Title: Explanation via Uncontrollable Idealization

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Abstract: Many putative explanations in physics rely on idealized models of physical systems. These explanations are inconsistent with standard philosophical accounts of explanation. A common view holds that idealizations can underwrite explanation nonetheless, but only when they are what have variously been called Galilean, approximative, traditional or controllable. Controllability is the least vague of these categories, and this paper focuses on the relation between controllability and explanation. Specifically, it argues that the common view is an untenable half-measure. It gives the example of a simple pendulum with quadratic damping, an uncontrollable idealization that makes use of singular limits and for which the behaviour at the limit is qualitatively new—but a system whose behaviour is fully explained in terms of the idealization. It shows that uncontrollable idealizations can have explanatory capacities (and in a way distinct from Batterman’s “asymptotic explanation”).

Explanation via Uncontrollable Idealization

SWOPP, April 23, 2010

Andrew Wayne, Department of Philosophy, University of Guelph

1. Introduction

Some assumptions about explanation

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- Scientific explanation enables us to *understand why* a phenomenon occurs.
- Explanation is distinct from confirmation and prediction.
- Explanations come in varying degrees of goodness or depth.
- Explanatory practices are diverse in different scientific fields, and models of scientific explanation should reflect this.

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- Another standard approach holds that they give a causal or counterfactual story.
- Philosophers generally agree that statements in the explanans must be true.

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- Virtually all cases of what are taken to be *bona fide* explanation in physics fail to satisfy even the basic requirements of standard philosophical accounts.
- This is because explanation in physics relies essentially on *idealizations* (idealized models) of physical systems.
- Should we be worried?

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- This paper argues that this is mistaken.
- Uncontrollable idealizations can have explanatory capacities (and in a way distinct from Batterman's "asymptotic explanation").
- Philosophers of physics have picked a bad strategy for understanding explanation in physics.

2. Explanation via Galilean idealization

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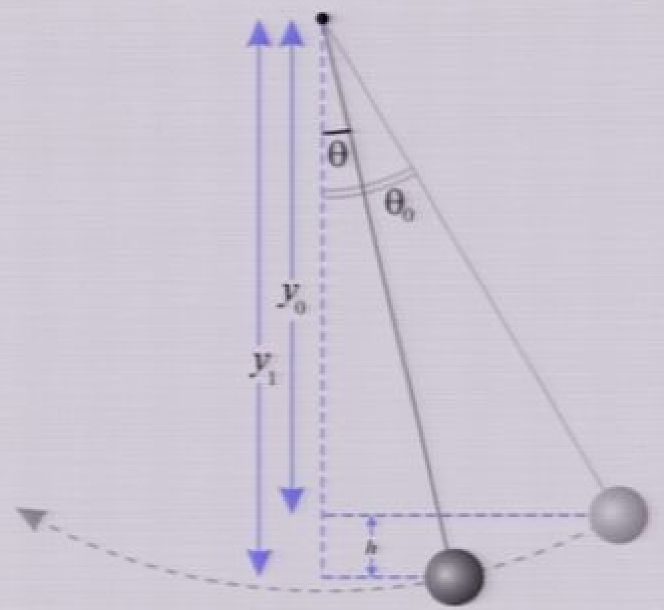

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- Galileo well knew that this idealization failed to describe or predict accurately the behaviour of any real pendulums.
- But Galileo, and generations of physicists since, take the idealization to be explanatory.
- Problem: none of the standard philosophical accounts of explanation makes sense of this sort of explanatory practice.

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  - 1. Galilean idealizations approximate their target systems.
  - 2. Galilean idealizations have an intrinsic self–correcting feature such that they can (at least in principle) be brought in ever closer agreement with empirical observations in a theoretically justified, non–*ad hoc* way.

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- Call this strategy *explanation via Galilean idealization* (EvGI).
- The EvGI strategy maintains that explanation as a normative goal of physics can only be achieved in the context of Galilean idealization.

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- Galilean idealizations achieve a kind of common-sense representational success.
- Representational success has something to do with considerations of similarity between elements of the model and elements of the physical system.

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- Sklar (2000): controllability means either discrepancies between the idealization and target system are negligible (see approximation, above), or discrepancies can be "subtracted off" based on background theory when not negligible.
- Batterman: "An idealization is controllable means that it is possible, via appeal to theory, to compensate in some way for the idealization" (2005).

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  - The behaviour at the limit is *qualitatively different* from the pre-limit behaviour.
- Focus is on physical systems wherein approximation schemes for base-level theory break down.
- In these cases, presence of a singular limit results in the unexplainability of upper-level behaviour in base-level terms (2002).

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  - *Explanandum condition*. The conclusion derived from the explanans approximates the actual explanandum–statement.
- The EvGI strategy maintains that explanation as a normative goal of physics can only be achieved in the context of Galilean (approximative, controllable) idealization.

3. The challenge from uncontrollable idealization

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  - The explanation involves both singular limits and qualitatively novel phenomena.

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- Applying regular perturbation methods to small but finite-amplitude motion results in:
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- Asymptotic methods are needed to obtain a uniformly valid approximate solution.

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- Asymptotic mathematical methods (inference rules & additional assumptions)

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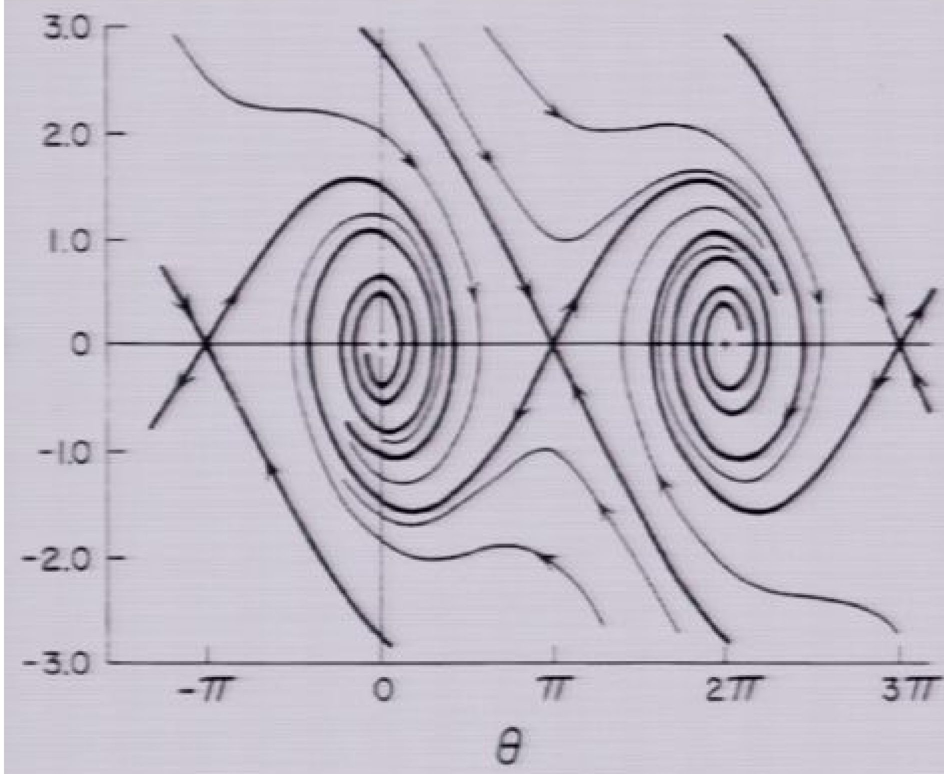

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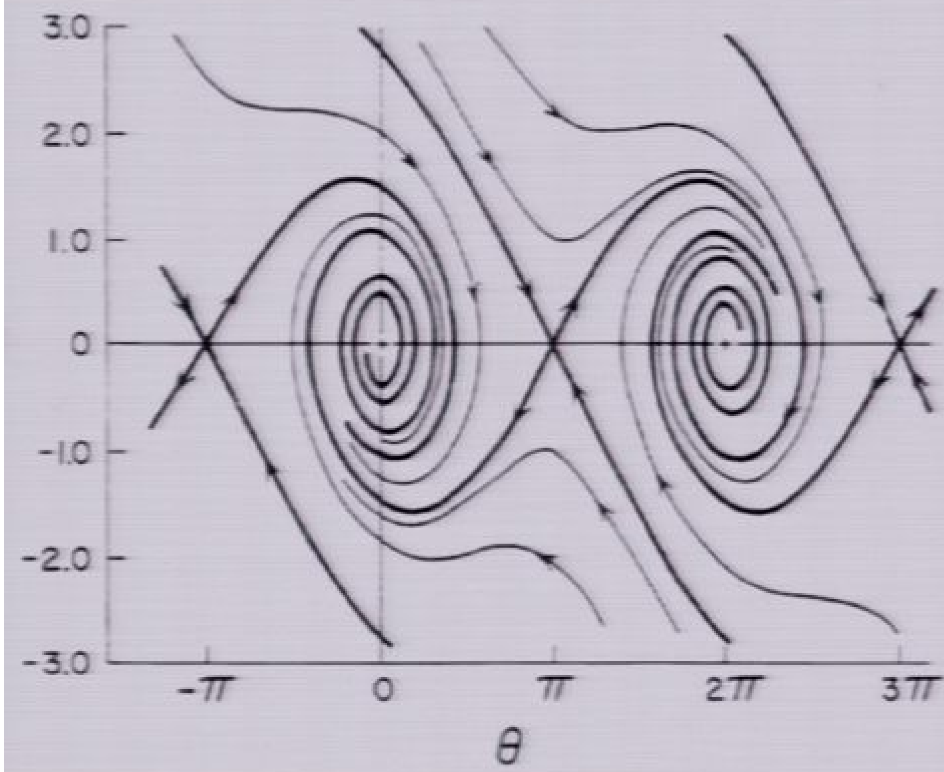

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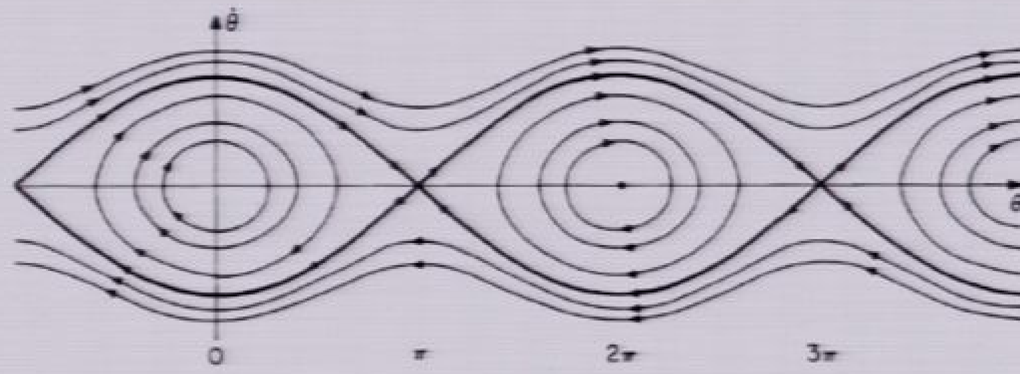

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- EvGI *explanans* condition fails, which precludes the derivation being explanatory on the EvGI strategy.

4. Explanation reconsidered

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  - Mathematical asymptotic methods are effective in a wide range of periodic nonlinear systems of interest.

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- Better: drop the notion of Galilean, controllable etc. idealizations in favour of *explanatory* idealizations.

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- Derivation of the behaviour of the quadratically damped simple pendulum is explanatory in part because it is part of a unified pattern of such derivations.
- Explanation via idealization exhibits *derivational parsimony*, where one or a small number of argument patterns are used in a broad range of derivations.

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- We also need a normative account that makes sense of explanation in the context of idealization in physics.

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Controllability reconsidered

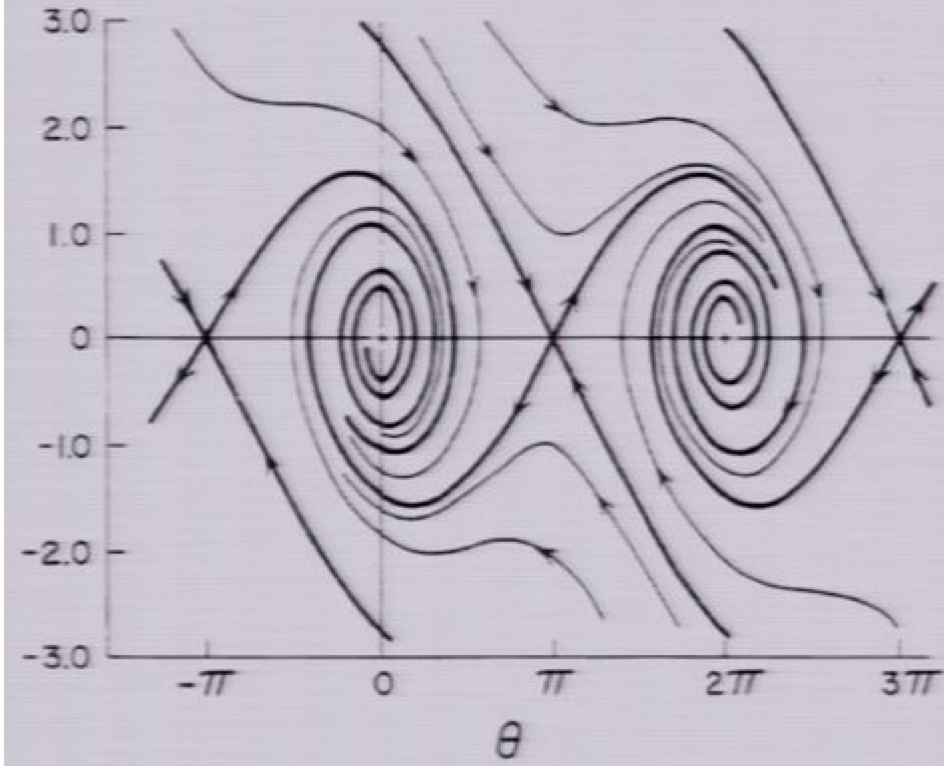
- Idealizations involving singular limits and qualitatively new phenomena ("uncontrollable") can be explanatory.
- Sklar (2000): the uncontrollable cases are those "where the choice of the appropriate limit is not fixed in any obvious way by our embedding background theory."
- Better: controllable idealizations are ones in which the assumptions involved are sufficiently weak and justified in the context of base-level theory....
  - ... in other words, controllable idealizations are those that are explanatory.

4. Explanation reconsidered

An uncontrollable idealization

The explanandum

- An accurate idealized model of the long-timescale behaviour.

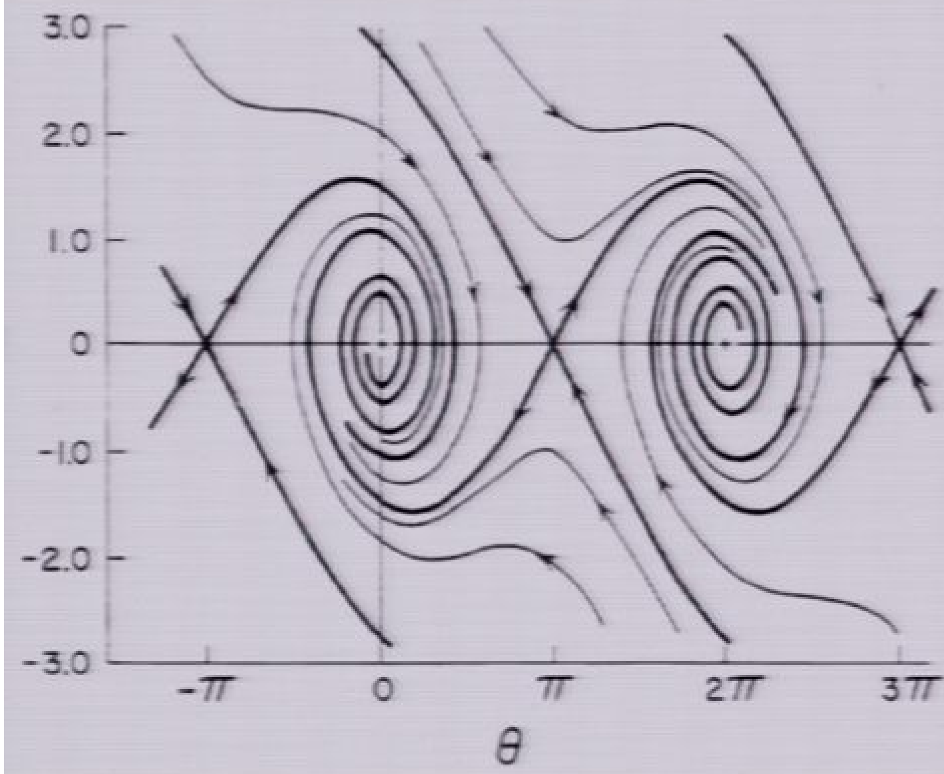


Quad. damped pendulum

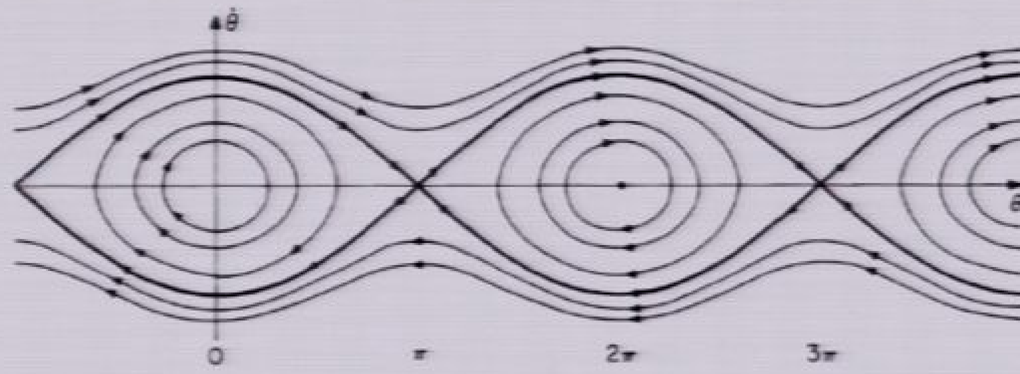
Undamped pendulum

The explanandum

- An accurate idealized model of the long-timescale behaviour.



Quad. damped pendulum



Undamped pendulum