Quantum metaphysics from an effective-field-theory viewpoint

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The fundamentality assumption: The primary way to understand a physical theory is to suppose that it is exactly true and represents the deepest features of reality. Interpretations based on the assumption that the theory is approximate, or otherwise non-fundamental are secondary and derivative on the primary understanding, or else of merely instrumental significance.

[I]t is not often that experiments are done under the stars. Rather they are done in a room. Although it is physically reasonable that the walls have no effect, it is true that the original problem is set up as an idealisation. (Feynman)

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- Pick a ‘cutoff’ scale, short compared to the scale on which we’re studying the system but (for the moment!) otherwise arbitrary
- Even if we have reason to think the theory is ‘really’ discrete on short lengthscales, the cutoff needn’t be put at that lengthscale and doesn’t in any realistic way describe the actual short-distance physics

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    - It obviously doesn't give the right description of the short-distance physics, but the short-distance physics ought to make a big difference!

The scalar field

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$$V(\varphi) = V_0 + \frac{m^2}{2}\varphi^2 + \frac{\lambda_4}{4!}\varphi^4 + \frac{\lambda_6}{6!}\varphi^6 + \cdots$$

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3. If desired, *reinterpret* this as describing the *original* theory at larger lengthscales/lower energies

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2. Those coefficients are *compulsory*: even if we try leaving one of them out of the Lagrangian, it gets added back in when we renormalise

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  - General relativity (fails at the Planck length)
  - Electroweak theory without the Higgs (fails at $\sim 1 TeV$)

Eliminate the cutoff? II

If there are only renormalisable interactions: how do they scale as we use the theory at higher and higher energies?

- If they tend to zero (‘asymptotic freedom’) or some finite value (‘asymptotic safety’) at short distances, there *might* be a continuum limit (example: pure QCD)
- If they diverge at some short lengthscale (a ‘Landau pole’) then there (probably) isn’t a continuum limit (examples: QED, the Standard Model)

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- . . . and so, conversely, we can infer very little about the degrees of freedom (ontology, if you like) of short distance physics by studying large-distance physics
- The degrees of freedom at large scales are determined by the degrees of freedom at small scales only in a very complicated, indirect, dynamically mediated way

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    2. Only the most fundamental quantum theory!

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- (again, cf the old observation language / theory language distinction)

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5. Restrict to certain combinations of temperature and density, so as to get spontaneous symmetry breaking and an effective field theory of solid matter

Redhead on EFTs (in Cao ed (1999))

[F]rom the point of view of methodology of science a recurring theme has been the search for an *ultimate* underlying order characterized by simplicity and symmetry that lies behind and explains the confusing complexity of the phenomenal world. To subscribe to the new EFT programme is to give up on this endeavour and retreat to a position that is admittedly more cautious and pragmatic and closer to experimental practice, but is somehow less intellectually exciting.

Weinberg on EFTs (hep-th/9702027)

It seems to me that this is analogous to saying that to balance your checkbook is to give up dreams of wealth and have a life that is intrinsically less exciting. In a sense thats true, but nevertheless its still something that you had better do every once in a while.

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A: Nobody ever promised you a rose garden.