

EPFL Master course

*Philosophical perspectives on the
exact sciences and their history*

What is a law of nature?

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Primitive ontology & dynamical structure

- **primitive ontology:** what is simply there, no function; the referent of our theories, what they talk about
- **criterion:** general & simple
- **atomism:** indivisible objects, not extended, characterized by their position in space → configuration of matter in space
- change in that configuration as permanent as are the atoms
- dynamical variables to capture that change: initial velocity, mass, charge, forces, energy, wave function, constants of nature, etc.
- **dynamical structure of a physical theory:** function to determine the evolution of what is simply there; relations that couple the motions of the particles to one another
- **claim:** primitive ontology theory invariant; dynamical structure varies as we make progress in formulating a simple and informative theory about the evolution of what simply exists
- **laws:** dynamical structure

Simplicity: ontology vs. dynamics

- simplicity in ontology opposed to simplicity in representation
- **most simple ontology:** matter points standing in distance relations. **BUT** nothing in distance relations in given configuration of matter points tells us something about how these relations change
- **law of motion needs more parameters than position**

$$\frac{d}{dt}Q_t = v_t(Q_t), \quad Q_t = (q_1(t), \dots, q_{N-1}(t))$$

- dynamical structure; fixes v

Determinism

- **task:** find parameters that enable formulation of law of motion such that given any configuration Q , the entire evolution of Q is fixed
- **& that single out probability measure** that enables formulation of propositions about which evolution of subsystems we can reasonably expect under ignorance of exact initial conditions
- determinism structure of physical theory in order to accomplish task of simple & informative representation; **no metaphysical proposition about the world**
- no consequence for free will, etc.

Dynamical structure and ontology

- argument: mass, charge, forces, fields, wave functions, etc. answer question why particles move in the way they in fact do
- counter-argument: mass, charge, forces, fields, etc. *defined* in terms of what they do for the particle motion
- → ontological commitment to them no gain in explanation
- drawback surplus structure & artificial problems: How does a particle accelerate other particles in virtue of properties that are intrinsic to it? How does a wave function influence the motion of matter?

Dispositionalism

- general scheme:

$$\frac{dx}{dt} = D_1 \dots D_n$$

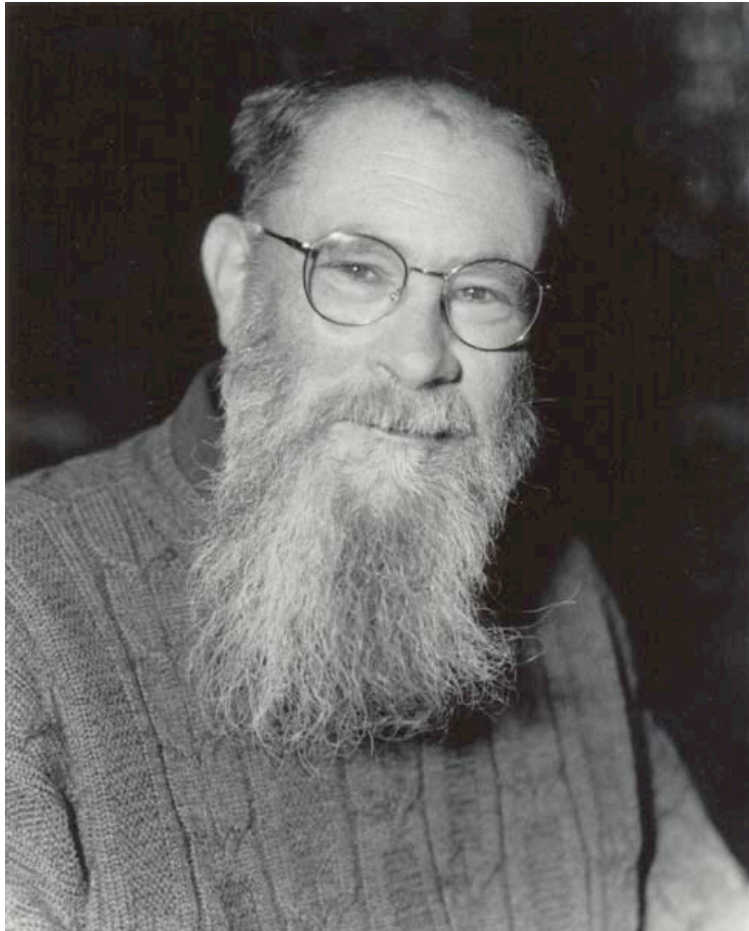
- dx/dt : explanandum, what the theory seeks to explain
- $D_1 \dots D_n$: explanans, what does the explanatory work
- $D_1 \dots D_n$: properties that determine the temporal development of $x \rightarrow$ dispositions
- dx/dt : manifestation of properties / dispositions
- $D_1 \dots D_n$: causes ; dx/dt : effect (\rightarrow physical causation without passing of time between cause and effect)
- universal, deterministic

Dispositions and laws

- dynamical laws fixed by dispositions
- dynamical laws reveal the causal roles that the dispositions exert
- *objective modality, necessity*: in any world w in which disposition D exists, D exerts the same causal role
 - same dynamical laws
 - necessary connection between disposition and its manifestation

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. ... All else supervenes on that.”

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.
- laws in our theories: best conjectures that we can make on the basis of our evidence

Super-Humeanism

- primitive ontology of matter in motion: **only relative positions and their change**
- that change manifests certain patterns or regularities
- laws require fixing of dynamical parameters (mass, charge, fields, etc.) as initial conditions over and above positions (primitive ontology)
- dynamical parameters, geometry and laws all come in as a package to achieve the best representation (most simple & most informative) of the overall change in the configuration of matter

Humeanism vs. objective modality

- **Humeanism:** explanation through unification in fundamental physics: identifying the salient patterns; **but no explanation why there are these patterns**
- **dispositionalism:** 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: law-making properties in the universe
- → **laws express / reveal modal connections, thereby explanatory**
- **problem:** every candidate for that constraint that science can name *defined* in terms of its effect on the development of the configuration of matter

Envoi

- **pertinent question:** What is the primitive ontology? What is the dynamical structure of a given theory?
- How do both explain the evidence?
- **atomism:** point particles individuated through spatial relations & change of these relations; everything else explained in terms of these relations and their change
- → primitive ontology remains the same, dynamical structure varies as we make progress in representing the actual particle motion
- **ontological commitment to geometry (absolute space and time) and dynamical parameters surplus structure, in dispute whether explanatory gain (Super-Humeanism vs. dispositionalism)**