Programmatic Realism in Physics and Foundations of Mathematics

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3. T accounts for acquiring the relevant experience in U by humans along with all other relevant phenomena in U;
4. T does not qualify the acquiring of human experiences in U as a fundamental process but explains it away in terms of some other (fundamental) processes.

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- (2) guaranties the empirical (as opposed to speculative) character of the given theory (cf. Kant). Since the possibility of any conceived experience can be, generally, judged in advance (i.e., in the absence of actual experience) only conjecturally, this

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- (3) guaranties that (i) U comprises the human observers and that (ii) T does not have an *a priori* part, which is not revisable (in the face of empirical evidences) in principle.

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- (4) allows for making sense of the "reality independent of the observer" - even if the acquiring of (human) knowledge about this reality is strictly impossible without such an observer (experimenter). Grounds for accepting (4) are physical and biological rather than merely speculative (naturalized epistemology).

Programmatic Realism vs. Metaphysical Realism

As they stand conditions (1)-(4) are *desiderata* for T. These conditions do not constitute by themselves a philosophical interpretation of T as a story about the "real". They do not offer any solution to the metaphysical question concerning the alleged reality (vs. non-realtiy) of objects in T.

Programmatic Realism vs. Metaphysical Realism

Instead (1)-(4) offer a certain methodology, i.e. a certain general program of building scientific theories. This program is by far more demanding than that of *saving phenomena* and making good predictions. It also suggests a reasonable meaning of "real", which belongs to the methodology of science rather than to metaphysics.

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The fact that science is all along socially constructed does not erase the difference between the realistic science and the myth or some other form of popular fiction.

Einstein on Programmatic Realism 1

Physics is an attempt conceptually to grasp reality as it is thought independently of its being observed. In this sense one speaks of "physical reality"

Einstein on Programmatic Realism 2

"Being" is always something which is mentally constructed by us, that is, something which we freely posit (in the logical sense). [..] The justification of the constructs, which represent "reality" for us, lies alone in their quality of making intelligible what is sensorily given ..

Einstein on Programmatic Realism 3

[T]he "real" in physics is to be taken as a type of program, to which we are, however, not forced to cling a priori.

Einstein on Programmatic Realism 4

Das Wirkliche ist uns nicht gegeben, sondern aufgegeben (nach Art eines Rätsels)

The Real is not given to us, but put to us (by way of a riddle)

Ptolemy

ΣΩΖΕΙΝ ΤΑ ΦΑΙΝΟΜΕΝΑ

ESSAI

Sur la Notion de Théorie physique

DE PLATON A GALILÉE

PAR

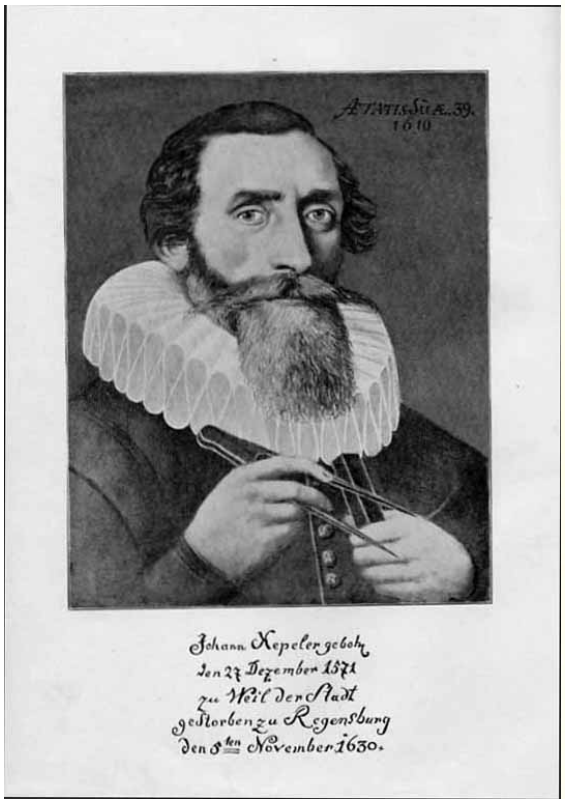
Pierre DUHEM

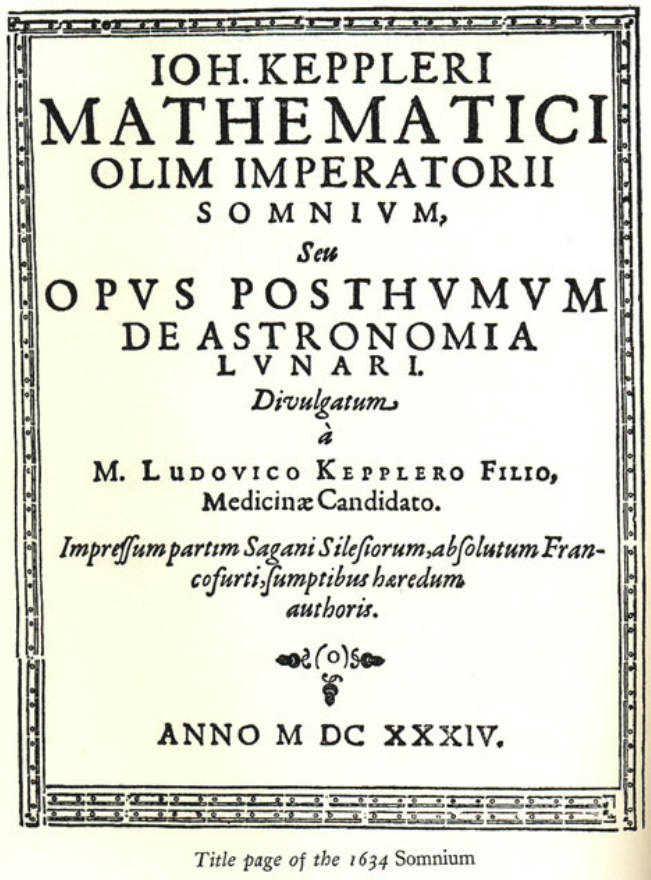
CORRESPONDANT DE L'INSTITUT DE FRANCE
PROFESSEUR A L'UNIVERSITÉ DE BORDEAUX

EXTRAIT DES *Annales de Philosophie Chrétienne*

PARIS
LIBRAIRIE SCIENTIFIQUE A. HERMANN ET FILS
6, RUE DE LA SORBONNE, 6
—
1908

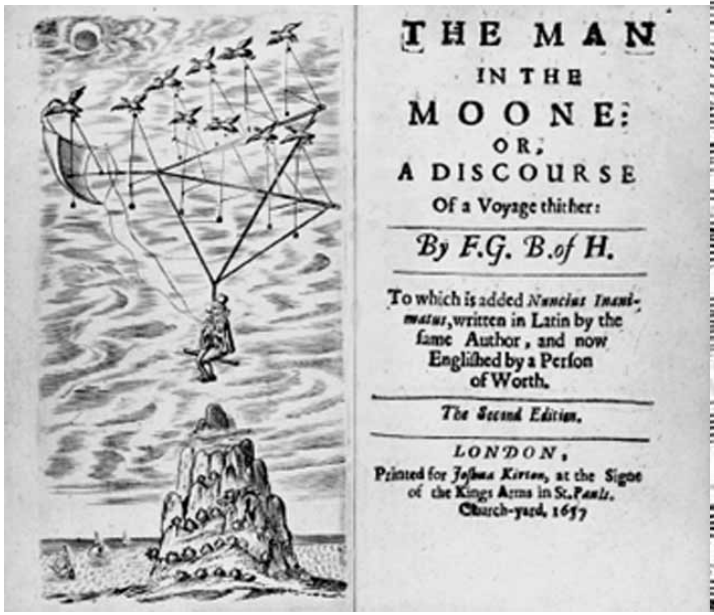
Kepler




IOH. KEPPLERI
MATHEMATICI
OLIM IMPERATORII
SOMNIVM,
Seu
OPVS POSTHVMVM
DE ASTRONOMIA
LVNARI.
Divulgatum
à
M. LUDOVICO KEPPLERO FILIO,
Medicinæ Candidato.
Impressum partim Sagani Silesiorum, absolutum Francofurti, sumptibus hæredum authoris.
ANNO M DC XXXIV.

Title page of the 1634 Somnium

Bishop Godwin (1562-1633)



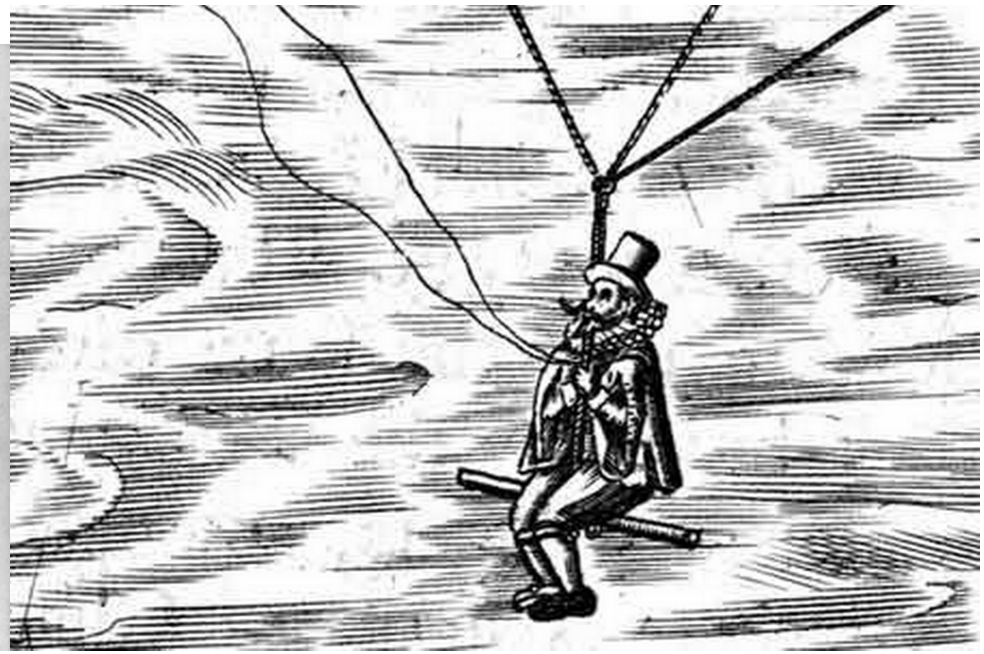
THE MAN
IN THE
MOONE:
OR,
A DISCOURSE
Of a Voyage thither:

By F.G. B.of H.

To which is added *Nuncius Inanimatus*, written in Latin by the same Author, and now Englished by a Person of Worth.

The Second Edition.

LONDON,
Printed for *Joshua Kirton*, at the Signe of the Kings Arms in St. *Pauls*. Church-yard, 1657



Science + Fiction = Scientific Realism!

Einstein-Schrödingier

Einstein (and Schrödingier): The existing QM must be replaced by a realistic theory, which accounts for (quantum) phenomena as events in a space-time. Since the existing GR (and its underlying Riemann geometry) does not provide an appropriate spatio-temporal framework for *realistic* quantum physics, this theory must be revised and perhaps wholly replaced by a better theory.

Bohr-Heisenberg

Bohr (and Heisenberg): A realistic quantum physics is impossible in principle. Quantum physics can be nothing but a "purely symbolic" tool for *saving quantum phenomena* and making predictions, which applies to certain *complimentary* (i.e., partial and incomplete) classical descriptions of these phenomena.

An analogy in mathematics

Notice a parallel development in the contemporary mathematics: Euclidean, arithmetical and other "classical" *models* of axiomatic non-Euclidean geometries and other axiomatic "non-classical" theories. (Hilbert, Tarski and their heirs)

Bohr 1949:

"However far the phenomena transcend the scope of classical physical explanation, the account of all evidence must be expressed in classical terms. The argument is simply that by the word "experiment" we refer to a situation where we can tell others what we have done and what we have learned and that, therefore, the account of the experimental arrangement and of the results of the observations must be expressed in unambiguous language with suitable application of the terminology of classical physics." (*my emphasis*)

Bohr 1949:

"An adequate tool [..] is offered precisely by the quantum mechanical formalism which represents a purely symbolic scheme permitting only predictions [..] as to results obtainable under conditions specified by means of classical concepts." (*my emphasis*)

Einstein 1928:

(to Schrödingier)
"Your claim that the concepts, p, q [i.e., momentum and position] will have to be given up, if they can only claim such "shaky" meaning seems to me to be fully justified. The Heisenberg-Bohr tranquilizing philosophy - or religion? - is so delicately contrived that, for the time being, it provides a gentle pillow for the true believer from which he cannot very easily be aroused. So let him lie there."

Einstein 1935:

(to Schrödingier)
I consider the renunciation of a spatio-temporal setting for the Real to be idealistic-spiritualistic. This epistemology-soaked orgy ought to come to an end. No doubt, however, you smile at me and think that, after all, many a young heretic turns into an old fanatic, and many a young revolutionary becomes an old reactionary.

Outcome

Since Einstein or anyone of his followers failed to provide the wanted replacement for GR, which could serve as a framework for realistic theory of quantum phenomena, in the mid-20th century Bohr-Heisenberg's viewpoint prevailed. Many philosophers convinced themselves that the contemporary physics "proved" to be non-realistic.

Historical Considerations

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- In the past all significant revisions of earlier spatio-temporal frameworks in Physics involved the revision of their underlying geometry and, more generally, of the foundations of mathematics. Examples: (i) Geometry of Curves by Barrow and Continuous Analysis by Newton (c. 1700), (ii) Geometry of Curve Spaces by Riemann later used by Einstein in GR.

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- Realization of Einstein's Realistic Program for Physics requires a new revision of foundations of geometry and perhaps of mathematics in general.
- Set-theoretic foundations of mathematics designed in the beginning of the 20th century, which later became standard, support Bohr's non-realistic model-theoretic approach in Physics rather than Einstein's realistic approach.

Set-theoretic Foundations

Indeed, the set-theoretic Mathematics applies sets as an universal material for model-building (cf. Tarski semantics for the 1st-order logic). The standard mathematical interpretation of sets implies that the "infinite sets don't exist in Nature". Thus mathematical objects construed as set-theoretic structures, generally, don't allow for any direct physical interpretation.

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- The alternative *category-theoretic* (and, more specifically, *topos-theoretic*) mathematical foundations, which has been first invented in late 1960ies and ever since become increasingly important in the everyday research mathematics, do allow for such interpretations in many important cases. Batterfield, Isham and Doring since around 2000.

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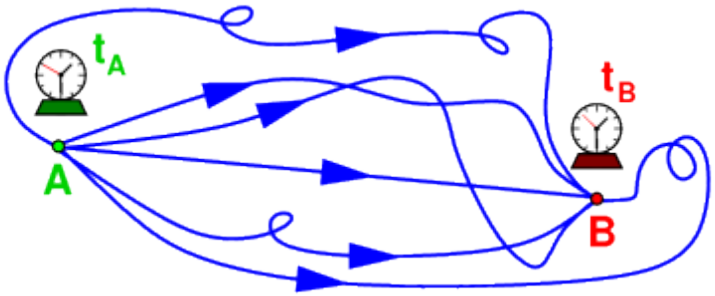
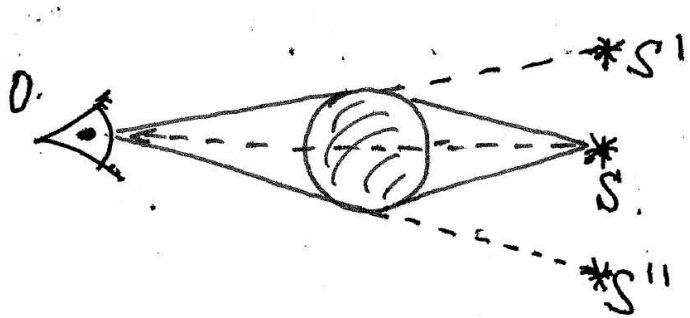
- Recent News: Homotopy Type theory and Univalent Foundations (Voevodsky since 2008) of mathematics provide an intuitive basis for (prospectively) the whole of today's mathematics, which are physically meaningful. Current work on QFT and Quantum Gravity by Schreiber et al.

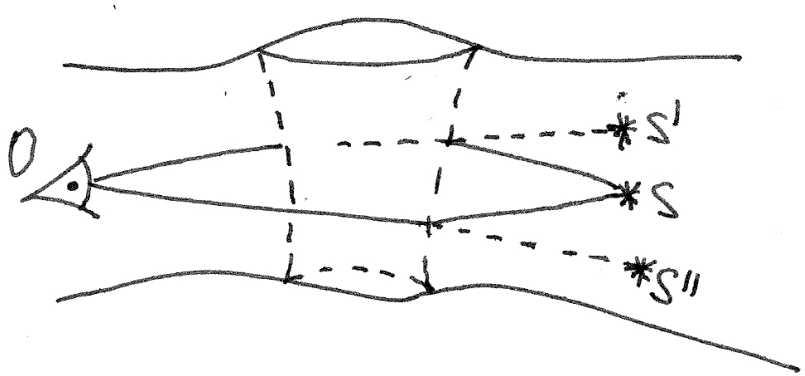
Homotopies in Physics

(Feynman) Path integrals



Gravitational Lensing





Philosophy for Quantum Gravity

ERC *Philosophy of Canonical Quantum Gravity*
PI Gabriel Catren (SPHERE, Paris-Diderot):

BOTH Physics AND MATHEMATICS meet Philosophy at the Plank Scale!

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- This research is closely related to the revision of the standard set-theoretic foundations of Mathematics;

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- Programmatic Realism is compatible with Constructivism in Mathematics;
- Programmatic Realism is compatible with (moderate forms of) Social Constructivism about Science. Moreover studying the social aspects of scientific knowledge, ultimately, makes part of Realism as a research program (along with studying the individual human cognition).

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- Programmatic Realism in Physics is evidently more demanding and more ambitious than its rivals. But there is no a priory reason why it should fail.

THANK YOU