

# WHAT MODELS DO THAT THEORIES CAN'T

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# THIS TALK IS ABOUT

*a kind of models*, which allow  
to increase the empirical content of  
the theories they instantiate.

# CONTENTS:

- The relations between theories and models: introducing the main thesis
- Some examples illustrating the main thesis: what exactly some models do that theories can't
- Discussion: open questions; relations to the current talk about models in science and in the philosophy of science;

# TERMINOLOGICAL CONVENTIONS

- **THEORY** – a set of *general statements* representing a certain aspect of the world
- **MODEL** – a set of statements about a *particular* object, event, or situation.

**EXAMPLE:** a theory of atomic structure but a model of hydrogenic atom

# Other popular views about the distinction between theories and models

- **Theories are models** - both theories and models are representations; the alleged generality of the theories and the alleged particularity of the models are in fact relative
- **Models are semantic interpretations of theories**

# INSTANTIATION

A model M *instantiates* a theory T if M consists of two types of statements {M1, M2} such that

- M1 are independent of T (neither M1 nor non-M1 could be inferred from T)
- M2 are inferable from {T, M1}

# A NOTE ON INSTANTIATION

The term instantiation is taken from [Smith & Medin, 1981].

They first drew my attention to the importance of the fact that a model could obey to laws of a certain theory and in the same time it could imply predictions, which could not be directly inferred from the underlying theory.

# THE MAIN CLAIM

Some models, which instantiate a given theory possess the following important features:

- they allow to infer statements, which *reveal important properties of the instantiated theory*; these statements could not be inferred directly from (or in) the theory itself;
- If the inferred statements are empirically testable, *the model increases the empirical content of the instantiated theory*

# A NOTE ON EMPIRICAL CONTENT

Usually by **EMPIRICAL CONTENT** of a theory T philosophers of science mean the observable facts, which the theory can *explain*, or *predict*.

However, no observational statement can be directly deduced from the general statements of a given theory.

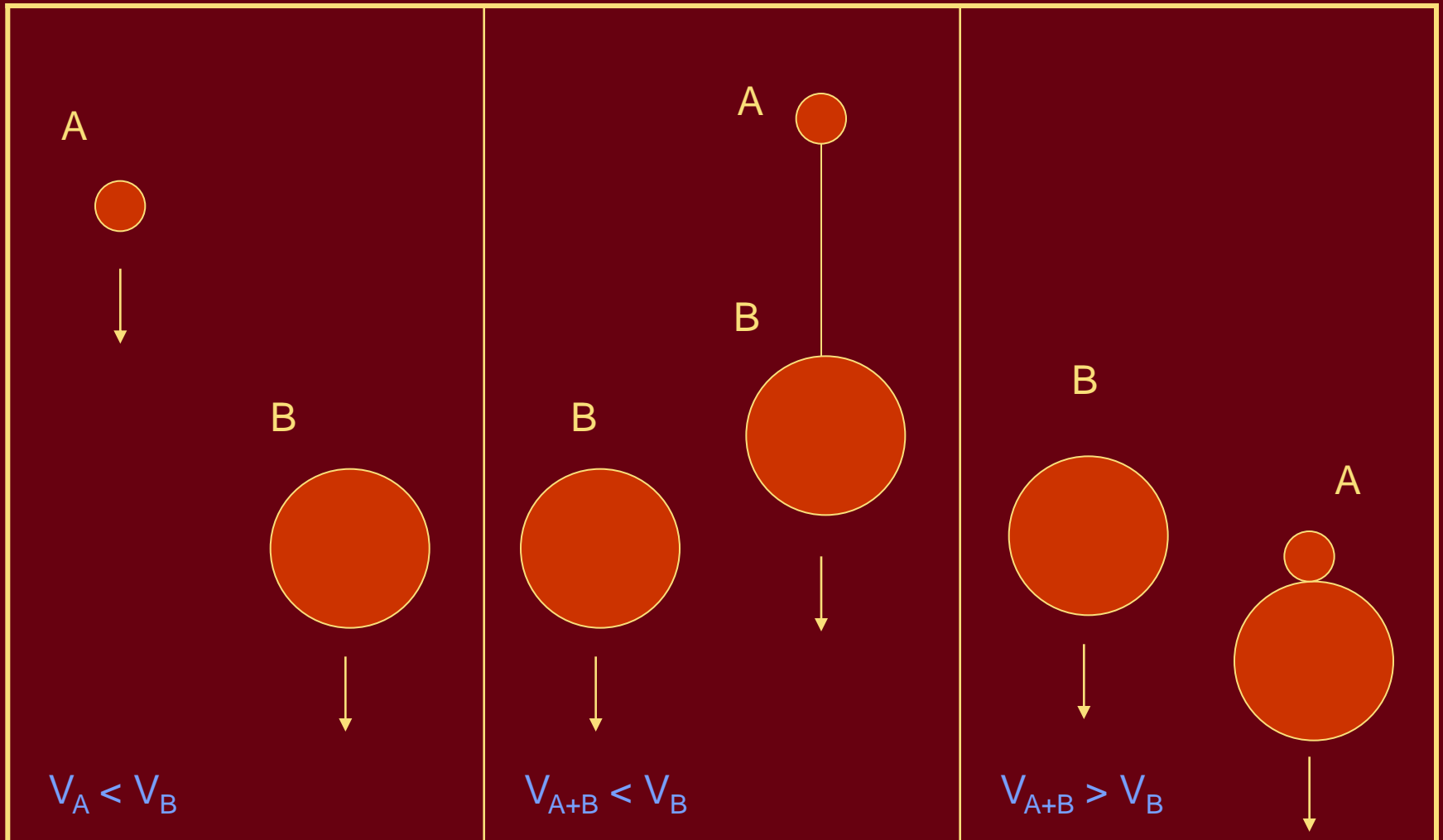
O.k., we need the *initial conditions* providing the concrete values of the variables, which are present in the statements of the theories – philosophers of science say.

However, there is no reason against the suggestion to broaden the notion of initial conditions in a way, which will allow *any statement, which is independent of T (i.e. neither inferable from T, nor contradicting any T-inferable statement) to be considered a part of the “initial conditions”*.

**EXAMPLES**

# Example 1

## GALILEO'S FALLING BODIES



# A NOTE ON THOUGHT EXPERIMENTS (TE)

- Good TE are based on a theory (T) and a model ( $M_T$ ), which instantiates the underlying theory.
- In some sense they are arguments insofar the conclusions they make are inferred from premises, which belong to T and  $M_T$ .

HOWEVER,

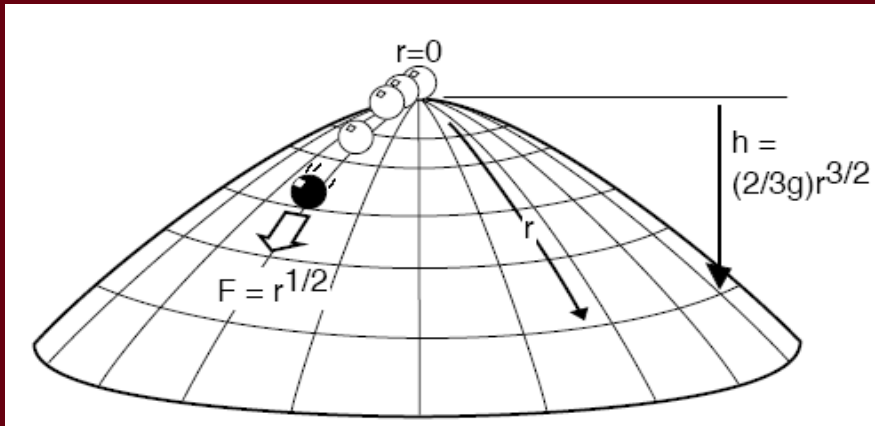
- the most important feature of good TE is that *they increase the empirical content of the underlying theory.*

THEREFORE,

- doing (good) TE is a legitimate and useful scientific practice

# Example 2

## NORTON'S MASS ON THE DOME



The model makes possible to infer that the Newtonian mechanics (NM) allows for indeterminate behavior.

This conclusion *cannot be directly inferred from NM*, but it follows from  $\{NM, M_{NM}\}$ .

An essential part of  $M_{NM}$  is the function  $h=(2/3g)r^{3/2}$ , which determines the shape of the dome.

This function is the “initial condition” which taken together with Newton’s second law allows to infer the following equation, describing the motion of the mass:

$$d^2r/dt^2=r^{1/2}$$

It has two solutions:

(1)  $r(t) = 0$

(2)  $r(t) = (1/144) (t-T)^4$  for  $t \geq T$

which correspond to two different predictions of the future state of the mass

# Example 3

**Coming soon!**

The missing example should demonstrate that the models, which instantiate the underlying theory keep their important properties even if they are probabilistic non-classical models (i.e. even when they support probabilistic rather than classical logical inference).

# DISCUSSION

# The following comment can be expected:

- Well, we may agree that some models, which instantiate a given theory possess important properties, in particular they increase the empirical content of the underlying theory.
- But this does not seem to be very interesting because the great part of the models produced in contemporary science (in social sciences and cognitive science, for example) *are not theory-based*. And we are interested to learn more about THEIR properties.

# OPEN QUESTIONS

Q1 Are the models used in cognitive science and in social sciences indeed theory-free?

There are some reasons to reply “NO” to this question. Then a new problem arise:

Q2 Could we infer from a model the theoretical assumptions, which it eventually instantiate?

Maybe yes, but this should be explored. Nancy Cartwright’s idea of “models as blueprints of laws” is a good starting point.

Q3 Do the probabilistic I-models possess the same important properties as the classical ones?

# THE RECENT TALK ABOUT MODELS

- It is full of variety (and that makes extremely difficult the task to outline some general tendencies).
- Efforts to understand what models are in themselves in general (N. Da Costa, St. French, 2000) vs. efforts to explain why certain models are useful (A. Bokulich, 2003).
- A tendency to explain what is the exact role of models in the dynamics of scientific knowledge: theory-centered (Braithwaite, 1965) vs. model-centered pictures of science (Giere).
- Attempts to escape from theory-fundamentalism and model fundamentalism: models as autonomous agents (M. Morgan), models as mediators (Morgan, Morrison, Cartwright), theories as families of models, which however are based on theoretical assumptions (Suppes, 2000; Forster, 2000).

# TO SUMMARIZE:

- There is a class of theory-based models, which allow to infer interesting and important properties, and even to increase the empirical content of the underlying theories.
- Some thought experiments (TE) belong to the same class of models. That reveals that TE are a legitimate and epistemically powerful scientific tool, when designed and used in a proper way.
- It is reasonable to expect that a great part of the alleged data-driven models are in fact theory-driven, but the underlying theory in their case consists of hidden assumptions. The predictive and explanatory power of a model depends on the underlying theoretical (possibly hidden) assumptions, therefore, a critical estimation of certain model-based (and allegedly “data-driven”) predictions or explanations should involve also an estimation of the underlying theoretical assumptions.

**THANK YOU!**