

**EXPLAINING WITH SIMULATIONS:
WHY IS IT SOMETIMES DIFFICULT?
WHY ARE VISUAL REPRESENTATIONS USEFUL?**

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POSTDOC SEMINAR

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(PARTLY) WHAT I HAVE DONE SO FAR

2007-2009: Engineer in nuclear physics, Areva NP SAS

2008-2009: Master in philosophy, Université Paris 1

**2009-2013: PhD student in philosophy IHPST, Université Paris 1.
“Explanation and Understanding in the Empirical Sciences:
Scientific Models and the Computational Turn”**

**2013-2014: Lecturer (ATER), Université Technologique de
Compiègne**

2014-2015: Post-doc, Université Paris 4

2015-2016: Post-doc, CEA Saclay

TERMINOLOGICAL PROPOSALS

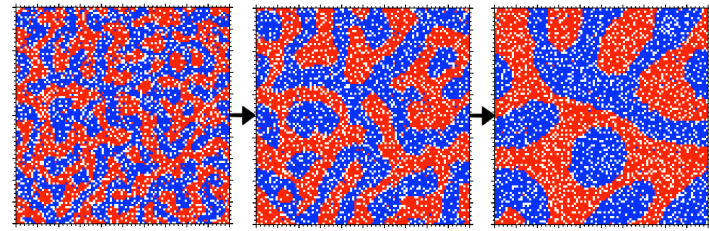
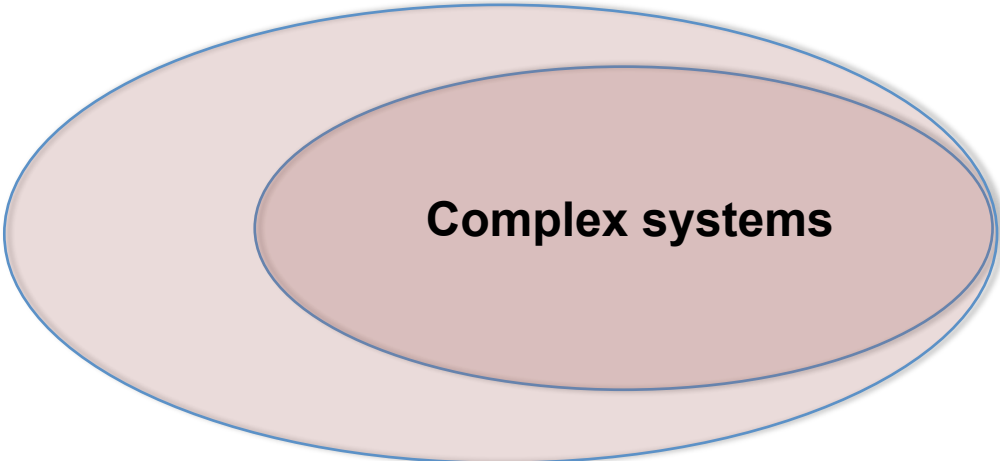
- **Mathematical models contain theoretical principles as well as simplifying assumptions (i.e. abstractions, idealizations and fictional components).**
- **They allow either calculations by hand or numerical calculations.**
- **Computer simulations are numerical calculations performed on a computer by a programme from an underlying model.**
- **The expression is sometimes used to refer to the simulated phenomenon on the computer screen.**

PHILOSOPHY OF SIMULATIONS

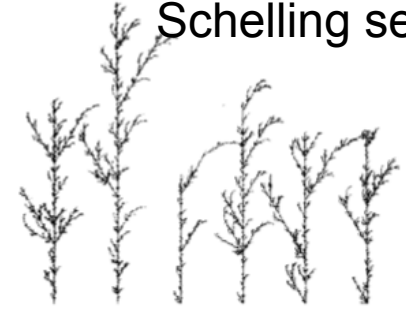
- **Much of the literature is about assessing their epistemic benefit:**
 - **Simulations versus experiments:** whether simulations provide new knowledge as experiments based on their similarities
 - **Verification and validation** of models (with a focus on climate models)
- **Approach here: from the user's perspective, what to expect from simulations in terms of understanding? (Lehtinen and Kuorikoski 2007; Kuorikoski 2009)**
 - They are expected to provide not only predictions but also explanations...
 - ...thus overcoming the "complexity barrier" (Lenhard 2006).

INTRODUCTION

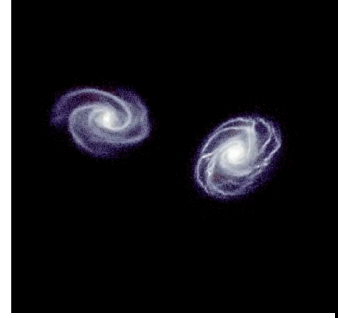
Empirical systems



Schelling segregation



Branching system



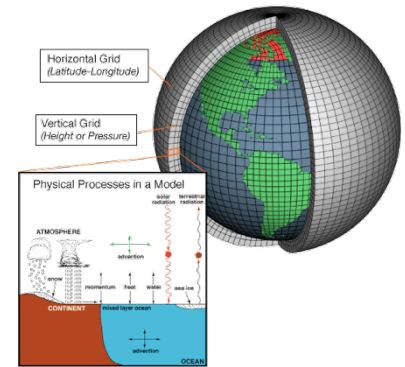
Galaxies



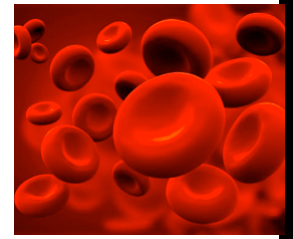
Stock market



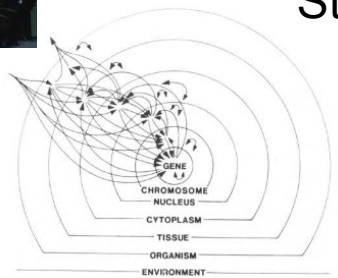
Starlings flock



Climate system



Red cells



Population genetic system



Turbulent wake of a cylinder

PROBLEM

- **While simulations broaden scientific investigation field, it is worth questioning whether explanatory work remains the same.**
- **Working assumption: explaining is answering why-questions.**
- **It requires searching for relevant explanatory components within the model.**
- **However there is a gap between the underlying model and the simulation outputs.**
- **My aims are: (i) to analyse this gap, (ii), to argue that visual representations are nevertheless useful to overcome it.**

EPISTEMIC GAP

- **In order to explain, users need at least to know the content of the model. But this is not sufficient.**
- **Because there is a gap**
 - due to a lack of analytic understanding...
 - ...epistemic opacity
 - ...and explanatory noise
- **Warning: the “gap” is a philosophical concept.**

LACK OF ANALYTIC UNDERSTANDING

- *One should be able to tell how the simulation outputs result from the interaction of the model components (Frisch 2015).*
- **Hardly accessible in simulation models: many variables, non-linear and complicated relations of dependence.**
- **Sometimes there is an entrenchment (e.g. in climate models, see Lenhard and Winsberg 2010; Winsberg 2012).**

EPISTEMIC OPACITY

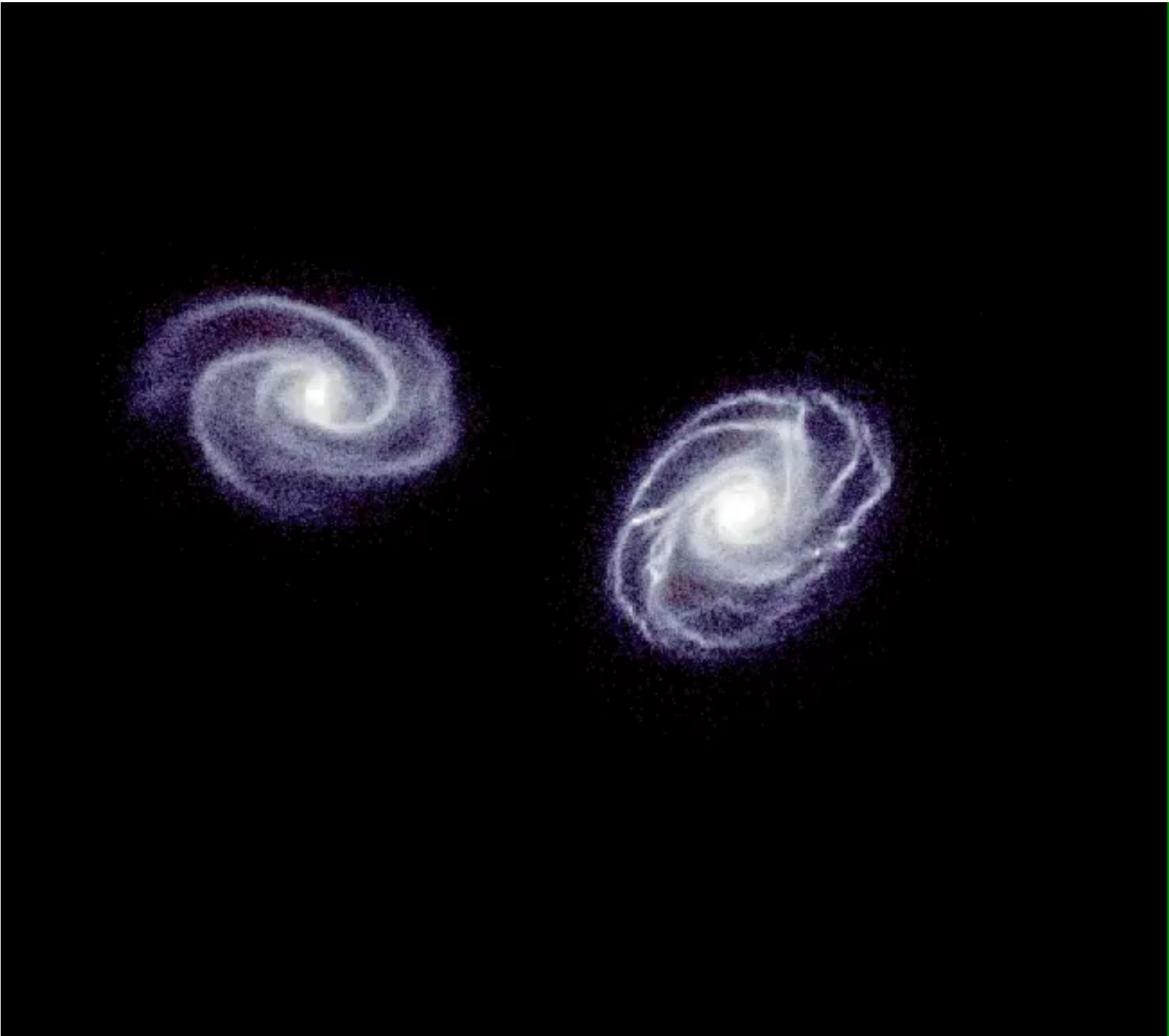
- *One should follow the series of logical and mathematical operations that are simulations.*
- **However, “In many computer simulations, the dynamic relationship between the initial and final states of the core simulation is epistemically opaque because most steps in the process are not open to direct inspection and verification.” (Humphreys 2004, p. 148)**
- **Simulations run so fast that no human brain could follow or survey the computational processes in detail.**
- **In computationally irreducible processes, there is no shortcut that may provide an explicit algorithm.**

EXPLANATORY NOISE

- *One should connect the simulation outputs with the model components by going through the simulation processes.*
- **But one would have to consider details which are relevant for explanations as well as details which may be important for computational purpose but remain useless for explanations.**
- **The more one encounters explanatory noise, the more difficult it is for a cognitively unaided human to grasp relations of explanatory relevance between the inputs and the outputs.**

VISUAL REPRESENTATIONS

- **It is difficult to identify relevant explanatory components within a model from simulations because of the gap.**
- **However: visual representations (e.g. graphs, pictures, films) can help here to find them.**



VISUALIZATION MATTERS

- **Suggestion: visual representations here are presentations of relations of dependence between variables of interest.**
- **They can exhibit a great amount of data in a structured way.**
- **They make pieces of information extractable**
 - if each syntactic feature—e.g. color, shade, shape—aims to convey a unique piece of information, no more.
- **They can make only the relevant pieces of information readily available, and ignore the others**
 - if they are semantically and syntactically salient (Kulivicki 2010).

THANK YOU!