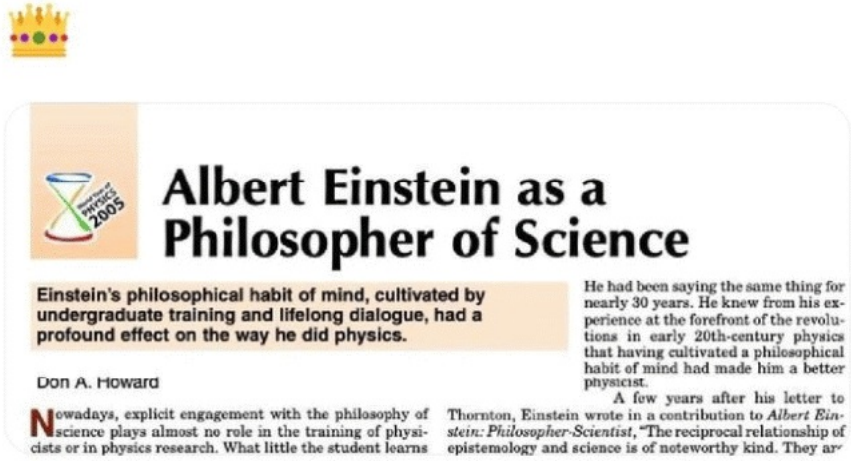
Philosophy of Science (PHIL/HPS 83801)

Don Howard was mentioned in a post.

Wayne Myrvold
February 23 ·

MC Hammer is now tweeting Don Howard.

MC HAMMER
@MCHammer



# Albert Einstein as a Philosopher of Science

**Einstein's philosophical habit of mind, cultivated by undergraduate training and lifelong dialogue, had a profound effect on the way he did physics.**

Don A. Howard

Nowadays, explicit engagement with the philosophy of science plays almost no role in the training of physicists or in physics research. What little the student learns

He had been saying the same thing for nearly 30 years. He knew from his experience at the forefront of the revolutions in early 20th-century physics that having cultivated a philosophical habit of mind had made him a better physicist.

A few years after his letter to Thornton, Einstein wrote in a contribution to *Albert Einstein: Philosopher-Scientist*, "The reciprocal relationship of epistemology and science is of noteworthy kind. They ar

You, Stathis Psillos, Carl Hoefer and 31 others 12 Comments

Like Comment Share

## Philipp Frank

1907, Ph.D. Physics, Vienna

1910, Privatdozent, Physics, Vienna

1912, Professor of Physics, Prague

1938, Lecturer, Physics, Harvard

Philipp Frank (1884-1966)

# The First Vienna Circle – ca. 1905-1914

Philipp Frank (1884 - 1966)

Otto Neurath (1882 - 1945)

Hans Hahn (1879 - 1934)

# The Second Vienna Circle – 1922-1938

Moritz Schlick (1882 - 1936)

Rudolf Carnap (1891 - 1970)

Hans Reichenbach (1891 - 1953)

# Activities of the Vienna Circle


# Activities of the Vienna Circle

Eigenhändige Unterschrift des Inhabers:

Rose Rand

Wien, den 16. X. 1924

University of Pittsburgh

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## Rose Rand Papers

Programme.

I shall present the opinion if those ~~leading~~ members of the Vienna Circle who were present at the Circle and who were leading in discussions as well as in their publications in the Erkenntnis ~~&~~ Annalen of the Circle was also ~~Blätter~~ in the span of time 1928–1936

**What's online?**

Selected portions of the papers are scanned and online.

**What's in the entire collection?**

The papers comprise her personal and professional records, a significant amount of correspondence and working papers, as well as notebooks, research notes, manuscript fragments, and transcriptions from Vienna Circle discussions. They also include annotated books from her personal library. The personal and professional records cover items such as legal and educational documents, testimonials, financial and health care records, as well as photographs, travel documents, and address books. Her working papers, manuscripts, transcriptions, and note books record largely her work as a translator, her own research, and discussions and presentations from the Vienna Circle. The correspondence is extensive, more than 1600 letters, and covers a wide range of dates, from the early period in Vienna to the time right after her death. Correspondents include prominent members of the Vienna Circle and affiliated individuals, such as Rudolf Carnap, Moritz Schlick, Otto Neurath, Ludwig Wittgenstein, and Karl Popper. Covered are also exchanges with the Polish philosophers Tadeusz Kotarbinski, Kazimierz Ajdukiewicz, and Alfred Tarski, with family and friends, and numerous institutions. Read more...

**Description**

Comprises Rose Rand's personal and professional records, a significant amount of correspondence and working papers, as well as notebooks, research notes, manuscript fragments, and transcriptions from Vienna Circle discussions (1922-1938).

**Creator**

creator

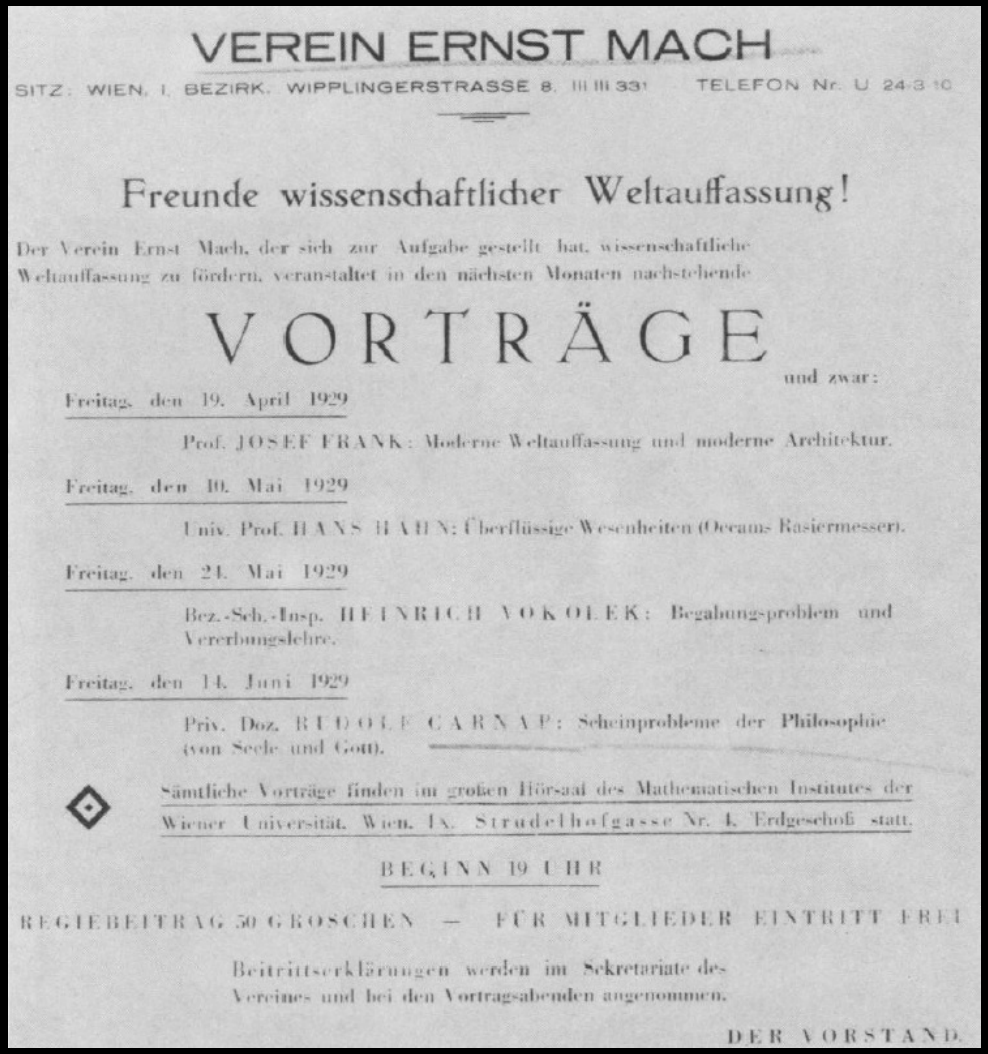
**Depositor**

University of Pittsburgh

**DC Creator**

Rand, Rose, 1903-1980

Activities of the Vienna Circle



VEREIN ERNST MACH

SITZ: WIEN, I. BEZIRK, WIPPLINGERSTRASSE 8, III. III. 331 TELEFON Nr. U 24-3 10

Freunde wissenschaftlicher Weltauffassung!

Der Verein Ernst Mach, der sich zur Aufgabe gestellt hat, wissenschaftliche Weltauffassung zu fördern, veranstaltet in den nächsten Monaten nachstehende

VORTRÄGE

und zwar:

Freitag, den 19. April 1929

Prof. JOSEF FRANK: Moderne Weltauffassung und moderne Architektur.

Freitag, den 10. Mai 1929

Univ. Prof. HANS HAHN: Überflüssige Wesenheiten (Occams Rasiermesser).

Freitag, den 24. Mai 1929

Bez.-Sch.-Insp. HEINRICH VOKOLEK: Begabungsproblem und Vererbungslehre.

Freitag, den 14. Juni 1929

Priv. Doz. RUDOLF CARNAP: Scheinprobleme der Philosophie (von Seele und Gott).

Sämtliche Vorträge finden im großen Hörsaal des Mathematischen Institutes der Wiener Universität, Wien, IX. Strudelhofgasse Nr. 4, Erdgeschoß statt.

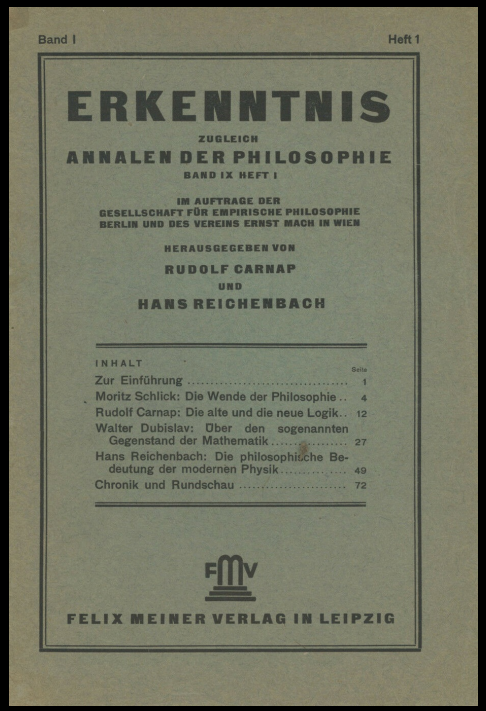
BEGINN 19 UHR

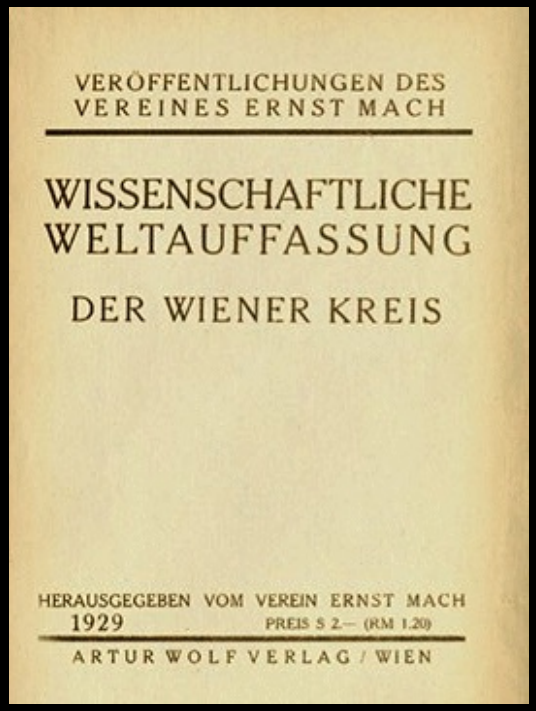
REGIEBEITRAG 50 GROSCHEN — FÜR MITGLIEDER EINTRITT FREI

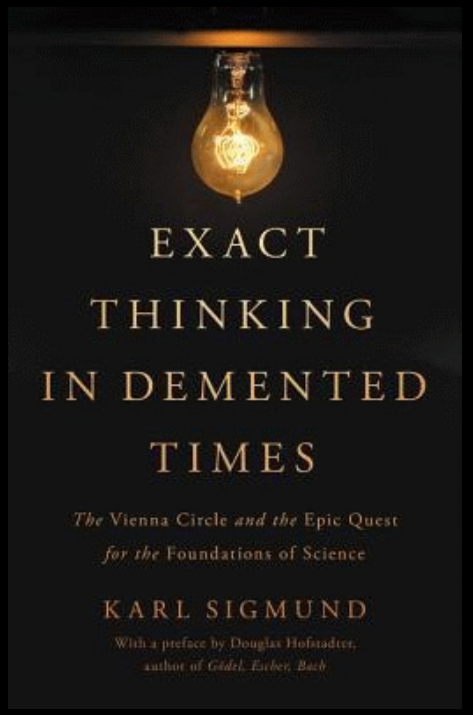
Beitrittserklärungen werden im Sekretariate des Vereines und bei den Vortragsabenden angenommen.

DER VORSTAND.

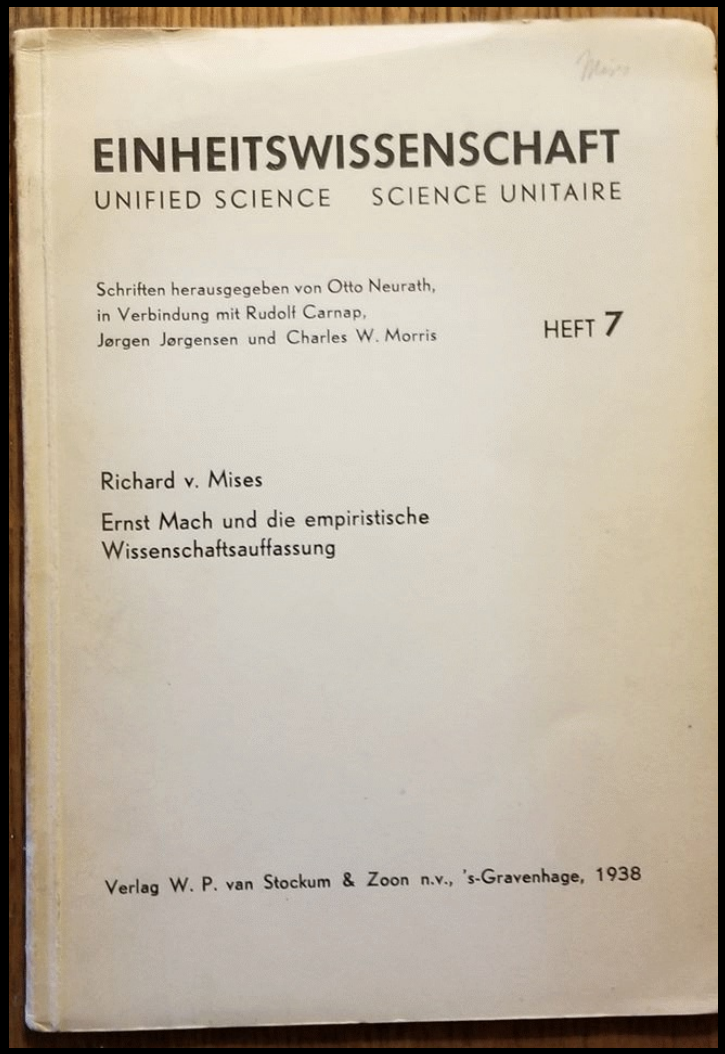
# Activities of the Vienna Circle



# Activities of the Vienna Circle



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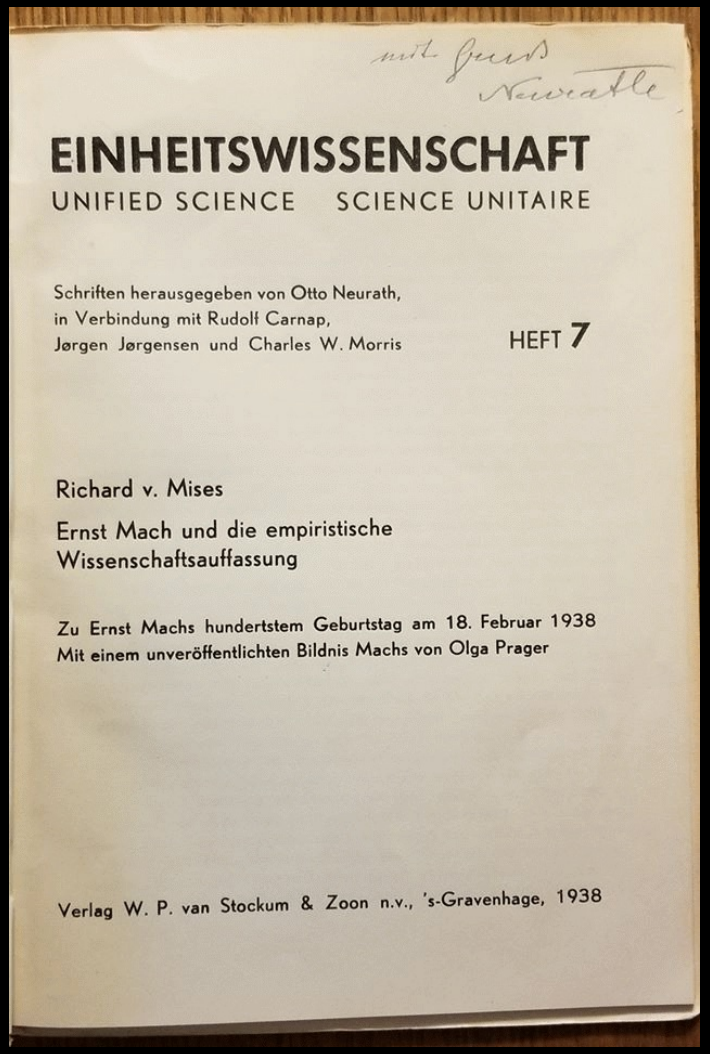
Schriften herausgegeben von Otto Neurath,
in Verbindung mit Rudolf Carnap,
Jørgen Jørgensen und Charles W. Morris

HEFT 7

Richard v. Mises

Ernst Mach und die empiristische
Wissenschaftsauffassung

Verlag W. P. van Stockum & Zoon n.v., 's-Gravenhage, 1938



mit Grüß
Neurath

EINHEITSWISSENSCHAFT

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Schriften herausgegeben von Otto Neurath,
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Jørgen Jørgensen und Charles W. Morris

HEFT 7

Richard v. Mises

Ernst Mach und die empiristische
Wissenschaftsauffassung

Zu Ernst Machs hundertstem Geburtstag am 18. Februar 1938
Mit einem unveröffentlichten Bildnis Machs von Olga Prager

Verlag W. P. van Stockum & Zoon n.v., 's-Gravenhage, 1938

# Ernst Mach

1860, Ph.D. Physics, Vienna

1864, Professor of Mathematics, Graz

1866, Professor of Physics, Graz

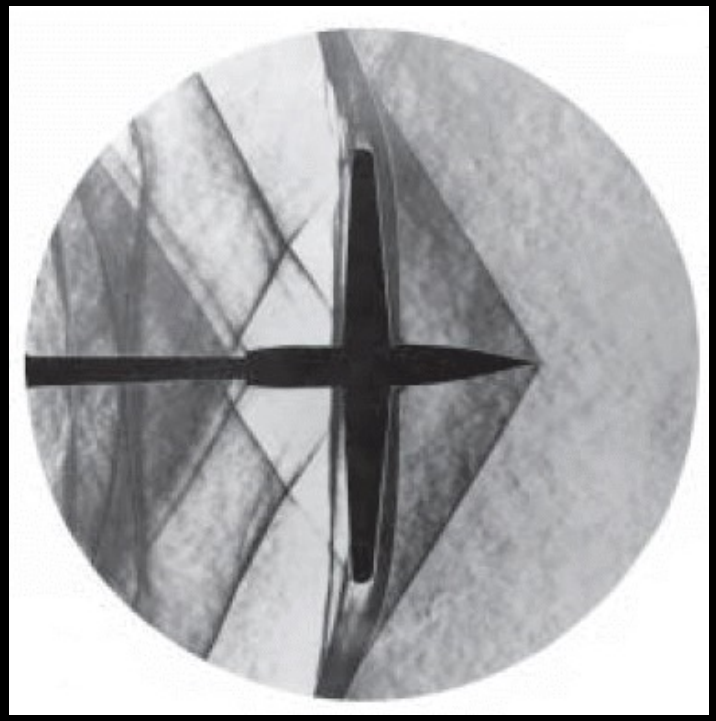
1867, Professor of Experimental Physics, Prague

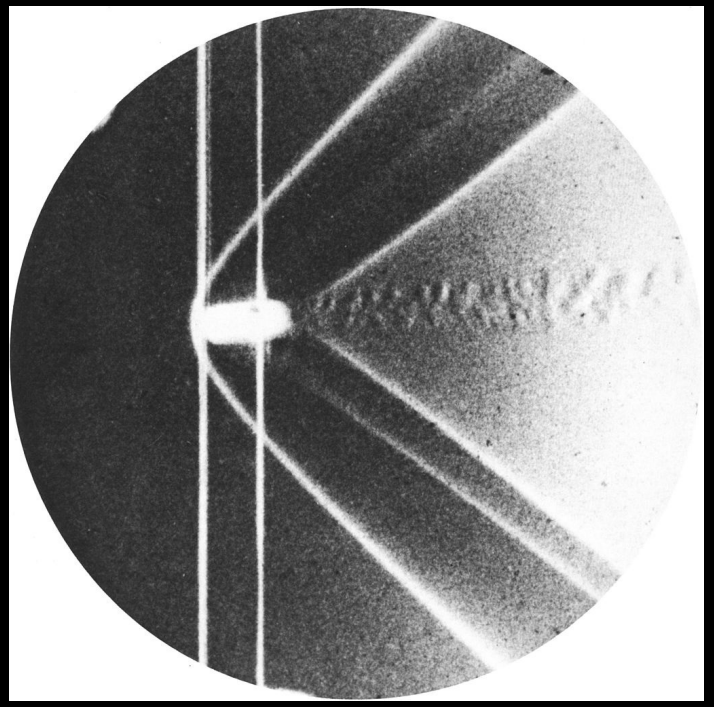
1895, Professor of "Philosophy, Especially the History of the Inductive Sciences"

1901, Retirement


Ernst Mach (1838-1916)

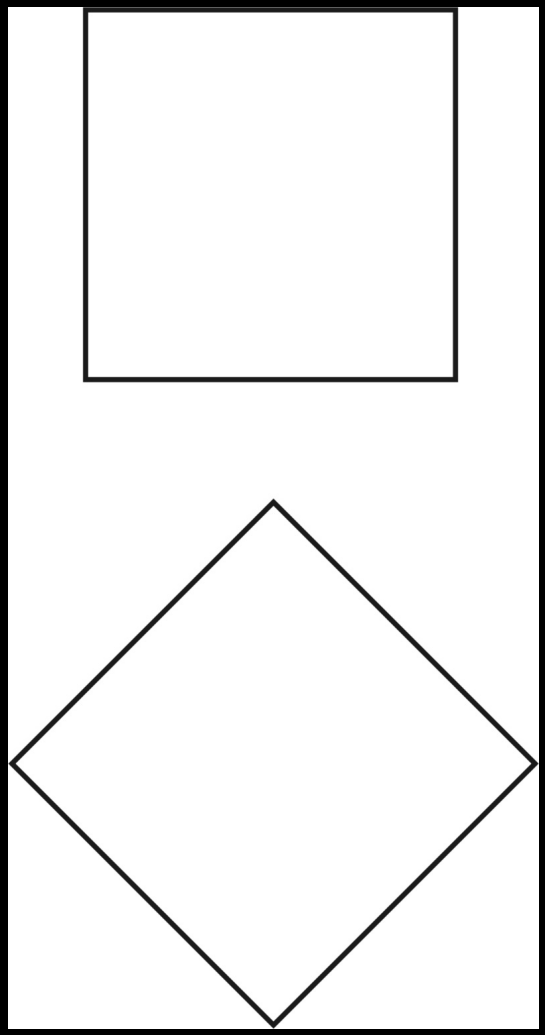
# Mach's Work in Physics





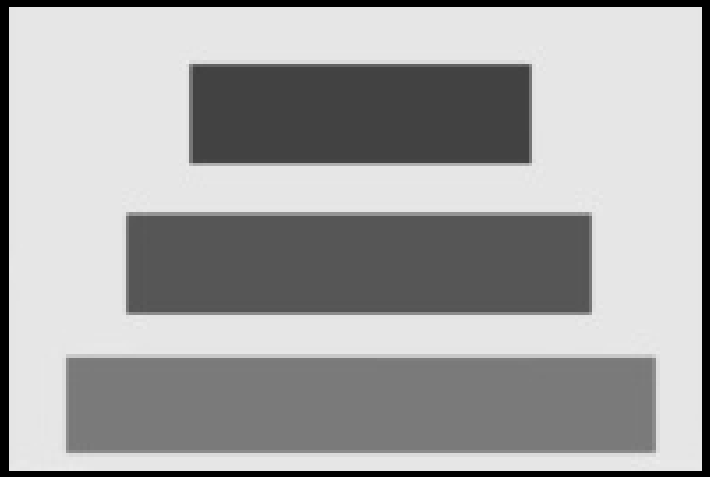
1886-1887, Study of Shock Waves Using Schlieren Photography

Mach’s Work in Psycho-Physics



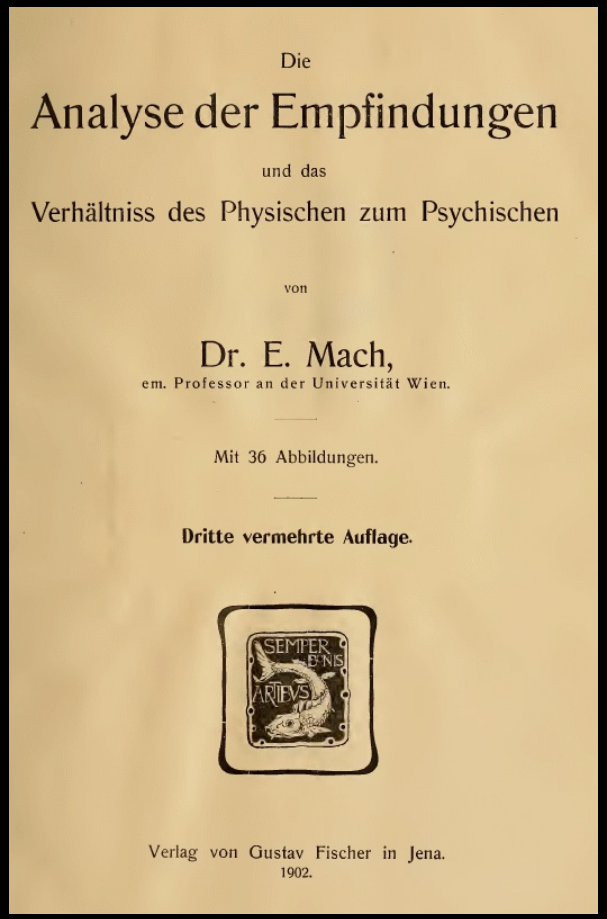
1861 - The Oblique Effect

# Mach's Work in Psycho-Physics



1865 - Mach Bands

Ernst Mach, *Beiträge zur Analyse der Empfindungen* (Jena: Gustav Fischer, 1886).



Die

Analyse der Empfindungen

und das

Verhältniss des Physischen zum Psychischen

von

Dr. E. Mach,

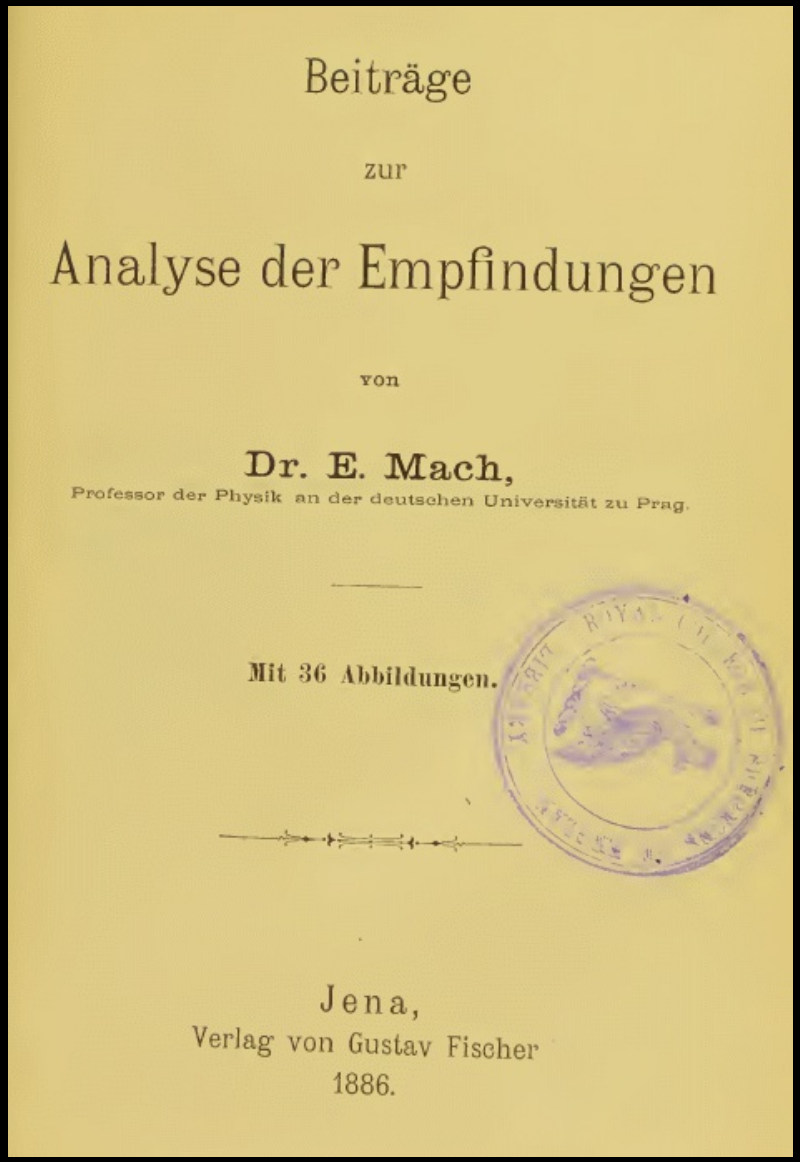
em. Professor an der Universität Wien.

Mit 36 Abbildungen.

**Dritte vermehrte Auflage.**

Verlag von Gustav Fischer in Jena.

1902.



Beiträge

zur

Analyse der Empfindungen

von

**Dr. E. Mach,**

Professor der Physik an der deutschen Universität zu Prag.

**Mit 36 Abbildungen.**

Jena,

Verlag von Gustav Fischer

1886.

Ernst Mach, *Die Mechanik in ihrer Entwickelung historisch-kritisch dargestellt* (Leipzig: Brockhaus, 1883).

DIE MECHANIK

IN IHRER ENTWICKELUNG

HISTORISCH-KRITISCH DARGESTELLT

VON

DR. ERNST MACH,

PROFESSOR DER PHYSIK AN DER DEUTSCHEN UNIVERSITÄT ZU PRAG.

MIT 250 ABBILDUNGEN.

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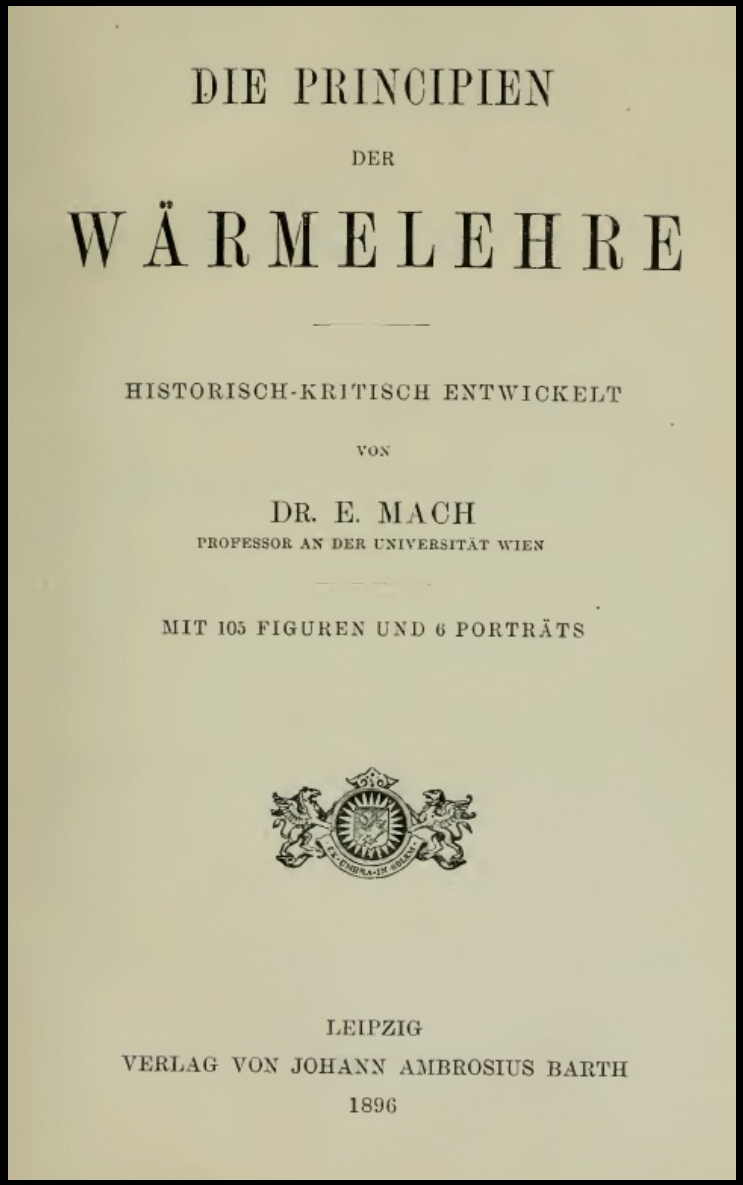
F. A. BROCKHAUS.
1883.

Ernst Mach, *Die Principien der Wärmelehre. Historisch-kritisch entwickelt* (Leipzig: Johann Ambrosius Barth, 1896).



DIE PRINCIPIEN

DER

WÄRMELEHRE

HISTORISCH-KRITISCH ENTWICKELT

VON

DR. E. MACH

PROFESSOR AN DER UNIVERSITÄT WIEN

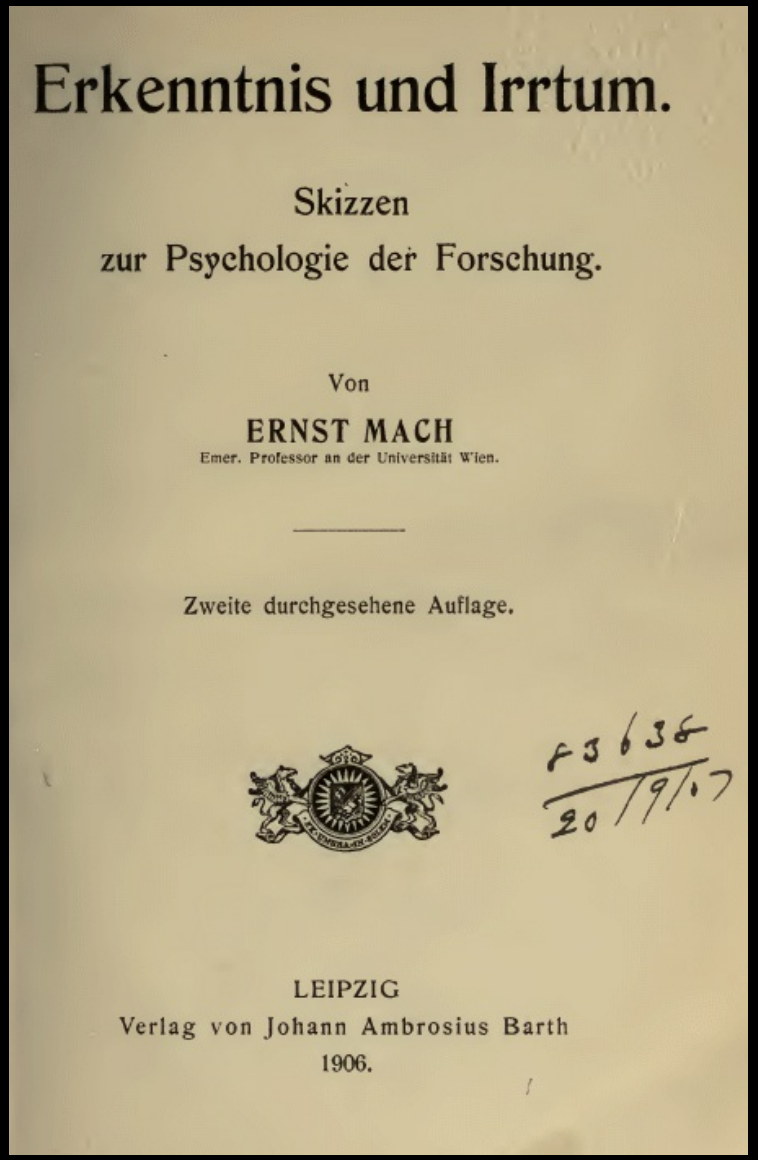
MIT 105 FIGUREN UND 6 PORTRÄTS

LEIPZIG

VERLAG VON JOHANN AMBROSIUS BARTH

1896

Ernst Mach, *Erkenntnis und Irrtum. Skizzen zur Psychologie der Forschung* (Leipzig: Johann Ambrosius Barth, 1905).



Erkenntnis und Irrtum.

Skizzen
zur Psychologie der Forschung.

Von
ERNST MACH
Emer. Professor an der Universität Wien.

Zweite durchgesehene Auflage.

F3636
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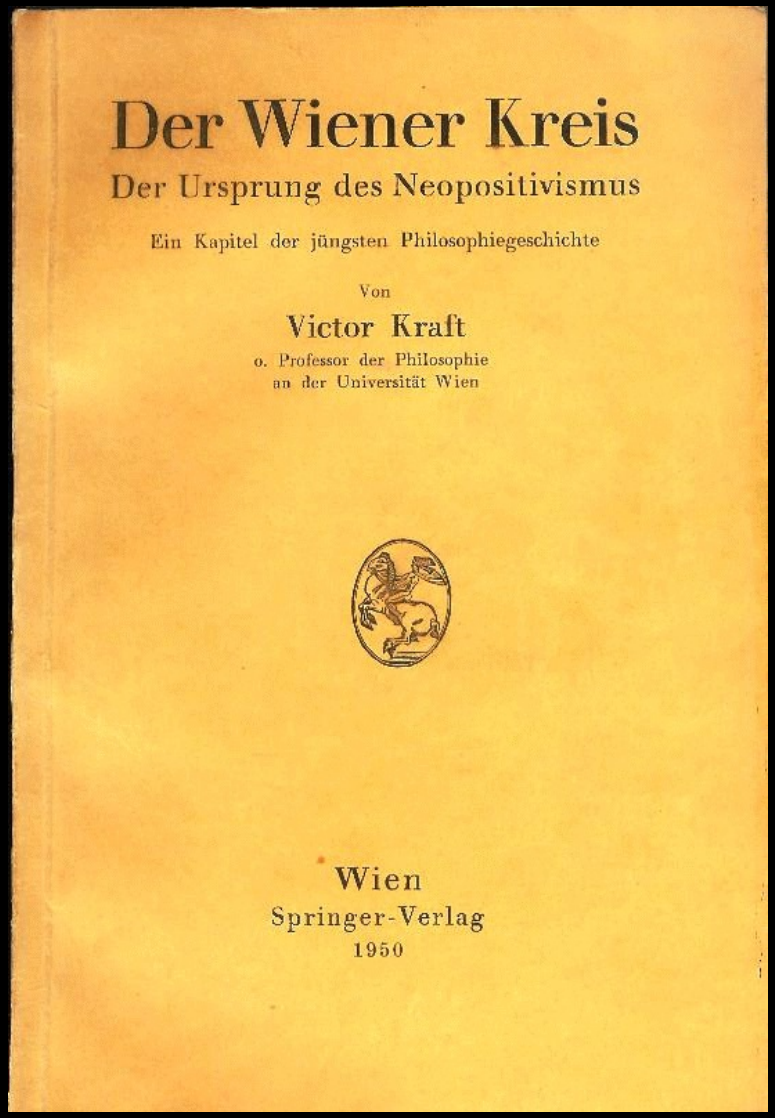
LEIPZIG
Verlag von Johann Ambrosius Barth
1906.

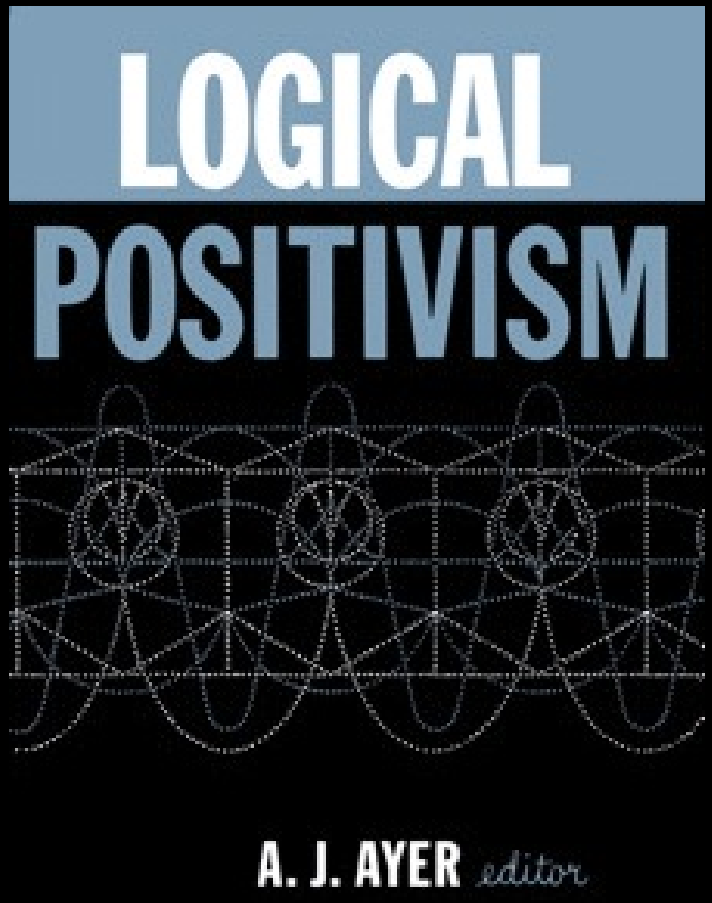
Most of the Twentieth-Century Historiography Made Mach Out to Be a Reductionist Phenomenalist

Victor Kraft, *Der Wiener Kreis. Der Ursprung des Neupositivismus. Ein Kapitel der jüngsten Philosophiegeschichte* (Vienna: Springer, 1950).



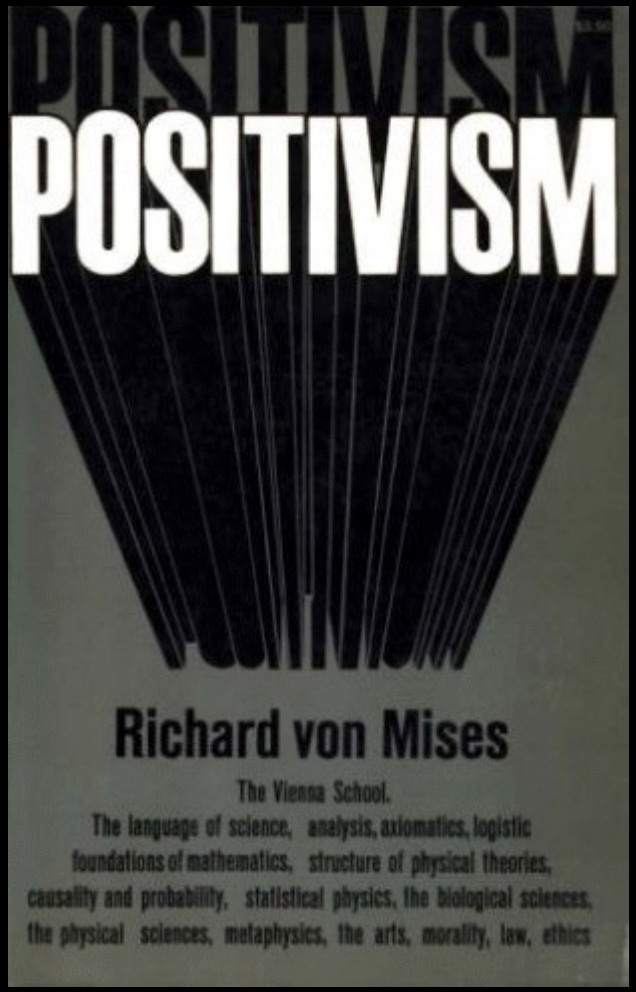
Most of the Twentieth-Century Historiography Made Mach Out to Be a Reductionist Phenomenalist

A. J. Ayer, ed., *Logical Positivism* (New York: The Free Press, 1959).



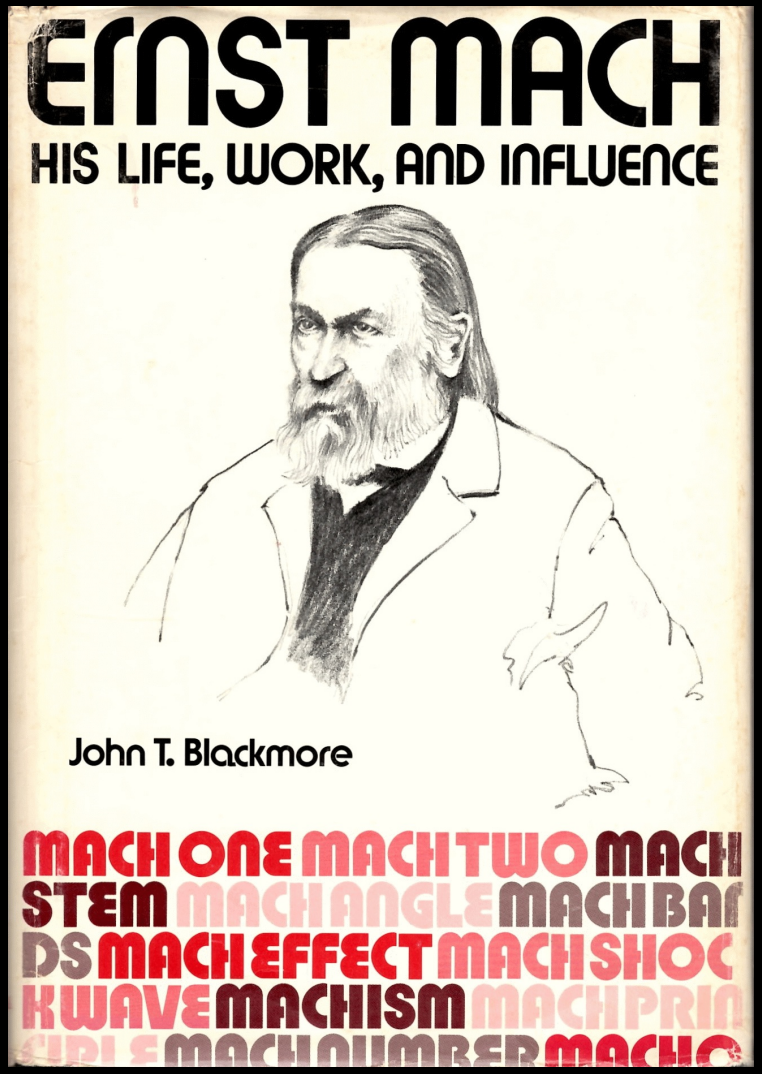
Most of the Twentieth-Century Historiography Made Mach Out to Be a Reductionist Phenomenalist

Richard von Mises, *Positivism: A Study in Human Understanding* (Cambridge, MA: Harvard University Press, 1951).



More than Anyone Else, It Was John Blackmore Who, in the Later Twentieth Century, Promoted this Reading

John Blackmore, *Ernst Mach: His Life, Work, and Influence* (Berkeley: University of California Press, 1972).

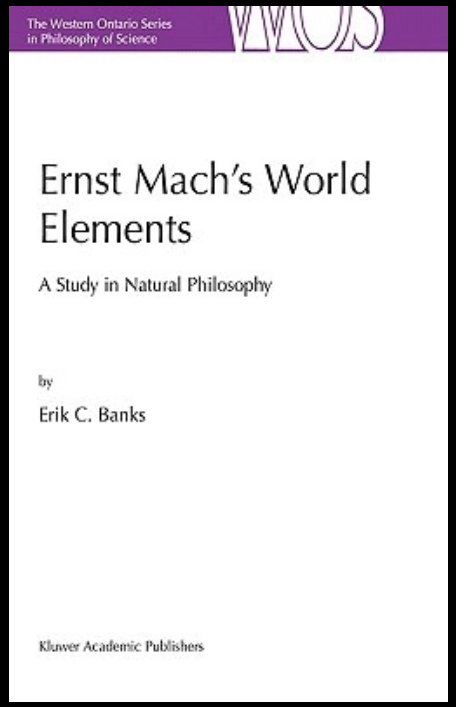


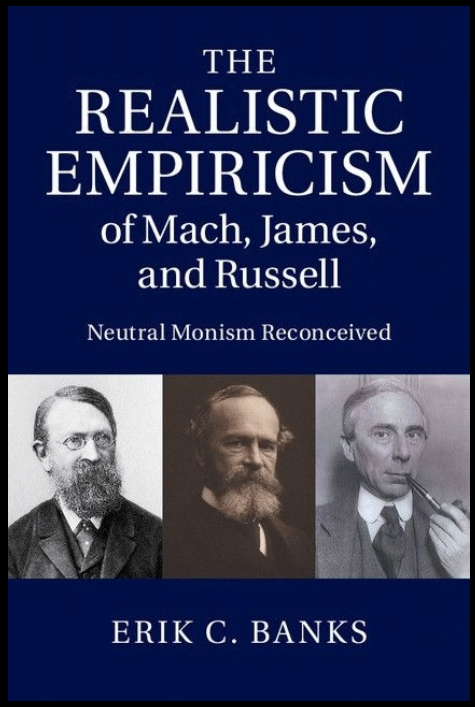
## But We Are Now Seeing the Emergence of Superb New Scholarship on Mach

In my opinion, Erik Banks is now setting the gold standard.

Erik Banks, *Ernst Mach's World Elements: A Study in Natural Philosophy* (Boston and Dordrecht: Kluwer, 2003).

Erik Banks, *The Realistic Empiricism of Mach, James, and Russsell: Neutral Monism Reconsidered* (New York: Cambridge University Press, 2014).

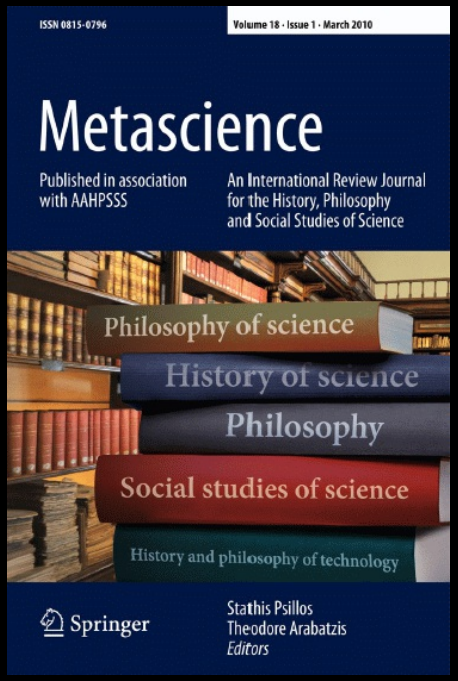


# Banks on Blackmore's Influence

John Blackmore, over his long career of writing about the life, work and influence of Ernst Mach, has never been able to see anything of value in Mach's philosophical writings, and what is more, his historical coverage of Mach's career is often punctuated with tirades against what Blackmore calls Mach's "phenomenalism," the belief in the reality of human sense experience and literally nothing else. Blackmore reiterates that view in *Ernst Mach's Philosophy: Pro and Con*, his first book devoted exclusively to Mach's philosophy, along with a recent offering about *Ernst Mach's Prague*. In previous work, Blackmore has identified as an historian and claimed to avoid taking sides in philosophical disputes, but this has never been entirely true. It seems he cannot resist promulgating an erroneous, though widely shared, reading of Mach's philosophy that has damaged Mach's reputation for more than one hundred years, and one that I have tried to set straight in my (2003) and will again in this essay.

Erik Banks, "Sympathy for the Devil: Reconsidering Ernst Mach's Empiricism," *Metascience* 21 (2012), 321-330.



# Einstein on Mach

How does it happen that a properly endowed natural scientist comes to concern himself with epistemology? Is there no more valuable work in his specialty? I hear many of my colleagues saying, and I sense it from many more, that they feel this way. I cannot share this sentiment. When I think about the ablest students whom I have encountered in my teaching, that is, those who distinguish themselves by their independence of judgment and not merely their quick-wittedness, I can affirm that they had a vigorous interest in epistemology. They happily began discussions about the goals and methods of science, and they showed unequivocally, through their tenacity in defending their views, that the subject seemed important to them. Indeed, one should not be surprised at this.

. . .

Concepts that have proven useful in ordering things easily achieve such an authority over us that we forget their earthly origins and accept them as unalterable givens. Thus they come to be stamped as "necessities of thought," "a priori givens," etc. The path of scientific advance is often made impassable for a long time through such errors. For that reason, it is by no means an idle game if we become practiced in analyzing the long commonplace concepts and exhibiting those circumstances upon which their justification and usefulness depend, how they have grown up, individually, out of the givens of experience. By this means, their all-too-great authority will be broken. They will be removed if they cannot be properly legitimated, corrected if their correlation with given things be far too superfluous, replaced by others if a new system can be established that we prefer for whatever reason.

Albert Einstein. "Ernst Mach." *Physikalische Zeitschrift* 17 (1916), 101-104.

## Henri Poincaré

1878, École des Mines, Paris

1879, Ph.D., Mathematics, Sorbonne, Paris

1879, Inspector, Corps des Mines, Vesoul

1879, Lecturer, Mathematics, Caen

1881, Professor of Mathematics, Sorbonne, Paris

1881, Ministry of Public Service

1893, Chief Engineer, Corps des Mines

1910, Inspector General, Corps des Mines

Henri Poincaré (1854-1912)

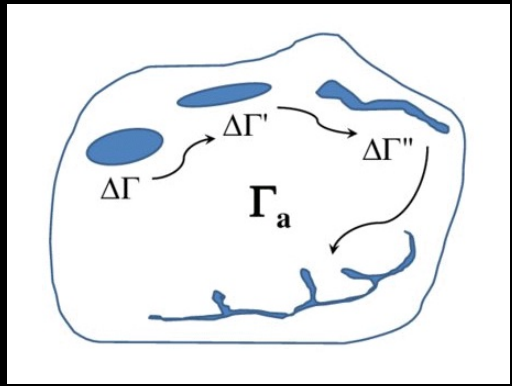
# Henri Poincaré

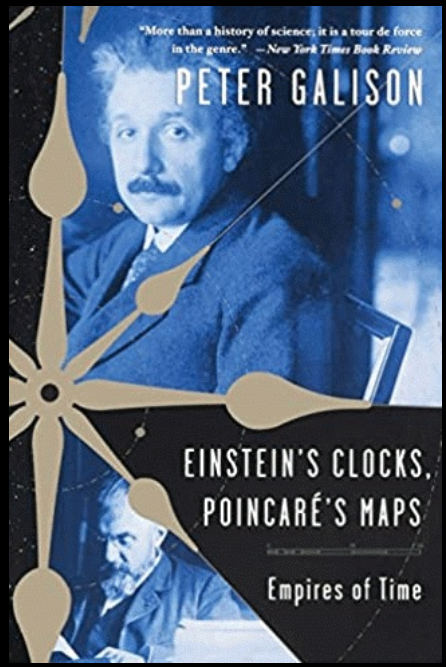
Poincaré Recurrence Theorem, 1890

A closed, conservative system, starting at any point in its phase space, will eventually return to a point arbitrarily close to that initial state.

Bureau des Longitudes, International Time Zones, Clock Synchronization, 1893

Principle of Relativity, Conventionality of Simultaneity, 1898-1904



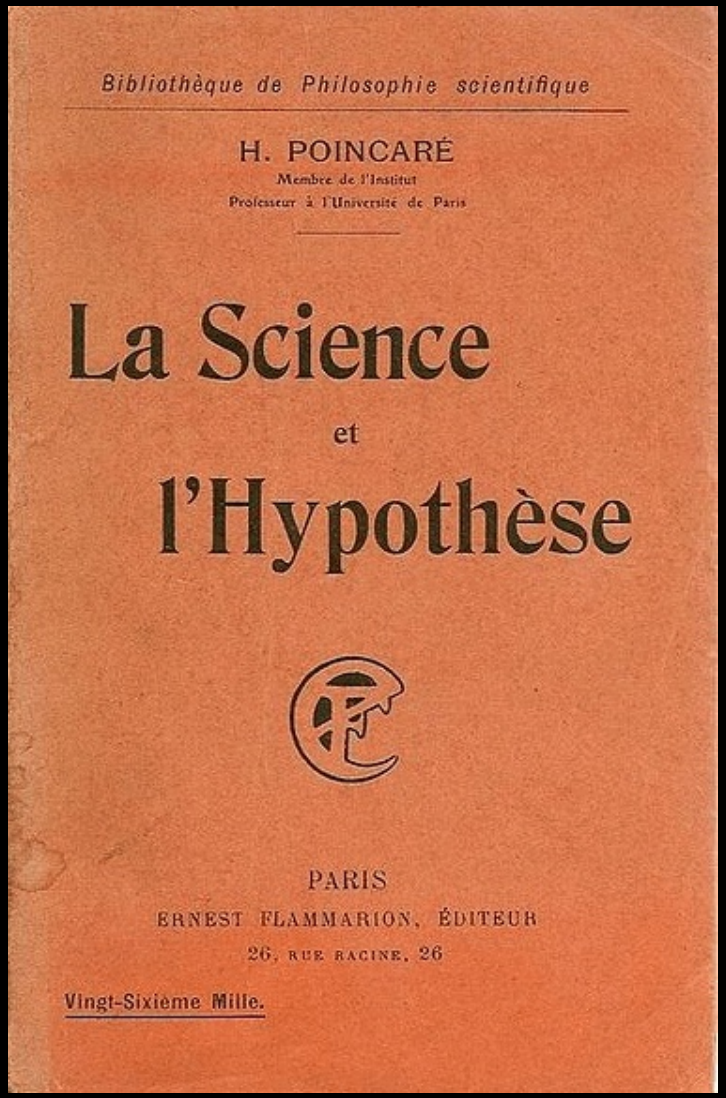
# Henri Poincaré

Henri Poincaré. *La Science et l'Hypothèse*. (Paris: Flammarion, 1902).

Henri Poincaré. *La Valeur de la Science*. (Paris: Flammarion, 1905).

Henri Poincaré. *Science et Méthode*. (Paris: Flammarion, 1908).

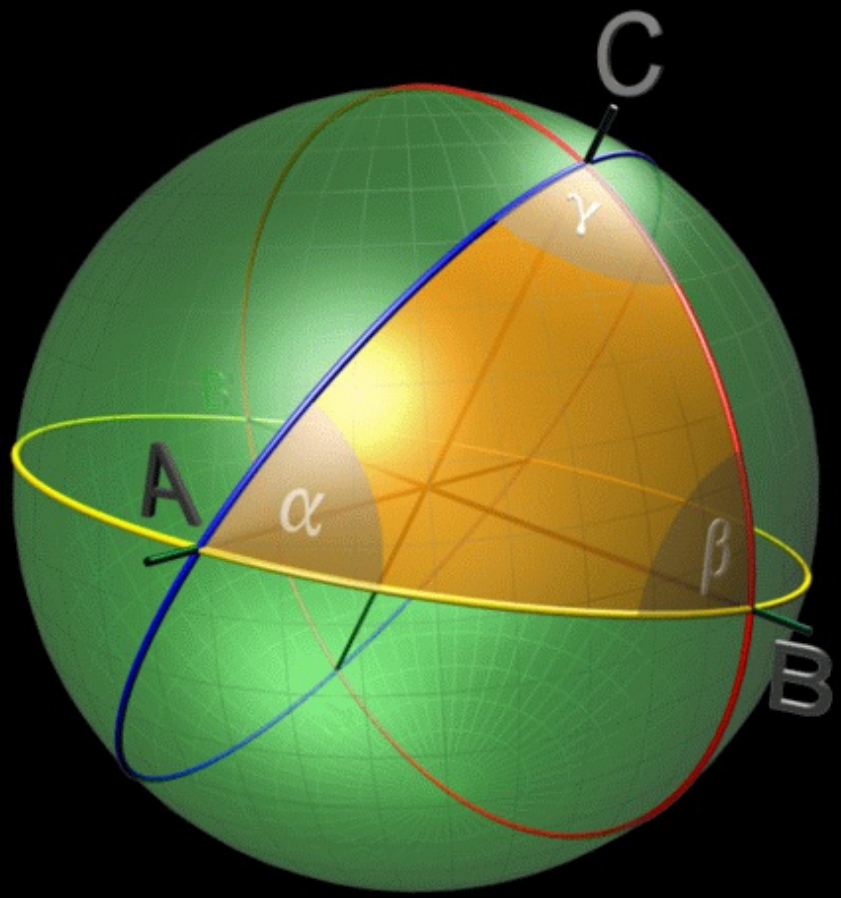
Henri Poincaré. *Dernières Pensées*. (Paris: Flammarion, 1913).



# Poincaré's Geometrical Conventionalism

What do we infer when

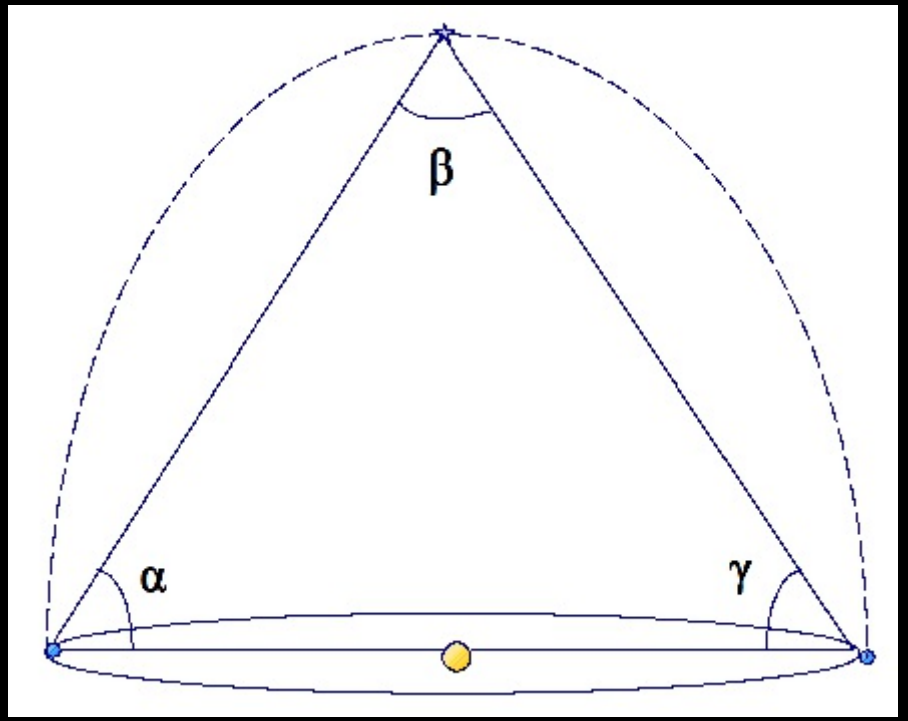
$\alpha + \beta + \gamma \neq 180^\circ$



# Poincaré's Geometrical Conventionalism

What do we infer when

$\alpha + \beta + \gamma \neq 180^\circ$



# Poincaré's Geometrical Conventionalism

Postulate of Free Mobility - Transcendental Argument for Necessity of Spaces with Constant Curvature.

Only in such spaces do objects remain self-congruent under transport.

Hermann von Helmholtz (1821-1894)

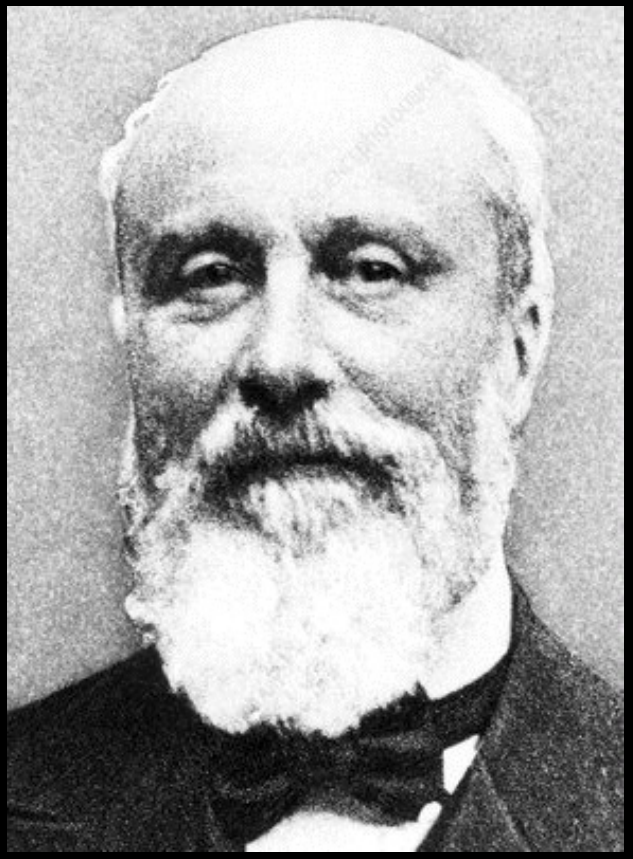
# Pierre Duhem

1887, Maitre de Conférences, Lille

1888, Ph.D., Applied Mathematics, Ecole Normale Supérieure

1893, Professor of Physics, Renne

1894, Professor of Theoretical Physics, Bordeaux



Pierre Duhem (1861-1916)

# Pierre Duhem

Pierre Duhem. *Le Mixte et la Combinaison Chimique. Essai sur l'Évolution d'une Idée.* (Paris: C. Naud, 1902).

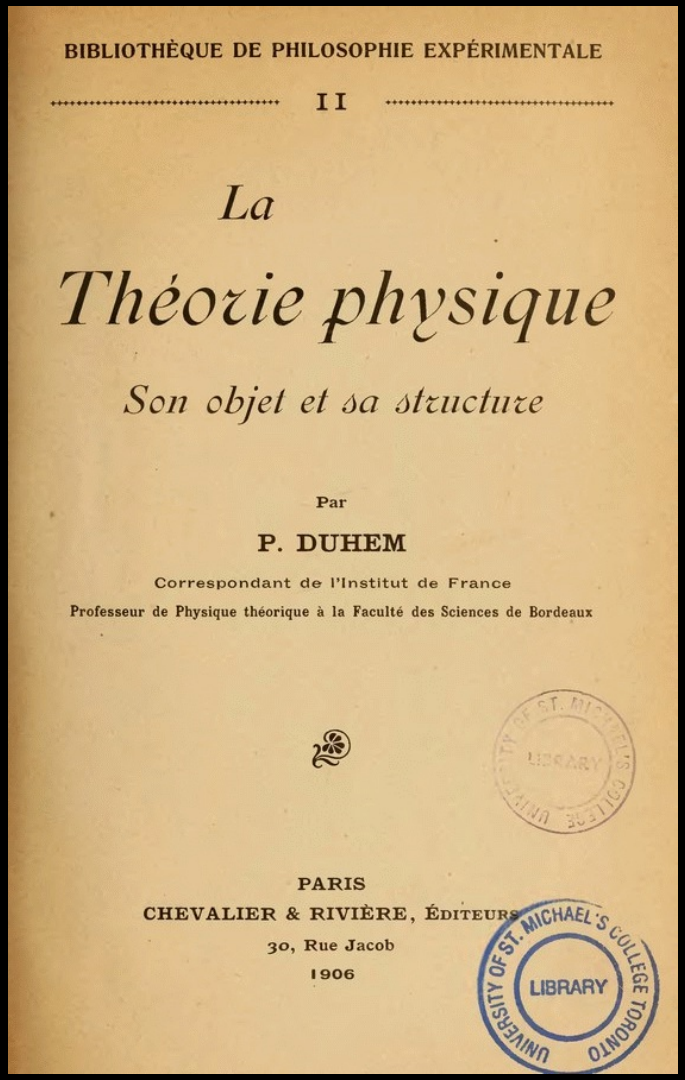
Pierre Duhem. *Les Origines de la Statique*. (Paris: A. Herman, 1903).

Pierre Duhem. *L'Évolution de la Mécanique*. (Paris, A. Hermann, 1905).

Pierre Duhem. *La Théorie Physique. Son Objet et sa Structure*. (Paris: Chevalier & Riviére, 1906).

Pierre Duhem. *Sauver les Phénomènes. Essai sur la Notion de Théorie Physique de Platon à Galilée*. (Paris: A. Hermann, 1908).

Pierre Duhem. *Le Système du Monde. Histoire des Doctrines Cosmologiques de Platon à Copernic*. (Paris: A. Hermann, 1913-1959).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II

La

Théorie physique

Son objet et sa structure

Par

P. DUHEM

Correspondant de l'Institut de France

Professeur de Physique théorique à la Faculté des Sciences de Bordeaux

PARIS

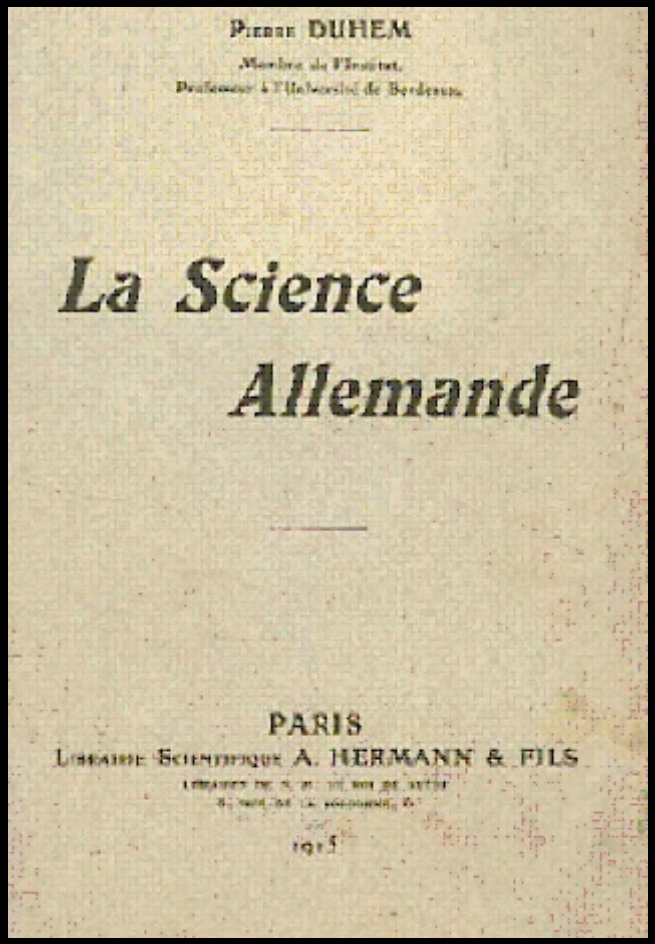
CHEVALIER & RIVIÈRE, ÉDITEURS

30, Rue Jacob

1906

Pierre Duhem

Pierre Duhem. *La Science Allemande.* (Paris: A. Hermann, 1916).



# Pierre Duhem

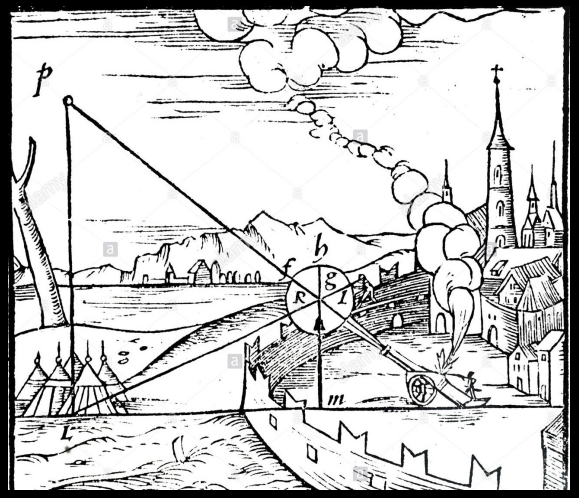
The First Duhem Thesis

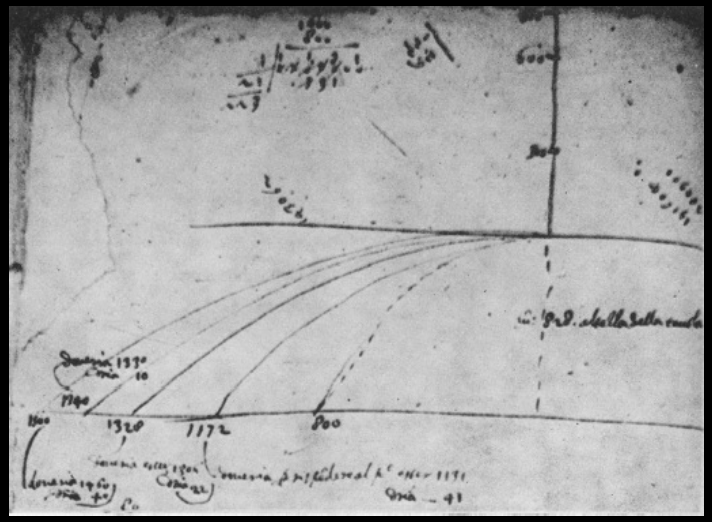
There was no scientific revolution, just a continuous development from medieval and renaissance to early modern natural philosophy.

Example: From impetus to inertia.

Impetus is an active principle.

Inertia is a passive tendency.



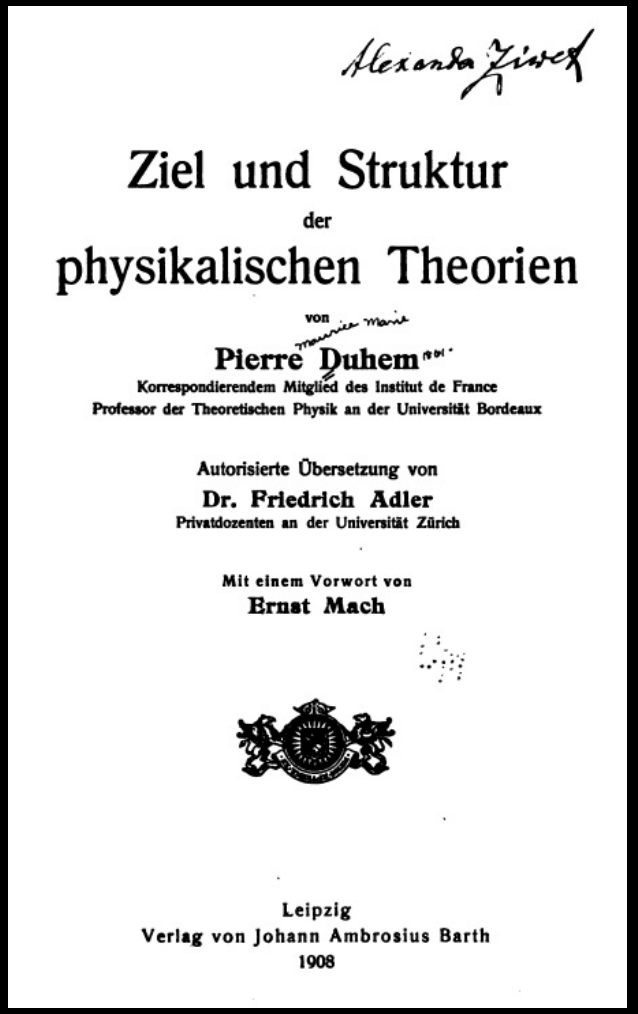



Pierre Duhem

Underdetermination, Holism, Bon Sens, and Faith

*The Aim and Structure of Physical Theory* (1906)

- Theories always tested only as wholes; individual hypotheses never tested in isolation
- Theory choice always underdetermined by logic and empirical evidence
- Bon sens – educated good sense or common sense – is trusted to lead us to the "natural classification"



Alexandra Ziseck

Ziel und Struktur
der
physikalischen Theorien

von
Pierre Duhem
Korrespondierendem Mitglied des Institut de France
Professor der Theoretischen Physik an der Universität Bordeaux

Autorisierte Übersetzung von
Dr. Friedrich Adler
Privatdozenten an der Universität Zürich

Mit einem Vorwort von
Ernst Mach

Leipzig
Verlag von Johann Ambrosius Barth
1908

Pierre Duhem

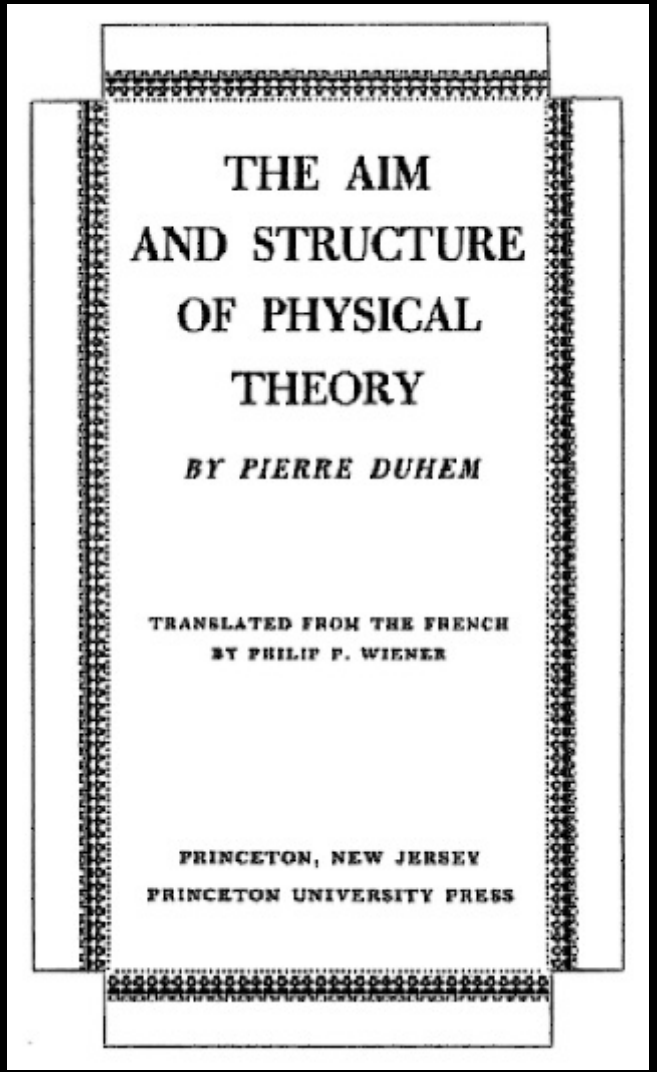
Underdetermination, Holism, Bon Sens, and Faith

*The Aim and Structure of Physical Theory* (1906)

H – hypothesis
$C_1$, $C_2$, $C_3$, etc. – auxiliary conditions
O – observation report

Simple (-minded?) Falsification

H => O
~O
∴ ~H



Pierre Duhem

Underdetermination, Holism, Bon Sens, and Faith

*The Aim and Structure of Physical Theory* (1906)

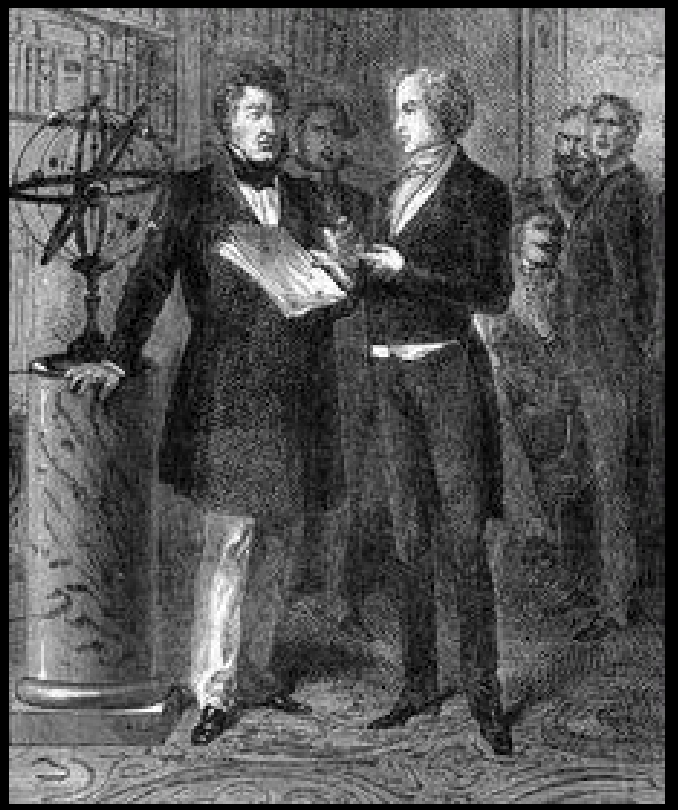
H – hypothesis
$C_1$, $C_2$, $C_3$, etc. – auxiliary conditions
O – observation report

Simple (-minded?) Falsification

$$H \Rightarrow O$$
$$\sim O$$
$$\therefore \sim H$$

Assuming a More Realistic Model of Theory Testing

$$H \,\&\, C_1, C_2, C_3, \ldots \Rightarrow O$$
$$\sim O$$
$$\therefore \sim H \vee \sim C_1 \vee \sim C_2 \vee \sim C_3 \vee \ldots$$



Urbain Le Verrier (1811-1877) Explaining the Discovery of Neptune to King Louis Philippe, 1846

Pierre Duhem

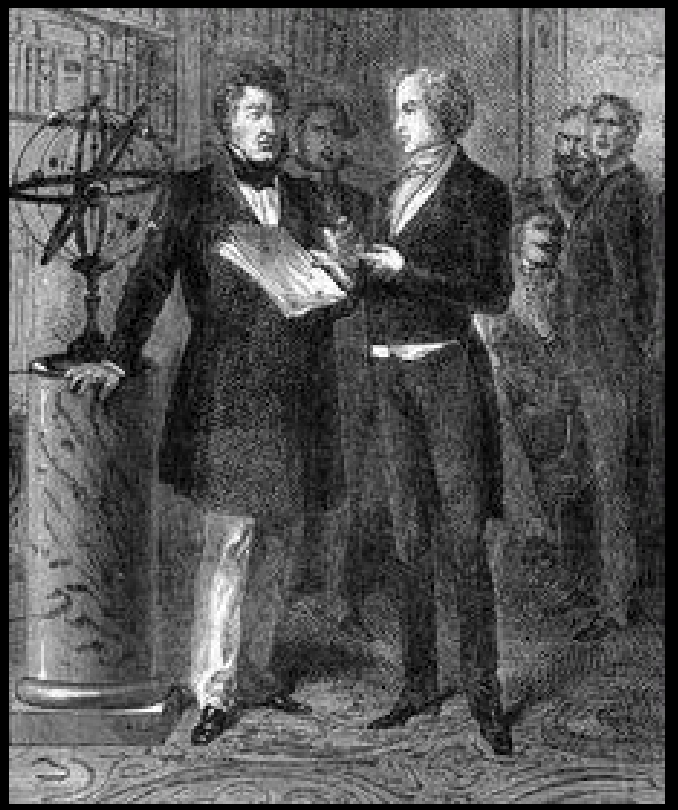
Underdetermination, Holism, Bon Sens, and Faith

*The Aim and Structure of Physical Theory* (1906)

There will always be a multiplicity of equally well confirmed total theories:

T1: $\sim H \,\&\, C_1 \,\&\, C_2 \,\&\, C_3 \vee \ldots$
T2: $H \,\&\, \sim C_1 \,\&\, C_2 \,\&\, C_3 \vee \ldots$
T3: $H \,\&\, C_1 \,\&\, \sim C_2 \,\&\, C_3 \vee \ldots$
T4: $H \,\&\, C_1 \,\&\, C_2 \,\&\, \sim C_3 \vee \ldots$
T5: $H \,\&\, \sim C_1 \,\&\, \sim C_2 \,\&\, C_3 \vee \ldots$
etc.

Choice among these is sometimes a matter of convention



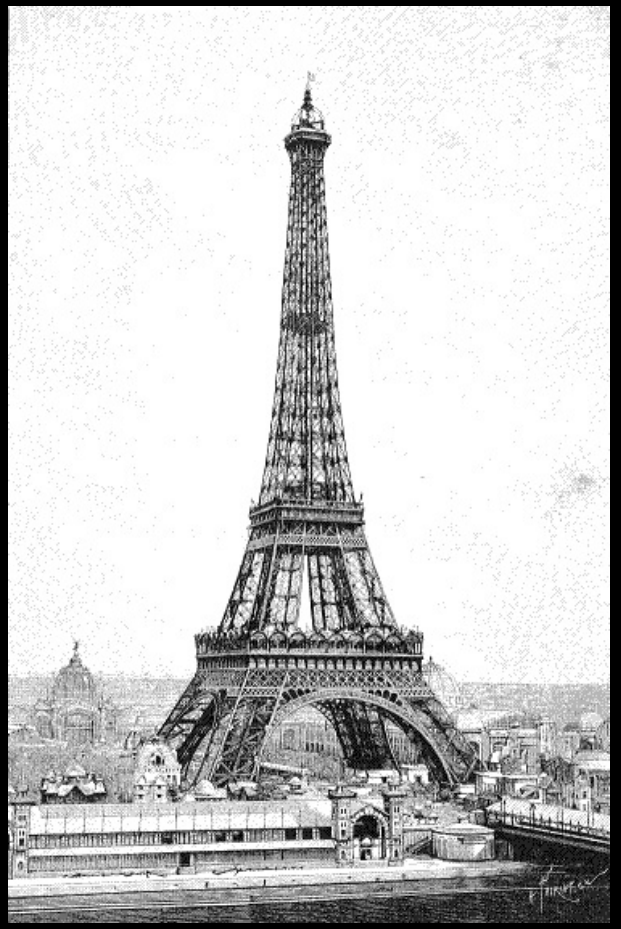
Urbain Le Verrier (1811-1877) Explaining the Discovery of Neptune to King Louis Philippe, 1846

Pierre Duhem –

Underdetermination, Holism, Bon Sens, and Faith

"Physique de croyant" ["Physics of a Believer"], *Annales de philosophie chrétienne* (1905)

- Conventionalism circumscribing the limits of science
- The challenge to a Catholic philosopher-scientist in highly secularized, third republic France, rebuilding itself after the Franco-Prussian War (1870-1871) on a high-tech foundation of science and engineering



Eiffel Tower, 1889

# Pierre Duhem

# Duhem and Quine

Willard Van Orman Quine. "Two Dogmas of Empiricism." *Philosophical Review* 60 (1951), 20-43.

TWO DOGMAS OF EMPIRICISM[1]

MODERN empiricism has been conditioned in large part by two dogmas. One is a belief in some fundamental cleavage between truths which are *analytic*, or grounded in meanings independently of matters of fact, and truth which are *synthetic*, or grounded in fact. The other dogma is *reductionism:* the belief that each meaningful statement is equivalent to some logical construct upon terms which refer to immediate experience. Both dogmas, I shall argue, are ill founded. One effect of abandoning them is, as we shall see, a blurring of the supposed boundary between speculative metaphysics and natural science. Another effect is a shift toward pragmatism.

## I. BACKGROUND FOR ANALYTICITY

Kant's cleavage between analytic and synthetic truths was foreshadowed in Hume's distinction between relations of ideas and matters of fact, and in Leibniz's distinction between truths of reason and truths of fact. Leibniz spoke of the truths of reason as true in all possible worlds. Picturesqueness aside, this is to say that the truths of reason are those which could not possibly be false. In the same vein we hear analytic statements defined as statements whose denials are self-contradictory. But this definition has small explanatory value; for the notion of self-contradictoriness, in the quite broad sense needed for this definition of analyticity, stands in exactly the same need of clarification as does the notion of analyticity itself.[2] The two notions are the two sides of a single dubious coin.

Kant conceived of an analytic statement as one that attributes to its subject no more than is already conceptually contained in the subject.

[1] Much of this paper is devoted to a critique of analyticity which I have been urging orally and in correspondence for years past. My debt to the other participants in those discussions, notably Carnap, Church, Goodman, Tarski, and White, is large and indeterminate. White's excellent essay "The Analytic and the Synthetic: An Untenable Dualism," in *John Dewey: Philosopher of Science and Freedom* (New York, 1950), says much of what needed to be said on the topic; but in the present paper I touch on some further aspects of the problem. I am grateful to Dr. Donald L. Davidson for valuable criticism of the first draft.

[2] See White, *op. cit.*, p. 324.

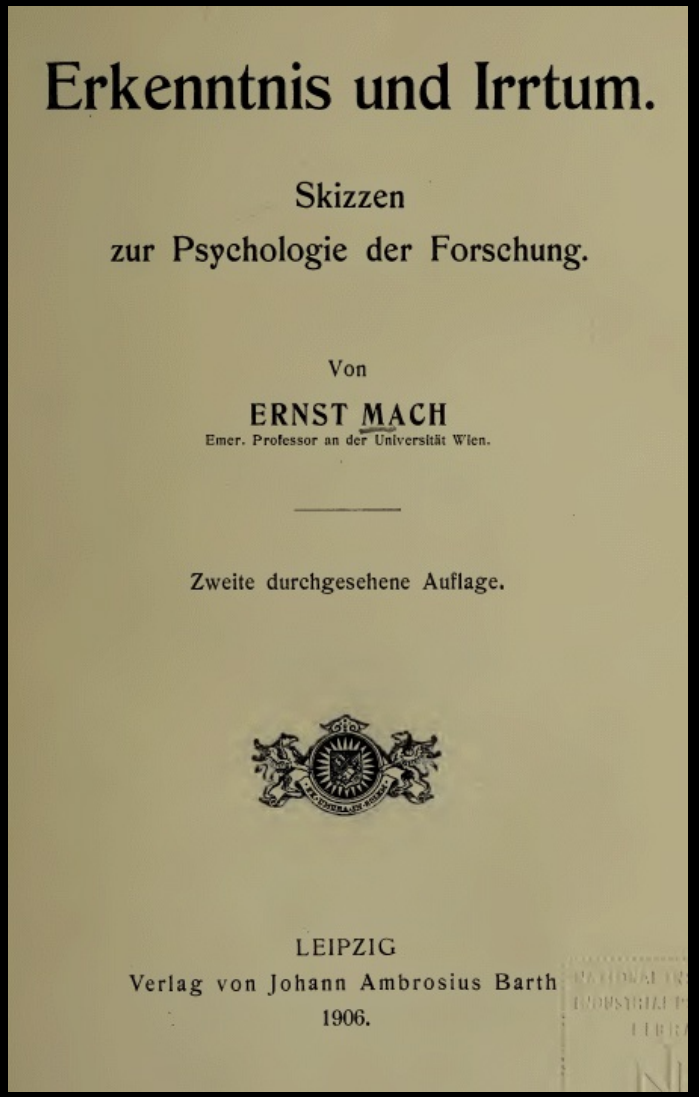
20

Willard Van Orman Quine (1908-2000)

Pierre Duhem

Duhem and Mach

Ernst Mach. *Erkenntnis und Irrtum. Skizzen zur Psychologie der Forschung*. 2nd. ed. (Leipzig: Johann Ambrosius Barth, 1906).



Erkenntnis und Irrtum.

Skizzen
zur Psychologie der Forschung.

Von
ERNST MACH
Emer. Professor an der Universität Wien.

Zweite durchgesehene Auflage.

LEIPZIG
Verlag von Johann Ambrosius Barth
1906.

# Immanuel Kant

*Kritik der reinen Vernunft*, 1781/1787

Immanuel Kant (1724-1804)

# Immanuel Kant

*Analytic/Synthetic*

Analytic: Concept of the predicate contained in the concept of the subject or true by definition.

Synthetic: Concept of the predicate not contained in the concept of the subject or ampliative.

*A priori/A posteriori*

A priori: Universally and necessarily true, prior to, hence independent of experience.

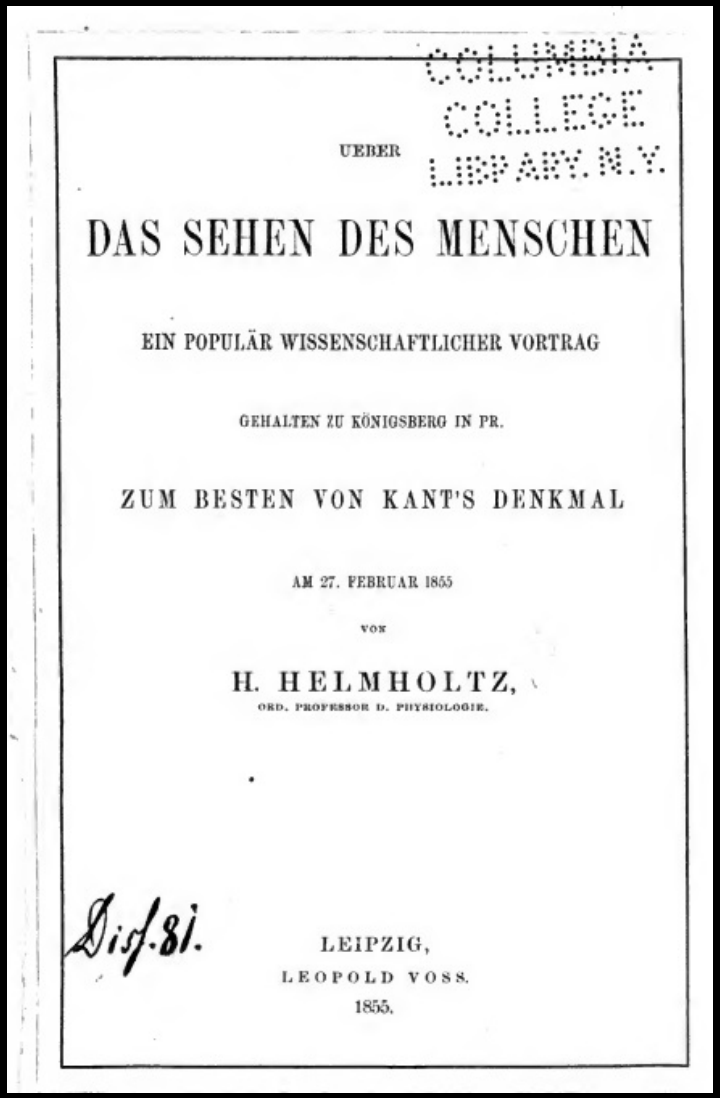
A posteriori: Based on experience

Four Possible Kinds of Judgments:

Analytic A posteriori – Empty class
Analytic A priori – True by definition
Synthetic A posteriori – Ordinary empirical judgments
Synthetic A priori – Kant's most important innovation – Examples: Space and time as the necessary apriori forms of outer and inner intuition

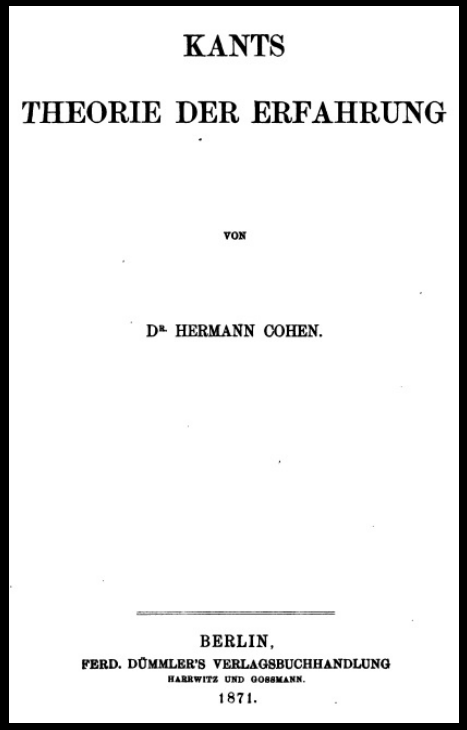
# Neo-Kantianism

Hermann von Helmholtz. *Ueber das Sehen des Menschen*. (Leipzig: Leopold Voss, 1855).



# Neo-Kantianism – The Marburg Tradition

Hermann Cohen. *Kants Theorie der Erfahrung*.
(Berlin: Ferdinand Dümmler, 1871).



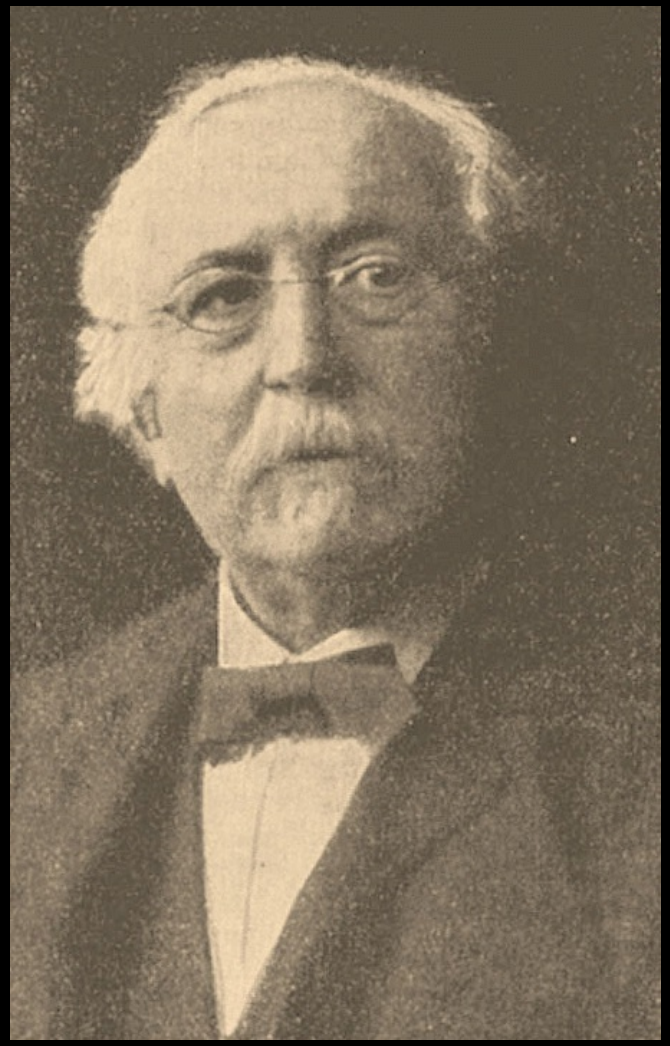
KANTS

THEORIE DER ERFAHRUNG

VON

Dr. HERMANN COHEN.

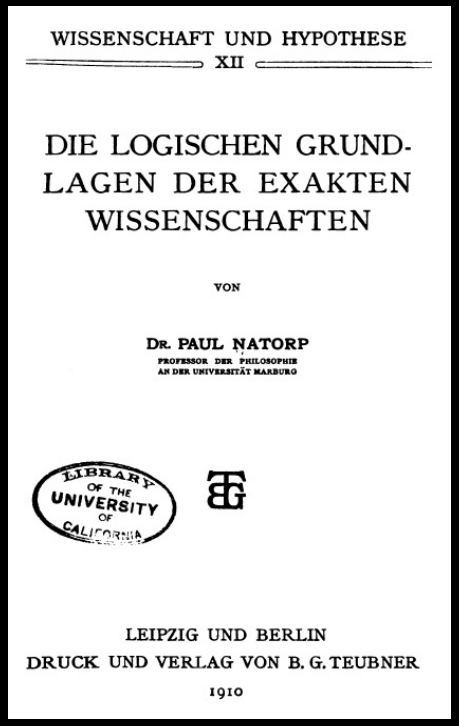
BERLIN,
FERD. DÜMMLER'S VERLAGSBUCHHANDLUNG
HARRWITZ UND GOSSMANN.
1871.



Hermann Cohen (1842-1918)

# Neo-Kantianism – The Marburg Tradition

Paul Natorp. *Die logischen Grundlagen der exakten Naturwissenschaften.* (Leipzig: B. G. Teubner, 1910).



WISSENSCHAFT UND HYPOTHESE
XII

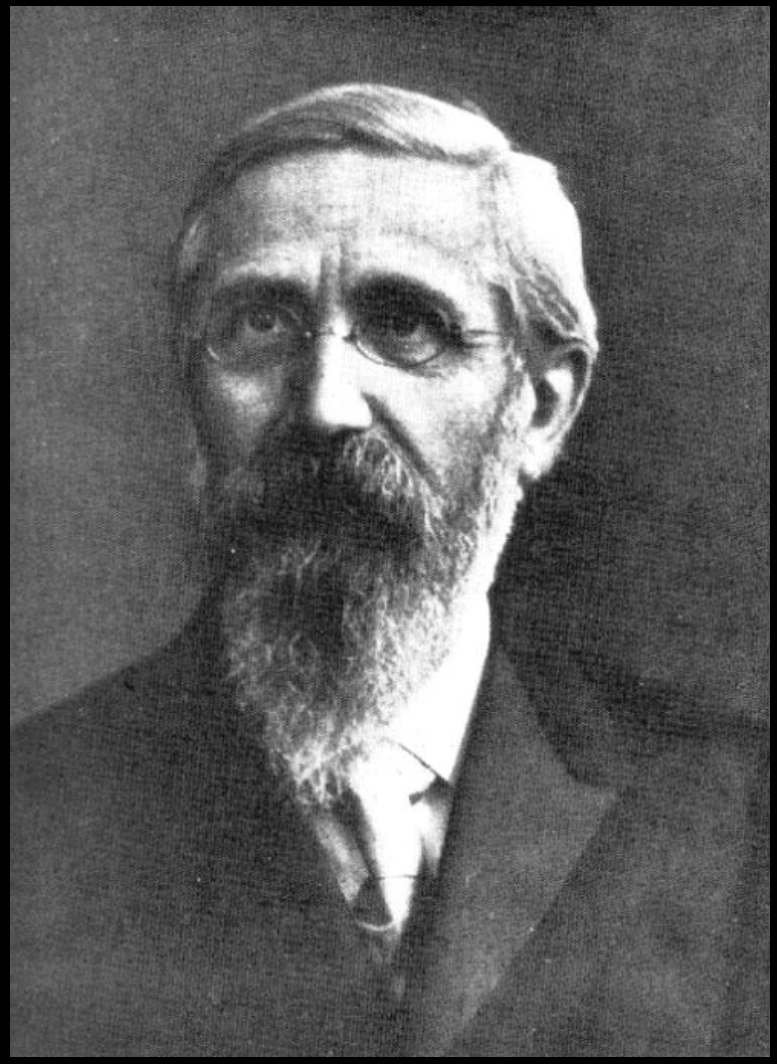
DIE LOGISCHEN GRUND-
LAGEN DER EXAKTEN
WISSENSCHAFTEN

VON

DR. PAUL NATORP
PROFESSOR DER PHILOSOPHIE
AN DER UNIVERSITÄT MARBURG



LEIPZIG UND BERLIN
DRUCK UND VERLAG VON B. G. TEUBNER
1910

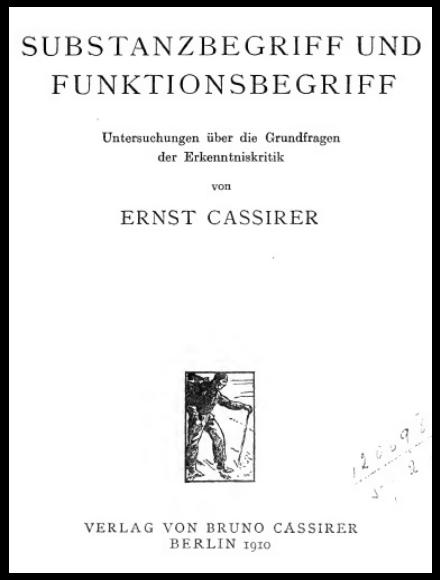


Paul Natorp (1854-1924)

# Neo-Kantianism – The Marburg Tradition

Ernst Cassirer. *Substanzbegriff und Funktionsbegriff.* (Berlin: Bruno Cassier,1910).

Ernst Cassirer. *Zur Einsteinschen Relativitätstheorie. Erkensnistheoretische Betrachtungen*. (Berlin: Bruno Cassirer, 1921).

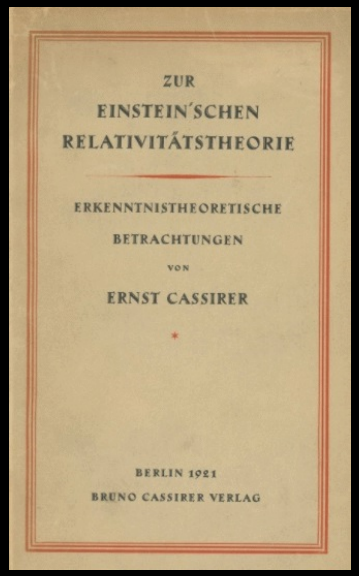

SUBSTANZBEGRIFF UND
FUNKTIONSBEGRIFF

Untersuchungen über die Grundfragen
der Erkenntniskritik

von

ERNST CASSIRER

VERLAG VON BRUNO CASSIRER
BERLIN 1910


ZUR
EINSTEIN'SCHEN
RELATIVITÄTSTHEORIE

ERKENNTNISTHEORETISCHE
BETRACHTUNGEN
VON
ERNST CASSIRER

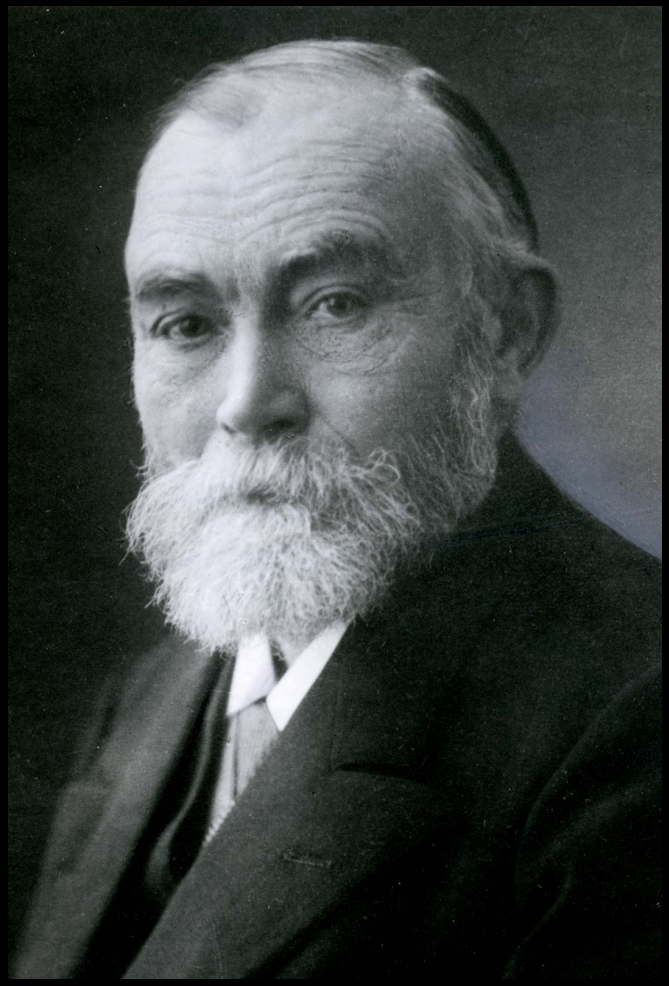
BERLIN 1921
BRUNO CASSIRER VERLAG

Ernst Cassirer (1874-1945)

# Logic in "Logical" Empiricism – The Logicist Program

Gottlob Frege. *Begriffsschrift: Eine der arithmetischen nachgebildete Formelsprache des reinen Denkens*. (Halle an der Saale: Louis Nebert, 1879).

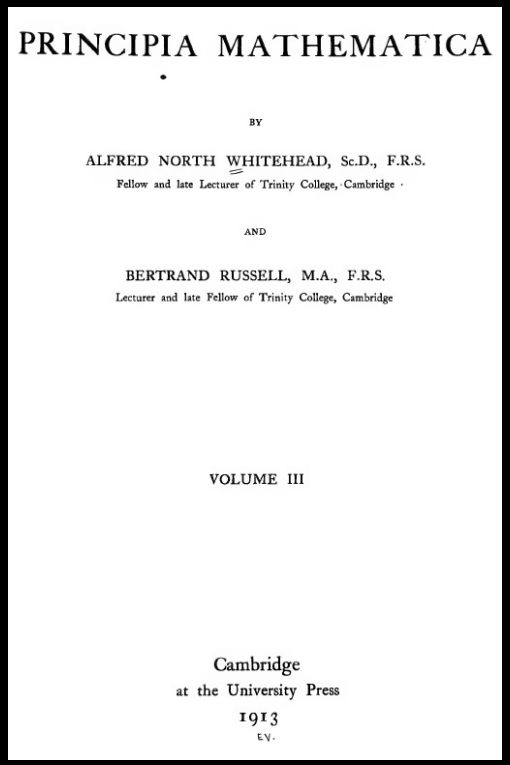
Gottlob Frege. *Grundgesetze der Arithmetik. Begriffschriftlich abgeleitet*. 2 vols. (Jena: Hermann Pohle, 1893, 1903).



Gottlob Frege (1848-1925)

# Logic in "Logical" Empiricism – The Logicist Program

Alfred North Whitehead and Bertrand Russell. *Principia Mathematica*. 3 vols. (Cambridge: Cambridge University Press, 1910-1913).



PRINCIPIA MATHEMATICA

BY

ALFRED NORTH WHITEHEAD, Sc.D., F.R.S.
Fellow and late Lecturer of Trinity College, Cambridge

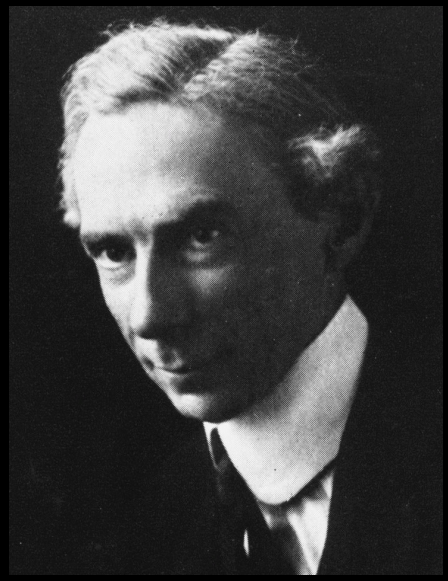
AND

BERTRAND RUSSELL, M.A., F.R.S.
Lecturer and late Fellow of Trinity College, Cambridge

VOLUME III

Cambridge
at the University Press
1913

Alfred North Whitehead (1861-1947)



Bertrand Russell (1872-1970)

# Logic in "Logical" Empiricism – The Logicist Program

Rudolf Carnap. *Der Raum. Ein Beitrag zur Wissenschaftslehre*. Inaugural-Dissertation zur Erlangung der Doktorwürde der hohen philosophischen Fakultät der Universität Jena. (Göttingen: Dieterich'schen Univ.-Buchdruckerei, 1921).

Rudolf Carnap. *Der logische Aufbau der Welt.* (Berlin-Schlachtensee: Weltkreis-Verlag, 1928).

Rudolf Carnap. *Abriss der Logistik. Mit besonderer Berücksichtigung der Relationstheorie und ihrer Anwendungen.* Schriften zur Wissenschaftlichen Weltauffassung, vol. 2. Philipp Frank and Moritz Schlick, eds. (Vienna: Julius Springer, 1929).

Rudolf Carnap (1891-1970)

# Logic in "Logical" Empiricism – The Logicist Program

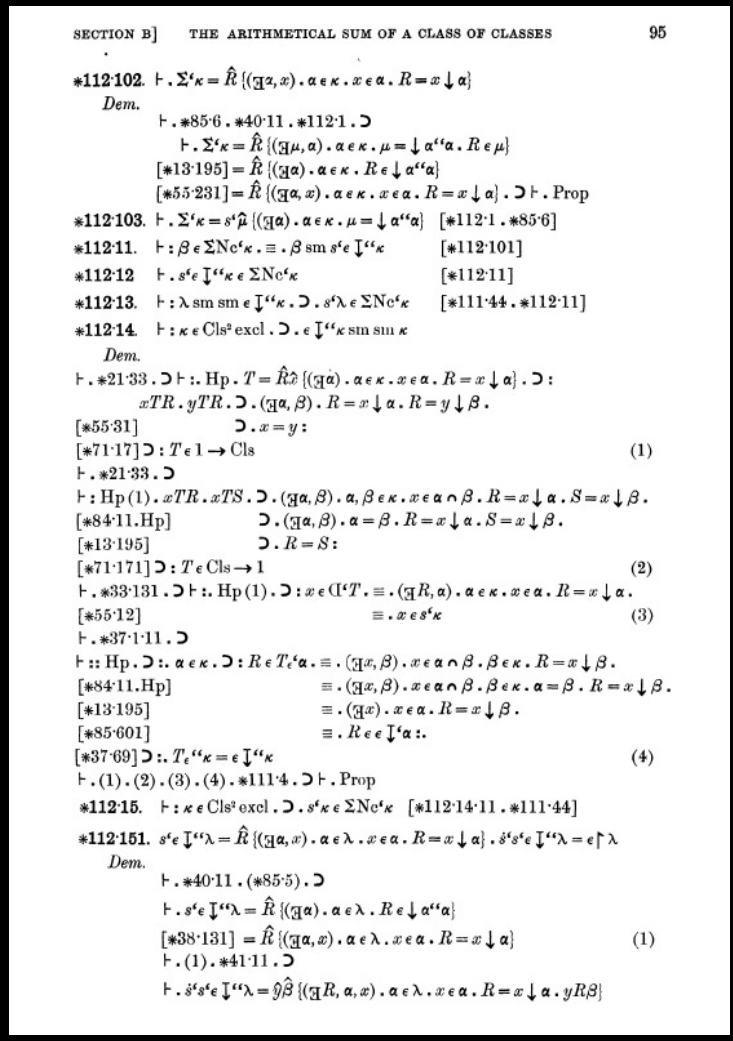
Development of Modern Symbolic Logic

Reduction of Mathematics to Logic

A Failure? Must Use Set Theory as Well

Is Set Theory Consistent?

Employment of Symbolic Logic in Other Reductionist Projects, Such as Carnap's *Der logische Aufbau der Welt*



SECTION B] THE ARITHMETICAL SUM OF A CLASS OF CLASSES 95

***112·102.** $\vdash . \Sigma`\kappa = \hat{R}\{(\exists \alpha, x) . \alpha \in \kappa . x \in \alpha . R = x \downarrow \alpha\}$

*Dem.*

$\vdash . *85·6 . *40·11 . *112·1 . \supset$

$\vdash . \Sigma`\kappa = \hat{R}\{(\exists \mu, \alpha) . \alpha \in \kappa . \mu = \downarrow`` \alpha \,.\, R \in \mu\}$

$[*13·195] = \hat{R}\{(\exists \alpha) . \alpha \in \kappa . R \in \downarrow`` \alpha``\alpha\}$

$[*55·231] = \hat{R}\{(\exists \alpha, x) . \alpha \in \kappa . x \in \alpha . R = x \downarrow \alpha\} . \supset \vdash .$ Prop

***112·103.** $\vdash . \Sigma`\kappa = s`\hat{\mu}\{(\exists \alpha) . \alpha \in \kappa . \mu = \downarrow`` \alpha``\alpha\}$ [*112·1 . *85·6]

***112·11.** $\vdash : \beta \in \Sigma \mathrm{Nc}`\kappa . \equiv . \beta \operatorname{sm} s`\epsilon \downarrow``\kappa$ [*112·101]

***112·12** $\vdash . s`\epsilon \downarrow``\kappa \in \Sigma \mathrm{Nc}`\kappa$ [*112·11]

***112·13.** $\vdash : \lambda \operatorname{sm} \operatorname{sm} \epsilon \downarrow``\kappa . \supset . s`\lambda \in \Sigma \mathrm{Nc}`\kappa$ [*111·44 . *112·11]

***112·14.** $\vdash : \kappa \in \mathrm{Cls}^2 \operatorname{excl} . \supset . \epsilon \downarrow``\kappa \operatorname{sm} \operatorname{sm} \kappa$

*Dem.*

$\vdash . *21·33 . \supset \vdash :. \mathrm{Hp} . T = \hat{R}\hat{x}\{(\exists \alpha) . \alpha \in \kappa . x \in \alpha . R = x \downarrow \alpha\} . \supset :$
$xTR . yTR . \supset . (\exists \alpha, \beta) . R = x \downarrow \alpha . R = y \downarrow \beta .$

$[*55·31] \quad \supset . x = y :$

$[*71·17] \supset : T \in 1 \rightarrow \mathrm{Cls}$ (1)

$\vdash . *21·33 . \supset$

$\vdash : \mathrm{Hp}(1) . xTR . xTS . \supset . (\exists \alpha, \beta) . \alpha, \beta \in \kappa . x \in \alpha \cap \beta . R = x \downarrow \alpha . S = x \downarrow \beta .$

$[*84·11.\mathrm{Hp}] \quad \supset . (\exists \alpha, \beta) . \alpha = \beta . R = x \downarrow \alpha . S = x \downarrow \beta .$

$[*13·195] \quad \supset . R = S :$

$[*71·171] \supset : T \in \mathrm{Cls} \rightarrow 1$ (2)

$\vdash . *33·131 . \supset \vdash :. \mathrm{Hp}(1) . \supset : x \in (\mathrm{I}`T . \equiv . (\exists R, \alpha) . \alpha \in \kappa . x \in \alpha . R = x \downarrow \alpha .$

$[*55·12] \quad \equiv . x \in s`\kappa$ (3)

$\vdash . *37·1·11 . \supset$

$\vdash :: \mathrm{Hp} . \supset :. \alpha \in \kappa . \supset : R \in T_\epsilon`\alpha . \equiv . (\exists x, \beta) . x \in \alpha \cap \beta . \beta \in \kappa . R = x \downarrow \beta .$

$[*84·11.\mathrm{Hp}] \quad \equiv . (\exists x, \beta) . x \in \alpha \cap \beta . \beta \in \kappa . \alpha = \beta . R = x \downarrow \beta .$

$[*13·195] \quad \equiv . (\exists x) . x \in \alpha . R = x \downarrow \beta .$

$[*85·601] \quad \equiv . R \in \epsilon \downarrow`\alpha :.$

$[*37·69] \supset :. T_\epsilon``\kappa = \epsilon \downarrow``\kappa$ (4)

$\vdash . (1) . (2) . (3) . (4) . *111·4 . \supset \vdash .$ Prop

***112·15.** $\vdash : \kappa \in \mathrm{Cls}^2 \operatorname{excl} . \supset . s`\kappa \in \Sigma \mathrm{Nc}`\kappa$ [*112·14·11 . *111·44]

***112·151.** $s`\epsilon \downarrow``\lambda = \hat{R}\{(\exists \alpha, x) . \alpha \in \lambda . x \in \alpha . R = x \downarrow \alpha\} . \dot{s}`s`\epsilon \downarrow``\lambda = \epsilon \restriction \lambda$

*Dem.*

$\vdash . *40·11 . (*85·5) . \supset$

$\vdash . s`\epsilon \downarrow``\lambda = \hat{R}\{(\exists \alpha) . \alpha \in \lambda . R \in \downarrow`` \alpha``\alpha\}$

$[*38·131] = \hat{R}\{(\exists \alpha, x) . \alpha \in \lambda . x \in \alpha . R = x \downarrow \alpha\}$ (1)

$\vdash . (1) . *41·11 . \supset$

$\vdash . \dot{s}`s`\epsilon \downarrow``\lambda = \hat{y}\hat{\beta}\{(\exists R, \alpha, x) . \alpha \in \lambda . x \in \alpha . R = x \downarrow \alpha . yR\beta\}$

# Logic in "Logical" Empiricism – The Logicist Program

Is Set Theory Consistent? The Contradiction in Frege's Set Theory

*Unrestricted Comprehension Principle*: A set exists corresponding to every well-defined predicate.

Example 1: $S_1 =_{df}$ Set of all sets that are members of themselves

Example 2: $S_2 =_{df}$ Set of all sets that are not members of themselves

*Question*: Is $S_2$ a member of itself?

Assume that $S_2 \in S_2$

Then, since $S_2$ is the set of all sets that are not members of themselves, $S_2 \notin S_2$

Therefore, $S_2 \in S_2 \Rightarrow S_2 \notin S_2$

Assume that $S_2 \notin S_2$

Then, since $S_2$ is the set of all sets that are not members of themselves, $S_2 \in S_2$

Therefore, $S_2 \notin S_2 \Rightarrow S_2 \in S_2$

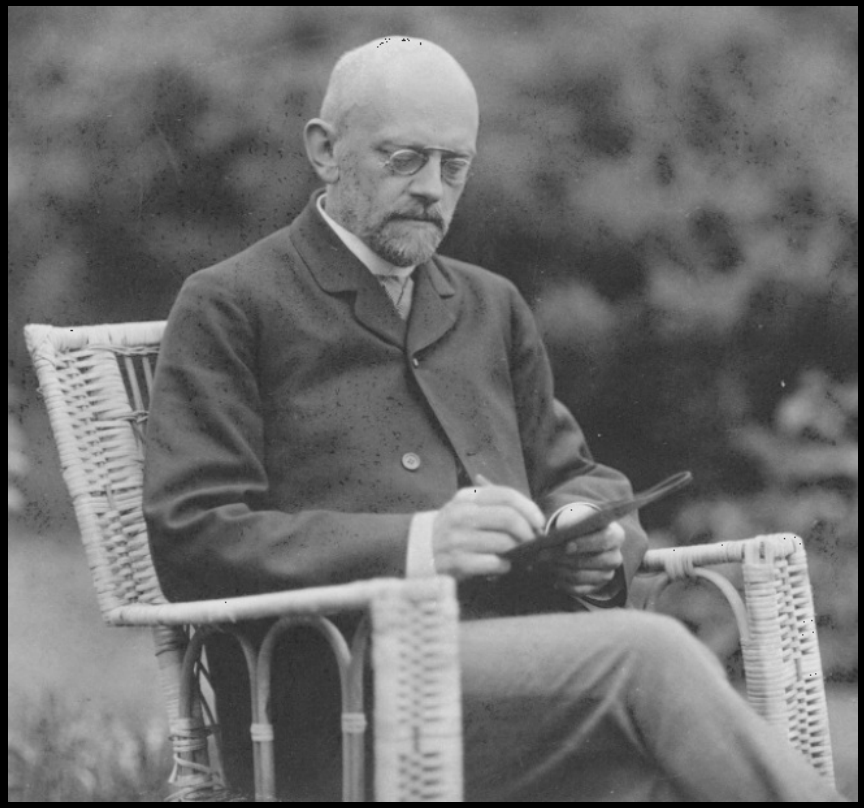
# Logic in "Logical" Empiricism – The Formalist Program

David Hilbert. *Grundlagen der Geometrie*. Leipzig: B. G. Teubner, 1899.

David Hilbert. "Axiomatisches Denken." *Mathematische Annalen* 78 (1910), 405-410.

David Hilbert. "Neubegründung der Mathematik. Erste Mitteilung." *Abhandlungen aus dem mathematischen Seminar der Hamburgischen Universität*. 1. Band, 2. Heft, 157-177.

David Hilbert. "Die logischen Grundlagen der Mathematik. *Mathematische Annalen* 88 (1923), 151-165.



David Hilbert (1862-1943)

# Logic in "Logical" Empiricism – The Formalist Program

Johann von Neumann. "Zur Hilbertschen Beweistheorie." *Mathematische Zeitschrift* 26 (1927), 1-46.

Johann von Neumann. "Die Axiomatizierung der Mengenlehre. *Mathermatische Zeitschrift* 27 (1928), 669-752.

Johann von Neumann. *Mathematische Grundlagen der Quantenmechanik*. (Berlin: Julius Springer, 1932).

John von Neumann and Oskar Morgenstern. *Theory of Games and Economic Behavior*. (Princeton: Princeton University Press).

John von Neumann. *The Computer and the Brain*. (New Haven, CT and London: Yale University Press, 1958).

John von Neumann (1903-1957)

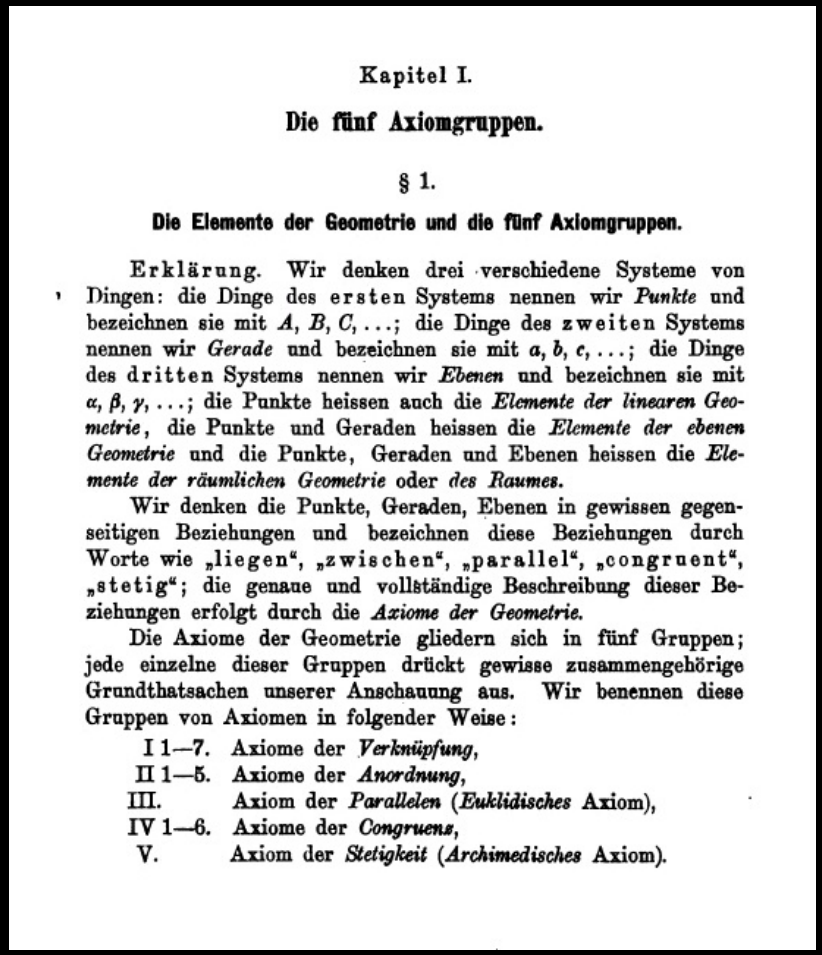
# Logic in "Logical" Empiricism – The Formalist Program

*Axiomatics*: "To think clearly is to think axiomatically."

*Proof Theory*: Demonstrate the consistency of a theory by reasoning finitistically not about the objects that the theory describes, which might be infinite, but about proofs, themselves, which are always finite objects. Likewise with demonstrations of completeness, categoricity, decidability, etc.

*Implicit Definition*: Primitive terms are defined not explicitly, but implicitly, by the systematic roles that they play in an axiomatically formulated theory

Example: The duality of "point" and "line" in Hilbert's own axiomatization of geometry



Kapitel I.

**Die fünf Axiomgruppen.**

§ 1.

**Die Elemente der Geometrie und die fünf Axiomgruppen.**

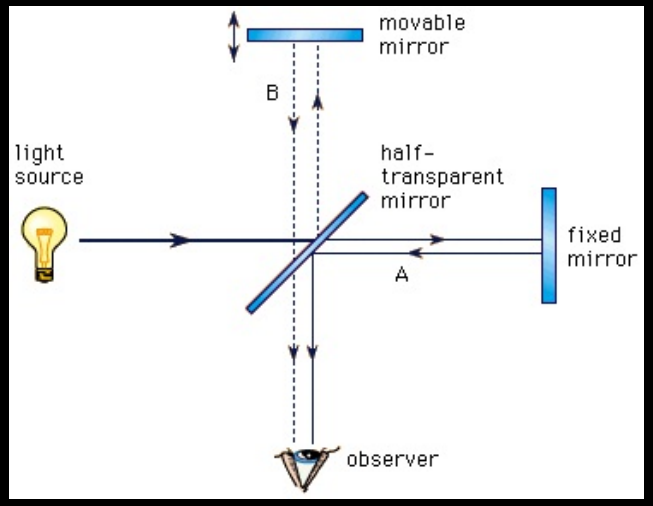
Erklärung. Wir denken drei verschiedene Systeme von Dingen: die Dinge des ersten Systems nennen wir *Punkte* und bezeichnen sie mit $A, B, C, \ldots$; die Dinge des zweiten Systems nennen wir *Gerade* und bezeichnen sie mit $a, b, c, \ldots$; die Dinge des dritten Systems nennen wir *Ebenen* und bezeichnen sie mit $\alpha, \beta, \gamma, \ldots$; die Punkte heissen auch die *Elemente der linearen Geometrie*, die Punkte und Geraden heissen die *Elemente der ebenen Geometrie* und die Punkte, Geraden und Ebenen heissen die *Elemente der räumlichen Geometrie* oder *des Raumes*.

Wir denken die Punkte, Geraden, Ebenen in gewissen gegenseitigen Beziehungen und bezeichnen diese Beziehungen durch Worte wie „liegen", „zwischen", „parallel", „congruent", „stetig"; die genaue und vollständige Beschreibung dieser Beziehungen erfolgt durch die *Axiome der Geometrie*.

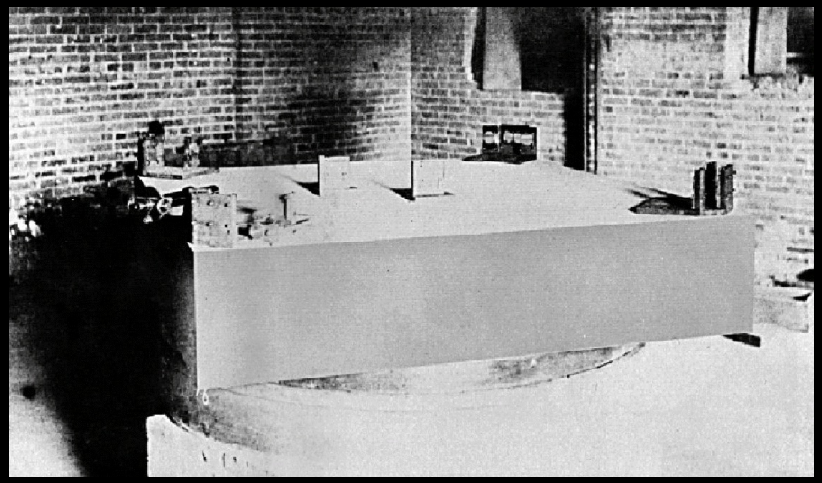
Die Axiome der Geometrie gliedern sich in fünf Gruppen; jede einzelne dieser Gruppen drückt gewisse zusammengehörige Grundthatsachen unserer Anschauung aus. Wir benennen diese Gruppen von Axiomen in folgender Weise:

I 1—7. Axiome der *Verknüpfung*,
II 1—5. Axiome der *Anordnung*,
III. Axiom der *Parallelen* (*Euklidisches* Axiom),
IV 1—6. Axiome der *Congruenz*,
V. Axiom der *Stetigkeit* (*Archimedisches* Axiom).

# Special Relativity



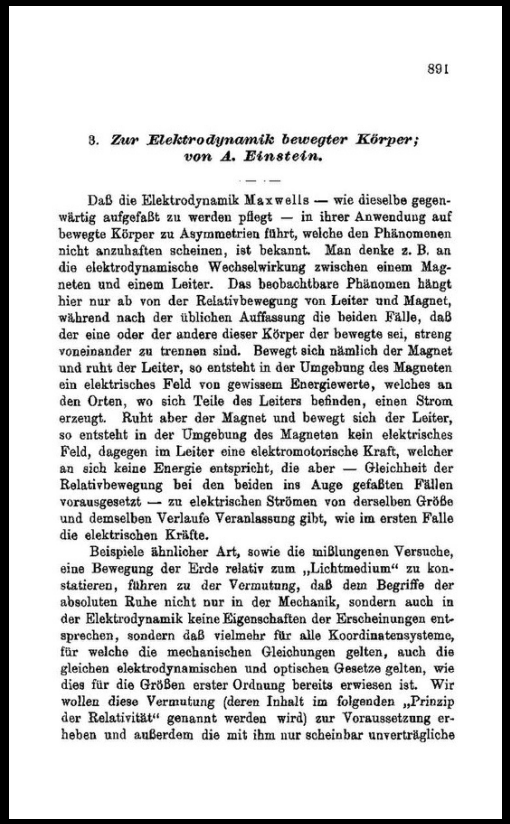

The Michelson Interferometer
(1887)



Albert Abraham Michelson
(1852-1931)

# Special Relativity

Albert Einstein. “Zur Elektrodynamik bewegter Körper.” *Annalen der Physik* 17 (1905), 891-921.



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3. ***Zur Elektrodynamik bewegter Körper; von A. Einstein.***

Daß die Elektrodynamik Maxwells — wie dieselbe gegenwärtig aufgefaßt zu werden pflegt — in ihrer Anwendung auf bewegte Körper zu Asymmetrien führt, welche den Phänomenen nicht anzuhaften scheinen, ist bekannt. Man denke z. B. an die elektrodynamische Wechselwirkung zwischen einem Magneten und einem Leiter. Das beobachtbare Phänomen hängt hier nur ab von der Relativbewegung von Leiter und Magnet, während nach der üblichen Auffassung die beiden Fälle, daß der eine oder der andere dieser Körper der bewegte sei, streng voneinander zu trennen sind. Bewegt sich nämlich der Magnet und ruht der Leiter, so entsteht in der Umgebung des Magneten ein elektrisches Feld von gewissem Energiewerte, welches an den Orten, wo sich Teile des Leiters befinden, einen Strom erzeugt. Ruht aber der Magnet und bewegt sich der Leiter, so entsteht in der Umgebung des Magneten kein elektrisches Feld, dagegen im Leiter eine elektromotorische Kraft, welcher an sich keine Energie entspricht, die aber — Gleichheit der Relativbewegung bei den beiden ins Auge gefaßten Fällen vorausgesetzt — zu elektrischen Strömen von derselben Größe und demselben Verlaufe Veranlassung gibt, wie im ersten Falle die elektrischen Kräfte.

Beispiele ähnlicher Art, sowie die mißlungenen Versuche, eine Bewegung der Erde relativ zum „Lichtmedium“ zu konstatieren, führen zu der Vermutung, daß dem Begriffe der absoluten Ruhe nicht nur in der Mechanik, sondern auch in der Elektrodynamik keine Eigenschaften der Erscheinungen entsprechen, sondern daß vielmehr für alle Koordinatensysteme, für welche die mechanischen Gleichungen gelten, auch die gleichen elektrodynamischen und optischen Gesetze gelten, wie dies für die Größen erster Ordnung bereits erwiesen ist. Wir wollen diese Vermutung (deren Inhalt im folgenden „Prinzip der Relativität“ genannt werden wird) zur Voraussetzung erheben und außerdem die mit ihm nur scheinbar unverträgliche

Albert Einstein (1879-1955)

# Special Relativity

The Relativity Principle:

The laws of physics take the same form in all frames of reference.

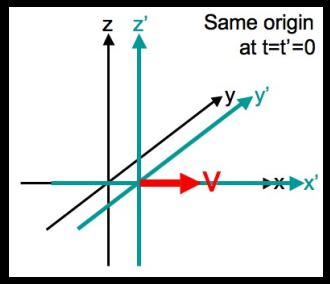
The Light Principle:

The speed of light is a constant, independent of the speed of the source.

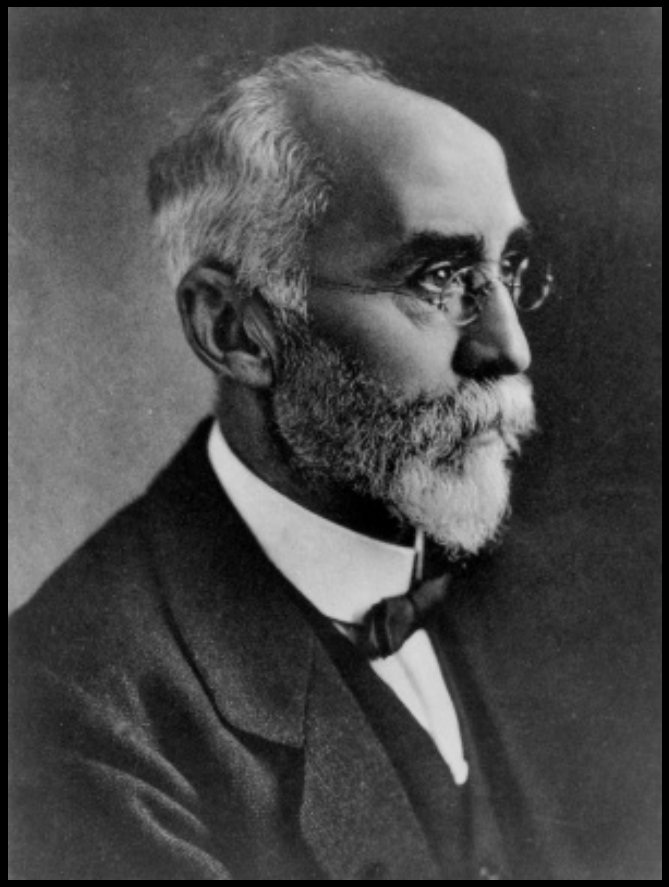
Galileo Galilei (1564-1642)

# Special Relativity

The relativity principle and the light principle can be made consistent with one another only if we switch from the Galilean transformations




to the Lorentz transformations



Hendrik Antoon Lorentz (1853-1928)

# Special Relativity

Several Important Implications:

- No absolute distant simultaneity
- Length contraction - meter sticks in non-comoving frames appear shorter
- Time dilation - clocks in non-comoving frames appear to run more slowly
- The speed of light is a limit velocity on all physical processes
- The intermingling of spatial and temporal coordinates in the Lorentz transformations imply that we live in a four-dimensional, Minkowski spacetime

Hermann Minkowski (1864-1909)

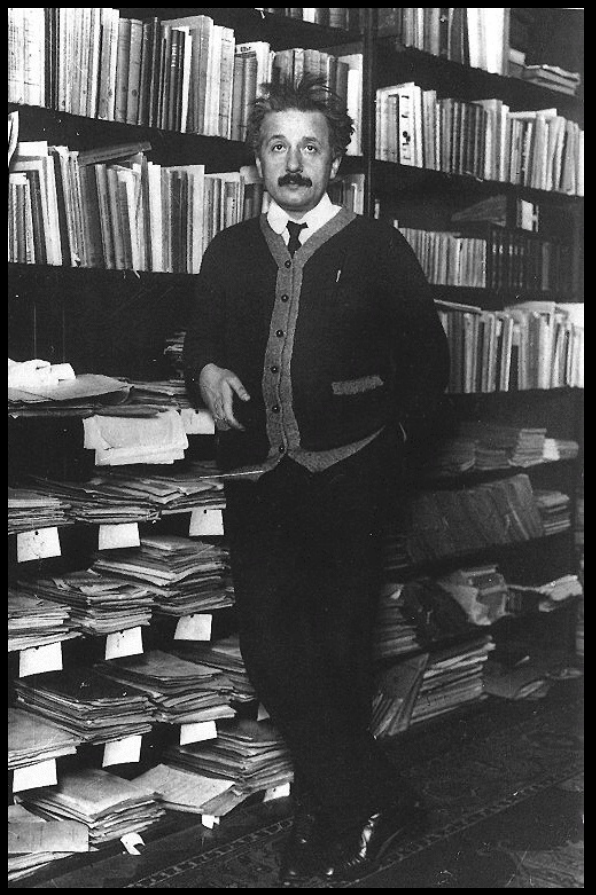
# General Relativity

Albert Einstin. “Zur allgemeinen Relativitätstheorie.” *Königlich Preussische Akademie der Wissenschaften* (Berlin). *Sitzungsberichte* (1915), 778-786, 799-801.

Albert Einstein. “Erklärung der Perihelbewegung des Merkur aus der allgemeinen Relativitäts-theorie.” *Königlich Preussische Akademie der Wissenschaften* (Berlin). *Sitzungsberichte* (1915), 831-839.

Albert Einstein. “Die Feldgleichungen der Gravitation.” *Königlich Preussische Akademie der Wissenschaften* (Berlin). *Sitzungsberichte* (1915), 844-847.

Albert Einstein. “Die Grundlage der allgemeinen Relativitätstheorie.” *Annalen der Physik* 49 (1916), 769-822.



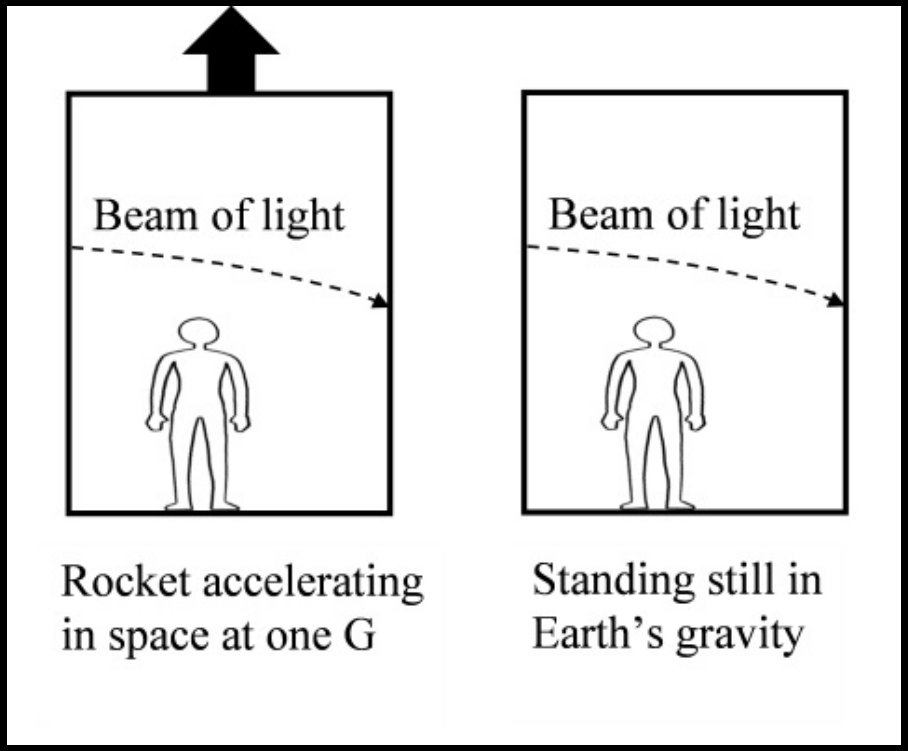
Albert Einstein (1879-1955)

# General Relativity

The Equivalence Principle:

A body's undergoing a linear acceleration and its being in a homogenous gravitational field are physically indistinguishable.

Hence a general theory of relativity will also be a theory of gravitation.



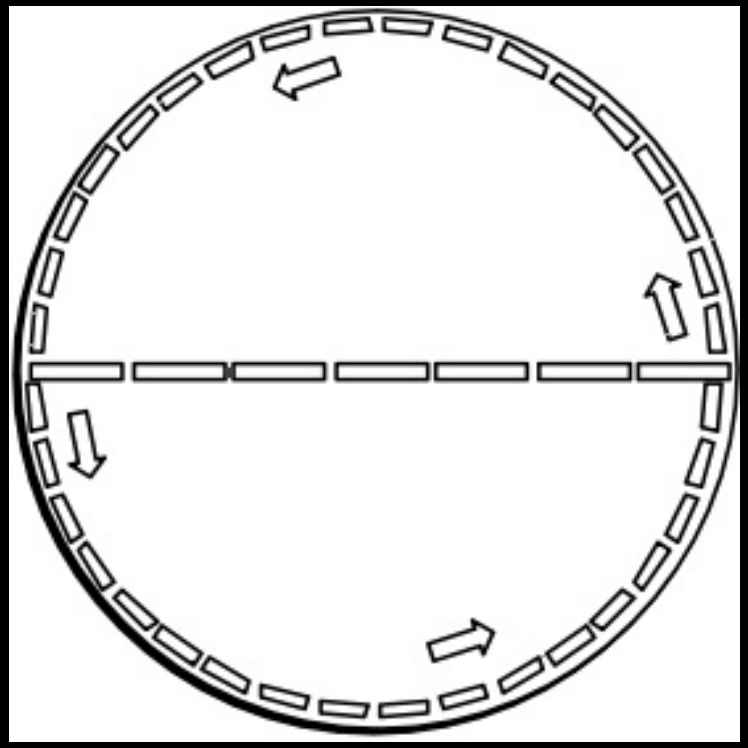

Motivated by the "Elevator" Thought Experiment

# General Relativity

## The Rotating Disk Thought Experiment

Rotation is a form of acceleration.

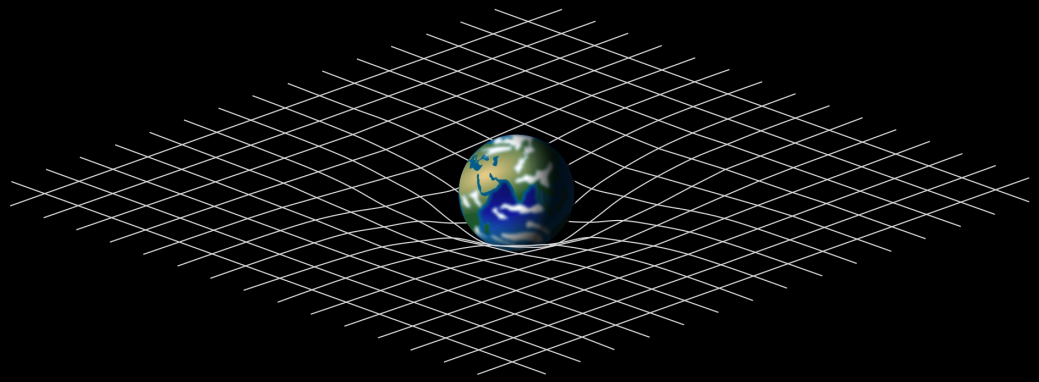
Because of length contraction, to an observer stationary at the center of a rotating disk, the circumference will appear larger than it would were the disk not rotating. Hence, for that observer, the ratio of the circumference of the disk to its diameter would appear to be greater than $\pi$, which corresponds to a space of negative curvature.



# General Relativity

The Einstein Field Equations

$R_{\mu\nu} - (1/2)Rg_{\mu\nu} = \kappa T_{\mu\nu}$



where

$R_{\mu\nu}$ - Ricci Tensor

$R$ - Ricci Scalar

$g_{\mu\nu}$ - Metric Tensor - curvature at a point in spacetime

$\kappa$ - Gravitational Constant

$T_{\mu\nu}$ - Stress-Energy Tensor - matter and energy content at a point in spacetime

# Empiricism, Kantianism, and General Relativity

Moritz Schlick. “Das Wesen der Wahrheit nach der modernen Logik.” *Vierteljahrsschrift für wissenschaftliche Philosophie und Soziologie* 34 (1910), 386-477.

Truth defined as a one-way univocal coordination between a proposition or theory and either the world or the relevant experience.

Multiple theories can be equally well coordinated with the world or experience.

Similar to Duhem’s holist underdeterminationism.

Moritz Schlick (1882 - 1936)

# Empiricism, Kantianism, and General Relativity

Moritz Schlick. *Raum und Zeit in der gegenwärtigen Physik. Zur Einführung in das Verständnis der allgemeinen Relativitätstheorie*. (Berlin: Julius Springer, 1917).

It is, however, possible to indicate identically the *same* set of facts by means of *various* systems of judgments; and consequently there can be various theories in which the criterion of truth is equally well satisfied, and which then do equal justice to the observed facts, and lead to the same predictions. They are merely different systems of symbols, which are allocated to the same objective reality: different modes of expression that reproduce the same set of facts.

**Raum und Zeit in der gegenwärtigen Physik**

Zur Einführung in das Verständnis der Relativitäts- und Gravitationstheorie

von

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**Moritz Schlick**

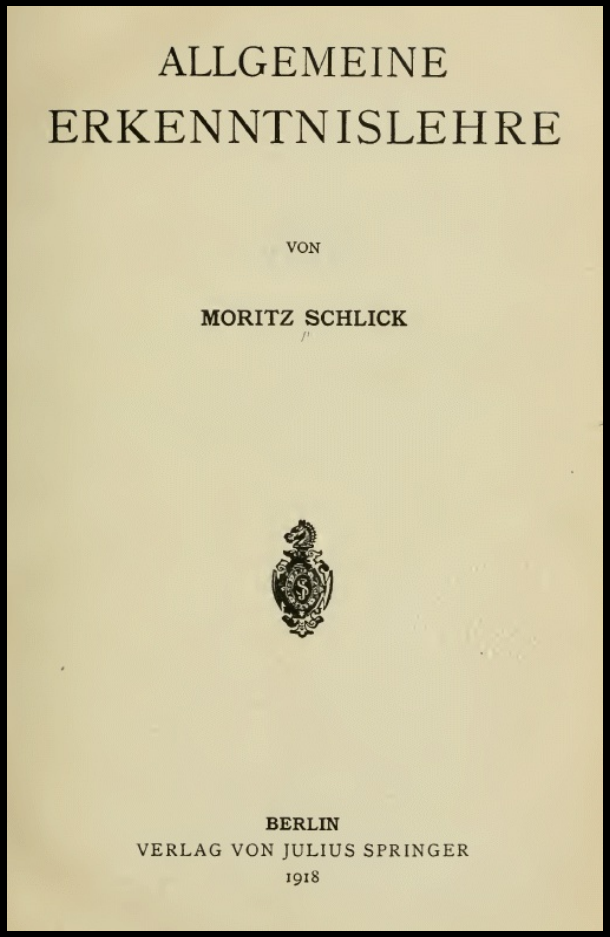
Dritte, vermehrte und verbesserte Auflage

Berlin
Verlag von Julius Springer
1920

# Empiricism, Kantianism, and General Relativity

Moritz Schlick. *Allgemeine Erkenntnislehre.* (Berlin: Julius Springer, 1918).

In a completely self-contained, deductively connected scientific system, genuine judgments can be distinguished from definitions only in a practical or psychological sense, not in a purely logical or epistemological one.


ALLGEMEINE
ERKENNTNISLEHRE

VON

MORITZ SCHLICK

BERLIN
VERLAG VON JULIUS SPRINGER
1918

# Empiricism, Kantianism, and General Relativity

Einstein to Max Born, 29 June 1918

I am reading Kant's *Prolegomena* here, among other things, and am beginning to comprehend the enormous suggestive power that emanated from the fellow and still does. Once you concede to him merely the existence of synthetic a priori judgments, you are trapped. I have to water down the "a priori" to "conventional," so as not to have to contradict him, but even then the details do not fit. Anyway it is very nice to read, even if it is not as good as his predecessor Hume's work. Hume also had a far sounder instinct.

Max Born (1882-1970)

# Empiricism, Kantianism, and General Relativity

Hans Reichenbach. *Relativitätstheorie und Erkenntnis Apriori*. (Berlin: Julius Springer, 1920.)

Ernst Cassirer. *Zur Einsteinschen Relativitätstheorie. Erkenntnistheoretische Betrachtungen.* (Berlin: Bruno Cassirer, 1921).

Moritz Schlick. "Kritizistische oder empiristische Deutung der neuen Physik." *Kant-Studien* 26 (1921), 96-111.

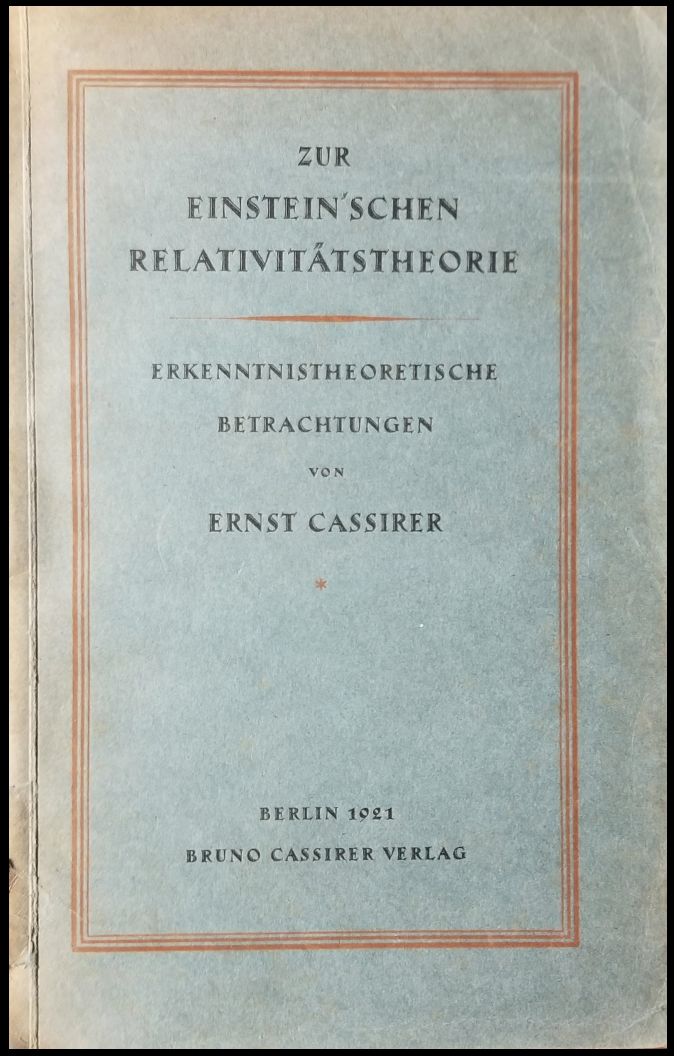
Moritz Schlick. Review of Reichenbach 1920. *Die Naturwissenschaften* 10 (1922), 873-874.

Hans Reichenbach (1891-1953)

# Empiricism, Kantianism, and General Relativity

Einstein to Cassirer, 5 June 1920

I can understand your idealistic way of thinking about space and time, and I even believe that one can thus achieve a consistent point of view. . . . I acknowledge that one must approach the experiences with some sort of conceptual functions, in order for science to be possible; but I do not believe that we are placed under any constraint in the choice of these functions *by virtue of the nature of our intellect.* Conceptual systems appear empty to me, if the manner in which they are to be referred to experience is not established. This appears most essential to me, even if, to our advantage, we often isolate in thought the purely conceptual relations, in order to permit the *logically* secure connections to emerge more purely.



# Empiricism, Kantianism, and General Relativity

Moritz Schlick. “Kritizistische oder empiristische Deutung der neuen Physik.” *Kant-Studien* 26 (1921), 96-111.

All exact science, whose philosophical justification undoubtedly forms the prime goal of the theory of knowledge founded by Kant, rests upon observations and measurements. But mere sensations and perceptions are not yet observations and measurements; they only become so by being ordered and interpreted. Thus the forming of concepts of physical objects unquestionably presupposes certain principles of ordering and interpretation. Now I see the essence of the critical viewpoint in the claim that these constitutive principles are *synthetic a priori judgments*, in which the concept of the *a priori* has the property of apodeicticity (of universal, necessary and inevitable validity) inseparably attached to it. . . . The most important consequence of the view just elaborated is that a thinker who simply perceives the necessity of constitutive principles for scientific experience should not yet be called a critical philosopher on that account. An empiricist, for example, can very well acknowledge the presence of such principles; he will deny only that they are synthetic and *a priori* in the sense defined above.

# Empiricism, Kantianism, and General Relativity

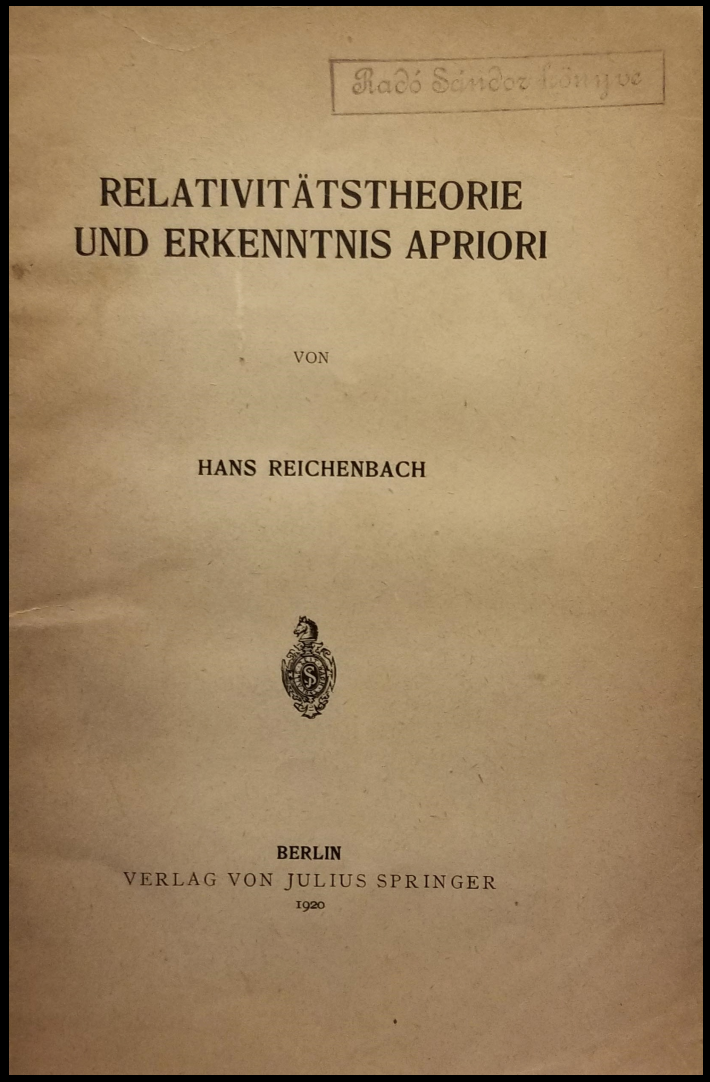
Moritz Schlick. “Kritizistische oder empiristische Deutung der neuen Physik.” *Kant-Studien* 26 (1921), 96-111.

He [Cassirer] quite rightly condemns the attempt sometimes made by Mach, to treat even analytico-mathematical laws like things “whose properties one can read off by immediate perception,” but that does not prove the truth of logical idealism, it merely refutes the sensualist theory. Between the two we still have the empiricist viewpoint, according to which these constitutive principles are either *hypotheses* or *conventions*; in the first case they are not *a priori* (since they lack apodeicticity), and in the second they are not synthetic.

# Empiricism, Kantianism, and General Relativity

## Reichenbach on Principles of Coordination

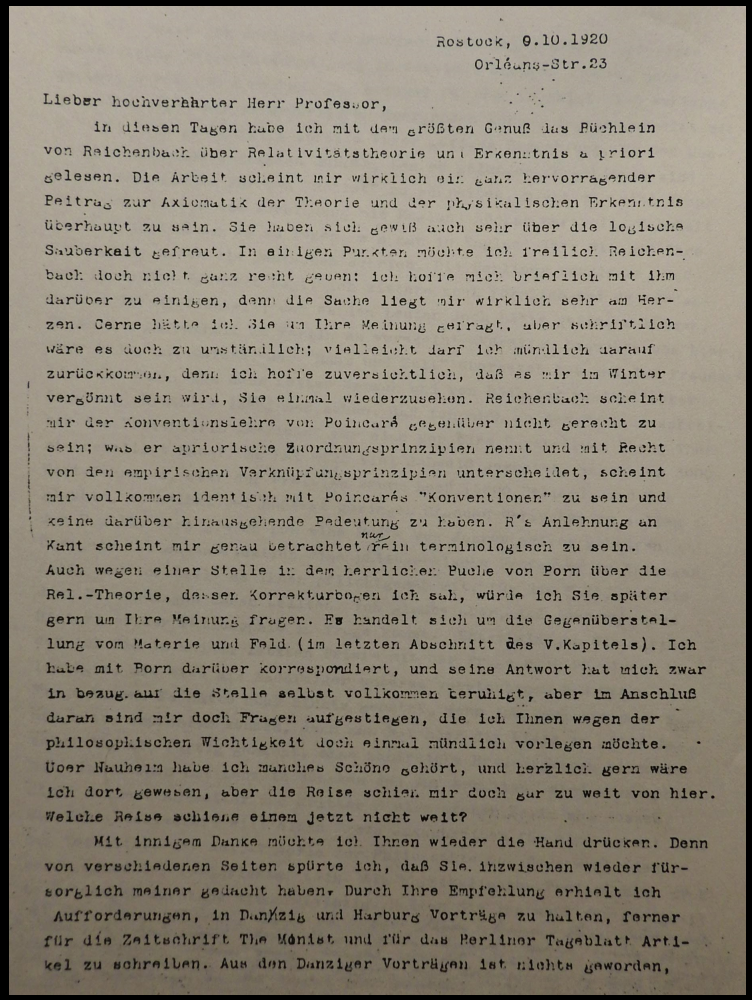
If we disclaim the Kantian analysis of reason, it cannot be contested that experience contains elements that are conformable to reason. Indeed, it is precisely the principles of coordination that are determined by the nature of reason; experience merely effects the choice among all conceivable principles. All that is contested is that the rational components of knowledge are maintained independently of experience. The principles of coordination represent the rational components of empirical science. Therein lies their fundamental significance and therein are they distinguished from every, individual law, even the most general. For the individual law represents only an application of those conceptual methods that are grounded by the principle of coordination; only by means of the methods fixed by such principles do we define how the knowledge of an object is effectuated conceptually.



# Empiricism, Kantianism, and General Relativity

Schlick to Einstein, 9 October 1920

In the last few days I have read with the greatest pleasure the booklet by Reichenbach on relativity theory and a priori knowledge. The work really appears to me to be a quite splendid contribution to the axiomatics of the theory and of physical knowledge in general. . . . Of course, in a few points I still cannot entirely support Reichenbach. . . . Reichenbach seems to me not to be fair with regard to the theory of conventions of Poincaré; what he calls a priori principles of coordination, and rightly distinguishes from the empirical principles of connection, seem to me to be wholly identical with Poincaré's "conventions" and to have no significance beyond that. R.'s reliance upon Kant seems to me to be, carefully considered, only purely terminological.



Rostock, 9.10.1920
Orléans-Str.23

Lieber hochverehrter Herr Professor,

in diesen Tagen habe ich mit dem größten Genuß das Büchlein von Reichenbach über Relativitätstheorie und Erkenntnis a priori gelesen. Die Arbeit scheint mir wirklich ein ganz hervorragender Beitrag zur Axiomatik der Theorie und der physikalischen Erkenntnis überhaupt zu sein. Sie haben sich gewiß auch sehr über die logische Sauberkeit gefreut. In einigen Punkten möchte ich freilich Reichenbach doch nicht ganz recht geben: ich hoffe mich brieflich mit ihm darüber zu einigen, denn die Sache liegt mir wirklich sehr am Herzen. Gerne hätte ich Sie um Ihre Meinung gefragt, aber schriftlich wäre es doch zu umständlich; vielleicht darf ich mündlich darauf zurückkommen, denn ich hoffe zuversichtlich, daß es mir im Winter vergönnt sein wird, Sie einmal wiederzusehen. Reichenbach scheint mir der Konventionslehre von Poincaré gegenüber nicht gerecht zu sein; was er apriorische Zuordnungsprinzipien nennt und mit Recht von den empirischen Verknüpfungsprinzipien unterscheidet, scheint mir vollkommen identisch mit Poincarés "Konventionen" zu sein und keine darüber hinausgehende Bedeutung zu haben. R's Anlehnung an Kant scheint mir genau betrachtet nur rein terminologisch zu sein. Auch wegen einer Stelle in dem herrlichen Buche von Born über die Rel.-Theorie, dessen Korrekturbogen ich sah, würde ich Sie später gern um Ihre Meinung fragen. Es handelt sich um die Gegenüberstellung von Materie und Feld (im letzten Abschnitt des V.Kapitels). Ich habe mit Born darüber korrespondiert, und seine Antwort hat mich zwar in bezug auf die Stelle selbst vollkommen beruhigt, aber im Anschluß daran sind mir doch Fragen aufgestiegen, die ich Ihnen wegen der philosophischen Wichtigkeit doch einmal mündlich vorlegen möchte. Über Nauheim habe ich manches Schöne gehört, und herzlich gern wäre ich dort gewesen, aber die Reise schien mir doch gar zu weit von hier. Welche Reise schiene einem jetzt nicht weit?

Mit innigem Danke möchte ich Ihnen wieder die Hand drücken. Denn von verschiedenen Seiten spürte ich, daß Sie inzwischen wieder fürsorglich meiner gedacht haben. Durch Ihre Empfehlung erhielt ich Aufforderungen, in Danzig und Harburg Vorträge zu halten, ferner für die Zeitschrift The Monist und für das Berliner Tageblatt Artikel zu schreiben. Aus den Danziger Vorträgen ist nichts geworden,

# Empiricism, Kantianism, and General Relativity

Schlick to Reichenbach, 26 November 1920

For me the presupposition of object-constituting principles is so self-evident that I have not pointed it out emphatically enough, above all in the Allg. Erkenntnisl. . . . It is quite clear to me that a perception can become an “observation” or even a “measurement” only through certain principles being presupposed by means of which the observed or measured object is then constructed. In this sense the principles are to be called a priori. . . . But there are indeed, moreover, two possibilities, that those principles are hypotheses or that they are conventions. In my opinion, precisely this turns out to be the case, and it is the central point of my letter, that I cannot discern wherein your a priori propositions are actually distinguished from conventions. That you passed over Poincaré's theory of conventions with so few words is what most amazed me about your essay. . . . The crucial places where you describe the character of your a priori principles of coordination appear to me, frankly, as quite successful definitions of the concept of convention. . . . I do not fear that you can object that conventionalism must also make use of the hypothesis that you find implicit in Kant's philosophy (p. 57) [there are no contradictory systems of principles, the hypothesis of the arbitrariness of coordinations]. Indeed, only such conventions are permitted that fit into a certain system of principles, and this system as a *whole* will be determined by experience; the arbitrariness only enters in the manner of its construction and is steered by the principle of simplicity, economy, or, as I would rather have said, the principle of the minimum of concepts. Here there appears to me to be a small gap in your essay, which is not without consequences: In the concept of knowledge you consider explicitly only the *one* side, the coordination, and you slight a little bit the other side, that the coordination should be accomplished with the fewest and consequently the most general possible concepts.

# Empiricism, Kantianism, and General Relativity

Reichenbach to Schlick, 29 November 1920

You ask me why I do not call my a priori principles *conventions*. I believe that we will easily come to agreement about this question. Even though several systems of principles are possible, nevertheless, only one *group* of principle-systems is always possible; and precisely in this restriction there lies some knowledge. Every possible system signifies in its possibility a *property* of reality. I miss in Poincaré an emphasis on the fact that the arbitrariness of the principles is restricted, in the way one *combines* principles. For that reason I cannot adopt the name "convention." Also, we are never certain that two principles that we today allow to exist alongside one another as constitutive principles, and which are therefore both *conventions*, according to Poincaré, might not tomorrow have to be separated because of new experiences, so that between the two conventions the alternative appears as synthetic.

# Empiricism, Kantianism, and General Relativity

Schlick to Reichenbach, 11 December 1920

1) on the question of the "conventions." If Poincaré did not explicitly emphasize that conventions are not independent of one another, but are always possible only as groups, still one would naturally do him quite an injustice, if one believed, that he was not aware of this circumstance. This was obviously the case, and he would have repudiated with mockery the nonsense that, e.g., Dingler has perpetrated with the concept of conventions while misunderstanding this circumstance. Thus, in my view, nothing stands in the way of the retention of the term.

# Empiricism, Kantianism, and General Relativity

Hans Reichenbach. *Axiomatik der relativistischen Raum-Zeit-Lehre*. (Braunschweig: Friedrich Vieweg und Sohn, 1924).

Definitions are arbitrary; they are neither true nor false. They are merely to be analyzed with respect to their logical properties, their uniqueness, consistency, and, under certain conditions, their simplicity. It is characteristic of the axiomatization of physics compared to that of mathematics that there exists such a distinction between axioms and definitions; an essential task of the axiomatization consists in tracing this distinction within the theoretical system.

However, even definitions in physics are different from definitions in mathematics. The mathematical definition is a *conceptual definition*, that is, it clarifies the meaning of a concept by means of other concepts. The physical definition takes the meaning of the concept for granted and coordinates to it a physical thing; it is a *coordinative definition*. Physical definitions, therefore, consist in the coordination of a mathematical definition to a "piece of reality"; one might call them *real definitions*.

# Empiricism, Kantianism, and General Relativity

Moritz Schlick. *Allgemeine Erkenntnislehre.* 2nd. ed. (Berlin: Julius Springer, 1925).

We might be tempted to think that the distinction between analytic and synthetic judgments cannot be drawn sharply, since one and the same judgment may be synthetic or analytic depending on what we include in the subject concept. But this opinion ignores the fact that the judgment is really *not* the same in the two cases. In the first case, we define the concept *body* in "All bodies are heavy" so that being heavy is one of its features; in the second case, we do not. True, the sentence contains the same *words* each time, but they designate different judgments, for the word "body" has a different meaning in each. We explained above (§ 8) that one and the same (linguistic) sentence can express both a definition and a piece of knowledge. It all depends on what concepts we connect to the words. The partitioning of judgments into analytic and synthetic is thus something quite well defined and objectively valid, and does not depend, say, on the subjective standpoint or mode of comprehension of the one who judges.

# Empiricism, Kantianism, and General Relativity

Moritz Schlick. *Allgemeine Erkenntnislehre.* 2nd. ed. (Berlin: Julius Springer, 1925).

Every judgment we make is either definitional or cognitive. This distinction, as we noted above (§ 8), has only a relative significance in the conceptual or "ideal" sciences. It emerges all the more sharply, however, in the empirical or "real" sciences. In these sciences it has a fundamental importance; and a prime task of epistemology is to make use of this distinction in order to clarify the kinds of validity possessed by various judgments.

. . .

Once a certain number of concepts are fixed by convention, the relations that hold between the objects so designated are not conventional. They must be determined through experience.

# Empiricism, Kantianism, and General Relativity

Moritz Schlick. *Allgemeine Erkenntnislehre.* 2nd. ed. (Berlin: Julius Springer, 1925).

The system of definitions and cognitive judgments, which constitutes any real science, is brought into congruence at individual points with the system of reality, and is so constructed that congruence then follows automatically at all remaining points. . . . If the whole edifice is correctly built, then a set of real facts corresponds not only to each of the starting points – the fundamental judgments – but also to each member of the system generated deductively. Every individual judgment in the entire structure is uniquely coordinated to a set of real facts.

# Empiricism, Kantianism, and General Relativity

Moritz Schlick. *Allgemeine Erkenntnislehre.* 2nd. ed. (Berlin: Julius Springer, 1925).

According to him [Kant], besides the two classes of judgments we have described – definitions in the widest sense (Kant calls them analytic judgments) and empirical judgments or hypotheses (these he calls synthetic judgments *a posteriori*)--there is a third class, the so-called synthetic judgments *a priori*. . . . The fact of the matter is that no one has as yet succeeded in exhibiting a synthetic judgment *a priori* in any science. That Kant and his followers nevertheless believed in their existence may be explained quite naturally by the fact that among both the definitions and the empirical propositions of the exact sciences we find statements that are deceptively similar to synthetic judgments *a priori*. In the class of definitions, which by their very nature possess a validity independent of experience and thus are *a priori*, there are a great many conventions that, viewed superficially, seem not to be derivable from definitions and hence to be synthetic. Their true character as conventions is revealed only by a most painstaking analysis. An example would be the axioms of the science of space. In the class of empirical judgments, which are clearly synthetic since their validity for reality does not follow from the definitions, there are many propositions (for example, the principle of causality) of such seemingly unconditional validity that in the absence of a more penetrating examination it is easy to mistake them for *a priori* judgments.

Once we demonstrate . . . that the judgments held to be synthetic and *a priori* are in fact not synthetic or not *a priori*, there is no reason whatever to suppose that judgments of this strange sort might yet exist in some obscure corner of the sciences. And this is sufficient ground for us to try in what follows to explain all knowledge of reality as a system built up exclusively of judgments belonging to the two classes described above.

# Empiricism, Kantianism, and General Relativity

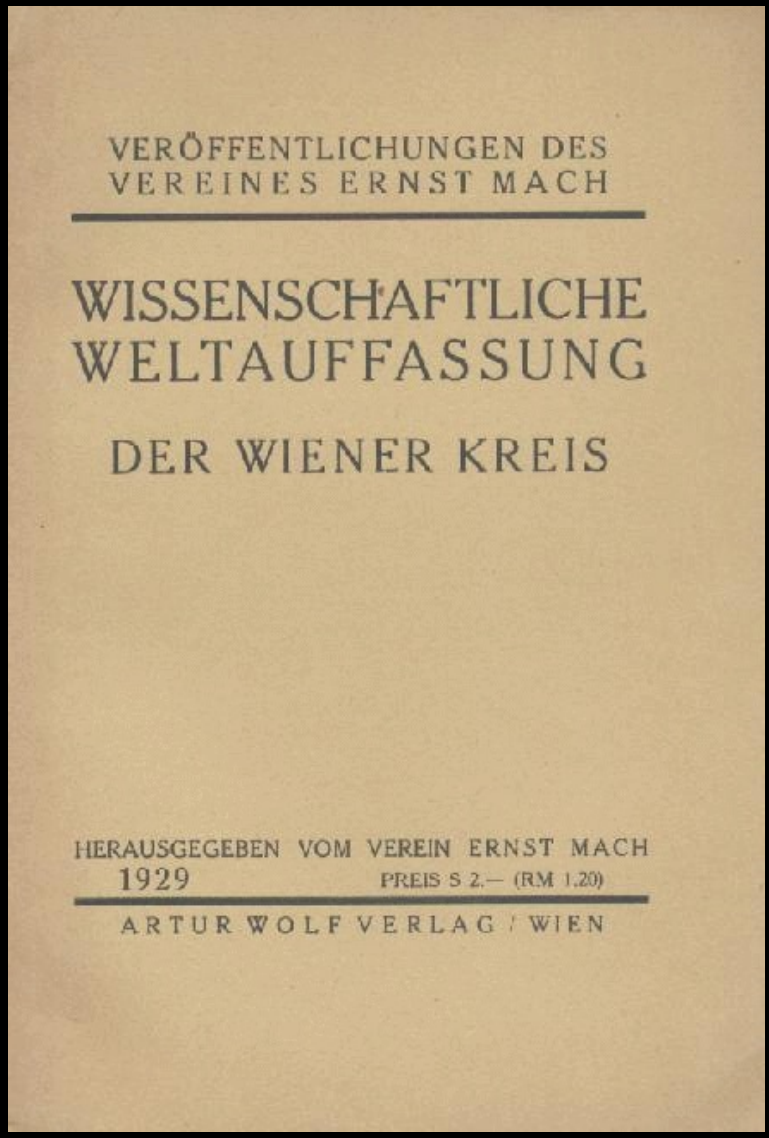
Albert Einstein. Review of: Alfred Elsbach. *Kant und Einstein. Untersuchungen über das Verhältnis der modernen Erkenntnistheorie zur Relativitätstheorie*. Berlin and Leipzig: Walter de Gruyter. 1924. *Deutsche Literaturzeitung* 45 (1924), 1685-1692.

This does not, at first, preclude one's holding at least to the Kantian problematic, as, e.g., Cassirer has done. I am even of the opinion that this standpoint can be rigorously refuted by no development of natural science. For one will always be able to say that critical philosophers have until now erred in the establishment of the a priori elements, and one will always be able to establish a system of a priori elements that does not contradict a given physical system. Let me briefly indicate why I do not find this standpoint natural. A physical theory consists of the parts (elements) A, B, C, D, that together constitute a logical whole which correctly connects the pertinent experiments (sense experiences). Then it tends to be the case that the aggregate of fewer than all four elements, e.g., A, B, D, without C, no longer says anything about these experiences, and just as well A, B, C without D. One is then free to regard the aggregate of three of these elements, e.g., A, B, C as a priori, and only D as empirically conditioned. But what remains unsatisfactory in this is always the arbitrariness in the choice of those elements that one designates as a priori, entirely apart from the fact that the theory could one day be replaced by another that replaces certain of these elements (or all four) by others.

# The Founding of the Vienna Circle

Otto Neurath, Hans Hahn, and Rudolf Carnap. *Wissenschaftliche Weltauffassung: Der Wiener Kreis*. (Vienna: Artur Wolf, 1929).

The increase of metaphysical and theologizing leanings which shows itself today in many associations and sects, in books and journals, in talks and university lectures, seems to be based on the fierce social and economic struggles of the present: one group of combatants, holding fast to traditional social forms, cultivates traditional attitudes of metaphysics and theology whose content has long since been superseded; while the other group, especially in central Europe, faces modern times, rejects these views and takes its stand on the ground of empirical science. . . In previous times, *materialism* was the expression of this view; meanwhile, however, modern empiricism has shed a number of its inadequacies and has taken a strong shape in the *scientific world-conception*.



# The Founding of the Vienna Circle

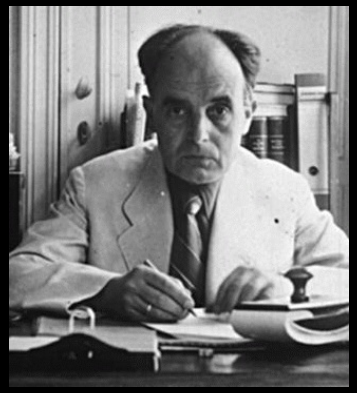
Moritz Schlick. “The Future of Philosophy.” *College of the Pacific Publications in Philosophy* 1 (1932), 45-62.

Thus the fate of all ‘philosophical problems’ is this: Some of them will disappear by being shown to be mistakes and misunderstandings of our language and the others will be found to be ordinary scientific questions in disguise. These remarks, I think, determine the whole future of philosophy.

Moritz Schlick (1882 - 1936)

# The Berlin Society for Empirical Philosophy

Hans Reichenbach
(1891 -1953)



Kurt Grelling
(1886 - 1942)

Carl Hempel
(1905 - 1997)

Walter Dubislav
(1895 - 1937)

Richard von Mises
(1883 - 1953)

# Erkenntnis

Hans Reichenbach. “Zur Einführung.” *Erkenntnis* 1 (1930), 1-3.

Because it is knowledge [Erkenntnis] that we set as the goal for philosophy, knowledge in the same sense as for every individual science, for that reason we have chosen that word as the emblem for the new journal. Our journal seeks no doctrines, no contrived systems, no conceptual poetry; it seeks knowledge.


ERKENNTNIS

IM AUFTRAGE DER
GESELLSCHAFT FÜR EMPIRISCHE PHILOSOPHIE
BERLIN UND DES VEREINS ERNST MACH IN WIEN

HERAUSGEGEBEN VON

RUDOLF CARNAP

UND

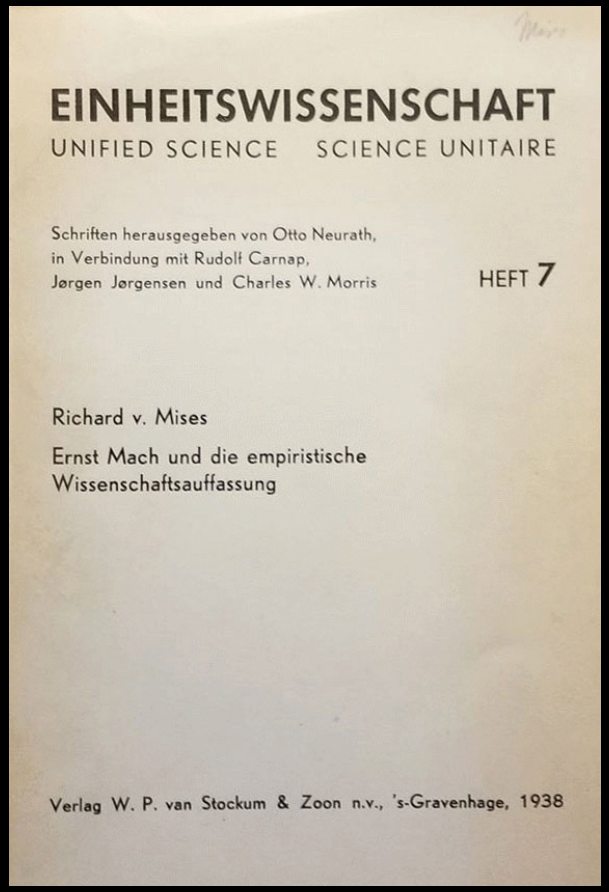
HANS REICHENBACH

ERSTER BAND
1930–1931

ZUGLEICH
ANNALEN DER PHILOSOPHIE
BAND IX

VERLAG VON FELIX MEINER IN LEIPZIG

Einheitswissenschaft and Schriften zur wissenschaftlichen Weltauffassung




# The Protocol Sentence Debate

Rudolf Carnap. “Die physikalische Sprache als Universalsprache der Wissenschaft.” *Erkenntnis* 2 (1931), 432-365.

## Die physikalische Sprache als Universalsprache der Wissenschaft

Von

**Rudolf Carnap** (Prag)

1. Die Zerspaltung der Wissenschaft.
2. Sprachen.
3. Die Protokollsprache.
4. Die physikalische Sprache als intersubjektive Sprache.
5. Die physikalische Sprache als universale Sprache.
6. Die Protokollsprache als Teilsprache der physikalischen.
7. Die Einheitswissenschaft in physikalischer Sprache.

### 1. Die Zerspaltung der Wissenschaft

Die Wissenschaft in ihrer herkömmlichen Gestalt bildet keine Einheit. Sie zerfällt in Philosophie und Fachwissenschaften; die Fachwissenschaften zerfallen in Formalwissenschaften (Logik und Mathematik) und Realwissenschaften; die Realwissenschaften pflegt man zu zerlegen in Naturwissenschaften, Geisteswissenschaften und Psychologie. Diese verschiedenen Wissenschaftsarten trennt man nicht nur aus praktischen Gründen der Arbeitsteilung. Die allgemein verbreitete Ansicht geht vielmehr dahin, daß sie sich grundsätzlich in Hinsicht ihrer Objekte, ihrer Erkenntnisquellen, ihrer Methoden unterscheiden. Demgegenüber soll hier die Auffassung vertreten werden, daß *die Wissenschaft eine Einheit* bildet: alle Sätze sind in éiner Sprache ausdrückbar, alle Sachverhalte sind von éiner Art, nach éiner Methode erkennbar.

Über die Philosophie und die Formalwissenschaften soll nur kurz gesprochen werden. Die hier vertretene Auffassung in diesem Punkt ist schon mehrfach von anderen dargestellt worden. Dagegen wollen wir auf die Frage der Einheit der Realwissenschaften näher eingehen.

Die Einsichten in den Charakter der Philosophie, der Logik und der Mathematik verdanken wir der Entwicklung der neuen Logik, insbesondere der logischen Analyse der Sprache. Diese Analyse ist schließlich zu dem Ergebnis gekommen, daß es nicht neben oder über

# The Protocol Sentence Debate

Otto Neurath. “Protokollsätze.” *Erkenntnis* 3 (1933), 204-214.

## Protokollsätze[1)]

Von

**Otto Neurath** (Wien)

Im Intereſſe der Forſchung werden in der Einheitsſprache der Einheitswiſſenſchaft immer mehr Formulierungen in wachſendem Maße präziſiert. Kein Terminus der Einheitswiſſenſchaft iſt aber von Unpräziſion frei, da ja alle Termini auf Termini zurückgeführt werden, welche für *Protokollſätze* weſentlich ſind, deren Unpräziſion doch jedem ſofort in die Augen ſpringt.

Die Fiktion einer aus *ſauberen Atomſätzen* aufgebauten *idealen Sprache* iſt ebenſo metaphyſiſch, wie die Fiktion des Laplaceſchen Geiſtes. Man kann nicht die immer mehr mit ſyſtematiſchen Symbolgebilden ausgeſtattete wiſſenſchaftliche Sprache etwa als eine Annäherung an eine ſolche Idealſprache auffaſſen. Der Satz „Otto beobachtet einen zornigen Menſchen“ iſt unpräziſer, als der Satz: „Otto beobachtet einen Thermometerſtand von 24 Grad“, ſofern man „zorniger Menſch“ weniger genau definieren kann, als „Thermometerſtand von 24 Grad“; aber „Otto“ ſelbſt iſt in vieler Richtung ein unpräziſierter Terminus, der Satz „Otto beobachtet“ wird erſetzt werden können durch den Satz „Der Menſch, deſſen ſorgſam aufgenommenes Photo in der Kartothek am Platz 16 liegt, beobachtet“, womit aber der Terminus „Photo in der Kartothek am Platz 16“ noch nicht erſetzt iſt durch ein Syſtem mathematiſcher Formeln, das eindeutig zugeordnet iſt einem anderen Syſtem mathematiſcher Formeln, das an die Stelle von „Otto“, von „zornigem Otto“, „freundlichem Otto“ uſw. tritt.

Gegeben iſt uns zunächſt unſere *hiſtoriſche Trivialſprache* mit einer Fülle unpräziſer, unanalyſierter Termini („Ballungen“).

[1)] Bemerkungen zu Rudolf *Carnaps* Aufſatz: *Die phyſikaliſche Sprache als Univerſalſprache der Wiſſenſchaft. „Erkenntnis“ 1932, S. 432.* Da mit Carnap weitgehende Übereinſtimmung beſteht, wird an ſeine Terminologie angeknüpft. Um nicht ſchon Geſagtes zu wiederholen, ſei verwieſen auf: Otto *Neurath*, Phyſikalismus. „Scientia“ 1931, S. 297. Otto *Neurath*, Soziologie im Phyſikalismus. „Erkenntnis“ 1932, S. 393.

Otto Neurath –

Underdetermination, Auxiliary Motives, and Pseudorationalism

"The Lost Wanderers of Descartes and the Auxiliary Motive (On the Psychology of Decision)" (1913)

- No difference in principle between practical and theoretical reason
- Auxiliary motives always play a role in science, especially in the social sciences
- Objectivity best achieved by openness about and honest, critical, empirical assessment of auxiliary motives

Which way out?

# The Protocol Sentence Debate

Moritz Schlick. “Über das Fundament der Erkenntnis.” *Erkenntnis* 4 (1934), 79-99.

## Über das Fundament der Erkenntnis

Von

**Moritz Schlick** (Wien)

I.

Alle großen Verſuche der Begründung einer Theorie des Erkennens entſpringen aus der Frage nach der Sicherheit menſchlichen Wiſſens, und dieſe Frage wiederum entſpringt aus dem Wunſche nach abſoluter Gewißheit der Erkenntnis.

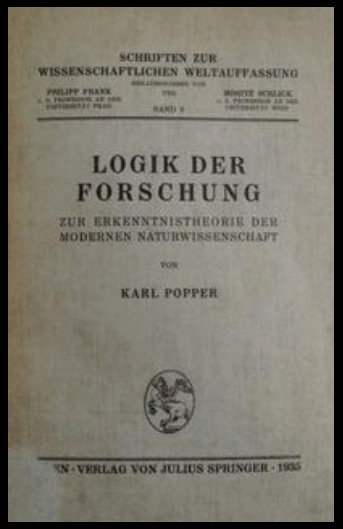
Die Einſicht, daß die Ausſagen des täglichen Lebens und der Wiſſenſchaft ſchließlich nur auf wahrſcheinliche Geltung Anſpruch machen können, daß auch die allgemeinſten in jeder Erfahrung bewährten Ergebniſſe der Forſchung nur den Charakter von Hypotheſen haben, dieſe Einſicht hat die Philoſophen ſeit Descartes, ja weniger deutlich ſchon ſeit dem Altertum, immer wieder angeſtachelt, eine unerſchütterliche Grundlage zu ſuchen, die allem Zweifel entzogen iſt und den feſten Boden bildet, auf dem das ſchwankende Gebäude unſeres Wiſſens ſich erhebt. Die Unſicherheit des Gebäudes führte man meiſt darauf zurück, daß es unmöglich — vielleicht prinzipiell unmöglich — war, durch menſchliche Denkkraft ein ſolideres aufzubauen; aber das hinderte nicht, nach dem natürlichen Felſen zu ſuchen, welcher *vor* allem Bauen da iſt und ſelber nicht wankt.

Dieſes Suchen iſt ein lobenswertes, geſundes Streben, und es iſt auch bei „Relativiſten“ und „Skeptikern“ wirkſam, die ſich ſeiner gerne ſchämen möchten. Es tritt in verſchiedenen Formen auf und führt zu ſonderbaren Meinungsverſchiedenheiten. Die Frage nach den „Protokollſätzen“, nach ihrer Funktion und Struktur, iſt die neueſte Form, in welche die Philoſophie, oder vielmehr der entſchiedene Empirismus unſerer Tage, das Problem des letzten Wiſſensgrundes kleidet.

Unter „Protokollſätzen“ dachte man ſich, wie der Name andeutet, urſprünglich jene Sätze, welche in abſoluter Schlichtheit, ohne jede Formung, Veränderung oder Zutat die *Tatſachen* ausſprechen, in

# Karl Popper

Karl Popper. *Logik der Forschung. Zur Erkenntnistheorie der modernen Naturwissenschaft*. (Berlin: Julius Springer, 1935).


SCHRIFTEN ZUR
WISSENSCHAFTLICHEN WELTAUFFASSUNG

PHILIPP FRANK — MORITZ SCHLICK

BAND 9

LOGIK DER
FORSCHUNG

ZUR ERKENNTNISTHEORIE DER
MODERNEN NATURWISSENSCHAFT

VON

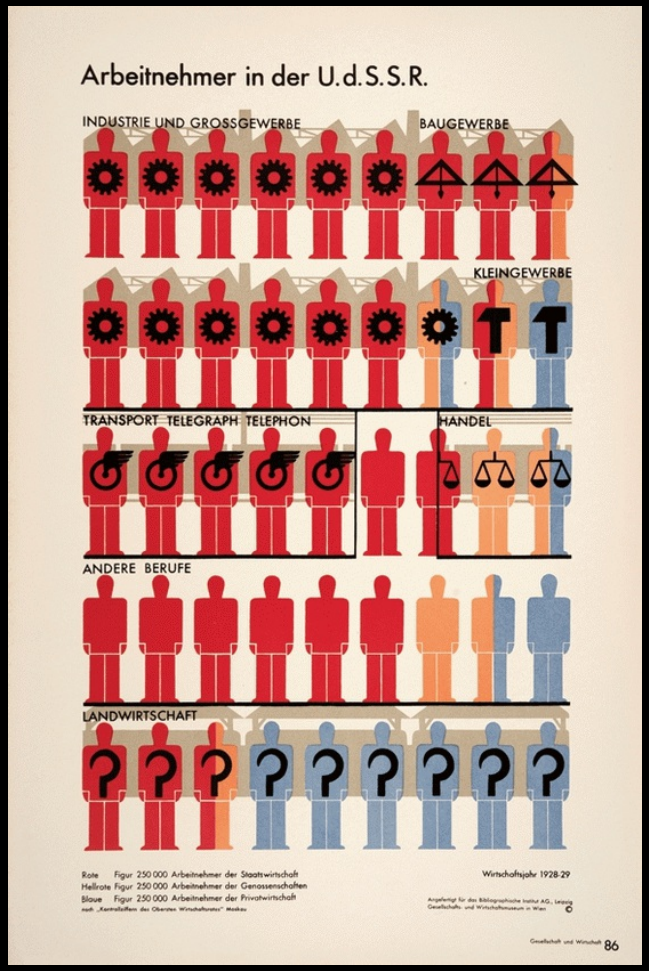
KARL POPPER

N · VERLAG VON JULIUS SPRINGER · 1935

Karl Popper (1902 - 1994)

# Otto Neurath


The Social and Economic Museum in Vienna




Isotype

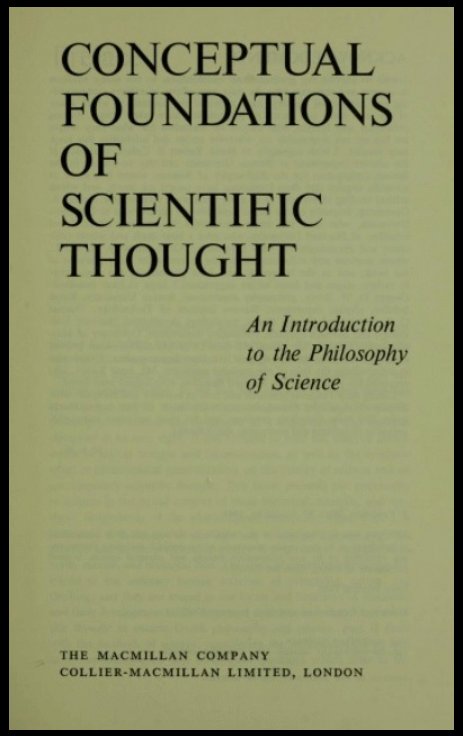
# Marie Reidemeister Neurath

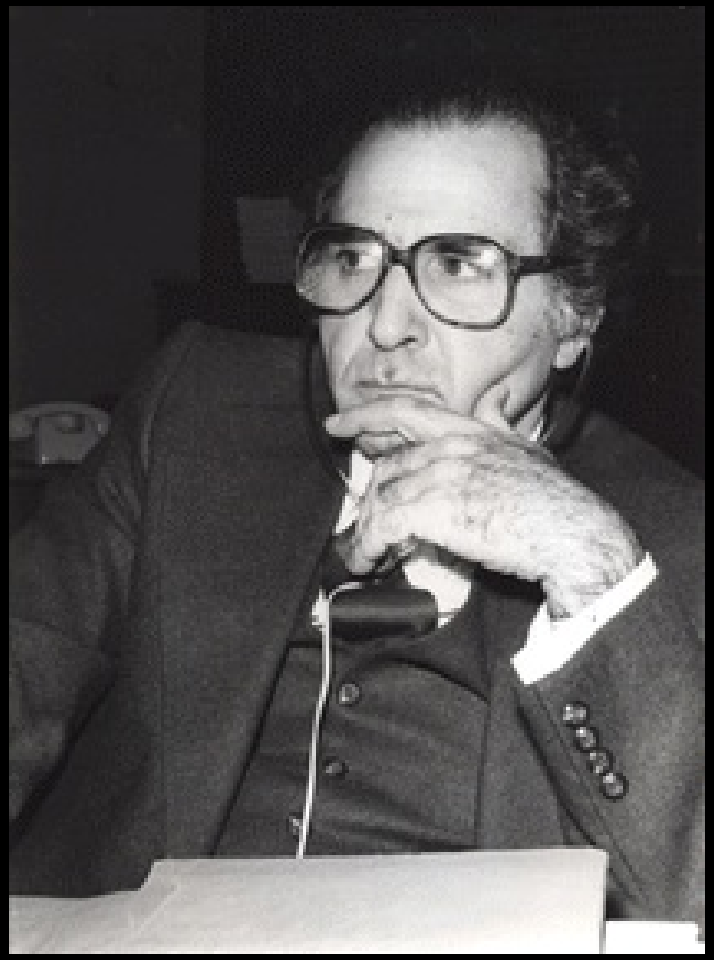

"Rich Man Poor Man," *Future* 3 (1948)

Marie Reidemeister Neurath (1898-1986)

# Marx Wartofsky

*Conceptual Foundations of Scientific Thought. An Introduction to the Philosophy of Science.*
New York: Macmillan, 1968.



Marx Wartofsky (1928-1997)

# Michael Friedman

*Foundations of Space-Time Theories: Relativistic Physics and the Philosophy of Science.* Princeton, NJ: Princeton University Press, 1983.

*Kant and the Exact Sciences*. Cambridge, MA: Harvard University Press, 1992.

*Reconsidering Logical Positivism*. New York, NY: Cambridge University Press, 1999.

*Dynamics of Reason: The 1999 Kant Lectures at Stanford University*. Chicago, IL: University of Chicago Press, 2001.

*Kant's Construction of Nature: A Reading of the Metaphysical Foundations of Natural Science*. New York, NY: Cambridge University Press, 2013.

Michael Friedman (1947- )

# Rudolf Carnap

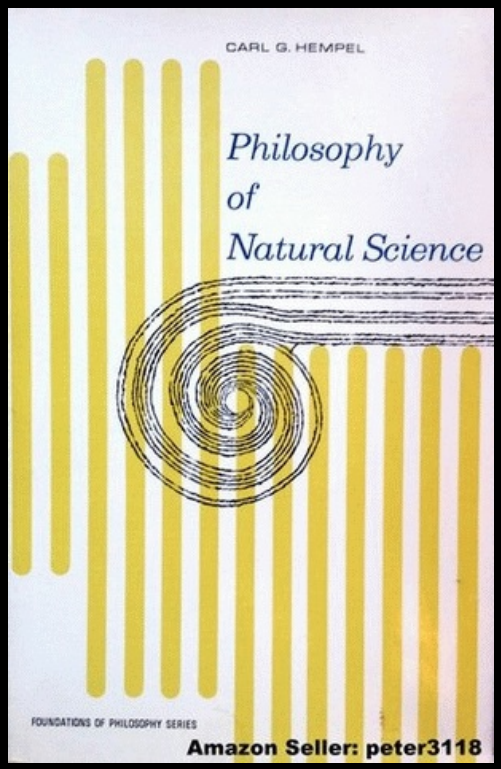
**Empiricism, Semantics, and Ontology**

by Rudolf Carnap

1. *The Problem of Abstract Entities*

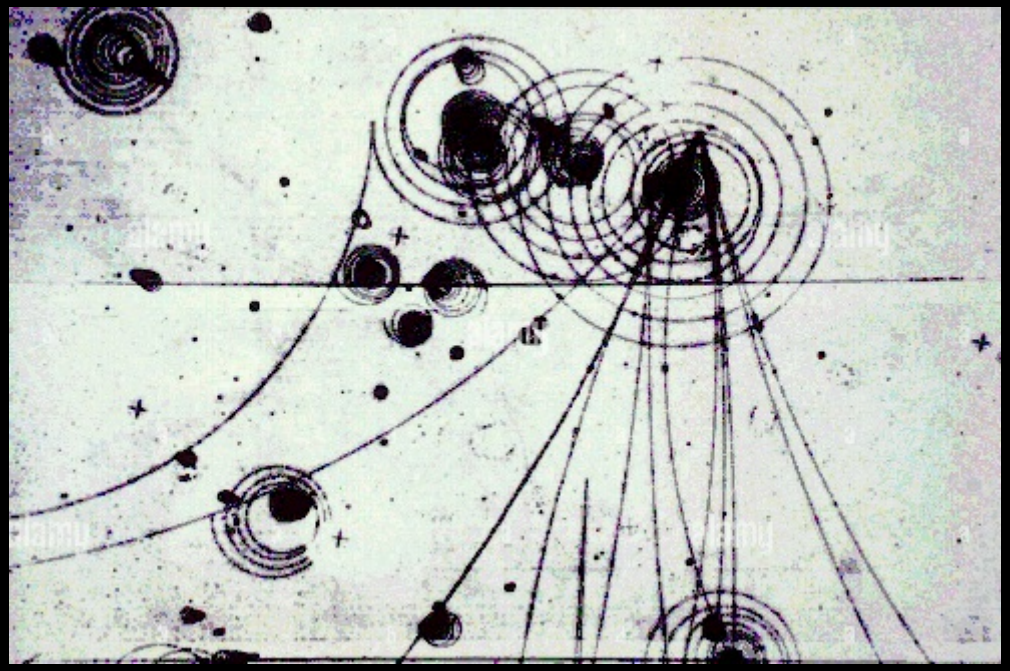
Empiricists are in general rather suspicious with respect to any kind of abstract entities like properties, classes, relations, numbers, propositions, etc. They usually feel much more in sympathy with nominalists than with realists (in the medieval sense). As far as possible they try to avoid any reference to abstract entities and to restrict themselves to what is sometimes called a nominalistic language, i. e., one not containing such references. However, within certain scientific contexts it seems hardly possible to avoid them. In the case of mathematics, some empiricists try to find a way out by treating the whole of mathematics as a mere calculus, a formal system for which no interpretation is given or can be given. Accordingly, the mathematician is said to speak not about numbers, functions, and infinite classes, but merely about meaningless symbols and formulas manipulated according to given formal rules. In physics it is more difficult to shun the suspected entities, because the language of physics serves for the communication of reports and predictions and hence cannot be taken as a mere calculus. A physicist who is suspicious of abstract entities may perhaps try to declare a certain part of the language of physics as uninterpreted and uninterpretable, that part which refers to real numbers as space-time coordinates or as values of physical magnitudes, to functions, limits, etc. More probably he will just speak about all these things like anybody else but with an uneasy conscience, like a man who in his everyday life does with qualms many things which are not in accord with the high

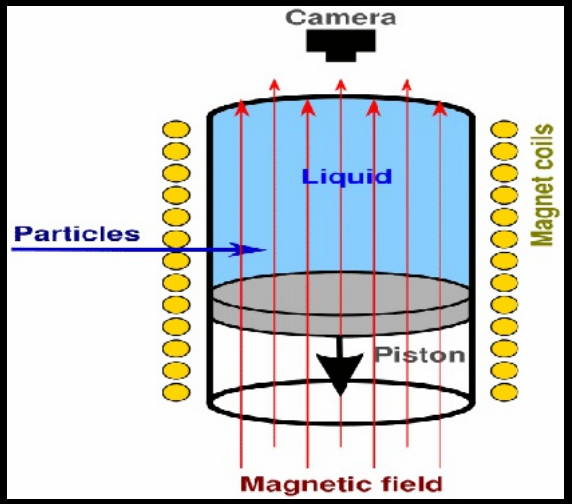
# Carl Hempel

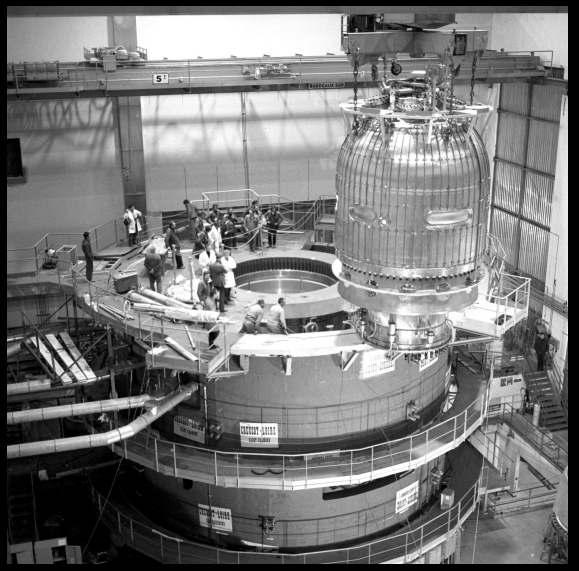



Carl Hempel (1905 - 1997 )

# Bubble Chamber

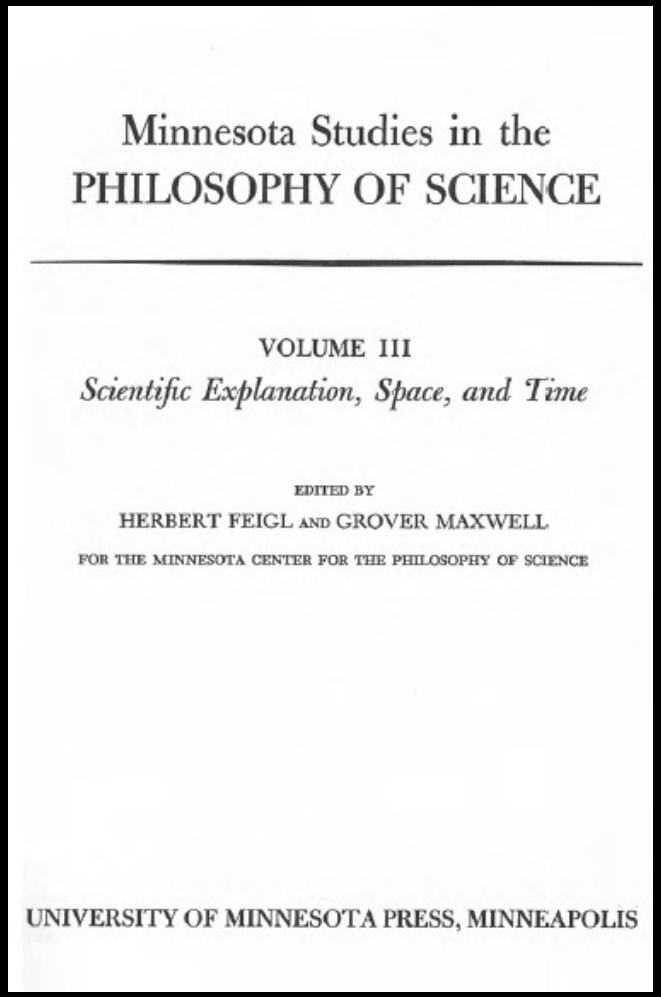




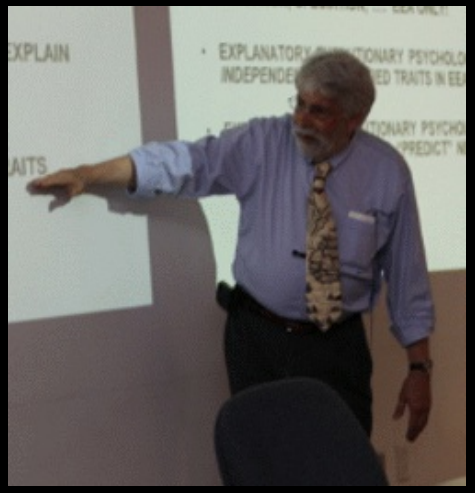



Grover Maxwell

(1918-1981)



Hilary Putnam (1926-2016)




Richard Boyd (1942-2021)

Ian Hacking (1936- )

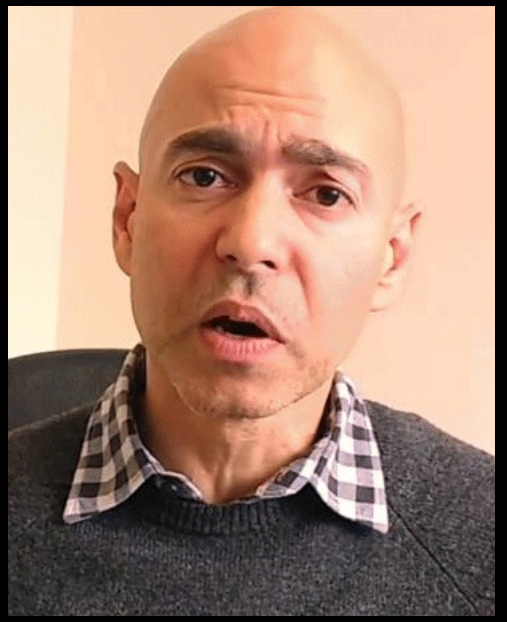
Ernan McMullin (1924-2011)

Bas van Fraassen (1941- )

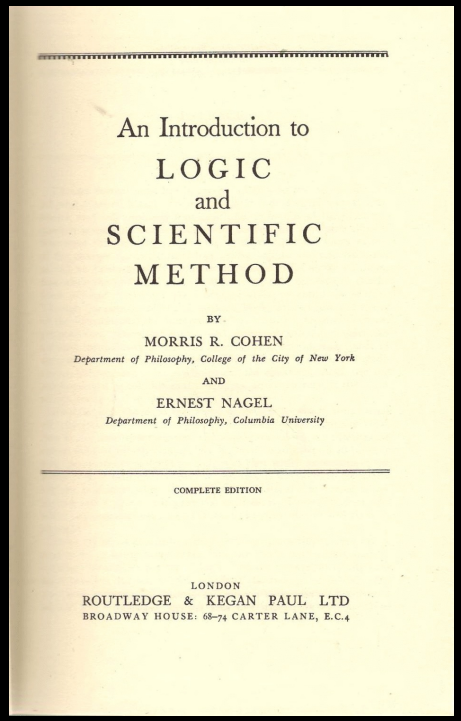
Arthur Fine (1937- )

John Worrall

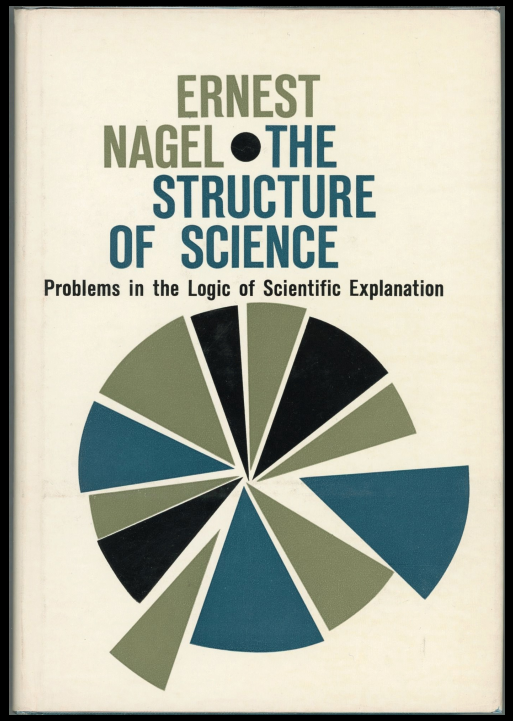
Stephen French



Anjan Chakravartty




1934




1961

Ernest Nagel (1901-1985)

# The Nicod Criterion

A hypothesis with the form of a universal conditional

$$(x)(P(x) \supset Q(x))$$

is confirmed by an observation statement of the form

$$P(a) \,\&\, Q(a)$$

and disconfirmed by an observation statement of the form

$$P(a) \,\&\, \sim Q(a).$$

But this sentence

$$(x)(\sim Q(x) \supset \sim P(x))$$

is logically equivalent to the original hypothesis and so it is confirmed by an observation report of the form

$$\sim Q(a) \,\&\, \sim P(a)$$

So non-black non-ravens confirm the hypothesis that all ravens are black.

# Hempel's Satisfaction Criterion

The development of a hypothesis H for a finite class of objects C is what H would assert if the elements of C were the only things that existed.

Thus, the development of the hypothesis (x)P(x) for the class {a,b} is the proposition: P(a) & P(b). The development of the hypothesis (x)(P(x) v Q(x)) for this same class is (P(a) v Q(a)) & (P(b) v Q(b)).

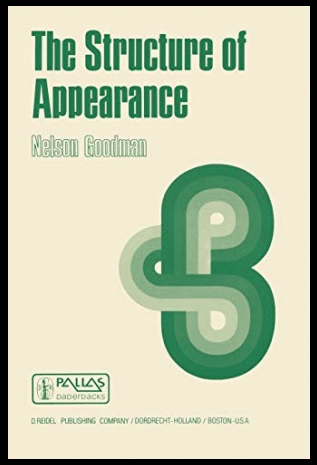
The Satisfaction Criterion:

9.1 Df. An observation report B *directly confirms* a hypothesis H if B entails the development of H for the class of objects mentioned in B.

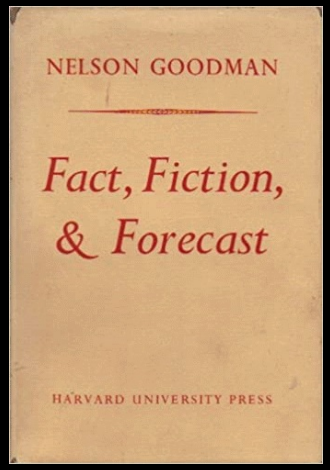
9.2 Df. An observation report B *confirms* a hypothesis H if H is entailed by a class of sentences each of which is directly confirmed by B.

9.3 Df. An observation report B *disconfirms* a hypothesis H if it confirms the denial of H.

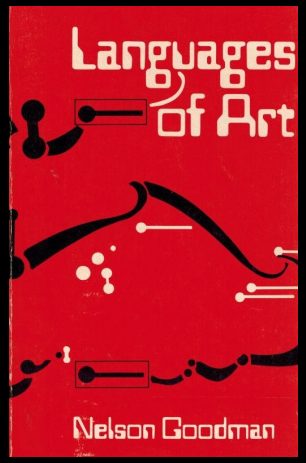
9.4 Df. An observation report B is *neutral* with respect to a hypothesis H if B neither confirms nor disconfirms H.



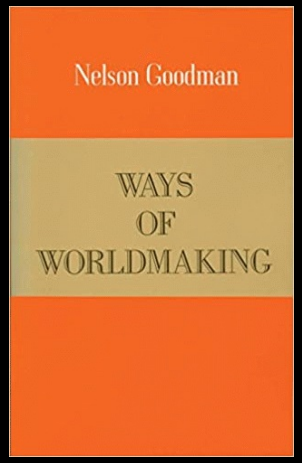

1951



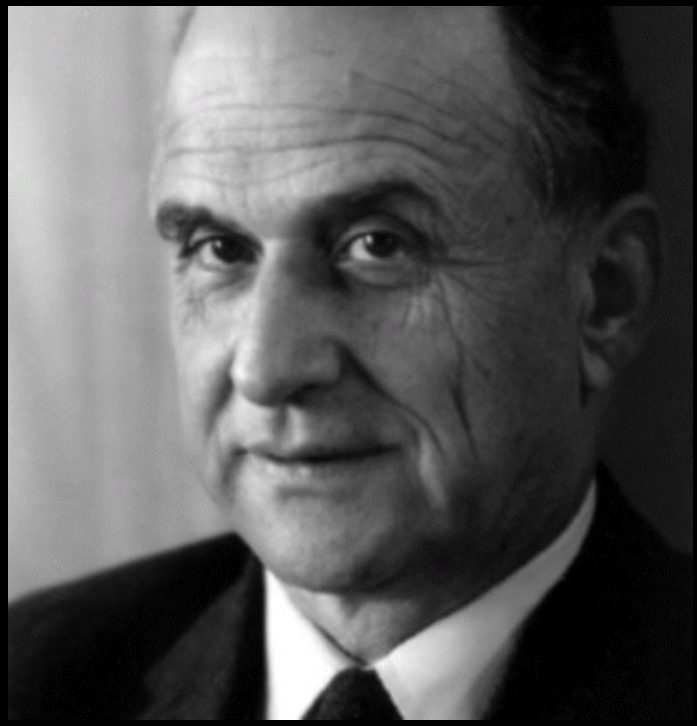

1955




1968




1978



Nelson Goodman (1906-1998)

# The New Riddle of Induction

grue $=_{df}$ observed for the first time before t and green, otherwise blue

bleen $=_{df}$ observed for the first time before t and blue, otherwise green

# The New Riddle of Induction

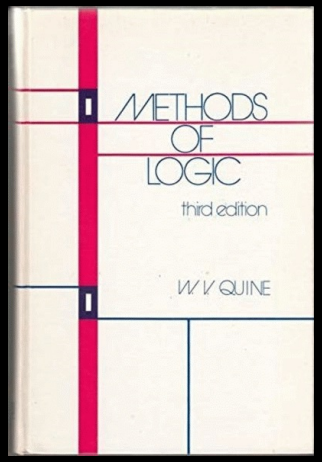
grue $=_{df}$ observed for the first time before t and green, otherwise blue

bleen $=_{df}$ observed for the first time before t and blue, otherwise green

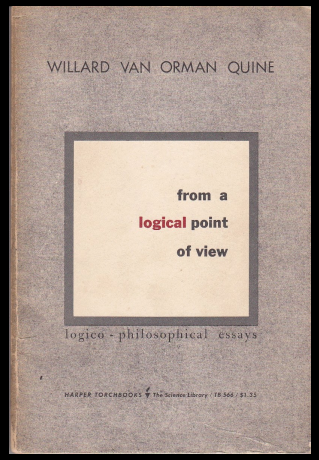
But also

blue $=_{df}$ observed for the first time before t and bleen, otherwise grue

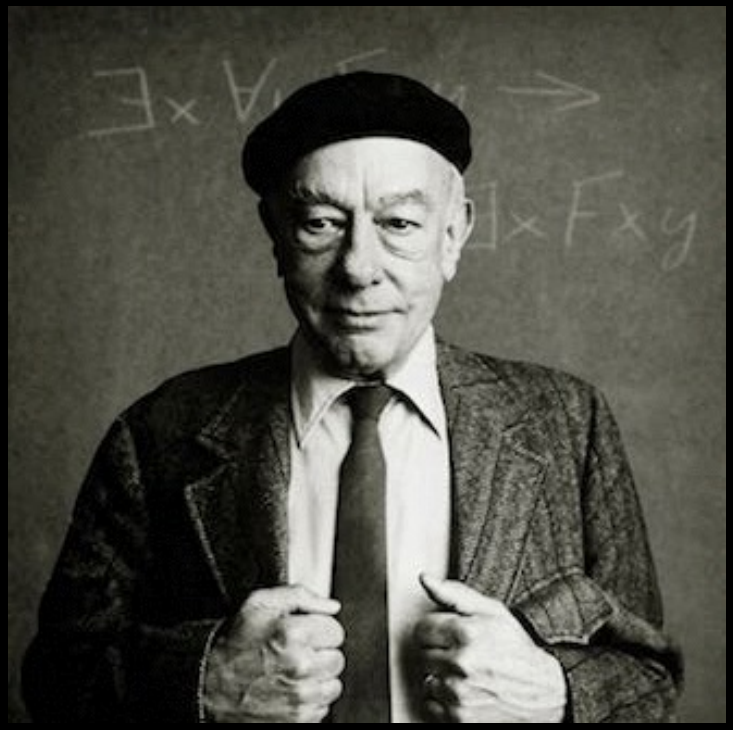
green $=_{df}$ observed for the first time before t and grue, otherwise bleen



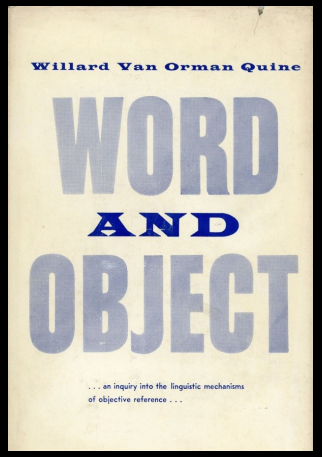

1950



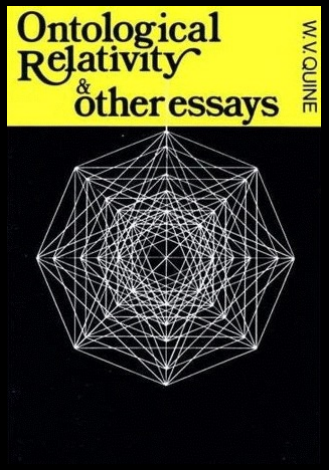

1953



W. V. O. Quine (1908-2000)



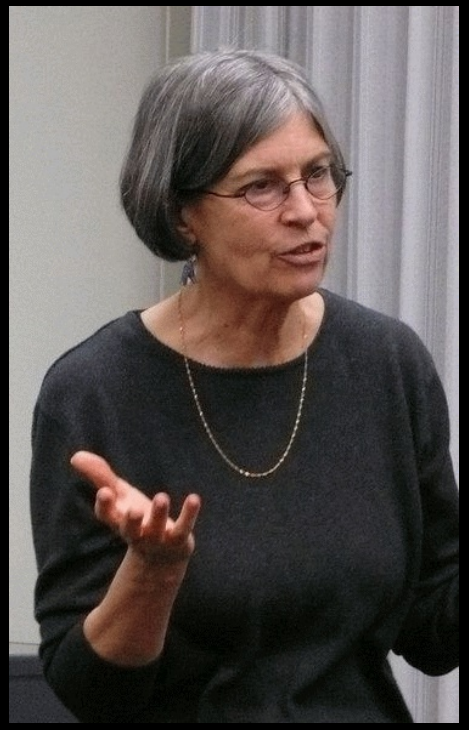

1960



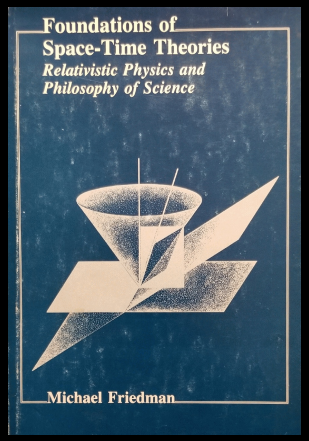

1969

Sandra Harding (1935 - )

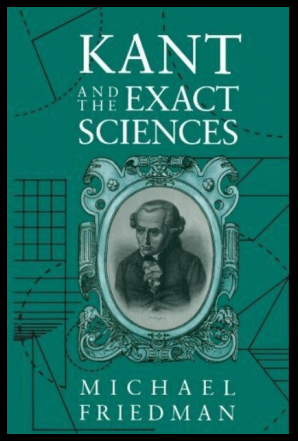
Janet Kourany (1947 - )



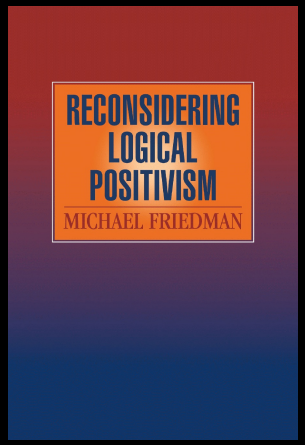
Helen Longino (1944 - )



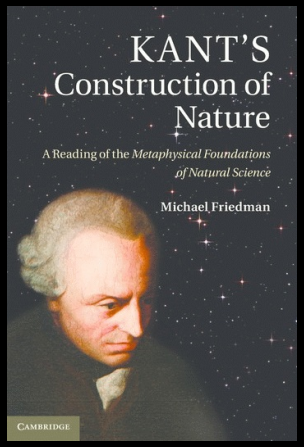

1983




1992

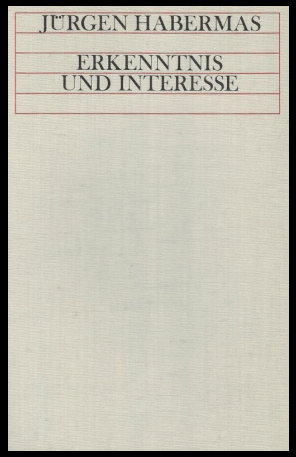



1999

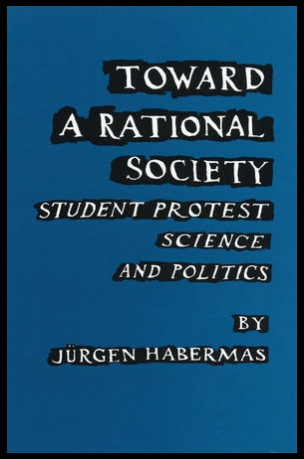



2013

Michael Friedman (1947 - )

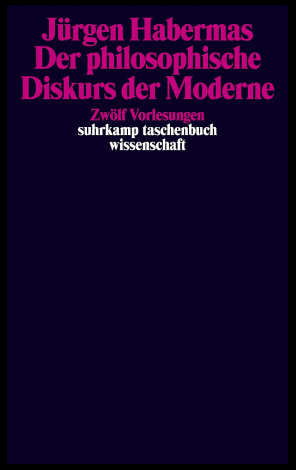



1968



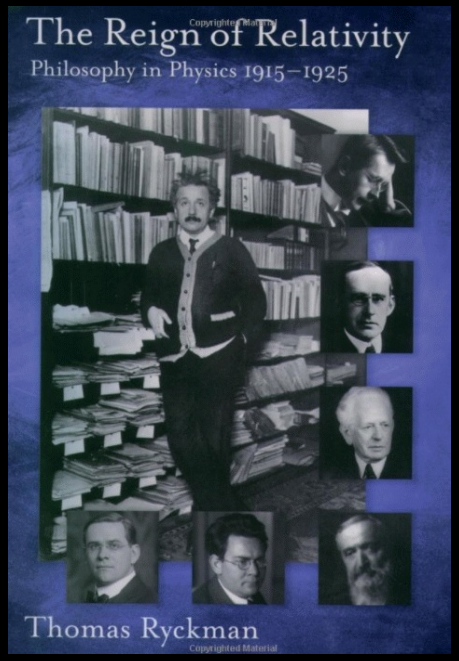

1971


1981

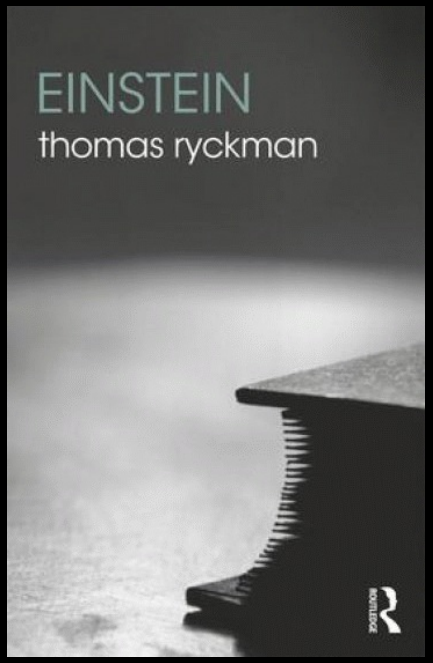



1985

Jürgen Habermas (1929 - )




2005




2017

Tom Ryckman