DOI:
10.1016/j.shpsa.2022.08.014

A Middle Way: A Non-Fundamental Approach to Many-Body Physics by Robert Batterman: Autonomy and Varieties of Reduction

Alexander Franklin*and Katie Robertson‡

August 2022

Abstract

We review Batterman's new book, and assess the various approaches to reduction that it critiques.

Keywords: autonomy; reduction; multiple realisability; explanation; methodology

1 Introduction

Batterman's latest book develops a series of arguments on important themes and questions which he is largely responsible for bringing to the attention of the philosophical community. One principal theme is that reduction is far more difficult to achieve once we properly pay attention to 'the devil in the details'.

This new book focuses on compelling case studies from materials science. In zooming out from the atomic scale to the hydrodynamic, or continuum, scale of the Navier-Stokes or Navier-Cauchy equations we need to find a way to construct certain parameters such as density functions. One

*alexander.r.franklin@kcl.ac.uk

†k.e.robertson@bham.ac.uk

‡Authors in alphabetical order.

response is given by the naive reductionist: 'that's easy—just take averages'! But Batterman demonstrates that this strategy only works for *homogeneous* systems; for inhomogeneous systems such as that shown in figure 5.1 (Batterman (2021, p. 92)) it matters not only what percentage of the cell is conductor rather than insulator, but whether the material is connected or not. Topology and geometry are therefore relevant and averaging loses too much information. To zoom out and scale up we need to take account of the mesoscale that resides between the microscale and continuous macroscale.

Batterman describes the homogenisation techniques deployed at the mesoscale. By looking at a representative volume element, we plot correlation functions (e.g. by throwing darts and plotting where they land) to map the structure (Batterman (2021, p. 94)). These allow us to characterise 'effective' material parameters, which Batterman glosses as describing a fictitious system that is continuous (or homogeneous), but nonetheless behaves like the inhomogeneous system we were trying to model. We think that the language of 'fictions' is distracting; as Batterman emphasises, these techniques are incredibly successful: why not say these 'effective' parameters capture real patterns?

This latter suggestion is in keeping with Batterman's overarching aims in emphasising the importance of the mesoscale. After understanding these techniques, it's fairly clear that they are indispensable to scientific progress. The 'true physicist' or 'reductionist' blunders, at least, in implying that calculating from the bottom up is possible for us! But Batterman goes further—and with this we heartily agree: the mesoscopic scale is "[not] merely pragmatically justified" (Batterman (2013, p. 272)) but captures something about the world independently of us. Thus, "mesoscale parameters ... are *natural* variables" and the defence of this claim is aimed at "addressing metaphysical concerns about the proper way to carve nature at its joints" (Batterman (2021, p. 121)).

In sum, such case studies show that one cannot just take the putative fundamental description (here the 'atomic level' description stands in for the fundamental description) and then 'just calculate' the higher or macrolevel description: substantive assumptions and machinery are required.

But does this rule out reduction—or just show that things are more complicated than some might have hoped? This depends on what you take reduction to be.

We think that Batterman's work (along with e.g. Mitchell (2009), Morrison (2006), and Wilson (2006)) puts pressure on derivational reduction à la Nagel, but that more sophisticated derivations may well be available for inhomogeneous systems, and, depending on one's preferred theory of reduction, these should also count as reductions.

In the remainder of this review we consider the light that Batterman's project sheds on various alternative forms of reductionism and evaluate the extent to which anti-reductionism is forced upon us in each case. If reductionism requires (i) methodological reduction (§1.1) or (ii) the best explanations to reside at the bottom level (§1.2), then, by our lights, Batterman's project succeeds in establishing anti-reductionism. But the door remains open for some more sophisticated account of reduction to succeed.

Lastly, much of Batterman's work has focussed on universality and multiple realisability: that radically different systems exhibit very similar behaviour. Discussion of such phenomena has led reductionists to retreat to 'local' reduction (e.g. Lewis (1980) and Rosaler (2015)); even if pain is multiply realised in different creatures, we can locally reduce pain as 'C-fibre firing' in humans, 'D-fibre firing' in octopodes ... While going local might recover some species of reduction, Batterman points out that the commonality between pains in different creatures remains unexplained—and this explanatory project is at the heart of this book. "(**AUT**) How can systems that are heterogeneous at some (typically) micro-scale exhibit the same pattern of behavior at the macro-scale?" (Batterman (2021, p. 31)). Batterman characterises AUT as asking "how multiple realizability is possible" (Batterman (2021, p. 33)); the argument in this chapter reprises themes developed in Batterman (2000, 2018), but also pressed in his work on minimal models explanation (Batterman and Rice (2014)) and much of his work on the renormalisation group (RG) and the universality of critical phenomena (e.g. Batterman (2005, 2010)).

In §1.3 we endorse the importance of the AUT question and consider the extent to which answers to this are compatible with reduction.

1.1 Methodological Reductionism

One form of reductionism is 'methodological reductionism'. John Stuart Mill, as considered by Oppenheim and Putnam (1958, p. 11) suggests that since "human social groups are wholes whose parts are individual persons, the 'laws of the phenomena of society' are 'derived from and may be resolved into the laws of the nature of individual man'". Methodological reductionism claims that the best way to investigate societies is by investigating the components: individuals. Analogously, the best way—the best *method*—for investigating the behaviour of fluids, cells, molecules or stars is to consider their respective components. Of course *sometimes* this is a successful strategy, but should we think it the best strategy?

In this new book Batterman's examples hammer another nail into the coffin of methodological reductionism. In particular, he shows how and why 'middle out' strategies can be more fruitful than 'bottom up' strategies.

Reductionism as a *methodology*, however, has long been out of favour.[1] Few think that progress at CERN will help with the physics of fluids. Arguably, Batterman has been instrumental in reviving and re-inspiring this debate since Fodor, but with far more attention to the details of actual scientific case studies (Fodor's (1974) example of Gresham's law is hardly scientifically respectable!).

Yet methodological anti-reductionism doesn't go far enough. We don't just need the mesoscale as a useful, and better, methodology for understanding how the microscopic is connected to the macroscopic. Batterman argues that mesoscopic structures also give better explanations than those available at the fundamental level.

1.2 Explanatory Fundamentalism

Another type of reductionism that Batterman clearly denies is one that holds that all the best explanations reside at the fundamental level; some, instead, reside at the mesoscale.

This view is now the mainstream view: for example Strevens (2008) argues that the best explanation is the one that leaves out as many details as possible whilst still entailing the explanandum, and Craver and Kaplan (2018) even argue that mechanistic explanations are best with fewer details. In contrast, when Batterman was first writing this view was nowhere near so widely held—see e.g. Railton (1978) and Batterman's (1992) critique. His early papers have been tremendously influential, and we'd argue that, at

[1] Perhaps one exception is in economics where it's claimed that more realistic foundations than rational choice theory will lead to better macroeconomics; see e.g. Kahneman and Tversky (1979).

least within philosophy of physics, it's significantly because of him that many philosophers are no longer explanatory fundamentalists.

How is this connected to reduction? Higher-level explanations being better does not preclude reduction; one might think that all higher-level theories can be appropriately derived from the underlying theories, and still maintain that the higher-level theories sometimes provide better explanations. That's because the higher-level explanations will be proportionate to the higher-level *explananda* (Yablo (1992)).[2]

Yet there remains a question—one which is central to Batterman's work—why do we have higher-level stability such that macroscale descriptions and explanations are available?

This is closely connected to the AUT *explanandum*. Here differentiating the possible *explananda* at hand is crucial: 'What is autonomy?' Arguably Batterman does not answer this; see Woodward (2018), and a development of these ideas in Robertson (2021). 'How can I derive the macro/continuum level from the atomic level?' Even if the reductionist can answer this—perhaps helping themselves to mesoscopic structure in the process—the AUT *explanandum* remains.

Batterman rightly points out that AUT is not successfully addressed by the more standard attempts at reduction. Those like Sober (1999) who are happy with disjunctions[3] do not get to the heart of the matter—it's left as a pure coincidence that such different systems end up exhibiting the same behaviour.

1.3 Explaining Autonomy From The Bottom Up

In the previous section we agreed with Batterman that the best explanations are often found at non-fundamental levels. Batterman, however, may be read as making a stronger set of claims: that stability, autonomy, or universality cannot be explained in more fundamental terms; that there just is no bottom-up explanation of some *explananda*; and that there are in-principle barriers to providing a bottom-up explanation of the answer to the AUT question.

[2]In our view (Franklin and Robertson (2022)), these higher-level explanations capture the worldly dependencies in just the right way.

[3]E.g. 'pain is identical to C-fibres or D-fibres, or ...'

As Batterman observes "the philosophical literature has by and large missed the fact that this is an interesting question to ask" Batterman (2021, pp. 47–8), and we concur that the answer to the question relies on techniques like renormalisation group (RG) methods and homogenisation. Batterman goes on to claim that such strategies essential to answer such questions are "*not* bottom-up derivational explanations" (ibid., p. 49). So how should we think of the status of the RG? Either the RG is explanatorily brute, or the RG explanations may themselves be explained thereby demonstrating their *explanatory reducibility*.[4]

While Morrison (e.g. 2012; 2014) is more forthright in endorsing the view that top-down organisational principles are involved in the RG, thus suggesting that the RG is explanatorily brute, Batterman's view is ambiguous between Morrison's stronger position and explanatory reducibility. If the RG account were explicable from the bottom up, this would vitiate the stronger form of anti-reductionism.

And one of us has suggested one way that this can be established—see Franklin (2019). The idea developed there is that the RG demonstration of stability rests on a certain set of assumptions: as Batterman successfully argues, the RG explains universality and thereby answers AUT by demonstrating that the critical phenomena are predicted in a way that's invariant with respect to changes in many details of the underlying system. That demonstration relies primarily on the assumption that the system can be described as self-similar, or scale invariant. Thus, in order to account for and explain the applicability of the RG, and the effectiveness of the RG explanation of universality, one needs to explain self-similarity from the bottom up. Franklin argues that just such bottom-up explanations of self-similarity are available, and characterises how they go in terms of the inter-molecular forces. Our suggestion is that, if the RG response to AUT is explanatorily reducible, perhaps analogous reductive strategies can be employed in other cases of multiple realisability.

Does the bottom up *explanans* assume rather than derive some kind of commonality? All explanations have to start somewhere, and the phenomenon of self-similarity is sufficiently general that the distinct interplay of forces that gives rise to it in liquid-gas and magnetic systems doesn't seem quite so coincidental to warrant a recurrence of the AUT *explanandum*—the question why such different systems each gives rise to

[4] Though, as detailed in §1.2, the RG may still offer the *best* explanation of its target phenomena.

self-similarity, albeit through different mechanisms. The beauty of the RG explanation is that it connects the relatively innocuous self-similarity (featured in any fractal system) to the distinctive universal behaviour.

We agree with Batterman that these questions are crucial, and that they are closely related to the reductionist project. But we suggest that the explanations that address such questions are, ultimately, reducible: the central assumptions in virtue of which they work may be further explained from the bottom up.

2 Conclusion

To sum up, this new book tackles important themes, and brings the philosophy of science community into contact with underappreciated areas of material science; this is now a growing sub-discipline of philosophy of physics, as exemplified by e.g. Bursten (2018). The type of reductionist at whom Batterman takes aim is shown to hold an implausible position—but it remains to be seen whether a more realistic and modest form of reductionism must be undermined by such case studies. If a necessary component of reduction is understanding how different scales are related, then the light shed by Batterman's latest book adds to the reductionist vision. Here we have more optimism than Batterman.

References

Batterman, Robert W. (1992). "Explanatory Instability". In: *Nôus* 26.3, pp. 325–348.
— (2000). "Multiple Realizability and Universality". In: *The British Journal for the Philosophy of Science* 51.1, pp. 115–145.
— (2005). "Critical phenomena and breaking drops: Infinite idealizations in physics". In: *Studies In History and Philosophy of Modern Physics* 36.2, pp. 225–244.
— (2010). "Reduction and renormalization". In: *Time, Chance, and Reduction: Philosophical Aspects of Statistical Mechanics*. Ed. by Gerhard Ernst and Andreas Hüttemann. Cambridge University Press, pp. 159–179.
— (2013). "The Tyranny of Scales". In: *The Oxford Handbook of Philosophy of Physics*. Ed. by Robert W. Batterman. Oxford University Press, pp. 256–286.

Batterman, Robert W. (2018). "Autonomy of theories: An explanatory problem". In: *Noûs* 52.4, pp. 858–873. DOI: 10.1111/nous.12191.

— (2021). *A Middle Way: A Non-Fundamental Approach to Many-Body Physics*. Oxford University Press.

Batterman, Robert W. and Collin C. Rice (2014). "Minimal model explanations". In: *Philosophy of Science* 81.3, pp. 349–376.

Bursten, Julia R (2018). "Conceptual strategies and inter-theory relations: The case of nanoscale cracks". In: *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 62, pp. 158–165. DOI: 10.1016/j.shpsb.2017.09.001.

Craver, Carl F. and David M. Kaplan (2018). "Are More Details Better? On the Norms of Completeness for Mechanistic Explanations". In: *The British Journal for the Philosophy of Science*. DOI: 10.1093/bjps/axy015.

Fodor, Jerry A. (1974). "Special Sciences (Or: The Disunity of Science as a Working Hypothesis)". In: *Synthese* 28.2, pp. 97–115.

Franklin, Alexander (2019). "Universality Reduced". In: *Philosophy of Science* 86.5. DOI: 10.1086/705473.

Franklin, Alexander and Katie Robertson (2022). "Emerging into the Rainforest: Emergence and Special Science Ontology". URL: http://philsci-archive.pitt.edu/19912/.

Kahneman, Daniel and Amos Tversky (1979). "Prospect Theory: An Analysis of Decision under Risk". In: *Econometrica* 47.2, pp. 263–291. ISSN: 00129682, 14680262. URL: http://www.jstor.org/stable/1914185.

Lewis, David (1980). "Mad pain and Martian pain". In: *Readings in the Philosophy of Psychology* 1, pp. 216–222.

Mitchell, Sandra D. (2009). *Unsimple Truths: Science, Complexity, and Policy*. The University of Chicago Press.

Morrison, Margaret (2006). "Emergence, Reduction, and Theoretical Principles: Rethinking Fundamentalism". In: *Philosophy of Science* 73.5, pp. 876–887. DOI: 10.1086/518746.

— (2012). "Emergent Physics and Micro-Ontology". In: *Philosophy of Science* 79.1, pp. 141–166. DOI: 10.1086/663240.

— (2014). "Complex Systems and Renormalization Group Explanations". In: *Philosophy of Science* 81.5, pp. 1144–1156. DOI: 10.1086/677904.

Oppenheim, Paul and Hilary Putnam (1958). "Unity of Science as a Working Hypothesis". In: *Minnesota Studies in the Philosophy of Science* 2, pp. 3–36.

Railton, Peter (1978). "A Deductive-Nomological Model of Probabilistic Explanation". In: *Philosophy of Science* 45.2, pp. 206–226.
Robertson, Katie (2021). "Autonomy generalised; or, Why doesn't physics matter more?" In: *Ergo*. Forthcoming.
Rosaler, Joshua (2015). "Local reduction in physics". In: *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 50, pp. 54–69.
Sober, Elliott (1999). "The multiple realizability argument against reductionism". In: *Philosophy of Science*, pp. 542–564.
Strevens, Michael (2008). *Depth: An account of scientific explanation*. Harvard University Press.
Wilson, Mark (2006). *Wandering Significance: An Essay on Conceptual Behaviour*. Oxford University Press.
Woodward, James (2018). "Explanatory autonomy: the role of proportionality, stability, and conditional irrelevance". In: *Synthese*. DOI: 10.1007/s11229-018-01998-6.
Yablo, Stephen (1992). "Mental causation". In: *The Philosophical Review* 101.2, pp. 245–280.