiom both in the *Third Meditation*, and in the *Second Set of Replies to the Meditations*, ax. iv: "there must be at least as much (reality) in the efficient and total cause as in the effect of that total cause" (*Third Meditation*, CSM II, 28); "Whatever reality or perfection there is in a thing is present either formally or eminently in its first and adequate cause" (*Second Set of Replies*, CSM II, 116). The addition in brackets is from the French translation of the *Meditations*. Through his reading of Descartes, Sturm would surely have been familiar with this principle.

49 In speaking of grounding, I do not exclude causal relations from counting as grounding relations.

> in every moment, now here, now there, now somewhere else, that is, which we observe being moved, must be attributed solely to the same highest and most efficacious volition? Because to make that something exists here, there, and somewhere else and in numerous parts of space successively is not something less, but much more than to make that it exists *simpliciter*.[50]

For matter to persist continuously through a series of infinite moments of time, there needs to be a ground for its existence, as matter's existence is not self-supporting. Insofar as matter's temporal existence is infinite, its ground needs to be infinite, too. Grounding something seems to require a power to do so. Grounding something infinitely would hence require an infinite power to do so. For Sturm, it seems to be clear that there can be only one such infinitely powerful ground which supports matter's indubitable existence since its creation, and that is God, the creator of matter.

While the creation and continuous existence of matter through time is due to God, matter also exists in an infinity of spatial points. Again, maintaining matter in existence in every (of the infinitely many) points of space requires an infinitely powerful being. Furthermore, since matter is not only stretched out in space infinitely, but can also be moved and thus acquire new spatial specifications, the need for a ground that is itself infinitely powerful supporting matter in every point of space is again pressing. For Sturm, as we saw earlier, setting matter in motion and maintaining it in motion is the work of the divine will. Bodies cannot move other bodies. Neither the human mind nor any other finite spirit can set bodies in motion. Their will is finite and inert. Sturm puts it as follows:

> Likewise that some matter should exist, before which nothing had (pre-)existed, was the work of the most powerful will of the Highest

50 "Nec illud etiam dubium esse cuiquam potest, ut eadem materia per infinita temporis præteriti momenta jugiter existeret, hodieque, & in futuri quoque temporis innumerabilia momenta (ut est credibile) existere pergat, adeoque hunc existentiæ modum quoque, puncta temporis diversa & infinita respicientem, non minori saltem potentiæ tribui posse; cùm existere infinities & facere aliquid infinities existere, sit quiddam infinities majus, quam existere semel, aut facere quiddam semel vel ad momentum, existere. Quidni ergo agnoscimus, alterum quoque illum existentiæ modum, quo materiam aut partes aliquas materiæ, nunc hîc, nunc ibi, nunc alibi existere singulis momentis, h.e. moveri observamus, eidem isti summæ & efficacissimæ voluntati unicè acceptum esse ferendum? quandoquidem hîc etiam, facere quicquam hîc, ibi, alibi, spatiique partibus innumeris successivè existere, non minus quippiam, sed multò majus est, quàm facere id simpliciter existere" (PE I.1, 161).

> Command […]; the continuation throughout all ages of that existence, which is not a different or a new thing, but some illustrious mode of the same existence, requires the same will even more; Therefore, also a different mode of existing so that the same matter exists here, there, over there, and in any other of the infinitely many points of space cannot suppose a power less than that which is needed to make it such that it existed *simpliciter*; indeed to bring it about that matter, or any of its parts at rest before, begins to be moved is the work of the infinite divine will alone, whose *will* and *power* are one and the same: consequently, neither can a body move any other body, nor can any one of them be moved by the will of the human mind or another finite spirit, because they clearly lack this will [i.e., the characteristics of the divine will]; they certainly do have a will, but a finite and inert one whose willing stands very far apart from the power, which is testified by innumerable daily examples.[51]

Sturm stresses that the same matter continues to exist through time. This does not preclude matter from undergoing different modifications. Not only is God the creator of matter, but He is also the only being capable of supporting matter's infinite existence as much as grounding its ever-new spatial modifications (acquired through motion) in virtue of His own infinity, to wit, the infinite unconstrained power of His will. Clearly, for Sturm, God is the only infinitely powerful being overall. Finite beings *qua* finite and finitely powerful cannot ground matter's infinite existence. Were this otherwise, there would be a clear mismatch between cause and effect, and matter's existence would be insufficiently grounded.[52]

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51 "Quemadmodum, ut materia aliqua existeret, cujus ante nihil præextiterat, opus erat voluntate Summi Numinis potentissimâ, […] multoque adeò magis eandem poscit illius existentiæ in tot Secula continuatio, quæ non est alia vel nova res, sed ejusdem existentiæ illustris aliquis modus; Ita, alium quoque existendi modum, ut eadem materia hîc, ibi, istic & in aliis spatii punctis infinitis existat, non minorem eâ potentiam supponere, quæ, simpliciter ut existeret, potuit exigere; adeoque efficere, ut materia aut ejus aliqua pars, antea quieta, incipiat moveri, solius infinitæ voluntatis divinæ opus esse, cujus *velle* & *posse* unum idemque sunt: consequenter, neque corpus ullum movere posse alterum, nec horum ullum aut mentis humanæ aut alius spiritûs finiti arbitrio moveri, quia illa voluntate planè carent, hi verò voluntatem quidem habeant, sed finitam & inertem, cujus velle quantum distet à τω posse, innumera exempla quotidie testantur" (CPMS, 48–49).

52 Readers familiar with discussions about arguments in favour of occasionalism will inevitably perceive a certain degree of similarity between Sturm's argument from spatio-temporal grounding, and the argument that the conservation (of the world) is but continuous creation (CCC). CCC has its most prominent appearance in Malebranche's *Entretiens sur la Metaphysique et la Religion* (dialogue VII). There is a growing literature around CCC, its main target, and how it should be understood – e.g., Sukjae Lee, "Conservation as

By now we have seen how occasionalism solves the problem of the lack of activity in nature due to Sturm's adherence to a Cartesian-style mechanical philosophy. We will now turn to the last constitutive element of Sturm's natural philosophy: finality or the acceptance of final causes.

3 Finality

Final causes are foreshadowed in the way Sturm reconceives substantial forms, and the role they play in 'performing' certain functions. Perhaps surprisingly, Sturm sides with the classical (late) Aristotelian-Scholastic position which conceives of the world and its constituent parts as striving – knowingly or unknowingly – towards certain ends.[53] Sturm himself ascribes this position to Aristotle and Galen, and refers to its reception in their respective schools.[54] In contrast to other early modern philosophers such as Descartes, Sturm admits final causes into natural philosophy.[55]

Sturm presents to his readers numerous phenomena which are supposed to support, or at least make his readers inclined to accept, the existence of finality in nature: Sturm mentions *inter alia* bodily organs fulfilling certain functions – the eyes are there to see; the heart pumps blood through the body –, and the well-adaptedness of certain animals, e.g., the wings, or lightness of bones, or

Continuous Creation Just like Creation but not Necessarily Recreation," in *Occasionalism: From Metaphysics to Science*, ed. Matteo Favaretti Camposampiero, Mariangela Priarolo and Emanuela Scribano (Turnhout, 2018), 61–83; Nadler, *Occasionalism*; Ott, "Régis's Scholastic Mechanism"; Andrea Sangiacomo, "Malebranche's Arguments for Occasionalism in their Historical Context," *History of Philosophy Quarterly*, 34 (2017), 133–154; Tad Schmaltz, "Continuous Creation and Cartesian Occasionalism in Physics," in *Occasionalism*, ed. Favaretti Camposampiero et al., 41–60. An in-depth discussion of the difference between Sturm's argument and CCC would be obstructive to the purpose of this paper. I will confine myself to saying this much: (1) Sturm's argument takes the world as its starting point and has a certain *a posteriori* flavour to it, while CCC takes the nature of God's will and actions as its starting point, and has a certain *a priori* flavour. (2) Infinity plays a major role in Sturm's argument, but none in CCC. (3) Finally, Sturm's argument establishes only that substances are immediately grounded. Passive forms or modes partake in the workings of nature in that they passively channel God's power and thus provide some kind of passive determination on their own. CCC, however, is standardly taken to imply the conservation-creation of substances and modes alike.

53 For the late Aristotelian-Scholastic position, see Des Chene, *Physiologia*, ch. 6, "Finality and Final Causes," 168–211.

54 PE I.1, 206.

55 Descartes fiercely rejects the idea that natural philosophy should be treating of final causes (*Principles of Philosophy*, I, §28, CSM I, 202–203). Descartes' approach is cited by Sturm in PE I.1, 208–209.

a certain type of beak of certain types of birds, such as geese, ducks, or storks. Sturm then provocatively asks:

> Indeed, who [...] does not see as if placed in the light itself of the Sun that all natural and artificial bodies, matter and form, as well as other conditions that are particularly proper and peculiar to them, respect certain uses, scopes and ends, and even more that the consideration of final causes in Physics is actually most useful?[56]

For Sturm, ends and uses are an inextricable part of the world as a whole and of its parts.[57] However, Sturm diverges from previous authors in thinking that ends and uses are not really distinct, but can be conceived as two sides of the same coin.[58] The end designates the intentions of the maker of a thing whereas the use designates the function of the thing used:

> It can in no way be denied that that which is the use of someone's work already done [e.g., of a clock to distinguish time in hours, minutes, etc.], was the end or scope in the mind of the maker, when it was still to be done, or when the work was first contrived.[59]

Following up on Sturm's example, the use of the clock to tell the time, distinguishing between hours and minutes, is nothing but the end *propter quid* (on account of which) – as the Schoolmen would say – it was designed by its maker.[60] The clock's ability to tell the time – setting aside the role of its intelligent user – is, of course, mirrored by its make-up: matter with some, but not just any, material passive forms or modifications, springs, gears, an hour hand, and a minute hand, etc.

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56 "Quis denique ex his paucis, quæ hoc & præcedentibus phænomenis enarravimus, non in ipsa quasi Solis luce positum cernat, omnia naturalia æquè, ac artificialia, corpora & materiam, & formam aliasque, conditiones, cuique proprias præsertim & speciales, certos usûs, scopos & fines respicere, adeoque finalium quoque causarum considerationem in Physicis etiam utilissimam esse?" (PE I.1, 205).

57 PE I.1, 226.

58 PE I.1, 218–219; CPMS, 62–64. Ends and uses have, of course, been distinguished by previous authors, and this terminological distinction has a long history dating back (at least) to Aristotle. The details of such an intricate story are beyond the scope of this paper.

59 "[...] enim negari neutiquam possit, id quod operis alicujus jam facti usus est (e.g. horologii, distinguere tempora in horas, minuta &c.) id in opificis mente, cum esset adhuc faciendum, aut primitus excogitatum opus, fuisse finem & scopum" (PE I.1, 219).

60 Des Chene (*Physiologia*, 172) points out that for the Aristotelians "[t]he most general definition of 'end' is 'that on account of which', *propter quid*, something is done."

Sturm's example is suggestive. The fact that things are designed to fit a certain use, or seem to strive towards a certain end, leads to the idea of a designer purposefully designing and creating things in that way.[61] Once the finality of the whole of nature is the subject of scrutiny, one is inevitably led to contemplate the most intelligent designer-creator of the world:

> Hence, everything in this world acts on account of some certain ends, but unbeknownst to itself and not intended by any of its own resolutions, but known and constantly, as it were, put before the eyes of the omniscience of that most powerful Director alone; nay [speaking] with philosophical rigour they do not act so much on account of them [i.e., ends], but are acted upon towards them by the same Most Wise Director, who always foresees most precisely the means and directs them towards innumerable [ends]; not even (as we have already mentioned elsewhere) by means of an absolute, but a conditioned volition not repeated on a case-by-case basis, but by means of a simple act of His, reaching out most efficaciously as it were by means of a certain universal law into every corner of the Universe, into all moments of times and centuries.[62]

In general, things need not be aware of the ends for which they strive. It suffices that God knows the ends and purposes of things.[63] He directs non-cognitive beings towards certain ends. While humans as rational beings are conscious of the ends towards which they seem to strive, non-rational beings – both animate and inanimate – are not. Non-rational agents are immediately guided by God alone. This intimate connection between cognition and final causation has recently been called the 'cognition condition', "according to which only agents that cognize their ends can operate for the sake of these ends in virtue of their own nature or internal principle of change" and this is a development

61 PE I.1, 226–227.

62 "Agunt ergo in hoc mundo omnia propter certos aliquos fines, sed ignotos sibi nec ullo suo consilio intentos, adeoque solius Directoris illius potentissimi omniscientiæ cognitos ac perpetuò ejus quasi oculis expositos; imo in rigore philosophico non tam agunt propter illos, quam aguntur in illos, ab eodem Sapientissimo Directore, in istos, innumerabiles licet, exactissimè semper prospiciente mediaque certissimè dirigente; non absolutâ quidem (ut alibi jam monuimus) sed conditionatâ, nec iteratâ in singulos casûs, voluntate, sed uno simplici hujus actu, tanquam lege quadam universali in omnes Universi angulos omniaque temporum & seculorum momenta efficacissimè se exporrigente" (PE I.1, 227); see also CPMS, 62.

63 CPMS, 65.

originating in late scholasticism.[64] Bearing in mind Sturm's occasionalist stance, however, he cannot simply adopt the late scholastic position, since finite beings do not possess a genuine internal principle of change – they are not endowed with a substantial form, force or anything of the kind. What then is Sturm's considered opinion? Given that inanimate and animate non-rational beings are purely physical and lack a mind, finality remains external to them. Setting aside the level of complexity which distinguishes the living from the non-living, any non-rational being is directed towards certain ends by God. Thus, Sturm extends to every non-rational being what Des Chene remarked concerning the late scholastic stance vis-à-vis inanimate beings and their actions, i.e., that they "have ends only at second hand, by virtue of being God's instruments."[65] Human beings, on the other hand, by virtue of being mind-body composites can contemplate their ends. While it remains true that they are dependent upon God for realising their goals, Sturm's occasionalism does not extend into the realm of the intramental. The mind's immanent actions and volitions are free.[66] Hence, the mind's own thinking is undisturbed by God's intervention. Finality is intrinsic to rational agents, i.e., human beings, and, of course, to God. In the narrowest sense, God is the only final cause, since He is the only efficient cause, and hence the only being truly able to bring about the goals and ends He chooses. According to Sturm, in studying nature and its

64 Andrea Sangiacomo, "Modelling the History of Early Modern Natural Philosophy," *British Journal for the History of Philosophy*, 27 (2019), 46–74, 50. Similarly, Des Chene notes that for the late scholastics "[o]nly in rational agents do ends operate straightforwardly. Animals are held to be acted upon by ends as rational agents are, but 'imperfectly,' because their ability to judge the goodness of things, and to deliberate about means, is limited. Inanimate things are not acted upon by ends except insofar as they are the instruments of God" (*Physiologia*, 187). I will come back to the role of rational agents. It should first be noted here, however, that due to the fact that animals lack cognition *tout court* for Sturm, they will be treated on a par with inanimate beings, that is, the goal-directedness of their actions is due only to the external workings of God.

65 Des Chene, *Physiologia*, 194.

66 PE I.1, 67, 176. Here, Sturm explicitly says that "when the same Du Hamel [whose position he discussed before] […] says that nothing is better known than that we think, doubt, love, and perform other vital acts, we easily concede this regarding the immanent actions of the mind (which are not to be discussed here)" (PE I.1, 176). The Latin reads: "cùm idem Hamelius […] eodem loco nihil notius esse dicit, quàm nos cognoscere, dubitare, amare, & alios actûs vitales exercere; id de actionibus mentis immanentibus (de quibus hoc loco quæstio non est) facile concedimus." In the *De ipsa natura* (*Philosophical Essays*, 161), Leibniz – referring to this exact same passage – positively acknowledges this aspect of Sturm's occasionalism, that is, the fact that it stops short of being applied to every causal dimension.

ends, we acquire knowledge not only of ourselves and the world, but also of God.[67] In this, Sturm's natural philosophy qualifies as a physico-theology.[68]

We may conclude that Sturm retains the finality of nature, but due to his mechanist and occasionalist commitments, he is bound to say that the finality of nature is realised by God's workings in the physical world, that is, through matter and passive forms. Using an image provided by Johann Jakob Scheuchzer (1672–1733), one of Sturm's students, we may picture God as a mechanic who runs the world-machine through a system of levers according to His decreed general laws, instilling and maintaining motion.[69] The levers, i.e., bodies constituted by matter and passive forms, enable God to bring about the effects, and goals He wishes, unbeknownst to all but rational beings.

4 Life

Explaining the phenomenon of life is the touchstone of mechanical philosophy, and a useful test case for a working natural philosophy overall.[70] The discussion of life in this paper will serve to show how mechanism, occasionalism, and finality work together in providing a solution to a notoriously difficult problem: the distinction between the living and the non-living. Occasionalism in particular might provide Sturm with the additional means necessary to mend the shortcomings of a strict and austere mechanism à la Descartes. God's causal role not only gives a telling account of the origin and allocation of motion in the world, but also accounts for the (admittedly mostly extrinsic) finality as well as the complexity displayed by living beings.

For Sturm, plants, animals, and human beings count as living bodies, and we are told that "we say of a thing that it lives when it is nourished, grows, and

67 PE I.1, preface, article 4.5.

68 Lind (*Physik im Lehrbuch*, 15–22) points out that physico-theologies were widespread in eighteenth century physics. The purpose of physics as studying oneself, the world, and God is common to both Aristotelian and even (most) mechanist physics textbooks of late seventeenth- and eighteenth-century Germany (ibid., 58, 75).

69 This illustration by Scheuchzer is taken from ibid., 77.

70 Hutchins neatly captures what is at stake: "Living things present both a curious amenability to mechanisation and a serious resistance to it. For these reasons, the explanation of living things functioned as a highly productive testing ground for early modern mechanisation projects – if you could explain the complexity and apparent autonomy of living things on a mechanical basis, you might reasonably think yourself capable of explaining anything in the natural world" (Barnaby R. Hutchins, "Mechanisation of Life," in *Encyclopedia of Early Modern Philosophy and Science*, ed. Dana Jalobeanu and Charles T. Wolfe (Cham, 2021), <https://doi.org/10.1007/978-3-319-20791-9_139-1>, 6).

is conserved intrinsically."[71] The use of 'intrinsic' here indicates that it is the internal processes within a living being that allow it to carry out these tasks. Nourishment entails internal physiological processes (such as digestion) by means of which the body is replenished. Growth happens from within, not by means of extrinsic addition of lumps of matter. To this definition of life Sturm adds that living beings produce beings of their own kind, i.e., procreate.[72] Living beings are alike with regard to 'performing' these functions (*munia vitalia*), that is, nutrition, growth, generation/procreation and conservation. I will call this the *life-function*. However, strictly speaking, it is only God who acts (through creatures) – hence, the addition of scare quotes. All living beings have an organic body and some kind of soul (*anima*) by virtue of which they are called 'animated'.[73] We will see shortly that except for the case of human beings, Sturm has a mechanist and materialist conception of what the scholastics called the vegetative and the sensitive soul. The only truly immaterial (and immortal) soul is that of human beings. Living beings, however, also differ: plants are only able to 'perform' the most basic functions of living beings – nutrition, growth, procreation and conservation. Animals, in addition, are able to move and sense. Humans, finally, possess every capacity of animals and plants, but they are also endowed with an immaterial mind.[74]

Prima facie, Sturm works with the Aristotelian-Scholastic tripartite distinction of souls, and this causes him some troubles. Plants are described as having a vegetative soul (*anima vegetativa*), animals as having sensitive soul (*anima sensitiva*) in addition to a vegetative soul, and human beings as having a rational soul (*anima rationalis*) in addition to the others.[75] However, the vegetative and sensitive soul are not immaterial or mental principles. According to Sturm, "the souls of brutes and plants are true substances but corporeal [ones]."[76] I will focus on the question of the souls of animals, because, according to Sturm, there is consensus among philosophers both old and new that they are alive, and because studying animals allows us to avoid the complications that arise with regard to the status of the immaterial soul of human beings and its relation to the body.

71 "[…] vivere rem dicimus, cùm ab intrinseco nutritur, augescit, & conservatur" (PE I.1, 111).

72 CPMS, 566–567.

73 CPMS, 562–563; PC, 243–244.

74 CPMS, 566–567.

75 For the Aristotelian-Scholastic account of the three souls, whether they are as one or distinct (and if so, how they can be united), as well as related problems, see Dennis Des Chene, *Life's Form* (Ithaca, NY, 2000), in particular parts three and four. Sturm dismisses questions along these lines as useless (*frustraneas*) (CPMS, 565–566).

76 "[…] brutorum & plantarum animas veras substantias, corporeas tamen; esse [infra constabit]" (CPMS, 607).

Animals lack the immaterial rational soul that marks out human beings.[77] They possess neither true language, nor reason, nor cognition, all of which are ascribed to the presence of an immaterial rational soul (united with a body).[78] Animals, for Sturm, 'perform' two kinds of operations: (1) they live, and (2) they move and sense, though in a purely mechanical-material way. Both of these operations are explicable by them having a vegetative and a sensitive soul, respectively. However, speaking with philosophical rigour, for Sturm, the operations of these "souls" can be explained in terms of purely physiological-mechanical processes:

> It is not necessary to ascribe to animated brutes, not even to the hottest ones or, as it seems, most astute ones, any reason or true cognition, since all their effects and whatever marvellous or admirable operations can come forth from (as we call it) a certain *natural instinct*, that is, from the internal structure or organisation of their bodies, and from the fluxes of blood, lymph, air, vital flame, and spirits; it is very credible from this that these mechanisms have the highest Will for their artificer and inventor by means of which many more admirable things can come about than all those [which] could until now be furnished [...] thought out by human ingenuity by means of automata and crafted by human hand.[79]

The quotation appears in the context of a discussion of animated bodies (*de corporibus animatis*).[80] Sturm points out that despite the fact that we observe operations in animals that make us want to ascribe a mind or an immaterial principle to them, all these operations are expressions of natural instinct, which, for Sturm, is reducible to the realm of physiology. Nothing in animals exceeds the realm of the purely mechanical, that is, matter, motion, modifications and higher-order structures of matter. Life in animals comes from the

77 CPMS, 646.

78 CPMS, 648, 653.

79 "[Hoc infero:] Non esse necesse, brutis animantibus, etiam callidissimis [sic], uti videntur, vel astutissimis, quicquam aut rationis aut veræ cognitionis tribuere; quandoquidem omnes ipsorum effectûs & operationes utcunque mirabiles & stupendæ, ex *naturali* quodam *instinctu*, quem vocamus, h.e. ex interna corporum suorum structura sive organizatione [sic!], his interfusis sanguinis, lymphæ, aëris, ignis vitalis, spirituumq: fluoribus, provenire posse, vel ex eo credibilissimum est, qùod hæ machinationes, ipsum summum Numen artificem & inventorem habeant, quibus mediantibus multò magis stupenda expedire valeant, quam [esse possunt] ea omina, quæ ab automatis humano ingenio excogitatis, & humanâ manu elaboratis præstari potuerunt" (CPMS, 653). Perhaps surprisingly, Sturm was sceptical of the doctrine of the beast-machine in his earlier *Physica Conciliatrix* (PC, 272–273).

80 CPMS, 646.

blood and the heat of the heart: "I can find nothing other than the vital heat in the blood, which can take over the functions of the vegetative soul."[81] Moving and sensing comes from the brain and the animal spirits, the latter being made out of the most subtle parts of the blood:

> All the power to perceive the sensible impressions, namely, in a bodily way, to excite the internal humours and move the external limbs (which the Schools call the *sensitive*, *appetitive*, and *locomotive* power, when they define the *sensing soul*, not ineptly as *the first act of the animate body by means of which it perceives and apprehends those* things *that are outside itself, seeks the ones beneficial, avoids the ones detrimental and engages in self-motion*) is due to the *spirit* which they call *animal*, the offspring of the vital flame, i.e., the most spirituous parts of the blood secreted especially in the brain and diffused with the nervous juice through the nerves in the whole body.[82]

Sturm is availing himself here of Cartesian physiology. Bodily processes in animals are of a purely material nature. They are purely mechanical-hydraulic. Sturm agrees with the 'more recent' philosophers (*recentiores*), that is, the mechanists, that heat, which in the form of the vital flame plays a key role here, is reducible to corpuscular motion: "heat consists in the fast and jumbled agitation of subtle and rigid particles."[83]

At this point, we are left with the following problem. Life consists in the 'performance' of a certain function: nutrition, growth, generation/procreation and conservation, the *life-function*. Some natural bodies are able to 'carry out' the life-function while some other natural bodies (those that are called

81 "[…] nihil aliud in animalibus reperire possum, quam calorem in sanguine vitalem, qui vegetantis animæ vices obire possit" (CPMS, 658).

82 "Omnis autem hæc impressiones sensibiles, modo corporeo puta, percipiendi, humores interiores ciendi & externa membra movendi potentia (quam *Sensitivam, Appetitivam & Locomotivam* Scholae vocant, *Animam sentientem* ideò non malè definientes *Actum primum corporis animalis, quo percipit & apprehendit ea quæ extra ipsum sunt, appetit salutaria, aversatur noxia & loco-movetur*) *Spiritui* quem vocant *animali*, vitalis flammæ soboli, h.e. partibus sanguinis spirituosissimis in cerebro præcipuè secretis & cum succo nervoso per nervos in totum corpus diffusis, debetur" (PC, 270–271).

83 "[…] calorem in subtilium & rigidiuscularum particularum celeri confusaque agitatione consistere [ostensum … distinctè fuerit]" (PE I.2, 598); see also PE II.1, 103. For Sturm's – correct, I believe – allusion to the general consensus among mechanist philosophers about the nature of heat as corpuscular motion, see PE I.2, 595–597. Indeed, e.g., Descartes (Hutchins, "Mechanisation of Life," 5), and Boyle (William R. Eaton, *Boyle on Fire: The Mechanical Revolution in Scientific Explanation* (London – New York, 2005), 109–127), perhaps the two most prominent mechanical philosophers, agree with this.

inanimate, like stones), and especially artificial bodies, which are generically non-living beings, are not. Furthermore, some living beings (animals) are able to perform even more complex functions, i.e., (what seems like) self-motion and (mechanical, non-phenomenological) sensing. However, living and non-living bodies are very much alike. To be alive does not come about due to the working of some vital principle, and to be alive does not mean to be active.[84] The modifications, dispositions and structures of matter enable the realisation of bodily processes. An explanation of the difference between living and non-living beings has to be sought elsewhere. Yet, conceiving the world as merely matter in motion, the mechanical philosophy that Sturm supports faces tremendous difficulties in providing a sufficient and satisfactory account of life.

However, Sturm hints at a possible way to tackle the problem: the degree of subtlety. Living beings are refined and perfected in a way that is impossible to recreate or imitate by a human artisan with finite knowledge. It is this difference in degree of *raffinement* that accounts for life, i.e., the ability to 'perform' an (extremely demanding) function. Function follows form. Passive forms are modifications of matter and they come about by means of motion. Yet, God is the only mover, because He is the only true cause. Hence, the ontogeny of life hangs on God and His actions. In virtue of His omniscience and His omnipotence, God designed some natural beings – those that live – in such that they are able to 'perform' a function significantly more complex than that 'performed' by non-living beings. He does so by creating passive forms and connections of passive forms in living beings, that is, modifications, dispositions and structures of matter that are intricate and thought out in a way impossible for an artificer endowed with a merely finite mind. Overall, however, to argue that the complexity of living beings is due to the infinitely complex design of an omniscient and omnipotent designer is not an entirely satisfactory answer but looks more like a *petitio principii*.

To sum up: In explaining living beings, Sturm is committed to a mechanist ontology. Everything in the world can be accounted for by means of matter in motion. Motion is what modifies matter. It brings about passive forms dependent upon matter, which is itself essentially passive. These passive forms, that is, modifications of matter to some extent, account for the 'performance' of functions. These functions capture the finality and goal-directedness in nature that Sturm takes to be plainly obvious. However, the creation of passive forms by means of motion leads to the problem of the cause of motion and change in the world. Bearing in mind the purely passive nature of both bodies and finite

84 Indeed, Hutchins ("Mechanisation of Life," 3) points out that "mechanists [such as Sturm] need to find ways to account for the apparent agency of living things in purely non-agential terms."

minds, and the absence of other immaterial principles, Sturm argues that it can only be God who gives existential support to the world in time and space. Only God brings about change in the world by means of motion. It follows that it is also only God who brings about living beings by supplying them with the complexity of passive forms needed to 'carry out' the life-function.

The complexity and (mostly external) goal-directedness of living beings (finality) which are made out of passive matter appropriately modified and disposed (mechanism) can only come from the divine artificer as the only true cause of the origin and transfer of motion (occasionalism). Hence, occasionalism grounds the connection between mechanism and finality.

Conclusion

In this paper, I have shown how Sturm aims at mechanising the natural philosophy of his Aristotelian-Scholastic predecessors. Matter and forms are both reinterpreted as merely passive. Substantial forms are reworked into modes of matter caused by motion. In ascribing the realisation of functions to passive forms of matter, that is, modifications, dispositions, and structures, Sturm retains finality as a central aspect of nature and natural philosophy, by contrast with Descartes (among others), but in line with the Aristotelians. Sturm's argument from spatio-temporal grounding rules out the causal efficacy of secondary causes, and establishes physical occasionalism. Forms *qua* merely passive modes of matter are brought about by local motion, the cause of which is God alone. Insofar as God produces and works through the modifications, dispositions, and structures of matter so as to make it 'perform' certain functions, finality remains by and large extrinsic to living beings – rational beings are somewhat exempted from this. Life consists in the 'performance' of the life function: nutrition, growth, procreation and conservation. Animate natural bodies like plants, animals and humans are able to 'perform' the life function while inanimate bodies are not. The much greater complexity and subtlety of animate bodies, the greater intricacy of their constituting modifications and dispositions distinguishes them from non-living beings and enables them to 'perform' the life-function.[85]

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