Laws of nature

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Plan

1. The accidental and the nomological
   - Newton's Law and Bode's Law
   - Counterfactual support as indicator of necessity
2. Humean vs. non-Humean analyses
   - A Humean approach: best-systems analysis
   - Non-Humean approaches: Armstrong and Cartwright

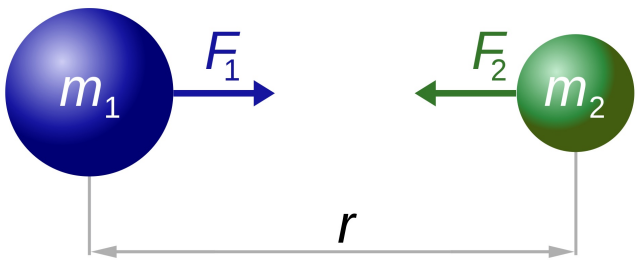
What is a law of nature?

Alex Rosenberg (2012). Why laws explain. In his *Philosophy of Science: A Contemporary Introduction*, Routledge: New York and London, 61-79.

Laws do important explanatory work—but just what is a law?

- first pass: true generalization, universal statement
- additional conditions: not merely true by definition, makes contingent claims about nature, not about merely local facts
- need to distinguish generalizations that are accidentally true from 'laws'
- example of accidental truth: 'All faculty members of the Department of Philosophy are right-handed', 'All fruits in the garden are apples'
- example of law: 'All gases expand when heated under constant pressure'

Newton's Law of Universal Gravitation



$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

Proposition 75, Theorem 35, p. 956

Every point mass attracts every single other point mass by a force pointing along the line intersecting both points. The force is proportional to the product of the two masses and inversely proportional to the square of the distance between them.

Newton, *Principia*. I.Bernard Cohen and Anne Whitman (trans.), University of California Press, 1999.

Bode's Law

Johann Elert Bode (1747-1826)

This latter point seems in particular to follow from the astonishing relation which the known six planets observe in their distances from the Sun. Let the distance from the Sun to Saturn be taken as 100, then Mercury is separated by 4 such parts from the Sun. Venus is 4+3=7. The Earth 4+6=10. Mars 4+12=16. Now comes a gap in this so orderly progression. After Mars there follows a space of 4+24=28 parts, in which no planet has yet been seen. Can one believe that the Founder of the universe had left this space empty? Certainly not. From here we come to the distance of Jupiter by 4+48=52 parts, and finally to that of Saturn by 4+96=100 parts.

Johann Elert Bode (1772). ***Anleitung zur Kenntniss des gestirnten Himmels***.

Bode's Law

Law ((Titius-) Bode)

"The law relates the semi-major axis a of each planet outward from the Sun in units such that the Earth's semi-major axis is equal to 10:

$$a = 4 + n$$

where $n = 0, 3, 6, 12, 24, 48...$ *with each value of* $n > 3$ *twice the previous value."*

(http://en.wikipedia.org/wiki/Titius-Bode_law, ***accessed 16 October 2013)***

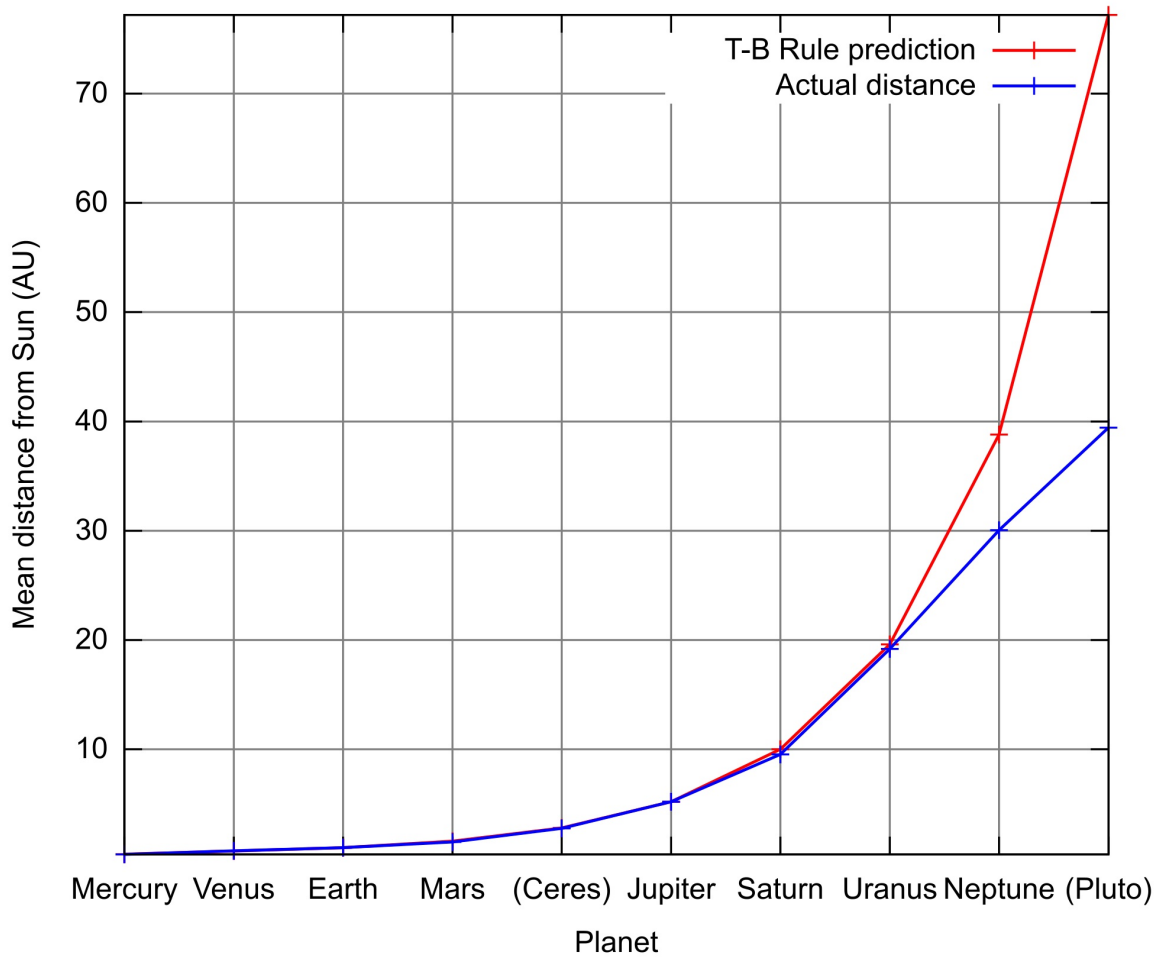
Bode's 'Law'?

- You might be inclined to dismiss this as pure coincidence...
- ... but then...
  - William Herschel discovered Uranus in 1781—at about a distance from the sun by $4 + 192 = 196$ parts!
  - And in 1801, Ceres is found at the location predicted by Bode, i.e., at $4 + 24 = 28$ parts

$\Rightarrow$ Triumph?

- Not quite...:
  - Neptune is discovered in 1846 at a location far off from where Bode's Law predicted (where, however, Pluto in found in 1930!).
  - And many objects other than Ceres are found in the Asteroid Belt, disrobing Ceres from status as planet.

Distances of planets in the Solar System



from Wikipedia at `http://en.wikipedia.org/wiki/Titius-Bode_law`

Counterfactual support as a symptom of the necessity of laws

- Laws seem to have some sort of 'necessity'.
- Hempel: 'counterfactual support' is diagnostic of lawhood, but philosophically hard to capture
- second pass: law = true, exceptionless generalization describing regularity PLUS some additional, yet unspecified conditions, which capture this necessity and explain counterfactual support

Counterfactual support

Comparez:

- "All solid spherical masses of pure plutonium weigh less than 100,000 kilograms."
- "All solid spherical masses of pure gold weigh less than 100,000 kilograms." (Rosenberg 2012, 63)

- Both statements seem true, but for very different reasons: explanations of both require laws, but only the latter must also include boundary or initial conditions.
- In other words, only the first would be true if counterfactual conditions obtained.

Conditionals: 'If p, then q.'

Terminology

If ANTECEDENT, then CONSEQUENT.

Definition (Types of conditionals)

A counterfactual conditional is a conditional of which the antecedent is not true, expressing (in the subjunctive tense) what would be the case, if something were the case that is not. An indicative conditional is a conditional of which the antecedent may or may not be true, expressing what is in fact the case, if its antecedent is in fact true.

On the difference between indicative and counterfactual conditionals

You can accept 'If Oswald didn't kill Kennedy, someone else did' as true, while rejecting 'If Oswald hadn't killed Kennedy, someone else would have' as false.

Adams, E. W. (1970). Subjunctive and indicative conditionals. *Foundations of Language* 6: 89-94.

A litmus test for lawhood: counterfactual support

Consider the following two counterfactuals, of which both antecedents (and both consequents) are false:

- "If it were the case that the Moon is made of pure plutonium, it would be the case that it weighs less than 100,000 kilos." (Rosenberg 2012, 63)
- "If it were the case that the Moon is made of pure gold, it would be the case that it weighs less than 100,000 kilos." (ibid., 64)

- First counterfactual seems clearly true, while the second seems false.
- The first is supported by a universal truth about plutonium, but the second isn't supported by a universal truth about gold.
- But what underwrites this difference?
- Counterfactual support is indicative of lawhood—but this doesn't explain difference yet!
- The difference is to be found in physical or nomic necessity (not in logical necessity!).

The causal connection

- Nomic necessity seems to be closely tied to causal connection we noticed before and which the logical positivists tried to avoid—it's metaphysics!
- But if it is something like this necessity which is responsible for the difference between explanatory laws and merely accidental generalizations, metaphysics cannot be avoided!
- Humean vs. non-Humean accounts of laws of nature: difference is how deeply 'metaphysical' these approaches are
- example of Humean approach: best-systems analysis
- example of non-Humean approach: universalism

Humean vs. non-Humean analyses of laws

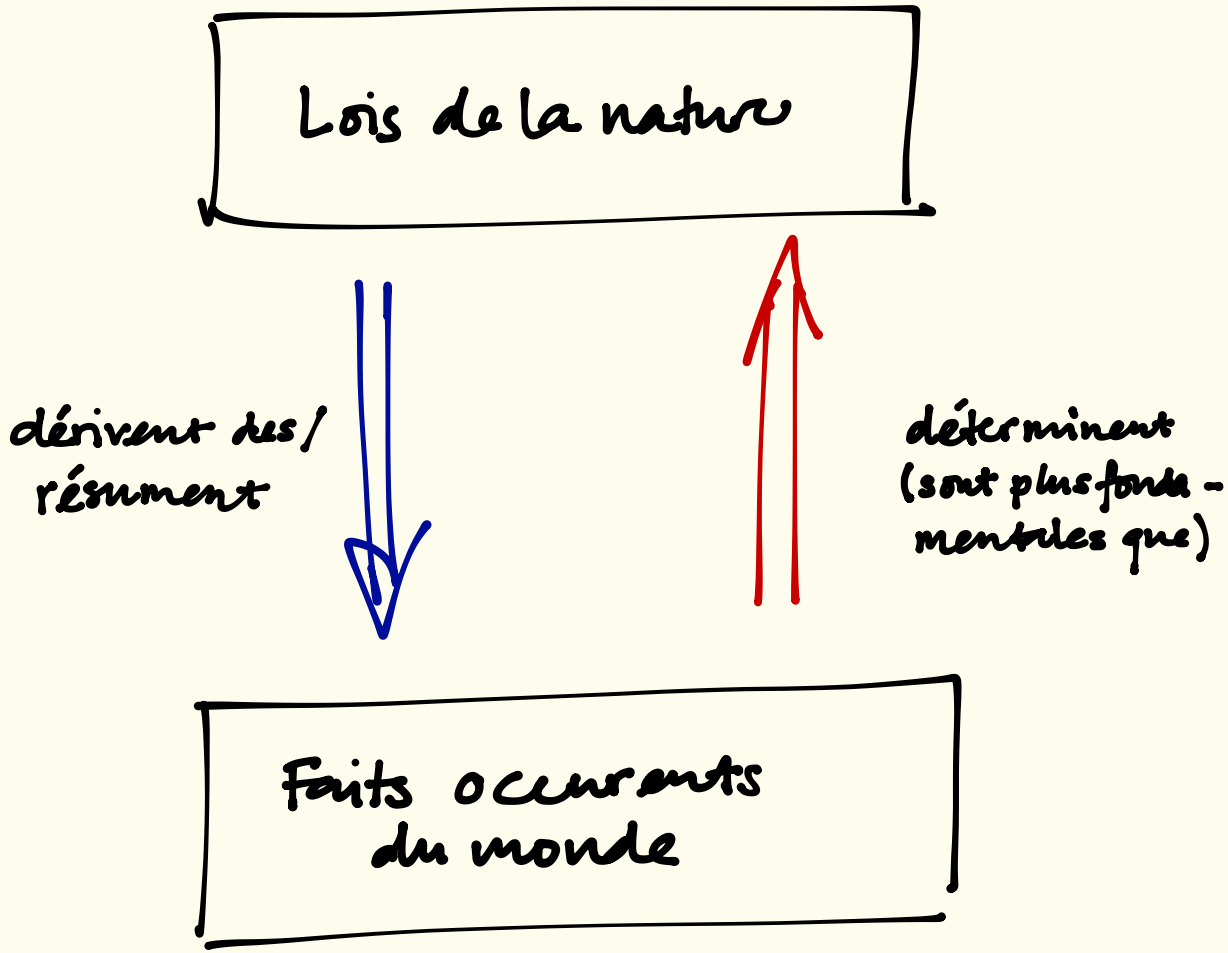
Alyssa Ney. *Metaphysics: An Introduction*. Routledge: Abingdon and New York, 2014.

Position (Humeanism about laws)

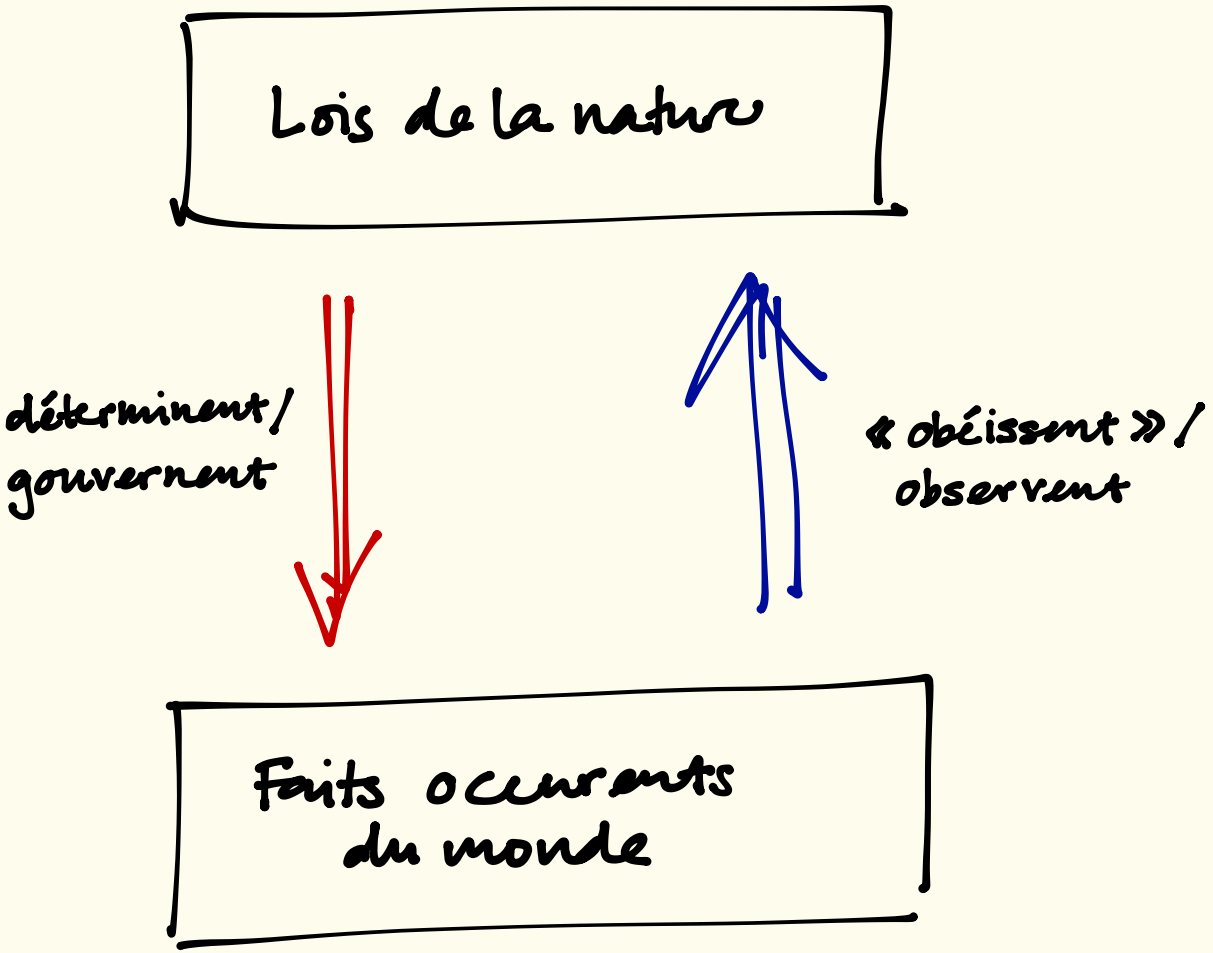
"Humeans believe that the facts about what the laws are are ultimately explainable in terms of or reducible to facts about what happens at a world, that is facts about what kinds of objects and events there are and how that are distributed over space-time. Anti-Humeans think that the facts about what the laws are are not reducible to facts about what happens. Rather the facts about what the laws are are additional facts over and above what happens at a world. The facts about the laws instead explain what happens.

"Humeanism is named after David Hume because it was he who held there were no necessary connections between distinct entities. Since if laws were fundamental, this would mean there are fundamental, necessary connections between the events that take place; the Humeans would want to explain what appear to be necessary connections in terms of more basic facts about what happens just as a matter of fact (not as a matter of necessity)." (Ney, 248)

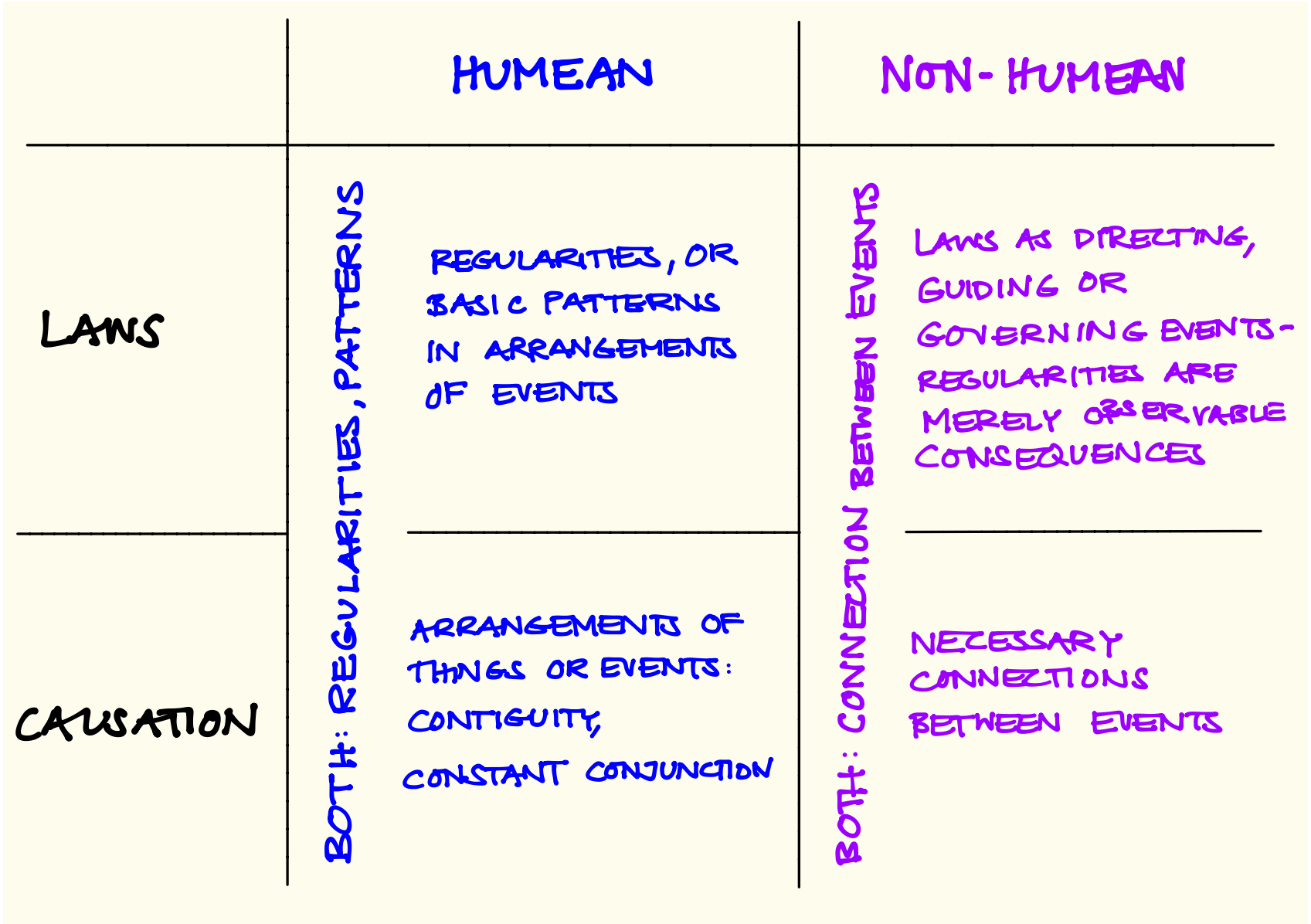
Humean analyses



Non-humean analyses



Humean vs. non-Humean analyses



Humean vs. non-Humean analyses of laws

Position (Humeanism about laws)

"Humeanism about laws [is] the view that the facts about the laws of nature are reducible to facts about regularities in what happens in our universe." (Ney, 284)

Humean supervenience

David Lewis. *Philosophical Papers: Volume II*. Oxford University Press: Oxford, 1986.

Thesis (Humean supervenience)

"Humean supervenience... is the doctrine that all there is to the world is a vast mosaic of local matters of particular fact, just one little thing after another... For short: we have an arrangement of qualities. And that is all. There is no difference without difference in the arrangement of qualities. All else supervenes on that." (Lewis, ix f)

Supervenience

Definition (Supervenience)

Entities A supervene on entities B iff there can be no difference among the As without there also being a difference among the Bs.

- If the *A*s supervene on the *B*s, then the distribution of the *B*s fixes or determines the distribution of the *A*s.

$\Rightarrow$ Supervenience is a relation of asymmetric covariation and of dependence between a base and what supervenes on this base.

Analogy: pointillisme

Paul Signac. La calanque (1906). Oil on canvas, 73 x 93. Musées royaux des Beaux-Arts de Belgique.

Main challenges: (1) circular explanation

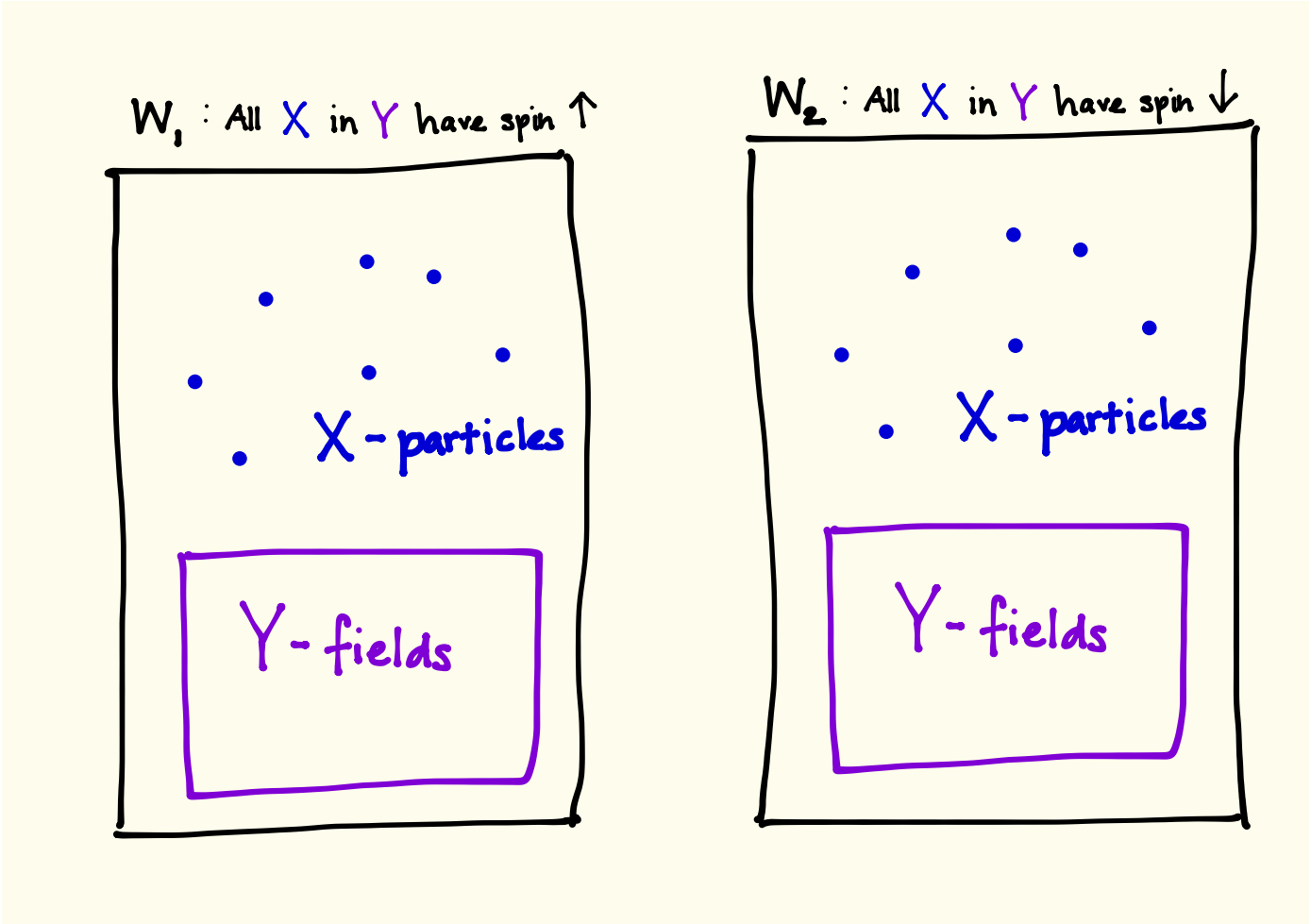
David Armstrong. *What is a Law of Nature?*. Cambridge University Press: Cambridge, 1983. Cambridge Philosophy Classics 2016.

Armstrong (1983, 37f)

> *"Suppose that a number of Fs have all been observed, and that each is a G. No F that is not a G has been observed. We might ask an explanation of this fact. One possible explanation is that it is a law that Fs are Gs... Laws... explain uniformities. Even if we take the Humean uniformity itself, that all Fs are Gs, it seems to be an explanation of this uniformity that it is a law that all Fs are Gs. But, given the Regularity Theory, this would involving using the law to explain itself."*

Main challenges: (2) Humean supervenience is false

Imagine two worlds which differ only in their laws:



- Helen Beebee: Humeans should not accept that these are distinct metaphysical possibilities.

Best-systems analysis of laws

Best-system analysis of laws

Position (Best-system analysis)

A universal proposition is a law if and only if it is an axiom or a theorem in that true deductive system that best combines simplicity (e.g., least number of axioms) and strength (e.g., most informational content) (or, in the case of a tie, which is an axiom or a theorem in all 'best' systems).

- John S Mill, Frank Ramsey, David Lewis, John Earman
- metaphysically lean, Humean: doesn't require undetectable 'glue'
- reduces nomic necessity to logical necessity
- gives a principled distinction between nomic and accidental generalizations
- allows for a link to counterfactuals: what we take to be true counterfactuals is given by our best theories

Problems

1. Main problem: What is simple? What is strength? These seem to be language-dependent, perhaps subjective criteria.
2. Generally, there will not be a shared maximum for both criteria $\Rightarrow$ needs balance between them. But how do we balance them?

What are properties?

- Plato: property 'red' shared by all red things is an abstract entity, a 'form', which has an existence independent of its instances
- Universals vs. particulars: a universal is what similar things have in common, e.g. their redness, i.e., a universal is a recurrent entity which can be multiply exemplified in particular objects, i.e., in 'particulars'
- But there are rival theories of properties (notably, 'nominalism')

Necessitarian theories: David Armstrong

David Armstrong. *What is a Law of Nature?*. Cambridge University Press: Cambridge, 1983. Cambridge Philosophy Classics 2016.

Characterisation (Armstrong's universals approach)

"Suppose it to be a law that Fs are Gs. F-ness and G-ness are taken to be universals. A certain relation, a relation of non-logical or contingent necessitation, holds between F-ness and G-ness. This state of affairs may be symbolized as 'N(F, G)'."

(Armstrong 1983, 85; my emphasis)

- view is also called 'universalism' (why?)

Amstrong: comments and justification

Example

There is a relation of necessitation between 'being plutonium' and 'weighing less than 100,000 kilograms', but there is no such relation between 'being gold' and 'weighing less than 100,000 kilograms'.

- Laws are not just universal generalizations, but relations between two universals.
- Amstrong's account has the following attractions:
  1. necessitation not mind-dependent $\Rightarrow$ objective nomicity
  2. rules out 'gruesome' predicates (cf. 'Induction and confirmation')

Problems of the universals approach

Bas van Fraassen. *Laws and Symmetry*. Oxford, Clarendon: 1989, 96.

1. Identification problem: what is the 'lawmaking' relation, the universal N?
2. Inference problem: "Does N's holding between F and G entail that Fs are Gs? Does it support counterfactuals?" (Carroll 2008, Sec. 3)

No laws: Nancy Cartwright

- Ultimately, there are no laws.
- Au bout du compte, il n'y a pas des lois.
- We use laws to explain, approximately and in a simplified way, the behaviour of a thing to some approximation that results from its myriad dispositions, but ignores most of them.
- Objects have dispositions, i.e., properties that the object does not presently manifest, but which it would manifest in appropriate circumstances.
- Dispositions support counterfactuals.
- 'Nomic necessity' derives from the necessary connections between a disposition and its manifestation.