# B. More historical and technical details

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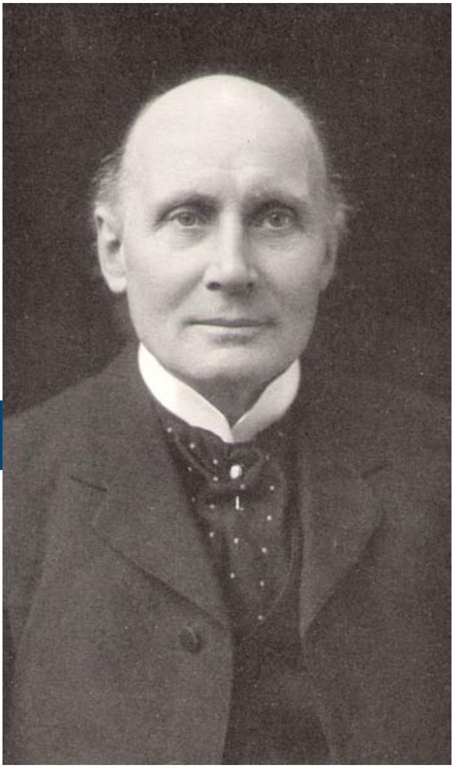
Paris, 21 oct. 2011

# Introduction



More details on Whitehead's theory of relativity

1) Historical details

==> Part 1

2) Technical details

==> Part 2

# PART ONE

Some historical details

# Whitehead's major sources

- 1908 "Space and Time" by Minkowski
- 1912 "The Space-Time Manifold of Relativity" by Wilson & Lewis (Cf. Preface of Whitehead's PNK)
- 1914 The Theory of Relativity by Silberstein (Cf. Preface of PNK)
- 1914 The Principle of Relativity + 1915 Relativity and the Electron Theory by Cunningham
- 1916 "Gravitation and the Principle of Relativity" + 1918 Report on the Relativity Theory of Gravitation + 1919 "The Total Eclipse of 29 May, 1919, ..." by Eddington
- 1916 "Space, Time, and Gravitation" + 1916-1917 set of three articles in The Monthly Notices by de Sitter
- 1918 "General Relativity without the Equivalence Hypothesis" by Silberstein

# Familiarity with Cunningham's work


- Whitehead succeeded Cunningham in 1911 at University College
- Similar training & teaching curricula
- Common interest in Thomson and Larmor's electronic theory of matter
- Popularity of Pearson's The Grammar of Science and text book status of Cunningham's The Principle of Relativity
- Whitehead and Cunningham discussed relativity, and met at BAAS meeting in September 1916

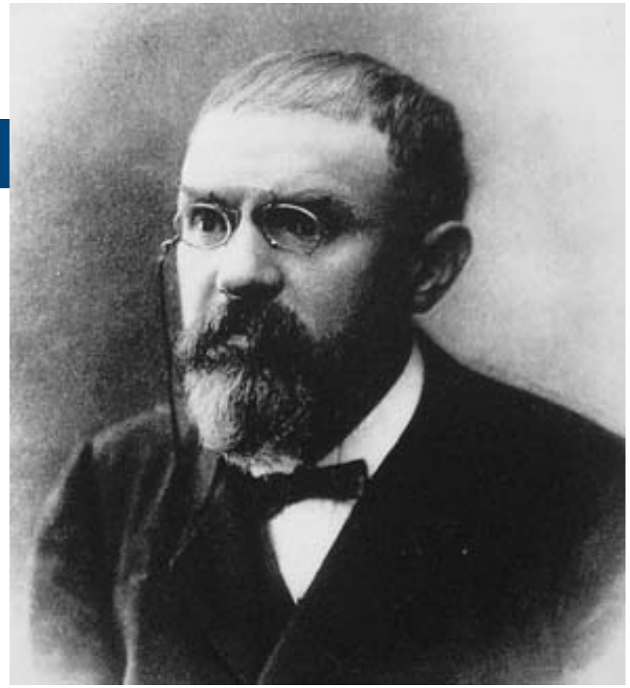
# Familiarity with Silberstein's work

- Whitehead and Silberstein were University College colleagues in 1912-1913; Silberstein's course ==> 1914 book
- Whitehead and Silberstein met at the Aristotelian Society from 1915 to 1920; other members engaged in relativity were Alexander, Broad, Carr, Haldane, Nunn
- Nunn was a common close friend
- Whitehead and Silberstein discussed relativity, and were present at the famous joint RS & RAS meeting of November 6, 1919 on the May 1919 solar eclipse observations

## Influence of Minkowski’s 1908 “Space and Time”

- union of space and time
- world-lines
- physical laws = reciprocal relations between world-lines, e.g., between electron world-lines in terms of Liénard-Wiechert potentials
- Gravitation: proposal based on analogy world-lines of point-masses and world-lines of point-charges

# Failure of special relativistic theory of graviation



- 1906 Poincaré
- 1908 Minkowski
- 1911 de Sitter
- 1914 Cunningham

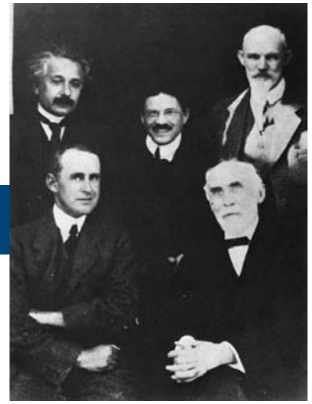
≠ correct precession of perihelion of Mercury

# Different assessment of the issue

- Minkowski in 1908: issue = minor problem
- Einstein in 1913: issue = “a hopeless undertaking” without good physical guiding principles; compare with turning electrostatics into electrodynamics when c is known, but no further experimental data
- Whitehead in 1915: “all physical influences require time ... This generalisation is a long way of being proved. Gravitation stands like a lion in the path.”

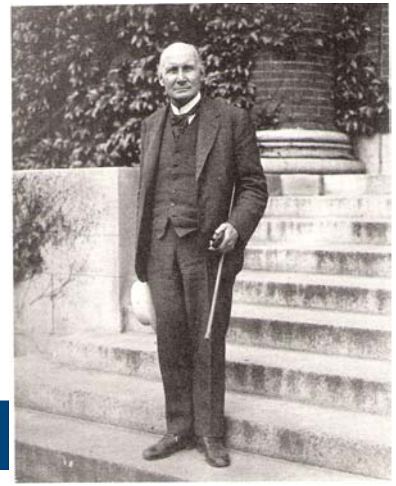
And yet: Einstein completed GTR in November 1915

# From Einstein to Whitehead despite World War One

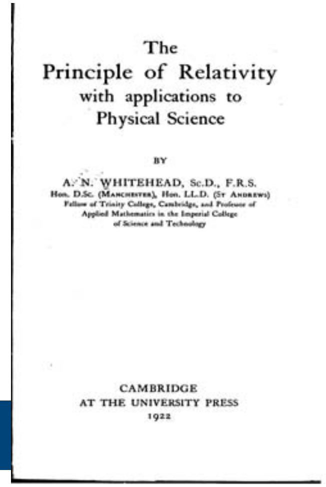


- Berlin: Einstein ==> Leiden & Switzerland
- Leiden: de Sitter ==> UK: Eddington
- Switzerland: Besso ==> UK: Silberstein
- UK: Eddington & Silberstein ==> Whitehead
  - BAAS Sept. 1916 and Eddington in Nature (premature)
  - De Sitter in Observatory and Monthly Notices (1916-1917) (anti-Machian)
  - Eddington's 1918 Report (anti-Machian)
  - Silberstein's 1918 "General Relativity without the Equivalence Hypothesis" (rejects both Mach's and Equivalence Principle) Cf. Temple
  - RS & RAS Nov. 1919 on May 1919 solar eclipse (momentous)

# Evolution of W's research



- Prin. Math. Vol. 4 ➔ How is Euclidean space rooted in experience?
- STR ➔ How is Minkowskian space-time rooted in experience? Answer: 1919 Principles of Natural Knowledge & 1920 Concept of Nature minus Chapter VIII
- GTR ➔ How to reinterprete Einstein's new law of gravitation in terms of a gravitational field against the background of Minkowski's space-time?



The
Principle of Relativity
with applications to
Physical Science

BY

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CAMBRIDGE
AT THE UNIVERSITY PRESS
1922

# How to reinterpret Einstein?

- Nov. 15, 1919, "A Revolution in Science" = orthodox (published in Nation)
- Febr. 12, 1920, "Einstein's theory" = critical & first outline of alternative theory of gravity (published in The Times)
- Spring, 1920, Chemical Society Lecture = similar to "Einstein's theory" (and published as Chapter VIII of CN)
- June 10 & 11, 1921: Whitehead-Einstein discussions at Lord Haldane's London home ...
- 1922, The Principle of Relativity = composed of Imperial College lecture courses & 1922 lectures in Edinburgh and US = detailed theory: philosophical, scientific, mathematical

# PART TWO

Whitehead’s alternative theory of gravity

# From electrostatics to electrodynamics

- Electrostatics by Poisson:

Laplace operator (scalar potential) = charge density

- Maxwell's electrodynamics by Minkowski

D'Alambert operator (4-potential) = 4-current

- Special case: point-charges, electrons

D'Alambert operator (4-potential) = 0, the wave equation

Liénard-Wiechert solution by Cunningham

4-potential = charge . 4-velocity / (4-velocity . 4-separation)

==> scalar potential = charge / (4-velocity.4-separation)
satisfies the wave equation

# From gravitostatics to Einstein

- Gravitostatics by Poisson:

Laplace operator (scalar potential) = mass density

- Einstein's gravitodynamics or GTR

Einstein tensor (10-potential) = energy-momentum tensor

==> 10-potential = fundamental tensor expressing both space-time manifold and gravitational field; "geometry is no longer an isolated self-contained science"

==> equation of motion of test mass is equation of geodesic in space-time: variation of integral of fundamental line-element = 0

(and equation of motion of light: line-element = 0)

- Special case: empty space outside source

Ricci tensor (10-potential) = 0

Solutions by Schwarzschild, resp. Kerr

for spherically symmetric, resp. rotating bodies

- Special case: weak gravitational field

Einstein tensor (10-potential) reduces to d'Alembert operator (10-potential)

# From gravitostatics to Whitehead

- Gravitostatics by Poisson:

Laplace operator (scalar potential) = mass density

- Whitehead's gravitodynamics for discrete masses

D'Alembert operator (scalar potential) = 0, the gravitational wave equation

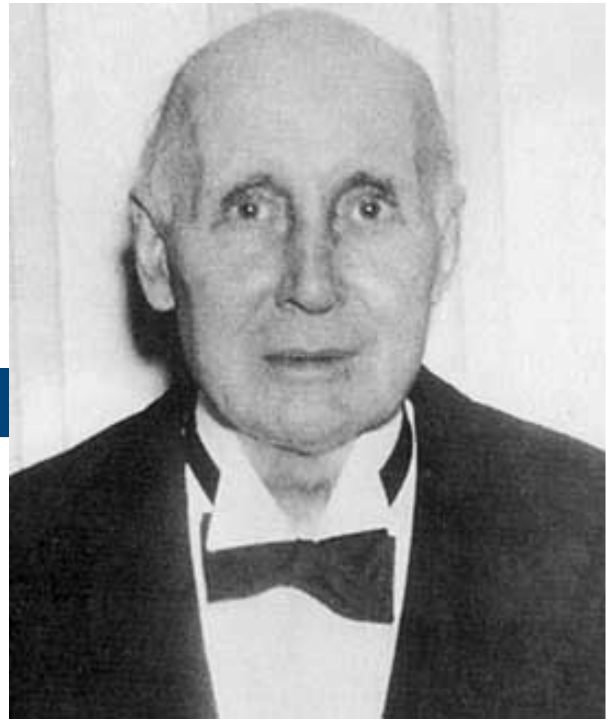
==> unique* Lorentz invariant scalar potential = mass / (4-velocity$_i$ . 4-separation$_i$)

==> impetus tensor = gravitational field in terms of the scalar potential ≠ Minkowskian space-time background; "the old division between physics and geometry"

==> equation of motion of test mass by zero variation of action-integral: variation of integral of impetus-element = 0 (and of light: impetus-element = 0)

- Schwarzschild solution by Eddington (1924)
- Kerr solution in terms of other* scalar potential by Russell & Wasserman (1996)
- Extended to constantly curved space-time backgrounds by Temple (1923)
- Extended to continuous, non-static mass distribution (relevant for cosmology) by Rainer (1954)
- "On the multiple deaths of W's theory of gravity" by Gibbons & Will (2008)

# Questions



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