Reichenbach and the Unified Field Theory Program

An Overview

marco.giovanelli@unito.it

Cambridge Reading Group

UNIVERSITÀ
DEGLI STUDI
DI TORINO

Introduction

- according to his later recollections, Einstein (1949, 73-75) had always considered his 1915 **field theory of gravitation** as nothing but a stepping stone toward a ‘unified field theory’
- most of Einstein’s published work from 1919 (Einstein 1919) until his death in 1955 (Einstein and Kaufman 1955) is dominated by the search for a **unified field theory**
- Reichenbach mostly famous for his work on both **theories of relativity**
- Reichenbach was possibly the only philosopher who able to find his bearings within the intricacies of the various **attempts at a unified field theory**

- Reichenbach as a staunch **defender** of relativity theory
- Reichenbach’s as an indefatigable **attacker** of the unified field theory-project.

Introduction

- according to his later recollections, Einstein (1949, 73-75) had always considered his 1915 **field theory of gravitation** as nothing but a stepping stone toward a ‘unified field theory’
- most of Einstein’s published work from 1919 (Einstein 1919) until his death in 1955 (Einstein and Kaufman 1955) is dominated by the search for a **unified field theory**
- Reichenbach mostly famous for his work on both **theories of relativity**
- Reichenbach was possibly the only philosopher who able to find his bearings within the intricacies of the various **attempts at a unified field theory**

- Reichenbach as a staunch **defender** of relativity theory
- Reichenbach’s as an indefatigable **attacker** of the unified field theory-project.

Introduction

- according to his later recollections, Einstein (1949, 73-75) had always considered his 1915 **field theory of gravitation** as nothing but a stepping stone toward a ‘unified field theory’
- most of Einstein’s published work from 1919 (Einstein 1919) until his death in 1955 (Einstein and Kaufman 1955) is dominated by the search for a **unified field theory**
- Reichenbach mostly famous for his work on both **theories of relativity**
- Reichenbach was possibly the only philosopher who able to find his bearings within the intricacies of the various **attempts at a unified field theory**

- Reichenbach as a staunch **defender** of relativity theory
- Reichenbach’s as an indefatigable **attacker** of the unified field theory-project.

Introduction

- according to his later recollections, Einstein (1949, 73-75) had always considered his 1915 **field theory of gravitation** as nothing but a stepping stone toward a ‘unified field theory’
- most of Einstein’s published work from 1919 (Einstein 1919) until his death in 1955 (Einstein and Kaufman 1955) is dominated by the search for a **unified field theory**
- Reichenbach mostly famous for his work on both **theories of relativity**
- Reichenbach was possibly the only philosopher who able to find his bearings within the intricacies of the various **attempts at a unified field theory**

- Reichenbach as a staunch **defender** of relativity theory
- Reichenbach’s as an indefatigable **attacker** of the unified field theory-project.

Introduction

- according to his later recollections, Einstein (1949, 73-75) had always considered his 1915 **field theory of gravitation** as nothing but a stepping stone toward a ‘unified field theory’
- most of Einstein’s published work from 1919 (Einstein 1919) until his death in 1955 (Einstein and Kaufman 1955) is dominated by the search for a **unified field theory**
- Reichenbach mostly famous for his work on both **theories of relativity**
- Reichenbach was possibly the only philosopher who able to find his bearings within the intricacies of the various **attempts at a unified field theory**

- Reichenbach as a staunch **defender** of relativity theory
- Reichenbach’s as an indefatigable **attacker** of the unified field theory-project.

Introduction

- according to his later recollections, Einstein (1949, 73-75) had always considered his 1915 **field theory of gravitation** as nothing but a stepping stone toward a ‘unified field theory’
- most of Einstein’s published work from 1919 (Einstein 1919) until his death in 1955 (Einstein and Kaufman 1955) is dominated by the search for a **unified field theory**
- Reichenbach mostly famous for his work on both **theories of relativity**
- Reichenbach was possibly the only philosopher who able to find his bearings within the intricacies of the various **attempts at a unified field theory**

- Reichenbach as a staunch **defender** of relativity theory
- Reichenbach’s as an indefatigable **attacker** of the unified field theory-project.

Introduction

- according to his later recollections, Einstein (1949, 73-75) had always considered his 1915 **field theory of gravitation** as nothing but a stepping stone toward a ‘unified field theory’
- most of Einstein’s published work from 1919 (Einstein 1919) until his death in 1955 (Einstein and Kaufman 1955) is dominated by the search for a **unified field theory**
- Reichenbach mostly famous for his work on both **theories of relativity**
- Reichenbach was possibly the only philosopher who able to find his bearings within the intricacies of the various **attempts at a unified field theory**

- Reichenbach as a staunch **defender** of relativity theory
- Reichenbach’s as an indefatigable **attacker** of the unified field theory-project.

Introduction

- The **Reichenbach-Weyl** Correspondence (1920-1922)
  - coordination
- The **Reichenbach-Einstein** Correspondence (1926-1927)
  - geometrization
- The **Reichenbach-Einstein** Correspondence (1928-1929)
  - unification

> The general theory of relativity by no means turns physics into mathematics. Quite the opposite: it brings about the recognition of a physical problem of geometry
>
> *(Reichenbach 1929c, 11)*

Introduction

- The **Reichenbach-Weyl** Correspondence (1920-1922)
  - coordination
- The **Reichenbach-Einstein** Correspondence (1926-1927)
  - geometrization
- The **Reichenbach-Einstein** Correspondence (1928-1929)
  - unification

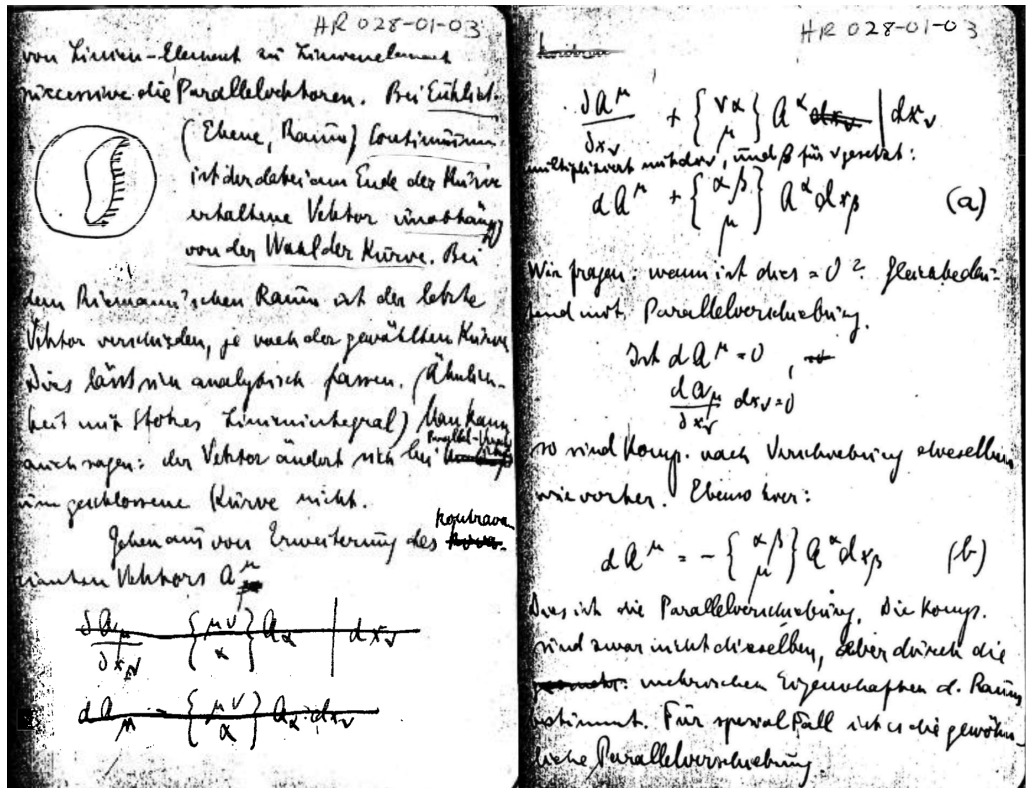
> The general theory of relativity by no means turns physics into mathematics. Quite the opposite: it brings about the recognition of a physical problem of geometry

(Reichenbach 1929c, 11)

Part I

The Reichenbach-Weyl Correspondence (1920-1922)

The Reichenbach-Weyl Correspondence (1920-1922)



Reichenbach's student notes. Einstein introduces the notion of parallel transport of vectors

The Reichenbach-Weyl Correspondence (1920-1922)

- Reichenbach accused Weyl of attempting a **reduction of physical reality to ‘geometrical necessity’** (Reichenbach 1920, 73);
- Reichenbach considered the greatest achievement of general relativity the **separation of geometrical necessity and physical reality**

spacetime geometry is in itself neither true nor false, it acquires a physical meaning only when it is **coordinated** with the behavior of physical probes, like rods and clocks.

The Reichenbach-Weyl Correspondence (1920-1922)

- Reichenbach accused Weyl of attempting a **reduction of physical reality to ‘geometrical necessity’** (Reichenbach 1920, 73);
- Reichenbach considered the greatest achievement of general relativity the **separation of geometrical necessity and physical reality**

spacetime geometry is in itself neither true nor false, it acquires a physical meaning only when it is **coordinated** with the behavior of physical probes, like rods and clocks.

The Reichenbach-Weyl Correspondence (1920-1922)

- Reichenbach accused Weyl of attempting a **reduction of physical reality to ‘geometrical necessity’** (Reichenbach 1920, 73);
- Reichenbach considered the greatest achievement of general relativity the **separation of geometrical necessity and physical reality**

spacetime geometry is in itself neither true nor false, it acquires a physical meaning only when it is **coordinated** with the behavior of physical probes, like rods and clocks.

The Reichenbach-Weyl Correspondence (1920-1922)

- Reichenbach accused Weyl of attempting a **reduction of physical reality to 'geometrical necessity'** (Reichenbach 1920, 73);
- Reichenbach considered the greatest achievement of general relativity the **separation of geometrical necessity and physical reality**

spacetime geometry is in itself neither true nor false, it acquires a physical meaning only when it is **coordinated** with the behavior of physical probes, like rods and clocks.

The Reichenbach-Weyl Correspondence (1920-1922)

- **Weyl's defense** (1921): spacetime geometry has nothing to do with the behavior of physical measuring devices;
- **Reichenbach's objection**: Weyl's theory became overly formal and lost its persuasive power (Reichenbach 1922, 367).

The Reichenbach-Weyl Correspondence (1920-1922)

- **Weyl's defense** (1921): spacetime geometry has nothing to do with the behavior of physical measuring devices;
- **Reichenbach's objection**: Weyl's theory became overly formal and lost its persuasive power (Reichenbach 1922, 367).

Part II

The Reichenbach-Einstein Correspondence (1926-1927)

The Reichenbach-Einstein Correspondence (1926-1927)

- by the end of 1922, **Einstein's pursuit of the unification program**, Eddington's approach (Einstein 1923);
- Reichenbach became convinced that, despite the initial failure of Weyl's approach, **Weyl's style of doing physics was prevailing**.

Physicists were convinced that after the **geometrization** of the gravitational field, further physical insight could be obtained by geometrizing the electromagnetic field;

The Reichenbach-Einstein Correspondence (1926-1927)

- by the end of 1922, **Einstein's pursuit of the unification program**, Eddington's approach (Einstein 1923);
- Reichenbach became convinced that, despite the initial failure of Weyl's approach, **Weyl's style of doing physics was prevailing**.

Physicists were convinced that after the **geometrization** of the gravitational field, further physical insight could be obtained by geometrizing the electromagnetic field;

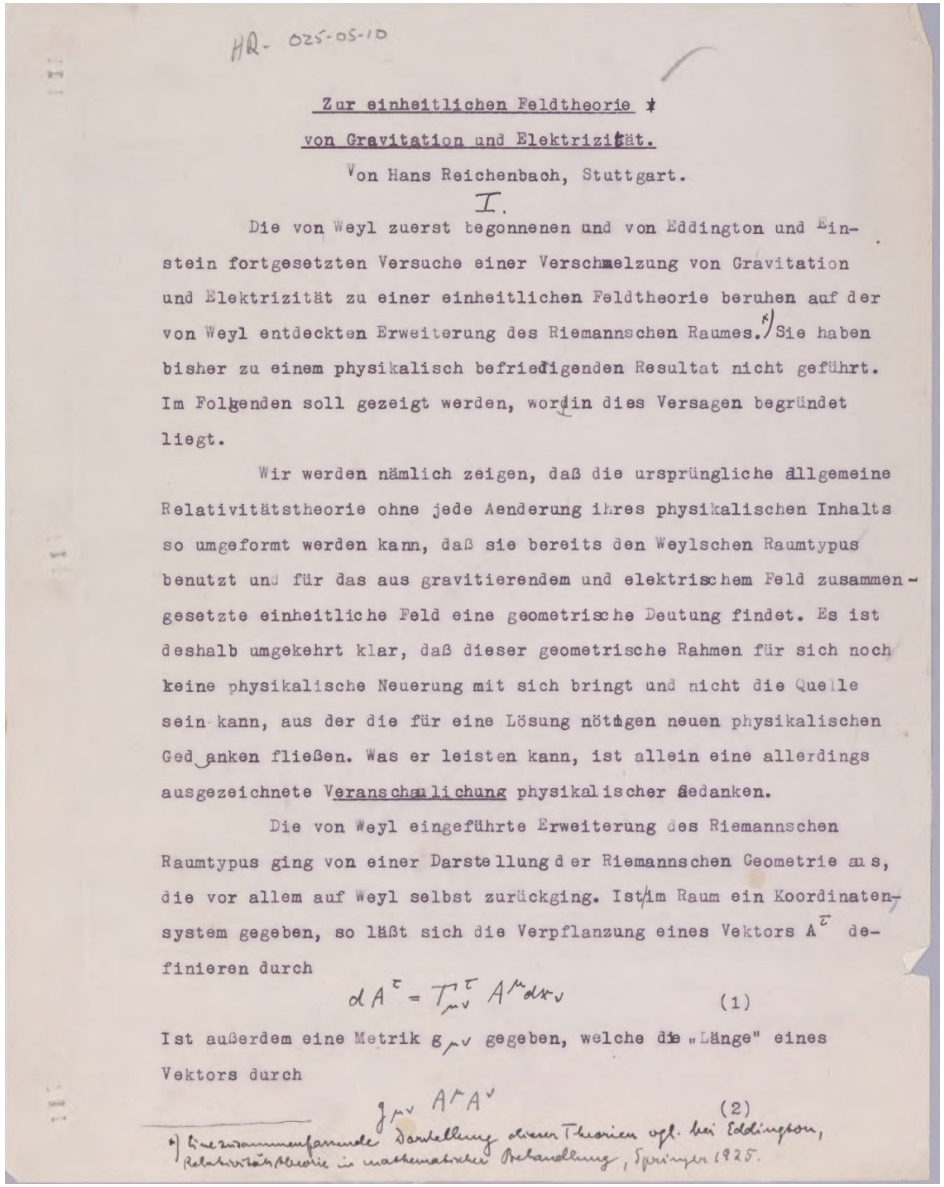
The Reichenbach-Einstein Correspondence (1926-1927)

- March 1925: started to work on a **two-volume book** with the ambitious title *Philosophie der exakten Naturerkenntnis*.
- March 1926: Reichenbach sent Einstein a **10-page 'note'**(Reichenbach 1926);

The Reichenbach-Einstein Correspondence (1926-1927)

- March 1925: started to work on a **two-volume book** with the ambitious title *Philosophie der exakten Naturerkenntnis*.
- March 1926: Reichenbach sent Einstein a **10-page ‘note’**(Reichenbach 1926);

The Reichenbach-Einstein Correspondence (1926-1927)



HQ- 025-05-10

Zur einheitlichen Feldtheorie *
von Gravitation und Elektrizität.

Von Hans Reichenbach, Stuttgart.

I.

Die von Weyl zuerst begonnenen und von Eddington und Einstein fortgesetzten Versuche einer Verschmelzung von Gravitation und Elektrizität zu einer einheitlichen Feldtheorie beruhen auf der von Weyl entdeckten Erweiterung des Riemannschen Raumes.*) Sie haben bisher zu einem physikalisch befriedigenden Resultat nicht geführt. Im Folgenden soll gezeigt werden, worin dies Versagen begründet liegt.

Wir werden nämlich zeigen, daß die ursprüngliche allgemeine Relativitätstheorie ohne jede Aenderung ihres physikalischen Inhalts so umgeformt werden kann, daß sie bereits den Weylschen Raumtypus benutzt und für das aus gravitierendem und elektrischem Feld zusammengesetzte einheitliche Feld eine geometrische Deutung findet. Es ist deshalb umgekehrt klar, daß dieser geometrische Rahmen für sich noch keine physikalische Neuerung mit sich bringt und nicht die Quelle sein kann, aus der die für eine Lösung nötigen neuen physikalischen Gedanken fließen. Was er leisten kann, ist allein eine allerdings ausgezeichnete Veranschaulichung physikalischer Gedanken.

Die von Weyl eingeführte Erweiterung des Riemannschen Raumtypus ging von einer Darstellung der Riemannschen Geometrie aus, die vor allem auf Weyl selbst zurückging. Ist im Raum ein Koordinatensystem gegeben, so läßt sich die Verpflanzung eines Vektors A^τ definieren durch

$$dA^\tau = \Gamma^\tau_{\mu\nu} A^\mu dx_\nu \qquad (1)$$

Ist außerdem eine Metrik $g_{\mu\nu}$ gegeben, welche die „Länge" eines Vektors durch

$$g_{\mu\nu} A^\mu A^\nu \qquad (2)$$

*) Eine zusammenfassende Darstellung dieser Theorien vgl. bei Eddington, Relativitätstheorie in mathematischer Behandlung, Springer 1925.

Reichenbach's note on the geometrization of the electromagnetic field

The Reichenbach-Einstein Correspondence (1926-1927)

- in the note, Reichenbach constructed a toy unification of the gravitational and electricity in a single geometrical framework, thereby showing that the **‘geometrization’ of a physical field** was a mathematical trickery rather than a physical achievement. After a back and forth, Einstein seemed to agree (Lehmkuhl 2014);
- the note was later included as section §49 in a lengthy technical Appendix to the *Philosophie der Raum-Zeit-Lehre* (Reichenbach 1928a, SS46-50) in which general relativity was presented as a **‘physicalization of geometry’** rather than a ‘*geometrizaton* of gravitation’ (Giovanelli 2021).

The Reichenbach-Einstein Correspondence (1926-1927)

- in the note, Reichenbach constructed a toy unification of the gravitational and electricity in a single geometrical framework, thereby showing that the **'geometrization' of a physical field** was a mathematical trickery rather than a physical achievement. After a back and forth, Einstein seemed to agree (Lehmkuhl 2014);
- the note was later included as section §49 in a lengthy technical Appendix to the *Philosophie der Raum-Zeit-Lehre* (Reichenbach 1928a, SS46-50) in which general relativity was presented as a **'physicalization of geometry'** rather than a '*geometrizaton* of gravitation' (Giovanelli 2021).

Part III

The Reichenbach-Einstein Correspondence (1928-1929)

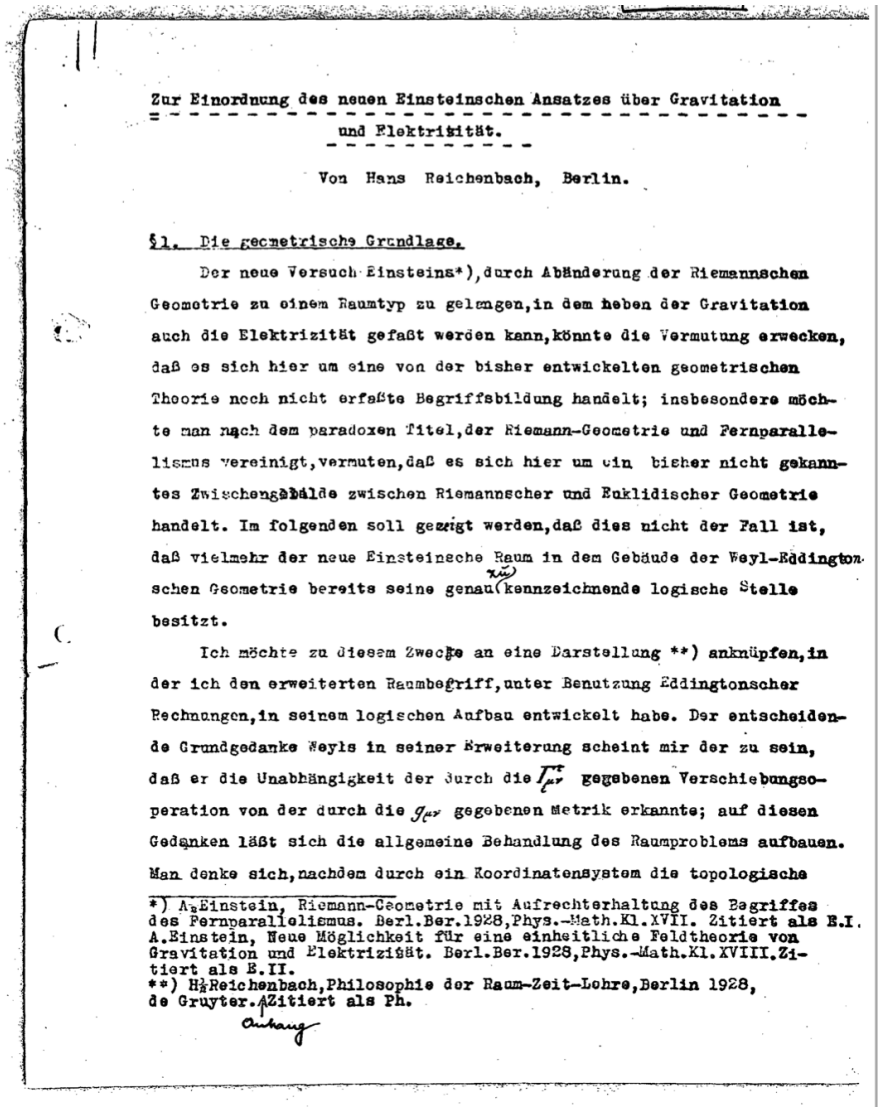
The Reichenbach-Einstein Correspondence (1928-1929)

- A few months after the publication of the *Philosophie der Raum-Zeit-Lehre* (Reichenbach 1928a), Einstein (1928a,b) launched yet another attempt at a unified field theory, the so-called ***Fernparallelismus*-field theory.**
- Reichenbach sent him once again a **manuscript** with some comments (Reichenbach 1928b) and discussed the new theory in person with Einstein.

The Reichenbach-Einstein Correspondence (1928-1929)

- A few months after the publication of the *Philosophie der Raum-Zeit-Lehre* (Reichenbach 1928a), Einstein (1928a,b) launched yet another attempt at a unified field theory, the so-called ***Fernparallelismus*-field theory.**
- Reichenbach sent him once again a **manuscript** with some comments (Reichenbach 1928b) and discussed the new theory in person with Einstein.

The Reichenbach-Einstein Correspondence (1928-1929)



Zur Einordnung des neuen Einsteinschen Ansatzes über Gravitation und Elektrizität.

Von Hans Reichenbach, Berlin.

§1. Die geometrische Grundlage.

Der neue Versuch Einsteins*), durch Abänderung der Riemannschen Geometrie zu einem Raumtyp zu gelangen, in dem neben der Gravitation auch die Elektrizität gefaßt werden kann, könnte die Vermutung erwecken, daß es sich hier um eine von der bisher entwickelten geometrischen Theorie noch nicht erfaßte Begriffsbildung handelt; insbesondere möchte man nach dem paradoxen Titel, der Riemann-Geometrie und Fernparallelismus vereinigt, vermuten, daß es sich hier um ein bisher nicht gekanntes Zwischengebilde zwischen Riemannscher und Euklidischer Geometrie handelt. Im folgenden soll gezeigt werden, daß dies nicht der Fall ist, daß vielmehr der neue Einsteinsche Raum in dem Gebäude der Weyl-Eddingtonschen Geometrie bereits seine genau kennzeichnende logische Stelle besitzt.

Ich möchte zu diesem Zwecke an eine Darstellung **) anknüpfen, in der ich den erweiterten Raumbegriff, unter Benutzung Eddingtonscher Rechnungen, in seinem logischen Aufbau entwickelt habe. Der entscheidende Grundgedanke Weyls in seiner Erweiterung scheint mir der zu sein, daß er die Unabhängigkeit der durch die $\Gamma^{\sigma}_{\mu\nu}$ gegebenen Verschiebungsoperation von der durch die $g_{\mu\nu}$ gegebenen Metrik erkannte; auf diesen Gedanken läßt sich die allgemeine Behandlung des Raumproblems aufbauen. Man denke sich, nachdem durch ein Koordinatensystem die topologische

*) A. Einstein, Riemann-Geometrie mit Aufrechterhaltung des Begriffes des Fernparallelismus. Berl.Ber.1928, Phys.-Math.Kl. XVII. Zitiert als E.I.
A.Einstein, Neue Möglichkeit für eine einheitliche Feldtheorie von Gravitation und Elektrizität. Berl.Ber.1928, Phys.-Math.Kl. XVIII. Zitiert als E.II.
**) H. Reichenbach, Philosophie der Raum-Zeit-Lehre, Berlin 1928, de Gruyter. Zitiert als Ph.

Anhang

First page of Reichenbach's manuscript (Reichenbach 1928b)

The Reichenbach-Einstein Correspondence (1928-1929)

-
  - to relinquish the coordination of geometrical notion of parallel transport of vectors with the behavior rods and clocks—and then to use the geometrical variables **calculation device**.
  - Reichenbach (1929a,b,d) came to realize that, in Einstein's mind, the actual goal of the unified field theory-project was not the geometrization, but the ***unification* of two different fields**.

the history of the unified field theory as the progressive *decline* of the geometrization program and the concurrent *ascent* of the **unification** program

The Reichenbach-Einstein Correspondence (1928-1929)

- to relinquish the coordination of geometrical notion of parallel transport of vectors with the behavior rods and clocks—and then to use the geometrical variables **calculation device**.
- Reichenbach (1929a,b,d) came to realize that, in Einstein's mind, the actual goal of the unified field theory-project was not the geometrization, but the ***unification* of two different fields**.

the history of the unified field theory as the progressive *decline* of the geometrization program and the concurrent *ascent* of the **unification** program

The Reichenbach-Einstein Correspondence (1928-1929)

- to relinquish the coordination of geometrical notion of parallel transport of vectors with the behavior rods and clocks—and then to use the geometrical variables **calculation device**.
- Reichenbach (1929a,b,d) came to realize that, in Einstein's mind, the actual goal of the unified field theory-project was not the geometrization, but the ***unification* of two different fields**.

the history of the unified field theory as the progressive *decline* of the geometrization program and the concurrent *ascent* of the **unification** program

The Reichenbach-Einstein Correspondence (1928-1929)

- to relinquish the coordination of geometrical notion of parallel transport of vectors with the behavior rods and clocks—and then to use the geometrical variables **calculation device**.
- Reichenbach (1929a,b,d) came to realize that, in Einstein's mind, the actual goal of the unified field theory-project was not the geometrization, but the ***unification* of two different fields**.

the history of the unified field theory as the progressive *decline* of the geometrization program and the concurrent *ascent* of the **unification** program

The Reichenbach-Einstein Correspondence (1928-1929)

- to relinquish the coordination of geometrical notion of parallel transport of vectors with the behavior rods and clocks—and then to use the geometrical variables **calculation device**.
- Reichenbach (1929a,b,d) came to realize that, in Einstein's mind, the actual goal of the unified field theory-project was not the geometrization, but the ***unification* of two different fields**.

the history of the unified field theory as the progressive *decline* of the geometrization program and the concurrent *ascent* of the **unification** program

Conclusion

- Einstein was willing to embrace a **speculative approach to physics** (Dongen 2010): heuristic of mathematical simplicity
- as early as in his habilitation, Reichenbach considered the great achievement of relativity theory the **separation of mathematical necessity and physical reality**.
- in the search for a unified field theory, Einstein had come close to a plea for a **reduction of physical reality to mathematical necessity**.

> ... even God *could not have established these connections otherwise* than they actually are, just as little as it would have been in his power to make the number 4 a prime number
>
> *(Einstein 1929, 127)*

Conclusion

- Einstein was willing to embrace a **speculative approach to physics** (Dongen 2010): heuristic of mathematical simplicity
- as early as in his habilitation, Reichenbach considered the great achievement of relativity theory the **separation of mathematical necessity and physical reality**.
- in the search for a unified field theory, Einstein had come close to a plea for a **reduction of physical reality to mathematical necessity**.

> ... even God *could not have established these connections otherwise* than they actually are, just as little as it would have been in his power to make the number 4 a prime number
>
> *(Einstein 1929, 127)*

Conclusion

- Einstein was willing to embrace a **speculative approach to physics** (Dongen 2010): heuristic of mathematical simplicity
- as early as in his habilitation, Reichenbach considered the great achievement of relativity theory the **separation of mathematical necessity and physical reality**.
- in the search for a unified field theory, Einstein had come close to a plea for a **reduction of physical reality to mathematical necessity**.

> ... even God *could not have established these connections otherwise* than they actually are, just as little as it would have been in his power to make the number 4 a prime number
>
> *(Einstein 1929, 127)*

Conclusion

- Einstein was willing to embrace a **speculative approach to physics** (Dongen 2010): heuristic of mathematical simplicity
- as early as in his habilitation, Reichenbach considered the great achievement of relativity theory the **separation of mathematical necessity and physical reality**.
- in the search for a unified field theory, Einstein had come close to a plea for a **reduction of physical reality to mathematical necessity**.

> ... even God *could not have established these connections otherwise* than they actually are, just as little as it would have been in his power to make the number 4 a prime number
>
> *(Einstein 1929, 127)*

Conclusion

- Einstein was willing to embrace a **speculative approach to physics** (Dongen 2010): heuristic of mathematical simplicity
- as early as in his habilitation, Reichenbach considered the great achievement of relativity theory the **separation of mathematical necessity and physical reality**.
- in the search for a unified field theory, Einstein had come close to a plea for a **reduction of physical reality to mathematical necessity**.

> ... even God *could not have established these connections otherwise* than they actually are, just as little as it would have been in his power to make the number 4 a prime number

(Einstein 1929, 127)

Thanks!

Marco Giovanelli

Università degli Studi di Torino
Dipartimento di Filosofia e Scienze dell’Educazione

marco.giovanelli@unito.it