

# The Laws of Physics

Philosophy for physicists  
Lecture VI

13/04/2026

- Simplification of the Laws of Nature
- Physics as a paradigm of all science
  
- Understanding the rules disregarding the strategy  
⇒ fundamental rules
  - fundamental
  - derived

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# Minimal Primitivism (MinP)

*Eddy Keming Chen – Laws of Physics*

- True and fundamental
- Not production of the future from the past, but rather bounds, restrictions
  - Requirements
  - Descriptions
  - Constraints
- What is their ontology? (Or just in our mind?)

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- Modality
- Causality
- Counterfactuals
- Time
- Induction
- Determinism

# Where do the Laws of Physics exist?

- **Metaphysical issues**

⇒ Our goal is to formalise

Conceptual complexity  $\Leftrightarrow$  enormous service to clarity

- fixed question to filter (*ontology & nomology*)

Existence outside space and time?

# How do we know the Laws of Physics?

- Epistemological issue
  - Induction?
  - In the case of empiric equivalence, how do we choose?  
Simplicity, universality, exactness  
⇒ Philosophical topics

- Nomological issue

- How do we select the laws?

*We refuse the existence of an invisible Elf moving the planets... why?*

- Ockham's razor

- Simplicity

- Exactness

- Objectivity

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# Humean - Non-Humean



# Humean - Non-Humean



Do the laws of Physics govern the  
physical world or simply describe it?

# Existence (?) and constraints

Dynamic production

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Dynamic production

## Minimal Primitivims

Bounding the possibilities of the natural/physical objects

Dynamic production

## Minimal Primitivims

Bounding the possibilities of the natural/physical objects

- No need to establish causal relationships
- No need of of presuming the concept of time
- ... bit too vague

## 1. Ontology

- What exists...

## 2. Nomology

- How what exists behave...

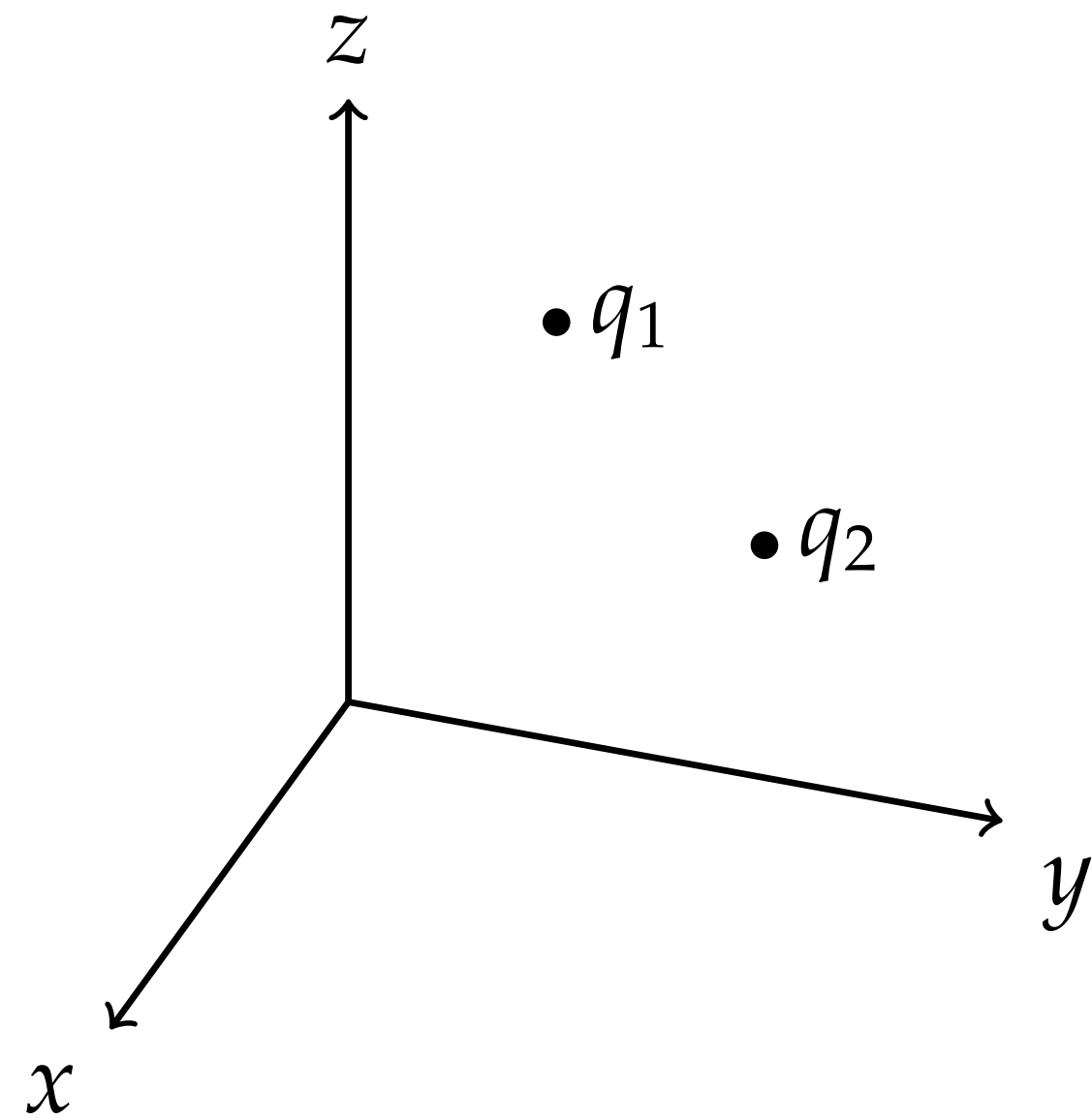
⇒ Fundamental Ontology

... Quantum Mechanics

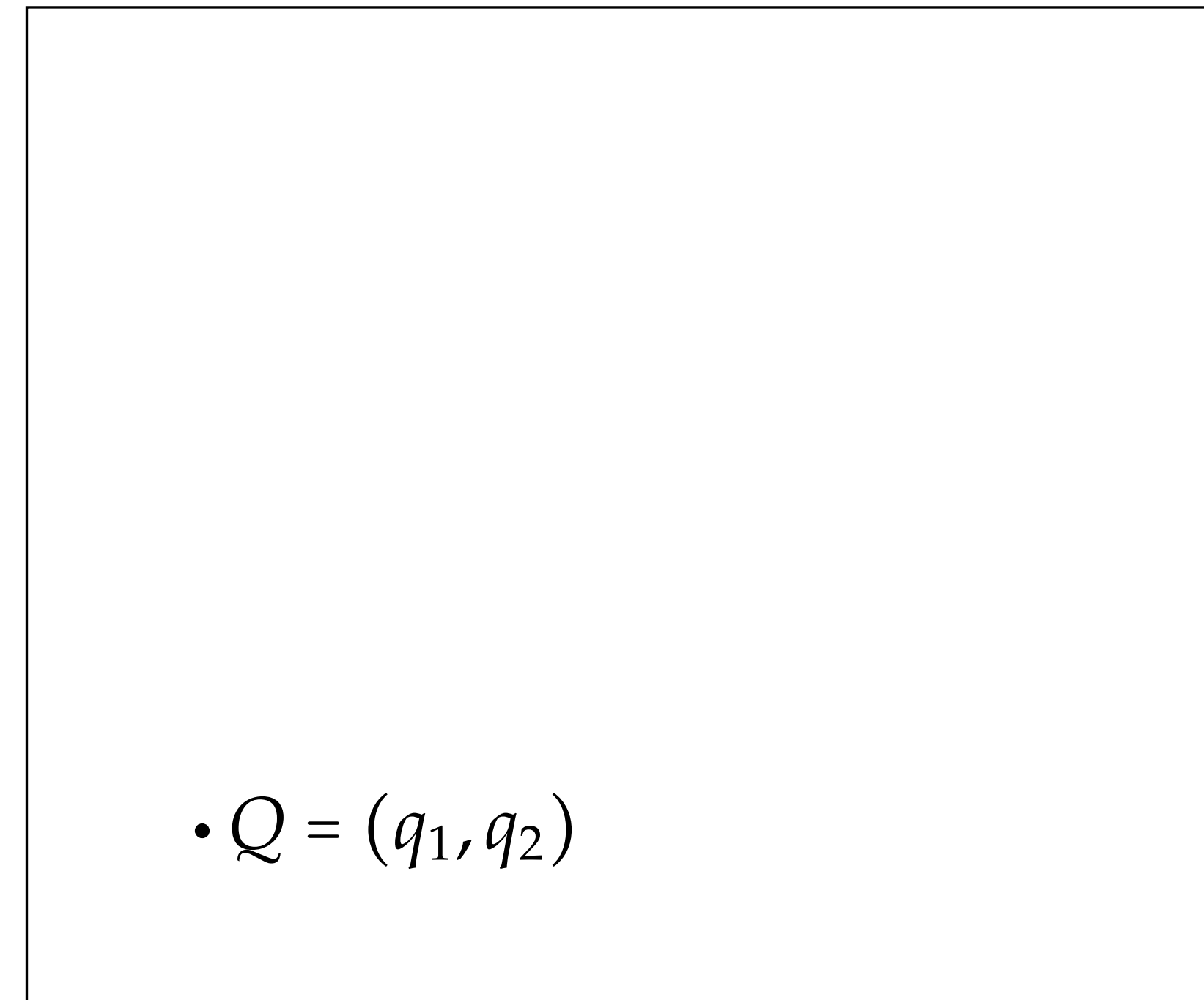
- Fundamental ontology:  $N$  particles
- Fundamental properties: masses  $(m_1, m_2, \dots, m_N)$ , trajectories in the physical space  $(q_1(t), q_2(t), \dots, q_N(t))$
- Space-Time: 3D Euclidean space,  $\mathbb{R}^3$

# Configuration of a two-particle universe

- State of the fundamental ontology



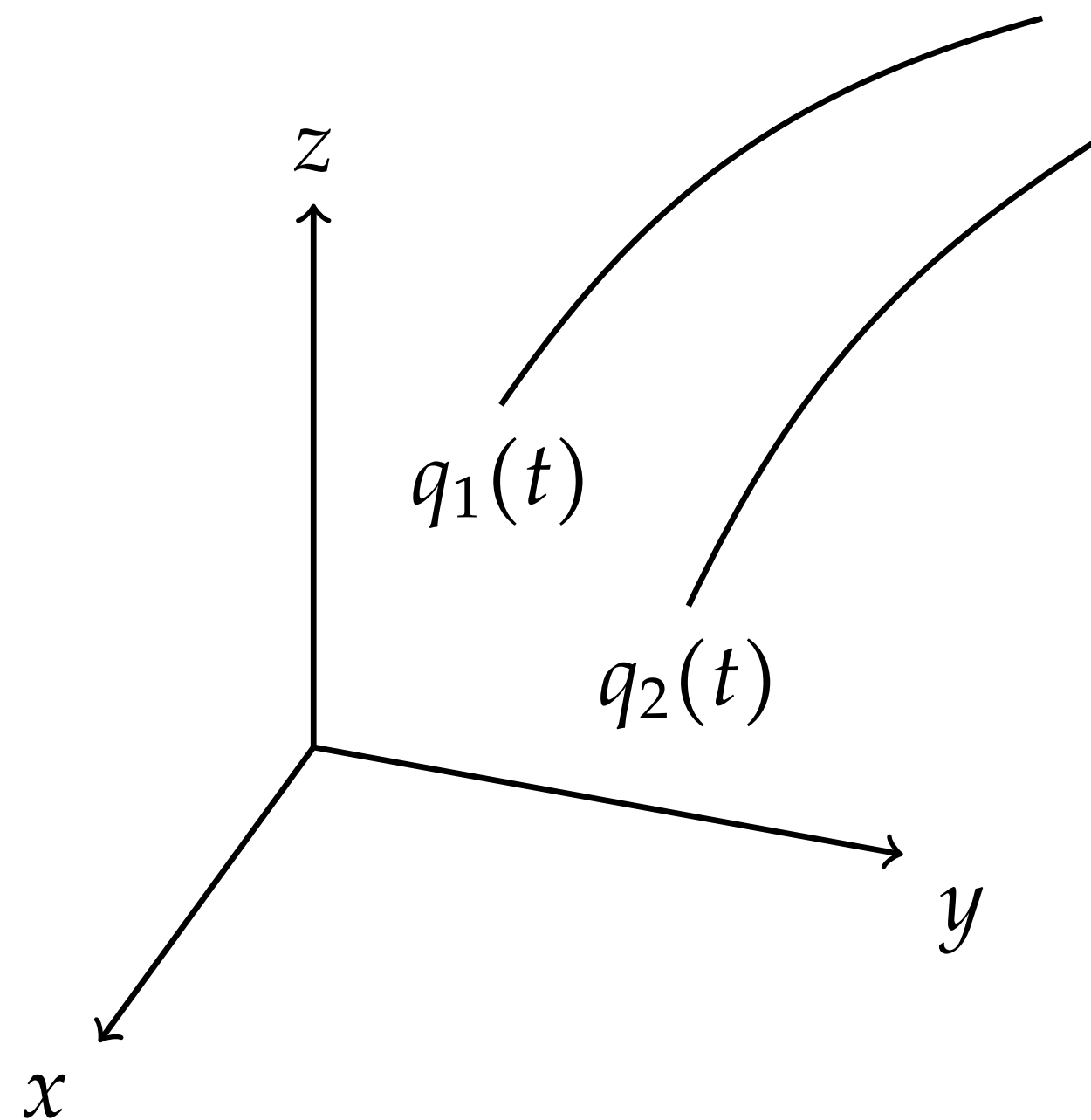
(a) Physical space  $\mathbb{R}^3$



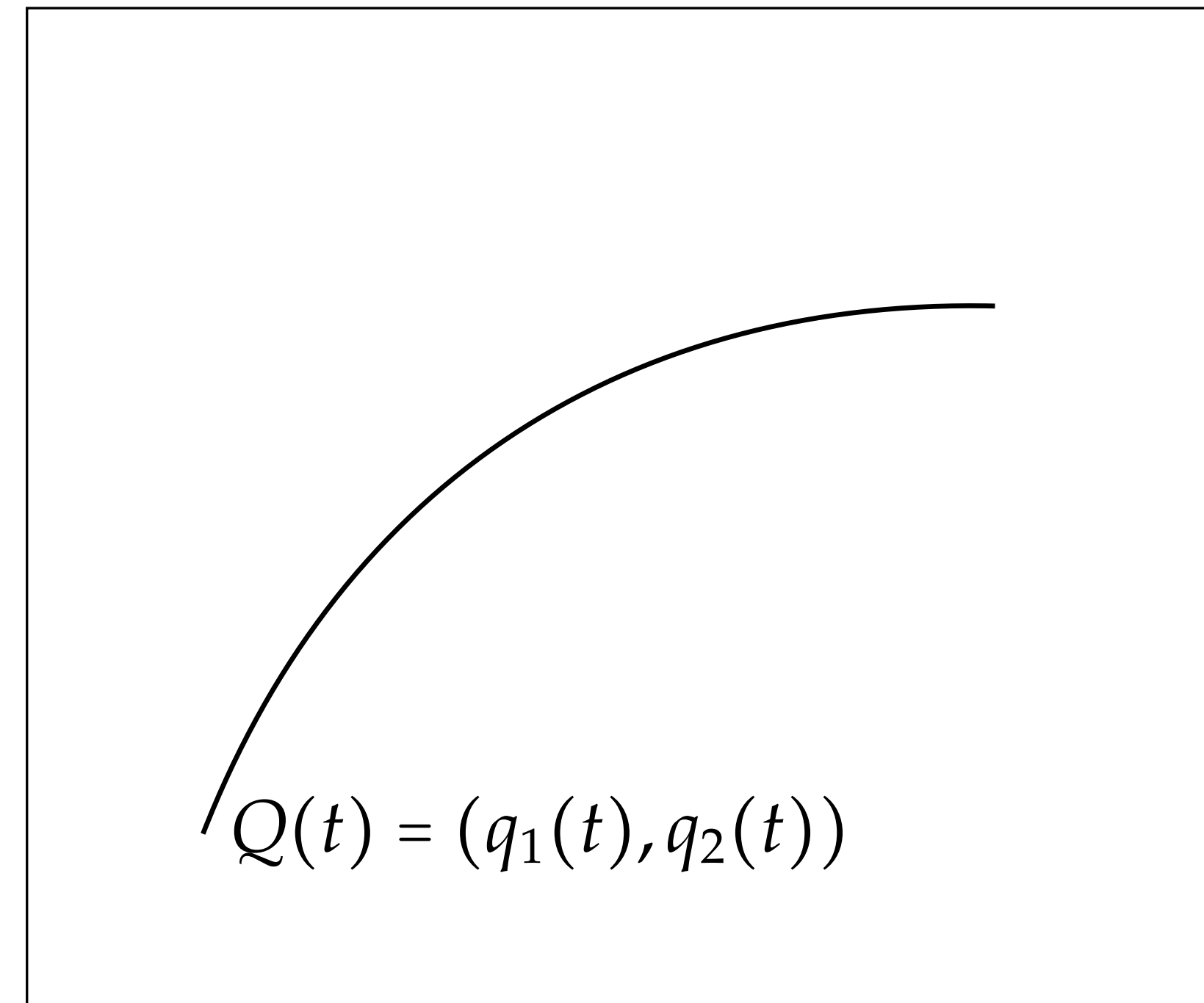
(b) State space  $\mathbb{R}^6$

# Physical history of a two-particle universe

- $N$  curves in physical space: positions of the  $N$  particles at different  $t$
- *Does not presuppose a direction of time*



(a) Physical space  $\mathbb{R}^3$



(b) State space  $\mathbb{R}^6$

# Direction of time?

- The fundamental laws of the theory

- Dynamical law:  $F_i(t) = m_i \frac{d^2 q_i(t)}{dt^2}$

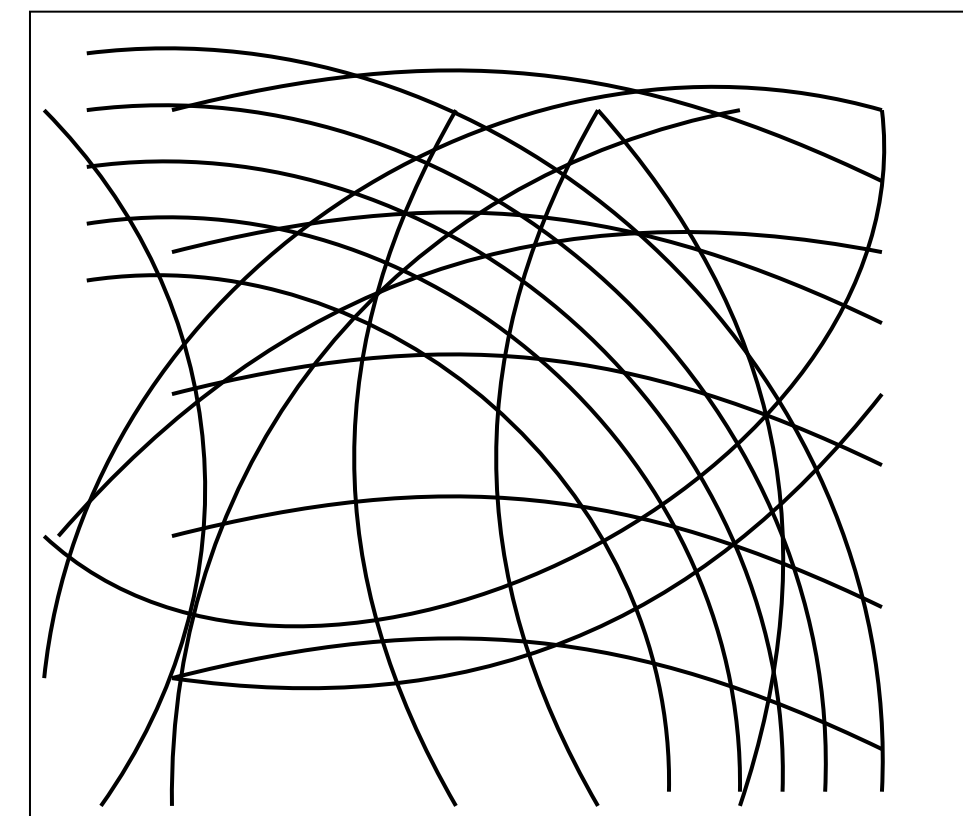
- Force law:  $F_i(t) = \sum_{j \neq i}^N \frac{G m_i m_j}{|q_i(t) - q_j(t)|^2}$

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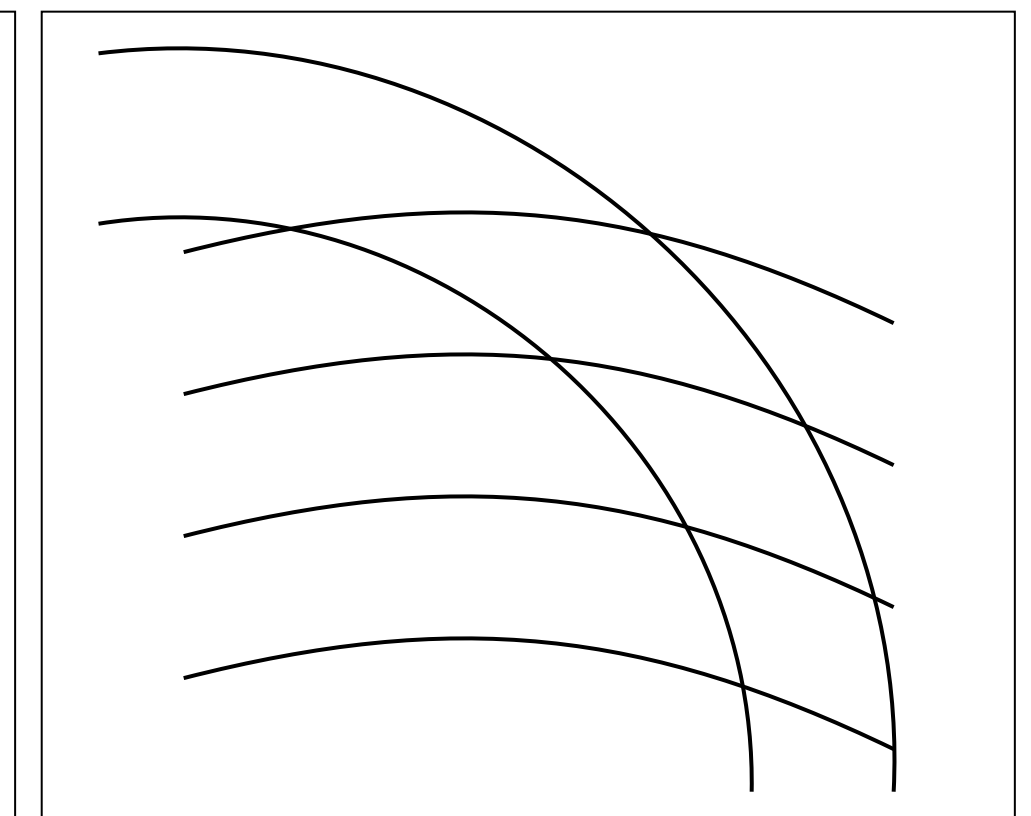
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**What physical histories are permitted**



(a) Arbitrary histories in state space



(b) Nomologically possible histories

- A possible world  $\omega$ :  
a spacetime and a distribution of material contents
- The actual world  $\alpha$ :  
actual spacetime and the actual distribution of material contents
- $\Omega^T$ :  
set of possible worlds that satisfy the fundamental laws specified in theory  $T$
- $\Omega_\alpha$ :  
the set of possible worlds that satisfy the actual fundamental laws of  $\alpha$ , i.e. the set of all nomologically possible worlds

# Possibility vs. Necessity

- **Nomological Possibility:**  
permitted in some nomologically possible world
- **Nomological Necessity:**  
has to occur in every possible world

When a theory is more complex all this is not just a verbal/linguistic complication

⇒ Clarity in our concepts: a set of fixed questions to filter the ontology and the nomology

If A were the case, then B would be the case

Joined together by laws

*“If this coin were in my pocket, it would have been silver”*

- It is accidental
- To support a counterfactual, the non-logical fact needs to have nomological necessity, corresponding to a law

## Causation

Events in the past, together with the laws, bring about events in the future

⇒ **Direction of Time**

(Fundamental Laws of Temporal Evolution) Maudlin

Where does the direction of time come from?

1. **Only FLOTEs.** The only kind of fundamental laws are fundamental laws of temporal evolution (FLOTEs)
2. **Dynamic Production.** Laws explain by producing later states of the universe from earlier ones.
3. **Temporal Direction Primitivism.** The direction of time is a fundamental feature of the universe.

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... *Past Hypothesis:*

*the direction of time is understood in terms of an entropy gradient*

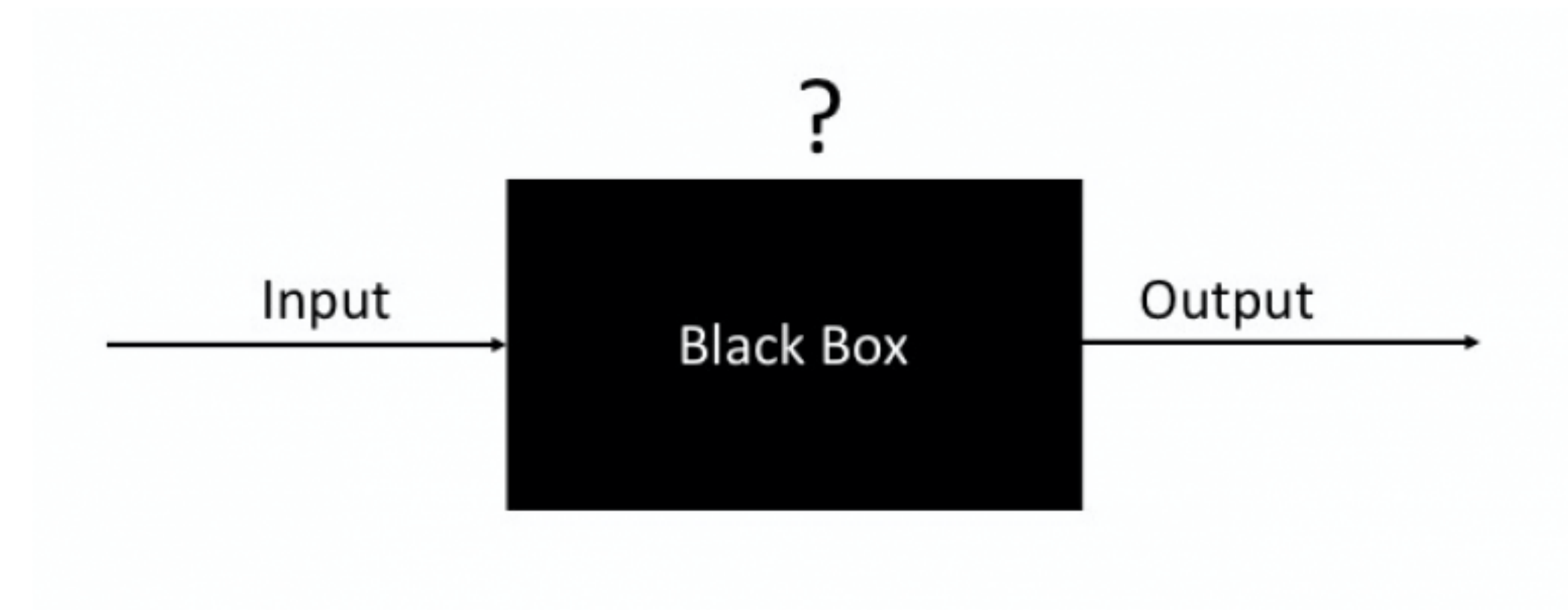
- Properties of the laws
- Determinism<sub>0</sub>  
The world is governed by (or is under the sway of ) determinism if and only if, given a specified way things are at a time  $t$ , the way things go thereafter is fixed as a matter of natural law.
- Determinism <sub>$T$</sub>   
Theory  $T$  is deterministic just in case, for any two  $w, w' \in \Omega^T$ , if  $w$  and  $w'$  agree at any time, they agree at all time
- Determinism <sub>$\alpha$</sub>   
The actual world  $\alpha$  is deterministic just in case, for any two  $w, w' \in \Omega_\alpha$ , if  $w$  and  $w'$  agree at any time, they agree at all times

# Prediction and Explanation

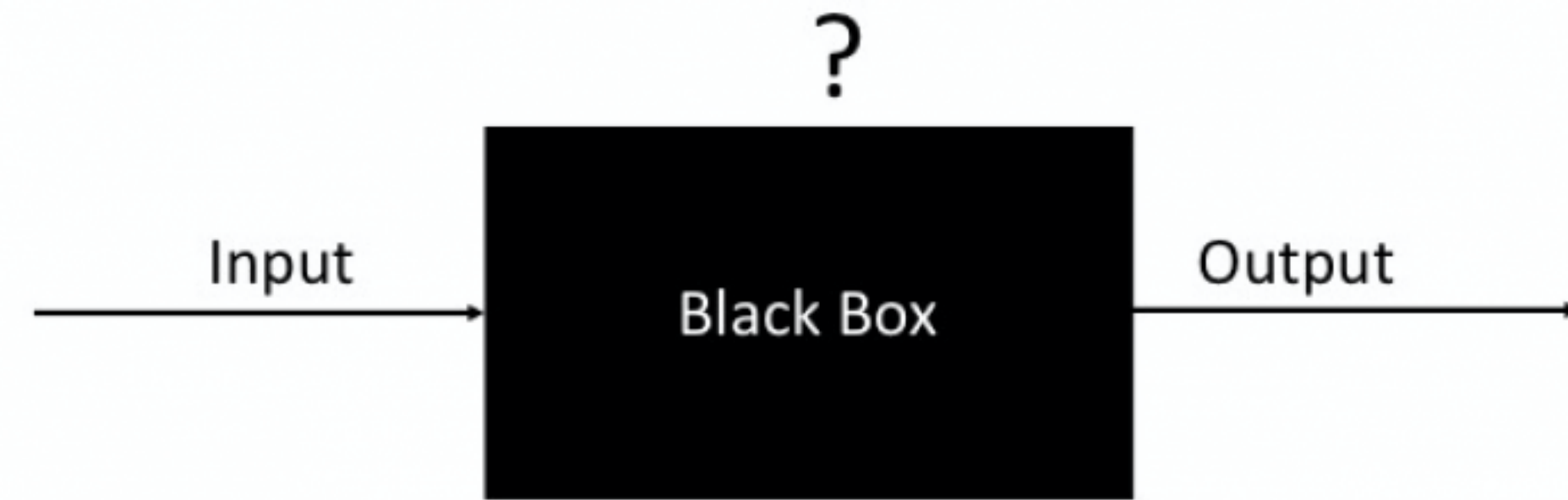
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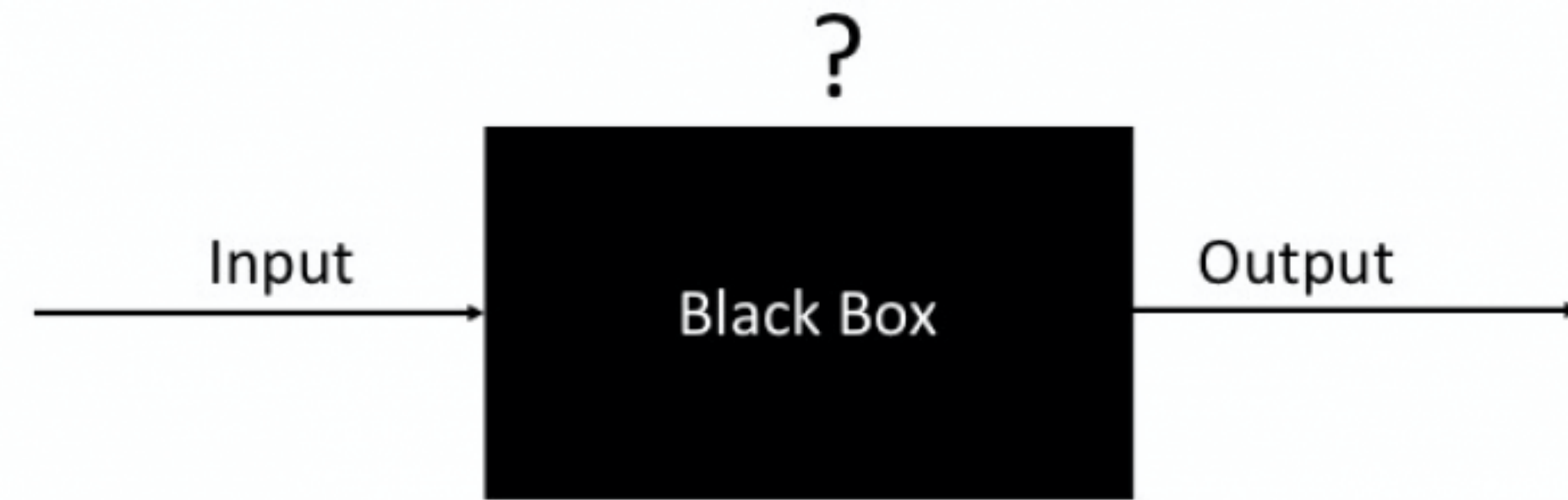


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- Deductive-nomological (DN)
- scientific explanation two parts:
  1. *Explanandum* describing the phenomenon to be explained
  2. *Explanans* that account for the phenomenon

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Conditional explanation: at least one law and at least one non-law as the explanans

Strong explanation: laws are the only explanans

Induction is the inference to unobserved phenomena from observed ones

Nature is uniform

Hume  $\Rightarrow$  we do not have non-circular justifications for inductive inference, because our justification for UP comes from induction

The variety and complexity in the matter distribution does not diminish our confidence in the viability and the success of induction

Fundamental Laws.

For any world  $w$ , fundamental laws of nature in  $w$  are the non-mathematical axioms (basic postulates) of the complete fundamental physical theory of  $w$

Cannot be derived from another non-equivalent physical theory that is true in  $w$

*The mathematical axioms are not laws of nature*

What about fundamental laws themselves? Are they metaphysically fundamental? Or are they metaphysically explained by something else?



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- ➔ Next year a series on Philosophical readings of Quantum Mechanics