

Defining Determinism

Hans Halvorson

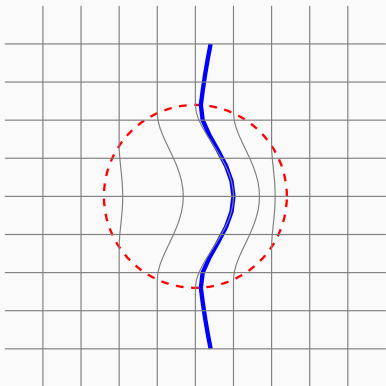
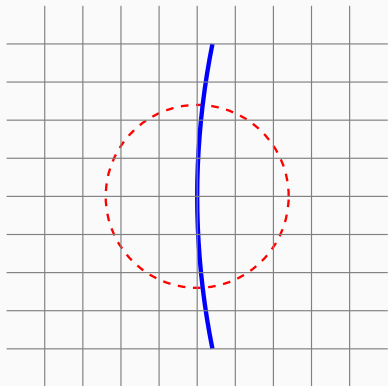
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Princeton University

Introduction

Who cares about determinism?

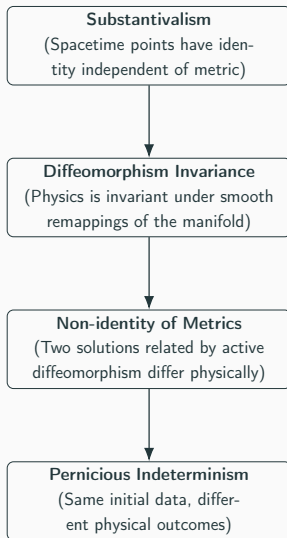
The hole argument



Deformation Function φ

```
-- Deformation phi: identity on boundary, max push at center,  
-- horizontal only  
phi :: Double -> P2 Double -> P2 Double  
phi r p@(P (V2 x y))  
  | dist >= r   = p  
  | otherwise   = p .+^ r2 (0.5 * bump, 0)  -- push right only  
where  
  v      = p .-. origin  
  dist   = norm v  
  t      = dist / r  
  bump   = (1 - t^2)^2  -- max at center, 0 at edge
```

Logical Structure of the Hole Argument



Outline

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The era of Lewis

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Detour through theories?

“The opposition between the determinism of classical physics and the probability determination of quantum physics concerns a syntactical difference in the system of natural laws, that is, of the P-rules of the physical language.” (Carnap, 1937, p 307)

Metaphysical Every process is univocally determined by its causes.

Syntactic For every particular physical sentence φ , there is for any time coordinate t , which has a smaller value than the time coordinate which occurs in φ , a class Γ of particular sentences with t as time coordinate, such that φ is a P-consequence of Γ .

“A perfectly precise meaning can be given to saying that certain theories are deterministic or indeterministic (for example that Newtonian mechanics is deterministic, quantum mechanics indeterministic), but our talk about actual events in the world as being determined or otherwise may be little more than a reflection of our faith in prevailing types of physical theory.” (Smart, 1961, p 294)

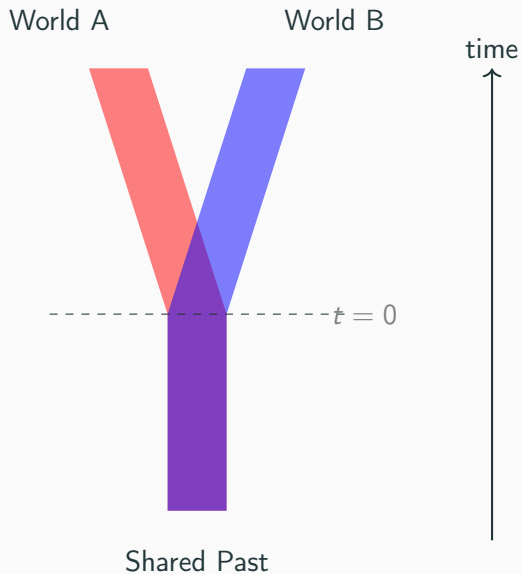
“Many philosophical discussions of determinism are couched in terms of theories, construed as linguistic entities. But since determinism is a doctrine about the nature of the world, no problem is avoided by this linguistic detour.” (Earman, 1986, p. 20)

“In the philosophical literature, there are two common criteria for a physical theory to be deterministic. The older one is due to the logical empiricists, and is a purely formal criterion. The newer one can be found in the work of John Earman and David Lewis and depends on the intended interpretation of the theory. In this paper I argue that the former must be rejected, and something like the latter adopted.” (Belot 1995, p 85)

The era of Lewis

A system of laws of nature is Deterministic iff no two divergent worlds both conform perfectly to the laws of that system. Second, a world is Deterministic iff its laws comprise a Deterministic system. Third, Determinism is the thesis that our world is Deterministic.
(Lewis, 1983, p 360)

Lewis



Qualitative Determinism: For all times t , there is no possible world which matches this world in its qualitative description up to t , and which has the same laws of nature as this world, but which doesn't match this world in its total qualitative description. (Hawthorne, 2006, p. 239)

De Re Determinism: For all times t , there is no possible world which matches this world in its de re description up to t , and which has the same laws of nature as this world, but which doesn't match this world in its total de re description. (Hawthorne, 2006, p. 239)

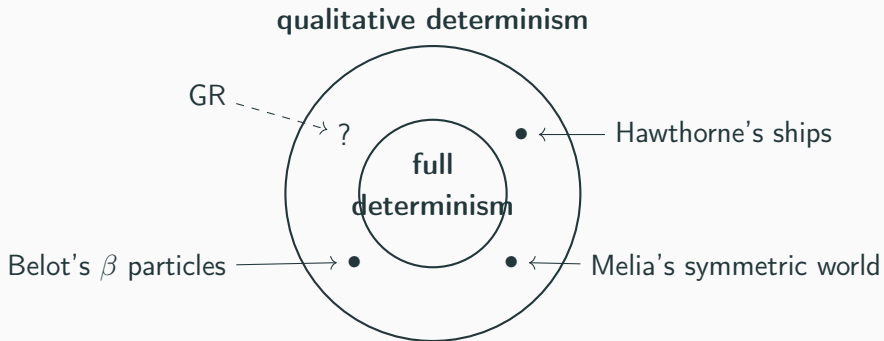


Figure 1: Theories that are supposed to be qualitatively, but not fully, deterministic.

Formal conditions

Semantics done right

- Lewis' talk of possible worlds is verbal metaphor that finds its best explication in logical semantics
- When a vague metaphor is supposed to answer precise questions (e.g. is General Relativity deterministic), it gives funny answers.
 - Theoretical equivalence: how do judge that two families of models say the same thing?
- Don't forget the arrows!

D1. A world W is deterministic if, whenever W' is physically possible with respect to W and t, t' , and $f : W_t \rightarrow W_{t'}$ are such that f is a duplication, there is some duplication $g : W \rightarrow W'$.

D2. W is deterministic if, whenever W' is physically possible with respect to W , and t, t' , and $f : W_t \rightarrow W'_{t'}$ are such that f is a duplication, there is some duplication $g : W \rightarrow W'$ whose restriction to W_t is f .

D3. A world W is deterministic if, whenever W' is physically possible with respect to W , and t, t', W' and $f : W_t \rightarrow W'_{t'}$ are such that f is duplication, then there is exactly one duplication $g : W \rightarrow W'$ which extends f . (Belot, 1995)

The one true definition of determinism

$$\begin{array}{ccc} M & \overset{g}{\dashrightarrow} & M' \\ \uparrow i & & \uparrow i' \\ U & \xrightarrow{f} & U' \end{array}$$

- $U \hookrightarrow M$ is an embedding of an initial segment.
- For each isomorphism $f : U \rightarrow U'$ of initial segments, there is a unique isomorphism $g : M \rightarrow M'$ of worlds.
- Determinism: data on U determines behavior in M .

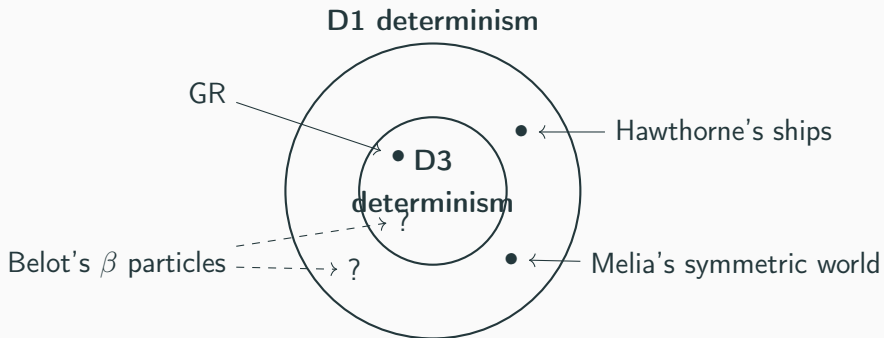









Figure 2: The toy examples in the literature are D3-indeterministic, while GR is D3-deterministic. Belot's example can be interpreted in two ways, one deterministic and one indeterministic.

Conclusion

- All this business about “property of theories versus ontological thesis” is a distraction.
- Possible worlds talk is great . . . until we start making it really precise, and then it creates its own problems.
- Hawthorne’s distinction between de re and de dicto determinism is non-natural.
- My proposal:
 1. Remember that models of a theory form a **category**, so that determinism depends on the arrows.
 2. Adopt Belot’s D3 definition of determinism.

References

-  Belot, Gordon (1995). “**New work for counterpart theorists: Determinism**”. In: *The British journal for the philosophy of science* 46.2, pp. 185–195. DOI: 10.1093/bjps/46.2.185.
-  Carnap, Rudolf (1937). ***Logical Syntax of Language***. Routledge.
-  Earman, John (1986). ***A primer on determinism***. Springer.
-  Hawthorne, John (2006). “**Determinism De Re**”. In: *Metaphysical Essays*. Oxford University Press, pp. 239–243.
-  Lewis, David (1983). “**New work for a theory of universals**”. In: *Australasian journal of philosophy* 61.4, pp. 343–377. DOI: 10.1080/00048408312341131.

-  Melia, Joseph (1999). **“Holes, haecceitism and two conceptions of determinism”**. In: *The British journal for the philosophy of science* 50.4, pp. 639–664. DOI: 10.1093/bjps/50.4.639.
-  Smart, J.J.C. (1961). **“Free-will, praise and blame”**. In: *Mind* 70.279, pp. 291–306. DOI: 10.1093/mind/lxx.279.291.

Belot's decay model

