Primitive ontology first

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The methodology

- **metaphysics: ontology = what there is**
- **revisionary metaphysics**
- **natural philosophy / naturalized metaphysics: science and philosophy one whole; contra both *a priori*, armchair metaphysics and neo-positivist metaphysics**
- **aim: complete and coherent view of nature**

The paper

- **outline of primitive ontology**
- **Is the primitive ontology the full ontology?**
- **YES: Humeanism:** primitive ontology and no additional quantum state
- **NO: modal realism:** primitive ontology and additional quantum state as property (power) of primitive ontology

Dürr-Goldstein-Zanghì (1992)

"What we regard as the obvious choice of primitive ontology—the basic kinds of entities that are to be the building blocks of everything else (except, of course, the wave function)—should by now be clear: Particles, described by their positions in space, changing with time—some of which, owing to the dynamical laws governing their evolution, perhaps combine to form the familiar macroscopic objects of daily experience."

Democritos (about 460-370 before J.C.)

"There is an infinite number of impenetrable atoms, **without qualities and indestructible, which move in the void where they are distributed.** But when they come close to each other or collide, their aggregation results in water, in fire, in a plant, or in a human being."

Newton, *Opticks* (1704)

"… it seems probable to me, that God in the Beginning form'd Matter in solid, massy, hard, impenetrable, moveable Particles … the Changes of corporeal Things are to be placed only in the various Separations and new Associations and motions of these permanent Particles."

Primitive ontology

- **primitive in the sense that it cannot be inferred from the formalism of textbook QM** (specific for QM; any theory that is a physics in the sense of Aristotle – e.g. classical mechanics – has a primitive ontology built into it)

- **primitive in the sense of basic entities**

- **primitive in the sense of primitive stuff (*materia prima*)**

First approximation

- **discrete (particles)**

- **absolute background space; 3-dimensional, Euclidean. Some points of space are occupied, others are empty (colouring of space)**

- **variation: points of space occupied or empty**

- **stipulation: each occupied point is distinct from all the other ones by some metrical relations, absolutely discernible individuals / no physical or metaphysical reason to call Leibniz' principle in question as far as the actual world is concerned**

- **contra continuous primitive ontology (gunk): variation would imply that there is more stuff at some points of space and less at others. But nothing primitive could constitute degrees of stuff at points**

Better formulation

- **matter points being connected by metrical relations (non-vanishing 3-dim distance between any two matter points that distinguishes them)**

- **no commitment to absolute space: only matter points and metrical relations, no points of space**

- **Cartesianism: matter points, because connected by metrical relations (extension); standing in spatial relations distinguishes primitive matter stuff from (hypothetical) primitive mind stuff**

- ➜ **ontic structural realism: all there is to the matter points are the metrical relations in which they stand**

Change: first approximation

- change in which points of space are empty and which ones are occupied

- **If change such that continuous lines of occupation of points of space, then worldlines = substances = particles**

- **If not, then only single events = flashes**

Change: better formulation

- **change in the metrical relations that connect the matter points**

- **If change such that number of matter points is conserved, then continuous lines of matter points = worldlines = substances = particles**

- **If not, then only single events = flashes**

Primitive ontology: summary

- primitive ontology = configuration of matter points (stipulation: particles)

- no state, no properties, just stuff

- Is the primitive ontology the full ontology?

- YES: Humeanism: nothing puts a constraint on how an initial configuration of matter points can develop

- NO: modal realism: there is something that puts a constraint on how an initial configuration of matter points can develop

David Lewis (1986)
Humean metaphysics
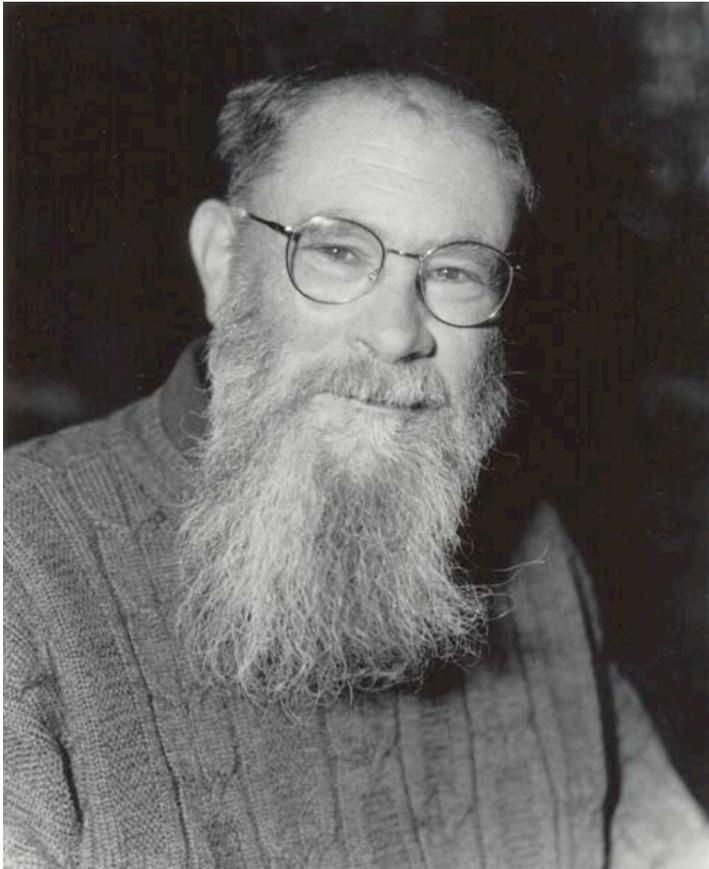
"It is the doctrine that all there is to the world is a vast mosaic of local matters of particular fact, just one little thing and then another. … We have geometry: a system of external relations of spatio-temporal distance between points. … And at those points we have local qualities … For short: we have an arrangement of qualities. And that is all."

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John Bell (1975)
"The theory of local beables"
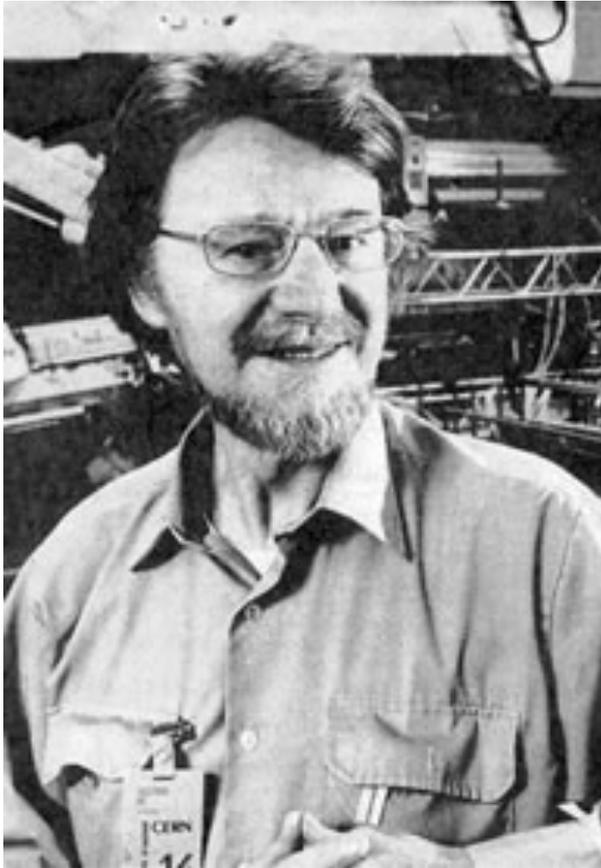
"One of the apparent non-localities of quantum mechanics is the instantaneous, over all space, 'collapse of the wave function' on 'measurement'. **But this does not bother us if we do not grant beable status to the wave function.** We can regard it simply as a convenient but inessential mathematical device for formulating correlations between experimental procedures and experimental results, i.e., between one set of beables and another."

Humeanism

- **distribution of matter throughout space-time:** **complete history of initial configuration of matter points**

- **that distribution manifests certain patterns**

- **Humean best system:** **the laws of nature are the axioms of the system that achieves the best balance between being simple and being informative in describing the distribution of matter throughout space-time**

- ➜ **What the laws of nature are is fixed only "at the end of the world".** **The laws do not determine the temporal development of matter. That development determines the laws.**

Humeanism: classical mechanics

- variables such as mass and charge figure in the laws
- mass and charge attributed to particles on the basis of patterns in the motion of the particles throughout space-time (Hall)
- propositions that ascribe mass and charge to particles true, but truth-maker not properties that particles possess; truth-maker distribution of particle positions throughout space-time
- ➔ mass and charge predicates, not properties
- inertial system, acceleration: defined through patterns in the history of the spatial relations among the matter points (Huggett)
- ➔ Everything else apart from initial configuration of matter points and its temporal development comes in one package from the patterns that this temporal development happens to manifest.

Humeanism: quantum mechanics

- universal wave-function figures in the laws
- attributed to configuration of stuff (Bohmian particles, GRW flashes, GRW matter density) on the basis of patterns in the distribution of the stuff in space-time (Callender, Esfeld, Miller)
- propositions that ascribe quantum state to particles / flashes / matter density true, but truth-maker not state that particles / flashes / matter density possess; truth-maker distribution of positions of stuff throughout space-time
- ➔ quantum state predicate, not property
- ➔ non-locality, EPR: quantum state true *description* that correlates matter points independently of spatial distance, but no relations of entanglement instantiated in space-time over and above spatio-temporal relations among matter points
- ➔ quantum state no addition to being

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Humeanism vs. modal realism

- **Humeanism:** no explanations in fundamental physics
- ➔   brute fact that regularities on which we rely in science and everyday life always turn out to be well-confirmed
- **modal realism:** given an initial configuration of matter points, there is something about this configuration that puts a constraint on how it can develop in time; that something expressed in the laws of nature
- ➔   laws express / reveal modal connections, thereby explanatory
- **more ambitious ontology:** primitive ontology & something modal that constrains development of primitive ontology
- **danger of surplus commitments:** commitment to modal realities that are there but that do not manifest themselves (differences that do not make a difference)

Modal realism: classical mechanics

▮ **dynamical variables that figure in the laws represent properties of particles whose essence it is to induce a certain temporal development of the particles: mass and charge as dispositional properties / powers of the particles that manifest themselves in the temporal development of the particles (Bird, Mumford)**

▮ **laws express these properties**

▮ **intrinsic properties = properties that the particles have taken individually**

Modal realism: quantum mechanics

- **universal wave-function at _t_ represents property of whole configuration of primitive ontology (Bohmian particles, GRW flashes, GRW matter density) whose essence it is to induce a certain temporal development of the configuration (Dorato & Esfeld for GRW, Esfeld et al. for BM)**
- **that essence expressed in dynamical law**
- **quantum state = dynamical state of configuration of matter points, its role is to put a constraint on the development of the configuration of matter**
- **quantum state = holistic property: power of configuration of matter points as a whole (not structure, since no relations among matter points; quantum entanglement not relation in addition to metrical relations, although that power truth-maker for ascriptions of correlations)**
- **In the same way as matter points taken individually can have powers (mass, charge), so the whole configuration of matter points can have a collective power.**
- **➔ EPR-correlations explained without action at a distance (no interaction at all between primitive stuff because no intrinsic properties)**

Conclusion

- **Humeanism fall back option, always available**
- **Plausibility of modal realism depends on its being spelled out in a manner that matches Humeanism in simplicity and elegance: as on Humeanism all dynamical variables & geometry come in one package, so on modal realism wrt QM (BM, GRW), quantum state qua power of (initial) configuration of matter as represented by the universal wave-function has to incorporate everything that determines / puts a constraint on the temporal development of the configuration of matter (including privileged foliation of space-time, if there is one)**
- **one holistic power that yields all the dynamics**
- **no problem of surplus commitments: that power automatically manifest in the temporal development of the configuration of matter**