Title: Ontology of the quantum state: wavefunction vs. spacetime state realism

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Abstract: TBA
Plan:

- Presenting wavefunction realism
  - Configuration vs Physical space
- Challenges to wavefn realism
- Against wavefn realism
- Spacetime State Realism
Wavefunction Realism

• Realist subdivision:
  – The q state represents a *thing* (well, what kind of thing?)
  – The q state ascribes genuine (realistic) properties to systems (e.g., via e-e link)
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• Case of EM field
Some distinctions:

- Representation and represented
  - Mathematical (representational) object vs Physical items (represented)
    - Mathematical: $\Psi(X,t)$, a fn defined on a (high D) space $\Delta$
    - Physical: a field ($\psi$-field) living in a high D physical space
- Configuration space, $\Gamma$, vs $\Delta$
  - $\Gamma$: a representation of 3-D configurations;
  - $\Delta$: a representation of positions in a 3N-D physical space
Thus, for wavefn realism:

• $(\psi, \Delta)$ represents a particular distribution of properties (a field) in a high-D physical space.
  – No 3D space at level of fundamental ontology.
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  - No 3D space at level of fundamental ontology.
- N.B. This is *realism*; the properties are not to be understood in terms of probabilities for measurement outcomes. They are *primitive* and *intrinsic*.
  - (Probs for measurement outcome will appear derivatively, following a *dynamical* analysis of measurement.)
Two kinds of problems:

1) Can we understand what the $\psi$-field is?

2) Is it possible to recover 3-D going’s on? (Monton, P. Lewis, Maudlin)
On (2)

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  ii) Don’t just focus on the space and on the synchronic; \( \psi \)-field should be included (diachronically) in the supervenience base.
Against Wavefn Realism:

- **Unnatural**
  - A) to prefer $\text{pos}^n \text{ repr}^n$
  - B) the Schrödinger form of dynamics

- What happens on move to QFT?
  - Particles not fundamental and their positions imprecisely defined; no decent notion of configuration space; variable particle number.
  - Field configurations? Non-unique.
  - Not taking role of spacetime sufficiently seriously
Spacetime State Realism

- Democracy: characterise state as a (positive normalised) linear functional of dynamical variables: a density operator $\rho$

- But what are the property bearers?
  - The Universe as a whole?
  - Better: subsystems
  - The $\rho$ assigned to a subsystem represents its intrinsic properties, understood as primitive.
• **Understanding $\rho$?**
  
  – Role in theory, cf. EM case, once more.
  
  – No mathematical segregation principle!
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• Understanding $\rho$?
  – Role in theory, cf. EM case, once more.
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• Uniform ontological picture for NRQM and QFT (can reformulate NRQM in Fock space terms with number states for spatial regions):

**PICTURE:** non-separable field on spacetime; field values for regions specified by their $\rho$.
(link to experience: somewhat standard; decoherence)
Conclusions

• We can find intelligible property-bearers and properties to specify the ontology of the quantum state;

• Wavefn Realism: high-D physical space, separable field;

• Spacetime State Realism: physical arena is spacetime, a non-separable field.

• The latter is to be preferred: a univocal ontological picture across different quantum theories; natural role for spacetime; no unnatural preference for a particular set of dynamical variables.
References:


References:


