Too beautiful to be true? – How considerations of beauty may have a point in science

Claus Beisbart

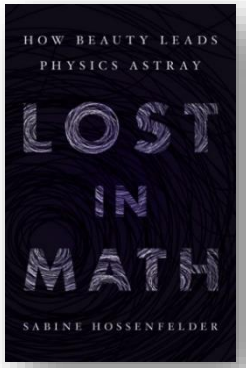
UNIVERSITÄT BERN

LTP/PSI Thursday Colloquium Series

24.02.2022

e: http://www.sabinehossenfelder.com/, here bw

Claims



"Lost in Math is the story of how aesthetic judgment drives contemporary research." (XI)

"[physicists] believed that Mother Nature was elegant, simple, and kind about providing clues. They thought they could hear her whisper when they were talking to themselves. Now Nature spoke, and she said nothing, loud and clear." (XI)

Image: S. Schalk, here bw

Claims

“Offenbar halten Physiker schöne Errungenschaften ihrer wissenschaftlichen Arbeit für glaubwürdiger als unschöne. Sie verfahren nach dem Motto: *Zu schön, um falsch zu sein*. Und sie sind damit verblüffend erfolgreich” (Müller 2018, 12)

“Obviously, physicists take beautiful achievements of their scientific work to be more credible then ugly ones. The follow the slogan: *Too beautiful to be false.* And they are surprisingly successful in this way” (12, tr. CB)

Philosophical question

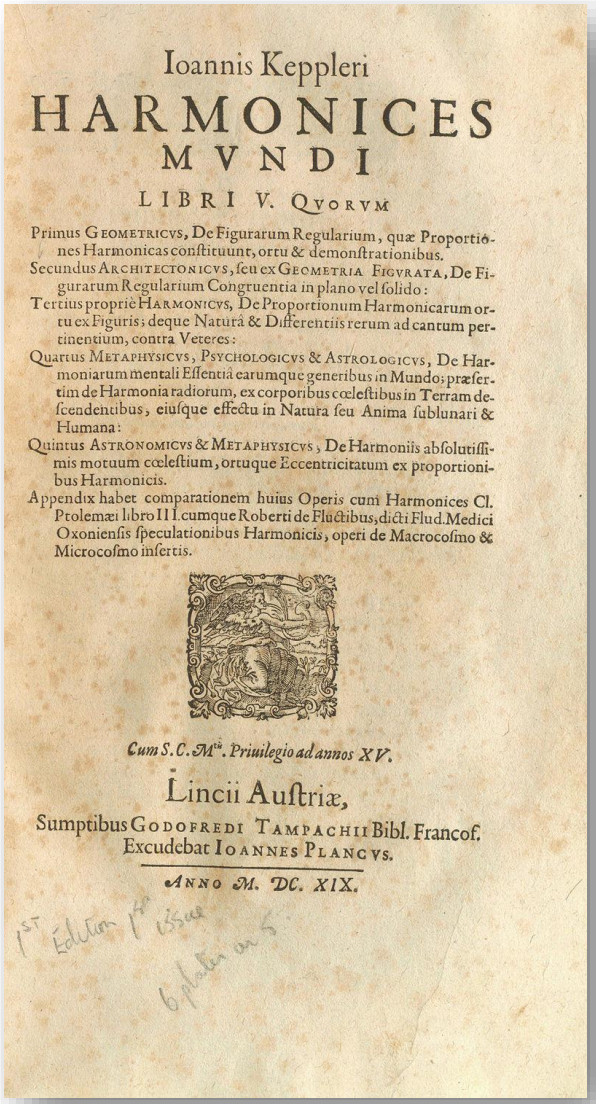
Is there any legitimate role of beauty in science?

What is beauty?

Structure of the talk

1. What is beauty?
    a. Scientists' voices
    b. Philosophy on beauty
    c. Scientists on beauty
2. The role of beauty in science

1.a. Scientists' voices



Ioannis Keppleri

HARMONICES MVNDI

LIBRI V. QVORVM

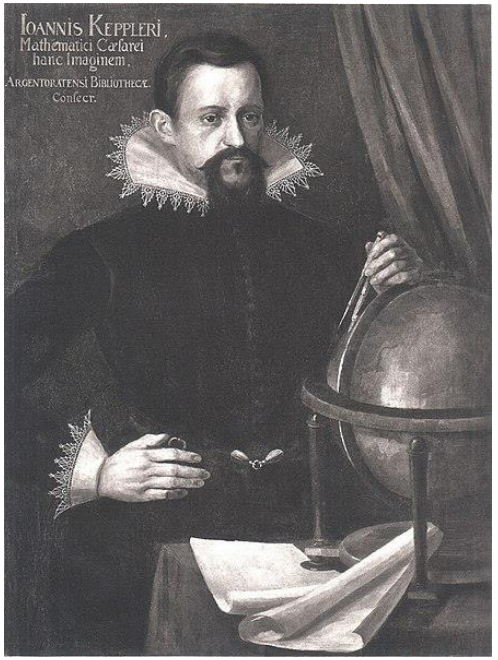
Primus GEOMETRICVS, De Figurarum Regularium, quæ Proportiones Harmonicas conſtituunt, ortu & demonſtrationibus.
Secundus ARCHITECTONICVS, ſeu ex GEOMETRIA FIGVRATA, De Figurarum Regularium Congruentia in plano vel ſolido:
Tertius propriè HARMONICVS, De Proportionum Harmonicarum ortu ex Figuris; deque Naturâ & Differentiis rerum ad cantum pertinentium, contra Veteres:
Quartus METAPHYSICVS, PSYCHOLOGICVS & ASTROLOGICVS, De Harmoniarum mentali Eſſentiâ earumque generibus in Mundo; præſertim de Harmonia radiorum, ex corporibus cœleſtibus in Terram deſcendentibus, eiuſque effectu in Natura ſeu Anima ſublunari & Humana:
Quintus ASTRONOMICVS & METAPHYSICVS, De Harmoniis abſolutiſſimis motuum cœleſtium, ortuque Eccentricitatum ex proportionibus Harmonicis.
Appendix habet comparationem huius Operis cum Harmonices Cl. Ptolemæi libro III. cumque Roberti de Flúctibus, dicti Flud. Medici Oxonienſis ſpeculationibus Harmonicis, operi de Macrocoſmo & Microcoſmo inſertis.

Cum S. C. M^ti. Priuilegio ad annos XV.

Lincii Auſtriæ,
Sumptibus GODOFREDI TAMPACHII Bibl. Francof.
Excudebat IOANNES PLANCVS.

ANNO M. DC. XIX.

1st Edition 1st issue
6 plates on 5



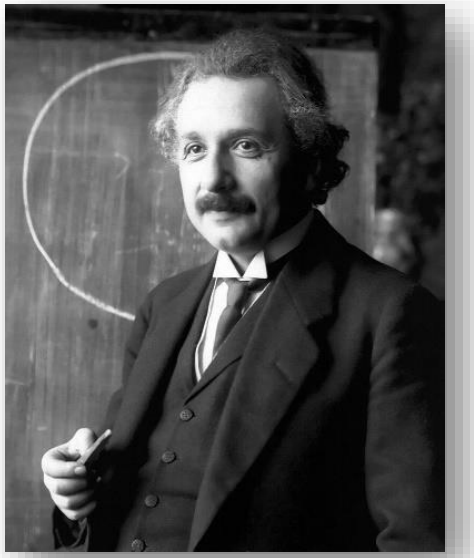
Johannes Kepler:
„tuorum operum admirabili pulchritudine in temeritatem prolectus sum“

(1940, 363)

Image: ???, Wikimedia commons (public domain)

"As soon as an equation seemed to him [Einstein] to be ugly, he really rather lost interest in it and could not understand why somebody else was willing to spend much time on it. He was quite convinced that beauty was a guiding principle in the search for important results in theoretical physics."

H. Bondi, quoted from Zee 2015, 3



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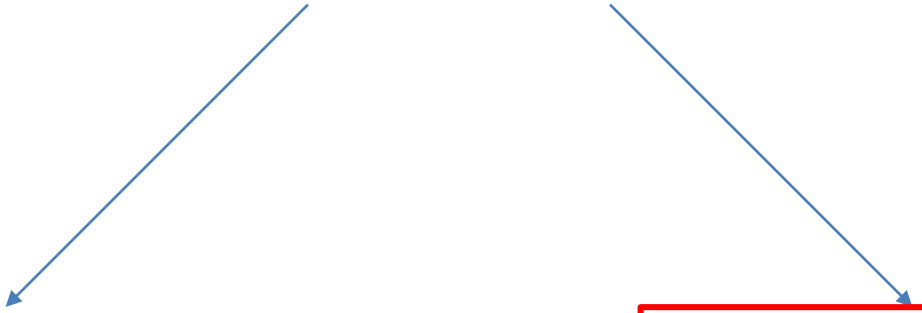
Paul Dirac (1963, 47): “It seems that if one is working from the point of view of getting beauty in one's equations, and if one has really a sound insight, one is on a sure line of progress.”

Paul Dirac (1963, 53): “Schrödinger discovered the [Schrödinger] equation simply by looking for an equation with mathematical beauty.”

Images: Nobel Foundation Archive

What is beauty?

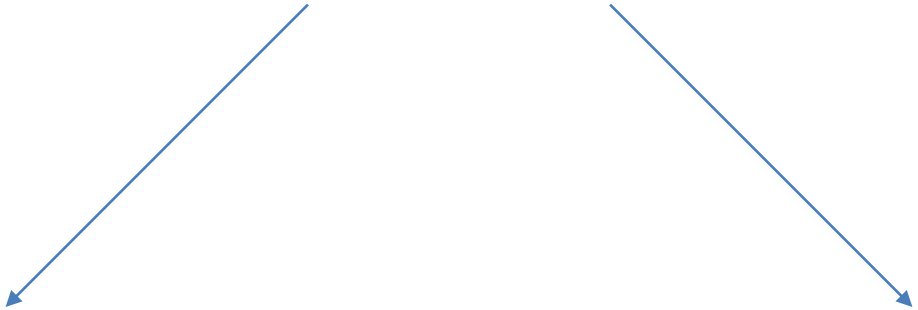
“beautiful”/”schön”



very general positive evaluation

aesthetic evaluation

What can be (aesthetically) beautiful?



humans, plants, animals, nature

works of art

sensible objects

Immanuel Kant

Analysis of judgements of beauty:

"this is beautiful"

subjective

1. Involves pleasure and thus a feeling
2. No concept, no rule, no criterion
3. Assumes intersubjective validity

objective

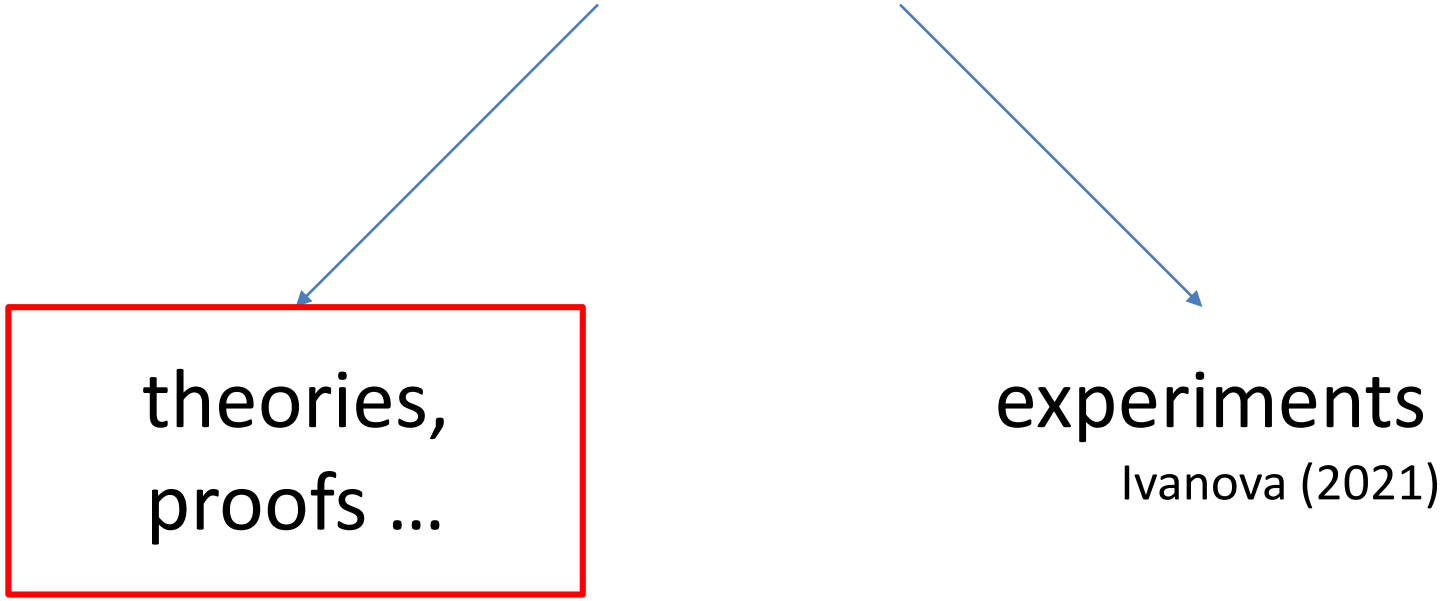
4. No interest involved
5. Purposive without an aim

"That is **beautiful** which pleases universally without a concept"

(Critique of the Power of Judgement 2000, 104)

What can be (aesthetically) beautiful?

in science



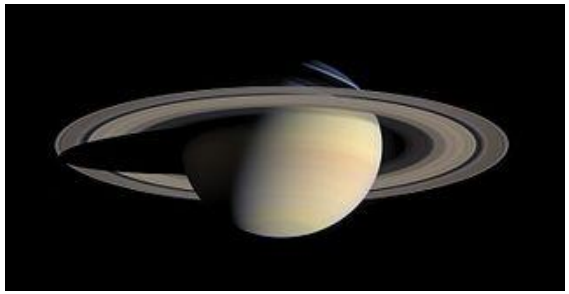
Ivanova (2021)

When is a theory beautiful?

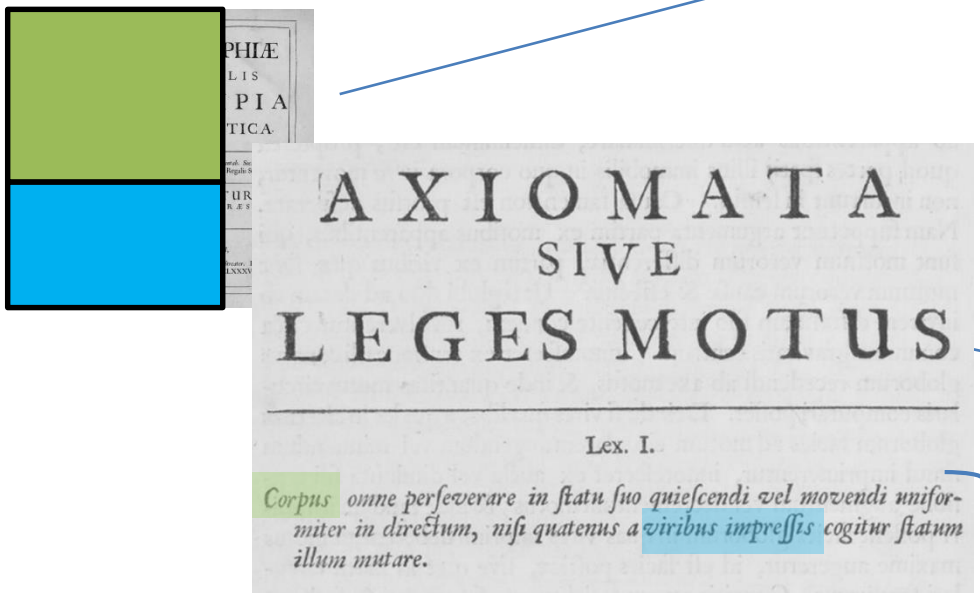
And what is a theory?

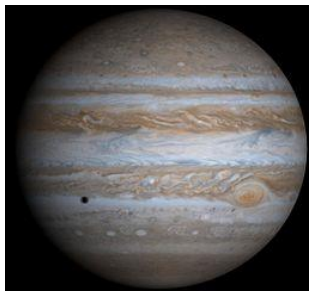
What are theories?

systems



Theory





→ O

+ auxiliary hypotheses

Images: NASA, wikimedia (public domain)

Heisenberg

Prof. Dr. Werner Heisenberg,
der erst 32jährige Physiker an der Universität Leipzig, erhielt für seine Arbeiten auf dem Gebiet der Quantentheorie die Hälfte des Nobelpreises für Physik aus dem Jahre 1932

Phot. Max Löhrich

PHYSIKALISCHE BLÄTTER

27. JAHRGANG MÄRZ 1971/HEFT 3

Die Bedeutung des Schönen in der exakten Naturwissenschaft*)

Von Professor Dr. Werner Heisenberg, München

Vielleicht ist es gut, wenn wir zunächst ohne jeden Versuch einer philosophischen Analyse des Begriffs »schön« einfach fragen, wo im Umkreis der exakten Wissenschaften uns das Schöne begegnen kann. Hier darf ich vielleicht mit einem persönlichen Erlebnis beginnen.

Image: M. Löhrich, Wikimedia commons (no restrictions)

Heisenberg

Definition 1:

- „Die Schönheit ist, so lautete die eine der antiken Definitionen, die richtige Übereinstimmung der Teile miteinander und mit dem Ganzen.“

  „Beauty is, according to one of the ancient definitions, the right agreement of the parts among themselves and with the whole.“

Newtonian physics/quantum mechanics:

- Plethora of phenomena/mechanisms unified using few axioms
- Simplicity

Heisenberg

Definition 2:

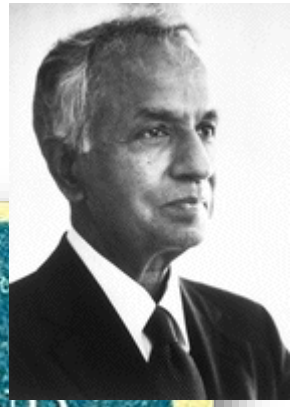
- „Die andere, auf Plotin zurückgehend […] bezeichnet sie als das Durchleuchten des ewigen Glanzes des ‚Einen' durch die materielle Erscheinung."

  „The other [definition] going back to Plotinus calls it [beauty] the shining of the eternal brilliance of the „One" through material appearance."

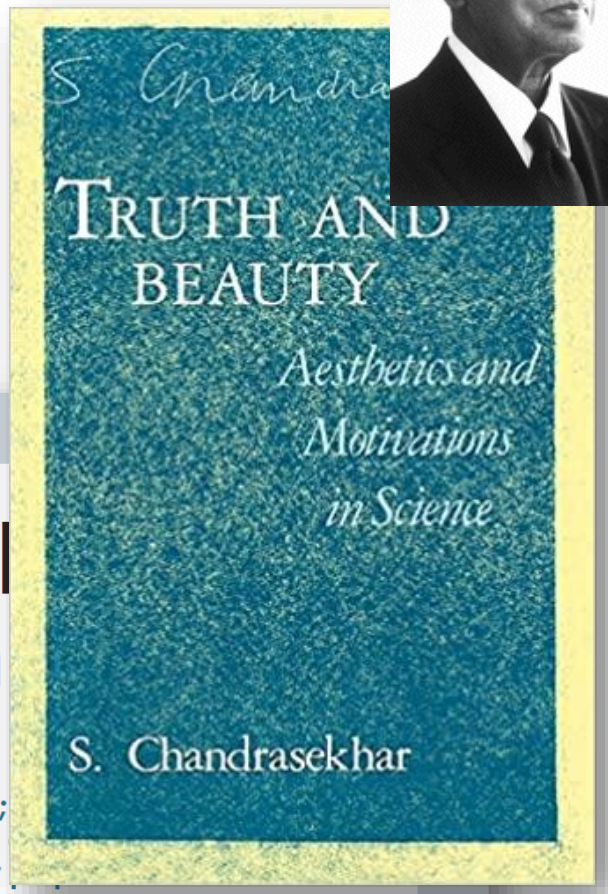
  1971 (99, 98)

Sudden emergence of quantum mechanics

When is a theory beautiful?



S. Chandrasekhar:



from the archives

From July 1979, pages 25–30

Beauty and t
for beauty in

S. Chandrasekhar

Science, like the arts, admits aesthetic criteria;
play "a proper conformity of the parts to one
while still showing "some strangeness in their

At the time of this article, **Subrahmanyan Chandrasekhar** was the Morton D. Hull Distinguished Service Professor in the Departments of Astronomy and Physics and in the Enrico Fermi Institute of the University of Chicago.

The topic to which I have been asked to address myself is a difficult one, if one is to avoid the trivial and the banal. Besides, my knowledge and my experience, such as they are, compel me to limit myself, entirely, to the theoretical aspects of the physical sciences—limitations, most serious. I must, therefore, begin by asking for your patience and your forbearance.

laws without theories would have, at most, only a practical utility, we see that the motives which guide the scientific man are, from the beginning, manifestations of
measure in which science falls short of art is the measure in which it is incomplete as science. . . .

Image: NASA, Wikimedia commons (public domain)

When is a theory beautiful?

Chandrasekhar: criteria

1. Francis Bacon: “There is no excellent beauty that hath not some strangeness in the proportion.”
2. Heisenberg: “Beauty is the proper conformity of the parts to one another and to the whole.”

quoted from Chandrasekhar 1979/2010, 61

Chandrasekhar on relativity theory

Foundations:

- Derived from principles, not just an attempt to fit the deviations from Newtonian theory, rather quest for simplicity

Theory and its consequences:

- Putting space and time together (strangeness)
- Black holes can be parameterized with 2 parameters
- Singularity theorems: Universe very small

Beauty of theories, summarized

"Criteria":

- Inner coherence (parts fitting together)
- Simplicity
- Unification
- Symmetry

Objection

This is really poor stuff.

It seems that, when physicists get older or a Nobel Prize, they want to say something uplifting.

But it’s not well-argued.

2. Truth and beauty

Question: how can we get beauty into the picture of science?

a. Science is about beauty

H. Poincaré:
"The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful. If nature were not beautiful, it would not be worth knowing"

Quoted after edition 2015, 366

Illustration

beauty

truth

science

a. Science is about beauty

J. W. N. Sullivan (1919):
"It is in its aesthetic value that the justification of the scientific theory is to be found, and with it the justification of the scientific method. Since facts without laws would be of no interest, and laws without theories would have, at most, only a practical utility, we see that the motives which guide the scientific man are, from the beginning, manifestations of the aesthetic impulse."

Quoted after Chandrasekhar (1979/2010, 57)

Objections against a.

What then is the difference to mimetic art?

Even if the Universe is (to some extent) ugly, it's worthwhile how it is like.

b. Beauty is truth-conductive

(knowledge of) truth

reality beautiful

science

b. Beauty is truth-conductive

(knowledge of) truth

reality beautiful

beauty

i. Metaphysical argument
ii. Empirical argument
iii. Transcendental argument

Ivanova (2017, 2020)

science

i. The metaphysical argument

1. The world is beautiful.
2. More beautiful theories are more likely true.

Objection 1: There is a category mistake here. The truth of a theory is not the same as truth of a theory.

Objection 2: How do we know that premise 1 is true?

ii. The historical argument

1. The quest for beauty has in the past led to true theories.

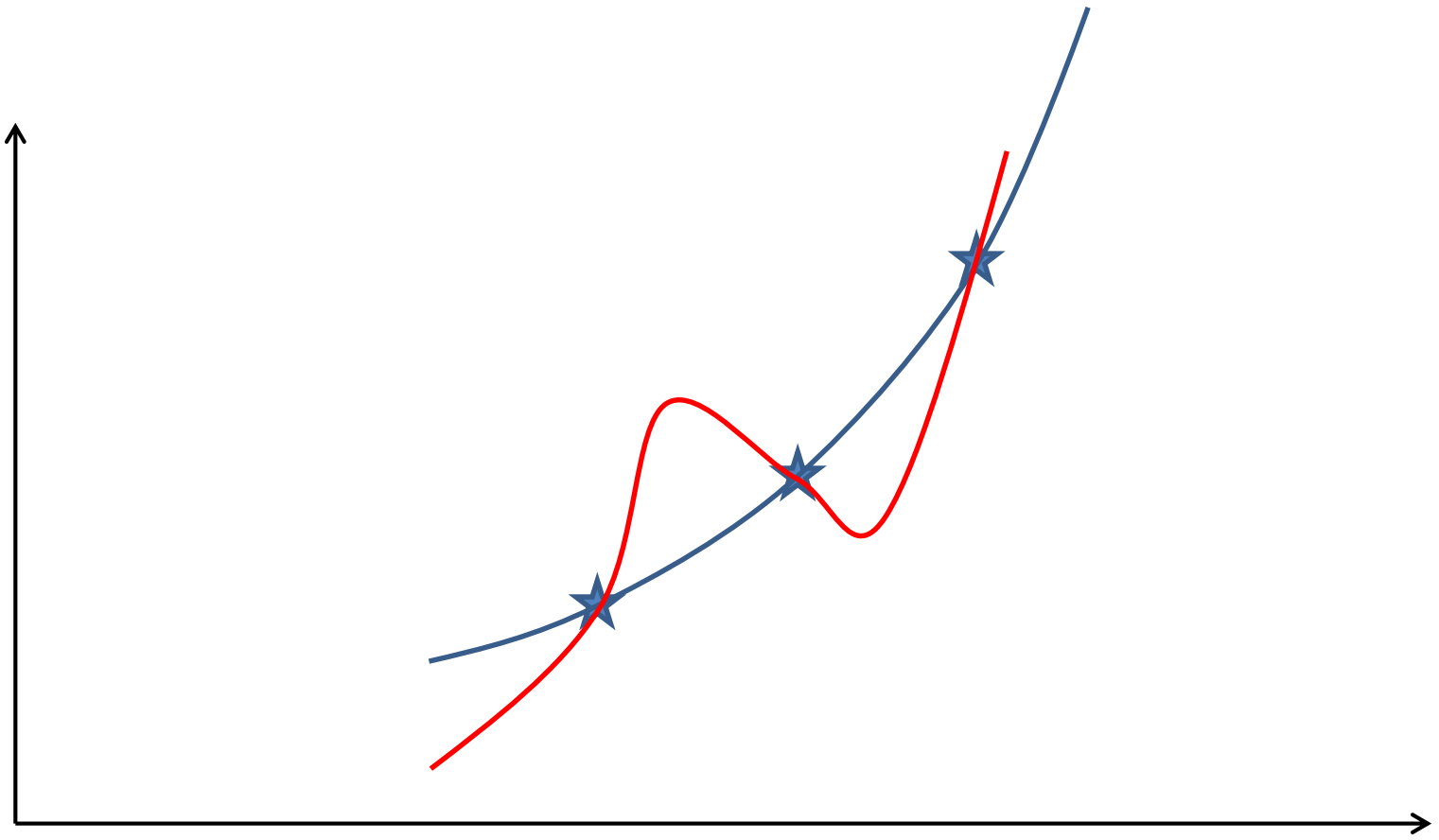
2. The quest for beauty will continue to lead to true theories.

Objection: Premise 1 is biased. The quest for beauty has also led to false theories. (Hossenfelder)

iii. The transcendental argument

1. Certain judgements that we make about evidence can only be justified by the assumption that beauty is truth-indicative.
2. Beauty is truth-indicative.

Example: curve-fitting



iii. The transcendental argument

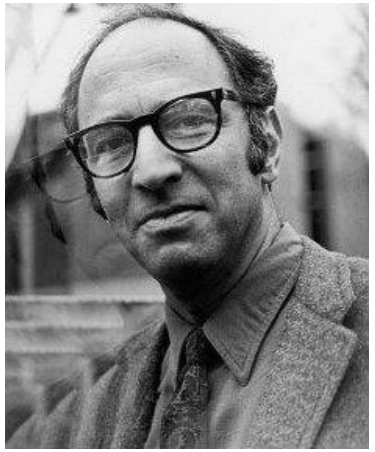
1. Certain judgements that we make about evidence can only be justified by the assumption that beauty is truth-indicative.
2. Beauty is truth-indicative.

Objection: The work done by beauty is dubious. There are better explanations why we choose the simple curve.

c. Theory choice reconsidered

Thomas S. Kuhn:
"characteristics of a good scientific theory":

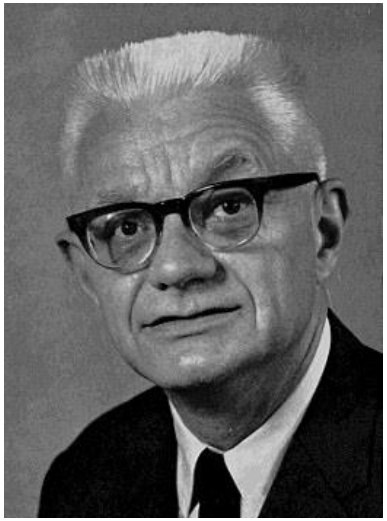
- Accuracy
- Consistency (internal and external)
- Broad scope
- Simplicity
- Fruitfulness



Kuhn (1977, 321 ff.)

Image: B. Pierce (Life Time Picture/Getty Images), wikimedia (fair use),

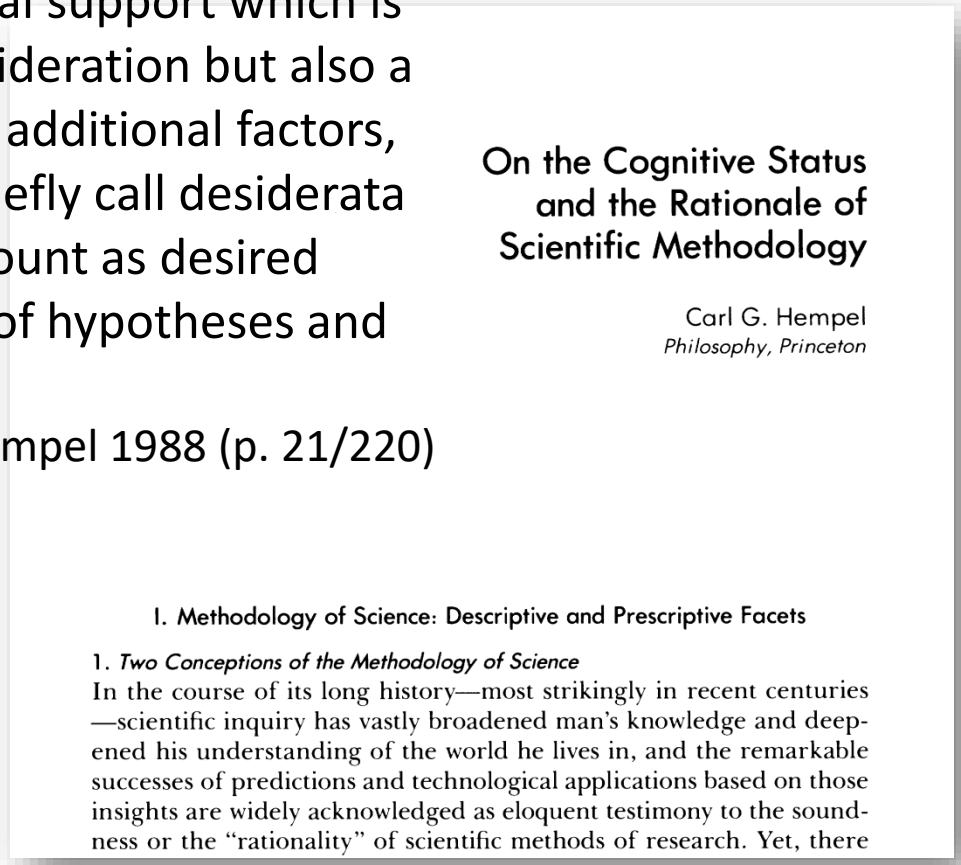
Theoretical virtues



Carl G. Hempel (1988)

"in the critical scientific appraisal of a hypothesis or theory, it is not only its empirical support which is taken into consideration but also a whole series of additional factors, which I shall briefly call desiderata because they count as desired characteristics of hypotheses and theories."

Hempel 1988 (p. 21/220)



On the Cognitive Status and the Rationale of Scientific Methodology

Carl G. Hempel
Philosophy, Princeton

I. Methodology of Science: Descriptive and Prescriptive Facets

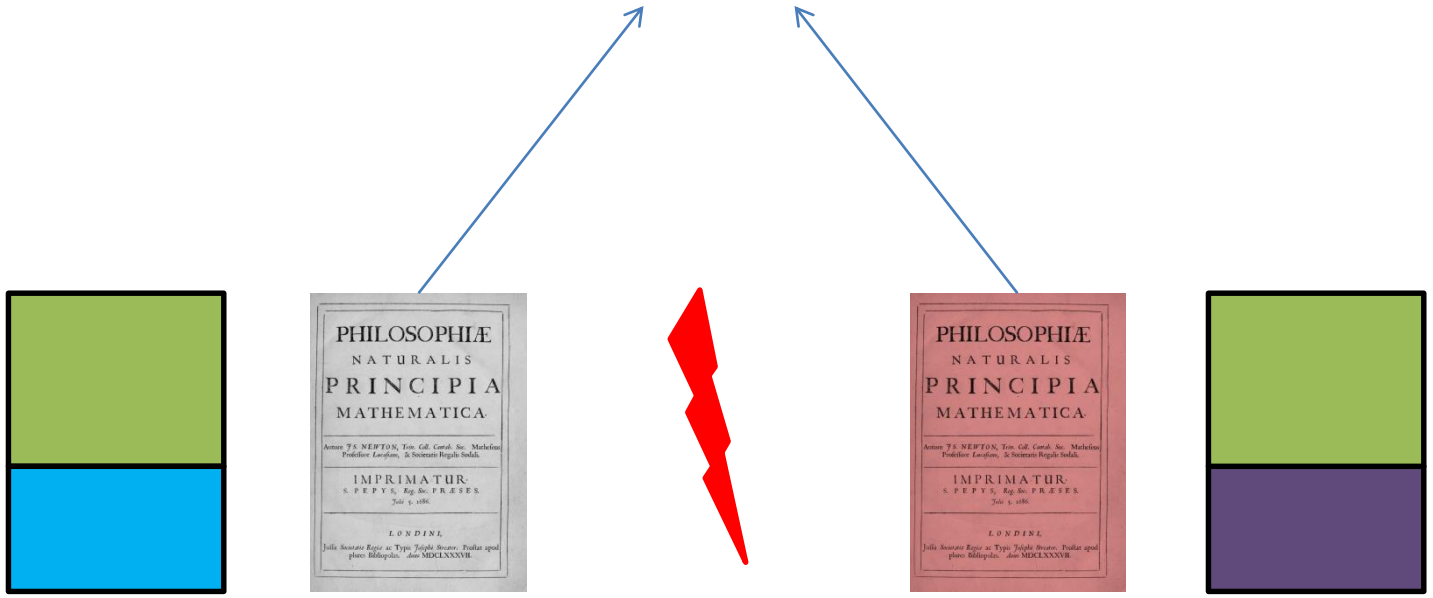
1. *Two Conceptions of the Methodology of Science*

In the course of its long history—most strikingly in recent centuries—scientific inquiry has vastly broadened man's knowledge and deepened his understanding of the world he lives in, and the remarkable successes of predictions and technological applications based on those insights are widely acknowledged as eloquent testimony to the soundness or the "rationality" of scientific methods of research. Yet, there

Image: ???, wikimedia (fair use)

Empirical equivalence

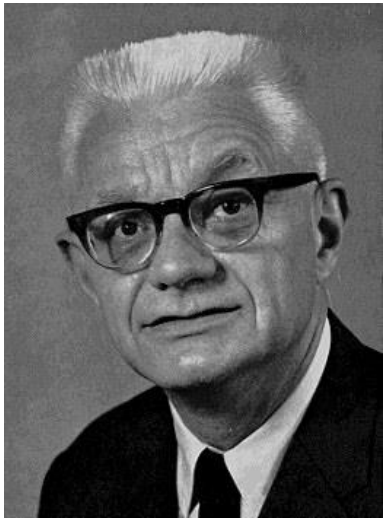
Empirical consequences



Threat: Choice between the theories is underdetermined.

Hope: theoretical virtues make difference.

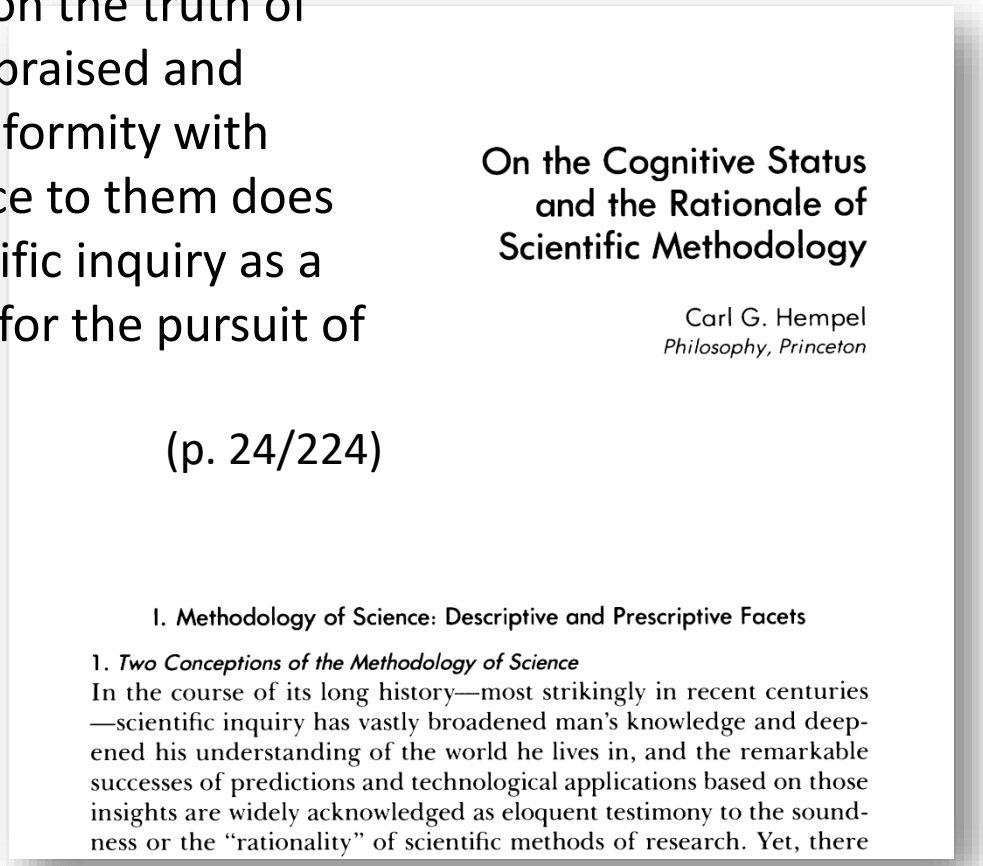
Hempel again



Hempel (1988)

"Skeptical considerations […] can be adduced to show for other desiderata that they have no logical bearing on the truth of the theories appraised and accepted in conformity with them; adherence to them does not mark scientific inquiry as a rational means for the pursuit of truth."

(p. 24/224)



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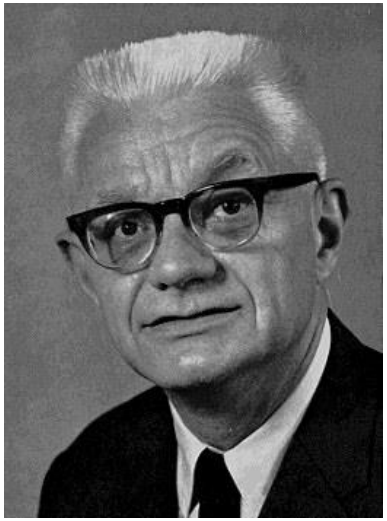
Aims of science



Hempel (1988)

"Instead, scientific research might be said to aim at attaining theories that are epistemically optimal in a sense roughly indicated, though by no means precisely explicated, by the desiderata; i.e., theories which, at the current stage of inquiry, are as accurate, precise and comprehensive as possible, which provide explanations and predictions of experimental findings and so on."

(p. 24/224)

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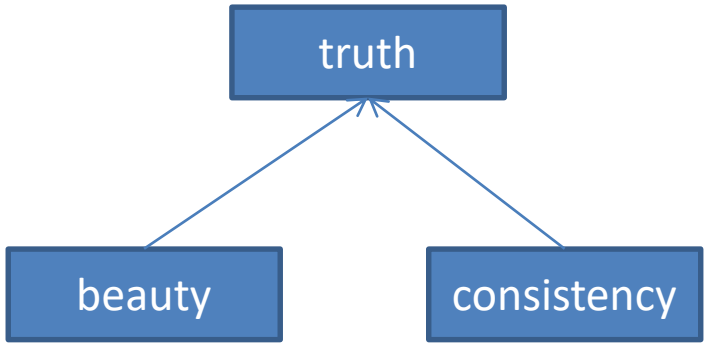
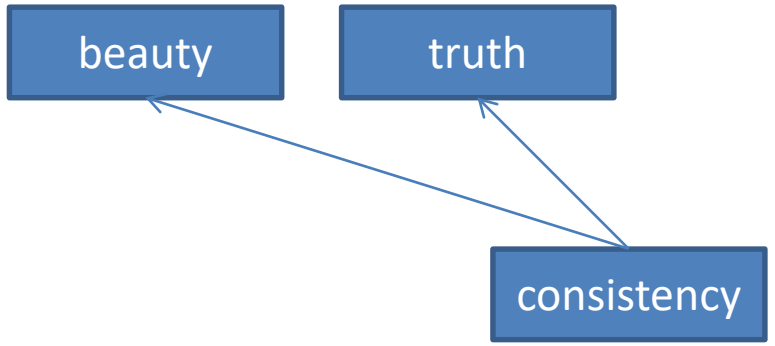
Epistemic pluralism

Science has more ultimate goals, not just truth.

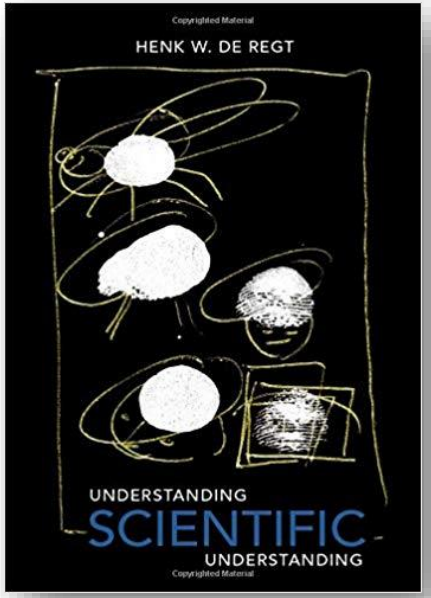




Objections:

- This is ad hoc.
- This is a slippery slope.

For pluralism



Science is also about understanding

Jonathan Kvanvig (2003, 192):
"Understanding requires the grasping of explanatory and other coherence-making relationships in a large and comprehensive body of information. One can know many unrelated pieces of information, but understanding is achieved only when informational items are pieced together by the subject in question."

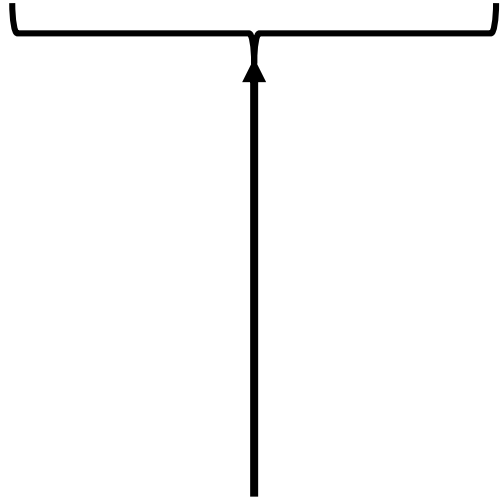
Unification
Systematize a lot of phenomena using few axioms

The place of beauty

(knowledge of) truth

Understanding*

beauty



science

*certain aspects of beauty facilitate understanding

Merci/thanks/danke

Conclusions

1. Scientists often call their theories or their discovery beautiful.
2. By this, they often mean that pieces fit together, that there is simplicity and symmetry.
3. If science and its theories only aim at truth, the appeal to beauty is difficult to justify.
4. But science is also aimed at understanding, and aspects of understanding can be seen as beautiful.

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