Renormalisation and Realism

Jeremy Butterfield---with thanks to Wayne Myrvold

“I come not to bury effective field theory, but to praise it…”

Conceptual Foundations of QFT, Wien 1-3 June 2026

For 40-plus years, physicists, especially high-energy physicists, have extolled the “effective field theory” view of quantum field theory.

A key idea has been about renormalisation. Whatever non-renormalizable interactions may occur at higher energies beyond our reach, their contributions to (the probabilities for) physical processes decline with decreasing energy, rapidly enough that they are negligible at the energies we *can* reach.

Philosophers have picked up on this. Recently, they suggested that this sheds light on the philosophical topic of scientific realism: both how to formulate it, and whether it is right.

First, I will celebrate the current conception of EFTs, especially for QFT.

Then I argue that it is compatible with scientific realism.

Then I give a bit more detail about the reduction of one theory to another, in application to quantum field theories.

My irenic stance will leave much unanswered.

And I will end by looking into the abyss of minuscule length scales.

Contents

1. Effective Field Theories: the Triumph of Modesty

The "effective field theory view" needs:

- 1: to mean more than the platitudes that:

(i) our theories are fallible; and

(ii) they are about "less than all the world", i.e. have a restricted topic (regime, or domain of application: a cluster of phenomena, a range of distances/energies). *In the sense of (i) and (ii), all theories are effective.*

- 2: to admit the value of investigating smaller distances/higher energies.
- 3: to admit discussion (meaningful? prospects?) of a/the fundamental theory (TOE).

And indeed: in the last 50 years, 'EFT' has come to mean so much more---and rightly so (cf. Weinberg 1996) . . .

- 4: The ‘Wilsonian revolution’ has bequeathed the great benefit of *calculating* the potential breakdowns of our theory. For QFT, a usual idea is expansion in 1/M, where M is a large mass far outside intended regime; or roughly equivalently: 1/M is a tiny length, irrelevant to observed phenomena.
- 5: There are vast technologies showing how a theory’s long-distance descriptions are robust to variations in short-distance descriptions; and how to compare those latter, for different theories. Of course: the more the latter differ, the less reason, *ceteris paribus*, we have to believe either of them.
- 6: In particular, this technology rehabilitates non-renormalizable interactions---so that renormalizability is nowadays *not* seen as a selection criterion for theories.

Credo: I believe all this is compatible with:

- Scientific realism, whose core tenet is: “we should believe the claims, even about the unobservable, of well-confirmed theories”;

and

- Referential semantics, including for the unobservable, in the Fregean tradition.

Specifically: The objectivity of our reference to an object, and its permanent existence, do *not* require:

- the object to be fundamental in any sense;
- nor us to believe it fundamental;
- nor our language to be exact (non-vague).

2: Interpretation . . . against the pessimistic meta-induction

Philosophers have erred about my (1) to (3) (going beyond fallibilism etc.).

Thus Williams (2019) says that the standard philosophical account of 'interpreting a theory' requires that a theory purports:

'to provide a true and exhaustive description of the physical world in all respects, including at all length scales'

and similar extreme requirements---which he then easily makes hay of (cf. his Section 2).

But his 'standard account' is undoubtedly a straw man. The targeted authors didn't intend those requirements.

Nor does *scientific realism* --- "we should believe the claims, even about the unobservable, of well-confirmed theories"--- need these requirements.

So for all the merits of Williams' ensuing positive account of EFTs and how to interpret them: these merits are old news, as regards scientific realism.

In this, I take my cue from Howard Stein and Wayne Myrvold.

They object to taking scientific realism so strongly---as many philosophers, both *pro* and *con*, have done---that it is subject to the pessimistic meta-induction (PMI): "Since all previous accepted theories have been refuted, so surely also today's ..." .

Thus Poincare (*Science and Hypothesis*, Introduction): 'The educated public is surprised to see how short-lived scientific theories are. They see them abandoned after a few years of favor, the wreckage of one theory piled on the rubble of another, anticipating that today's fashionable theories will soon give way, and from this conclude that these theories are completely futile... No theory seemed more solid than Fresnel's which attributed light to the motions of the ether. Nevertheless, we now prefer Maxwell's theory.'

The ensuing picture of scientific progress as "punctuated equilibrium" is encouraged by textbook snippets of history.

But the PMI is a paper tiger! Really:

- 1: yesterday's scientists cautiously distinguished (a) what is firmly established, (b) what is conjectured, (c) what plays a heuristic role (of various kinds); and
- 2: almost all the time, multiple avenues are being explored.

So: 'it is hard to find anything that was widely taken to be firmly established but is now rejected' (Myrvold 2026; cf. Myrvold 2020, Stein 1989).

Three implications:

- A: The "completed" or "mature" theories on which philosophers tend to focus e.g. classical electrodynamics tend to be theories that are "textbook precipitates". They have been relieved of certain responsibilities that one would otherwise have thought to lie within their scope e.g. the structure of charged matter, and the interaction of matter and radiation. In short: the theory's advocates agree that it is fallible and of limited scope.

B: If a fundamental theory (TOE) is to describe **all** distances or energies, indeed all parameter regimes, then: there have never been serious candidates---and rightly so … it would be *hubris*

C: All this is compatible with a cautious and local construal of scientific realism's core claim, namely:---

In many contexts scientists have been justified in inferring the actual existence of unobservables, and many details about them;

… and with referential semantics about such unobservables.

(Book advert! S. De Haro & JNB, *The Philosophy and Physics of Duality*, OUP 2025: Open access:

https://global.oup.com/academic/product/the-philosophy-and-physics-of-duality-9780198846338)

E.g. I believe that insulin consists of a ring of 52 amino acids; and that this is just as permanently established, as that grass is green.

(I set aside, as does the literature: global agnosticism i.e. about *all* unobservables.)

3. Reduction and all that: a simple view

Reduction: "Recovery/Encompassing" of the "top" theory by the "bottom" theory. (NB: "bottom" need not be fundamental!)

Nagel's account: recovery is deduction, once appropriate definitions ("bridge laws") of the top theory's terms are added to the bottom theory.

The top theory's items---objects and properties---are rendered as clusters/constructions of the bottom theory's items.

"Closing the circle": Eddington only had one table!

Philosophers (especially Batterman 2001f.) extoll renormalisation group methods as securing the "autonomy" of top theories.

One aspect of autonomy is universality: in philosophical jargon, multiple realizability. Cf. the calculation of critical exponents.

But there is also: epistemic confidence about survival in the future.

The idea: since the renormalization group protects low-energy physical theories from high-energy effects, we can and should believe that theories will not be overturned by later discoveries about high energies. (I set aside Hume's problem of induction!)

Foreshadowed, also in relation to scientific realism, by physicists, e.g. J. Bricmont and A. Sokal 2004:

'It is a reasonable guess that *none* of the theoretical entities in our present-day theories are truly fundamental, and that *all* of the theoretical entities in our present-day well-confirmed theories will maintain some status as derived entities in future theories.'

4. We are in danger of peace breaking out ...

But two concerns remain ...

(A) The modern EFT framework's "recovery" of the top theory (the macro-ontology) as real ... is:

(a) impressive and accurate, e.g. successful in cases where mean field theory gives wrong answers;

(b) alluring for its conceptual/philosophical aspects (cf. e.g. Rivat 2025);

(c) happily compatible with (though "not news" for) scientific realism.

But nothing above has addressed the questions:---

1: What is the ontology of quantum field theory, either micro (field vs. particle) or macro (e.g. collective phenomena, as described by QFT)? ... That is: beyond the "minimal" proposal, especially for micro, that the object is "the quantum system", with "all the action" is in specification of which quantities.

Again, my Credo:-- For bottom, as for top, theories: the existence of an object can be objective and permanent, without the object being fundamental, and with our language being vague.

2: The measurement problem?! ... The elephant in the room ...

(B) Is autonomy compatible with reduction?

Many say 'Yes' (Anderson 1973, JNB 2011). Reduction does not detract from the scientific creativity of our top theories!

(A) and (B) come together in the claim:---

RG explains, indeed deduces, the renormalizability of our empirically successful theories (in the SM).

For the RG flow on the space of theories to lower energies amounts to a set of bridge laws that enable a deduction *à la* Nagel, from a theory describing high-energy physics, of low-energy theory.

And because the same scheme shows how many high-energy theories flow to similar low-energy theories, we have not just a set but a conceptually unified family of Nagelian reductions. (JNB 2014)

5: Glimpsing the Abyss ...

Let us accept the real number continuum in our philosophy of mathematics; maybe as reconceived, e.g. by synthetic differential geometry. And let us admit that space time and spacetime could be continua, for all we know. And let us set aside how hard it might well be to know. Then here are two lines of thought for philosophers . . .

1: Ontological indeterminacy /worldly imprecision (Miller 2021)

I think (as do most philosophers) that the vagueness of our language is a matter of semantic indecision. That is: No one is so mad as to spend their time deciding for us some exact boundary beyond which the Ozzie outback begins.

That presumably implies that the world itself cannot possibly be indeterminate . . .

But could we somehow make sense of some finite (though minuscule) lower bound to the "granularity of physical facts"?

2: The Nielsen–Ninomiya Theorem:

This “forbids, under reasonable conditions” chiral fermions to live on a lattice. More precisely:---

A: A reasonable quantum field theory of fermions, formulated on a lattice, *must* have extra “mirror” fermions additional to those intended---mirror fermions that we do not see.

B: The unwelcome fermions can be sequestered in a term in the action with an explicit dependence on the lattice spacing etc.; while the fermions treated by the “continuum” term in the action are insensitive to these modelling details.

Williams (2019, Section 3.1) sees B as showing up the errors of the “standard(!) interpretation”: it must infer--rashly---to the mirror fermions . .

But if I may use A to ontologize . . .(Cf. also S. Rivat, “No peace on the lattice”, *Philosophy of Physics* 2025)

If we were sure that:

- (i) the reasonable conditions hold, and
- (ii) the theory is wholly confirmed by all evidence, and
- (iii) it has no tensions with any other theory (no gravitation!),
- (iv) [harder!] no such tensions would appear at the smaller scales we cannot probe:

Then surely:

a scientific realist *should* infer that spacetime *IS* a continuum.

Dankeschoen!