678th Wilhelm and Else Heraeus Seminar
Hundred Years Of Gauge Theory,
Bad Honnef 30 July- 3 August 2018

Weyl's *Raum-Zeit-Materie* and the Philosophy of Science

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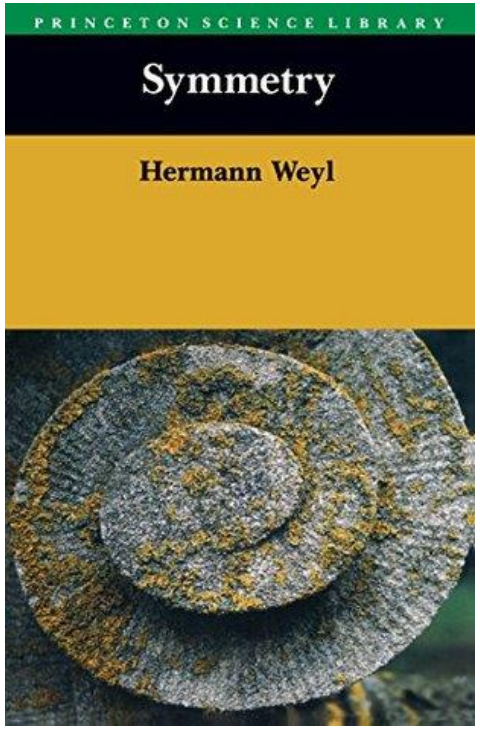
«Symmetry is a vast subject, significant in art and nature. Mathematics lies at its root, and it would be hard to find a better one on which to demonstrate the working of the mathematical intellect».

H. Weyl, Symmetry 1952, p. 145



Philosophy, Mathematics and Physics

“At the same time it was my wish to present this great subject as an illustration of the intermingling of philosophical, mathematical, and physical thought, a study which is dear to my heart. This could be done only by building up the theory systematically from the foundations, and by restricting attention throughout to the principles. But I have not been able to satisfy these self-imposed requirements: the mathematician predominates at the expense of the philosopher”.

(R-Z-M, Preface to the first edition)

Outline

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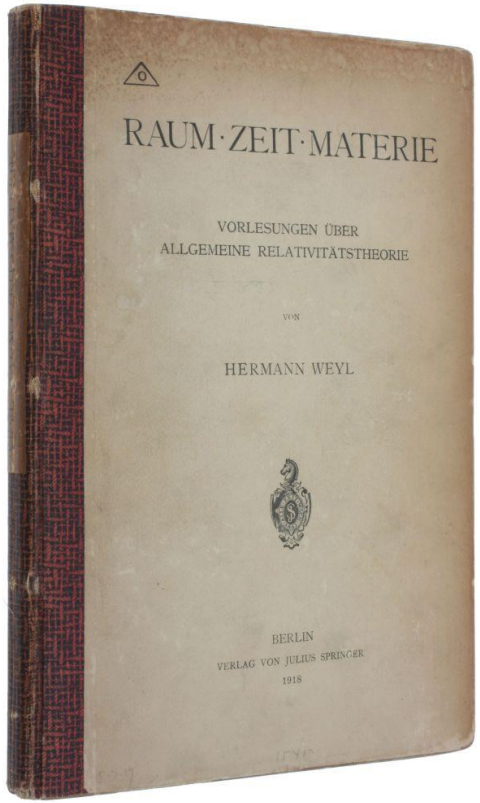
Part II: Hermann Weyl and the Philosophy of Science

Part III: Current and Future Perspectives



PART I

Philosophy in *Raum-Zeit-Materie*

Philosophy in R-Z-M

"Einstein's Theory of Relativity has advanced our ideas of the structure of the cosmos a step further. It is as if a wall which separated us from Truth has collapsed. Wider expanses and greater depths are now exposed to the searching eye of knowledge, regions of which we had not even a presentiment. It has brought us much nearer to grasping the plan that underlies all **physical happening (*physischen Weltgeschehen*)"**.

(R-Z-M Preface to the first edition)

Philosophy in R-Z-M

"Space and time are commonly regarded as the forms of existence of the real world, matter as its substance. A definite portion of matter occupies a definite part of space at a definite moment of time. It is in the composite idea of motion that these three fundamental conceptions enter into intimate relationship. Descartes defined **the objective of the exact sciences as consisting in the description of all happening** (*alles Geschehen*) in terms of these three fundamental conceptions, thus referring them to motion".

(R-Z-M, Introduction p. 1)

Philosophy in R-Z-M

- The notions of space-time and matter as developed by Einstein's theory change our view of "happening". But which one? Physical, subjective, or both?

- In 1918-1920 Weyl follows very closely the lines of Husserl's *Ideen zu einer reinen Phänomenologie und phänomenologischen Philosophie* (1913)

See T. Ryckman (2003). "The philosophical roots of the gauge principle: Weyl and transcendental phenomenological idealism".

Philosophy in R-Z-M

"As **the doer and endurer of actions** I become a single individual with a psychical reality attached to a body which has its place in space among the material things of the external world, and by which I am in communication with other similar individuals.

Consciousness, without surrendering its immanence, becomes a piece of reality, becomes this particular person, namely myself, who was born and will die. Moreover, as a result of this, consciousness spreads out its web, in the form of time, over reality".

(S-T-M, p. 6)

Philosophy in R-Z-M

“Change, motion, elapse of time, becoming and ceasing to be, exist in time itself; just as my will acts on the external world through and beyond my body as a motive power, so the external world is in its turn active (as the German word " Wirklichkeit," reality, derived from " wirken " = to act, indicates). Its phenomena are related throughout by a causal connection. **In fact physics shows that cosmic time and physical form cannot be dissociated from one another**. The new solution of the problem of amalgamating space and time offered by the theory of relativity brings with it a deeper insight into the harmony of action in the world”.

(S-T-M, p. 6)

Philosophy in R-Z-M

"Time is the primitive form of the stream of consciousness. It is a fact, however obscure and perplexing to our minds, that the contents of consciousness do not present themselves simply as being (such as conceptions, numbers, etc.), but as being now filling the form of the enduring present with a varying content. So that one does not say this is but this is now, yet now no more. **If we project ourselves outside the stream of consciousness and represent its content as an object, it becomes an event happening in time, the separate stages of which stand to one another in the relations of earlier and later**".

(S-T-M, p. 5)

Philosophy in R-Z-M

Philosophy of Mathematics and Natural Science (1st ed. 1927/2nd ed. 1949)*:*

"The objective world is, it does not happen. Only to the gaze of my consciousness, crawling along the lifeline of my body, does a section of this world come to life as a fleeting image in space which continuously changes in time."

- Eternalism vs. Presentism
- It seems to support the Block Universe view

Philosophy in R-Z-M

- General Relativity theory changes our conception (form/substance) of space, time, matter and therefore motion, but also sheds new light on the relationship between objectivity and subjectivity

- Einstein's theory can overcome this dualism thereby reshaping the philosophy of time, metaphysics etc.

Philosophy in R-Z-M

“Since the human mind first wakened from slumber, and was allowed to give itself free rein, it has never ceased to feel the profoundly mysterious nature of time-consciousness, of the progression of the world in time, of Becoming. It is one of those ultimate metaphysical problems which philosophy has striven to elucidate and unravel at every stage of its history. The Greeks made Space the subject-matter of a science of supreme simplicity and certainty. Out of it grew, in the mind of classical antiquity, the idea of pure science. Geometry became one of the most powerful expressions of that sovereignty of the intellect that inspired the thought of those times”.

(S-T-M Introduction, p. 1)

Philosophy in R-Z-M

- Why is geometry connected to the problem of Becoming?
- Pre-socratic tradition and Plato: *Timaeus* as the first example in Western thought of a geometrization of the physical world
- Plato: time (chronos) as something generated and developed the category of “coming into being” to grasp its function in view of our knowledge of the universe.
- The knowledge of the physical world depends on an operational definition of time, but the latter is not fundamental in nature and is not even present in the world of ideas.

Philosophy in R-Z-M

"Now, if on the one hand it is very satisfactory to be able to give a common ground in the theory of knowledge for the many varieties of statements concerning space, spatial configurations, and spatial relations which, taken together, constitute geometry, it must on the other hand be emphasised that this demonstrates very clearly with what little right mathematics may claim to expose the intuitional nature of space. Geometry contains no trace of that which makes the space of intuition what it is in virtue of its own entirely distinctive qualities which are not shared by "states of addition-machines" and "gas-mixtures" and "systems of solutions of linear equations".

(R-Z-M, p. 26)

Philosophy in R-Z-M

"It is left to metaphysics to make this "comprehensible" or indeed to show why and in what sense it is incomprehensible. We as mathematicians have reason to be proud of the wonderful insight into the knowledge of space which we gain, but, at the same time, we must recognise with humility that our conceptual theories enable us to grasp only one aspect of the nature of space, that which, moreover, is most formal and superficial."

(R-Z-M, p. 26)

Philosophy in R-Z-M

- Highest standpoint represented by the transition from special to general relativity: encompass both subjectivity and the objective world into a system. How?

Gauge invariance and invariance of laws are expression of objectivity

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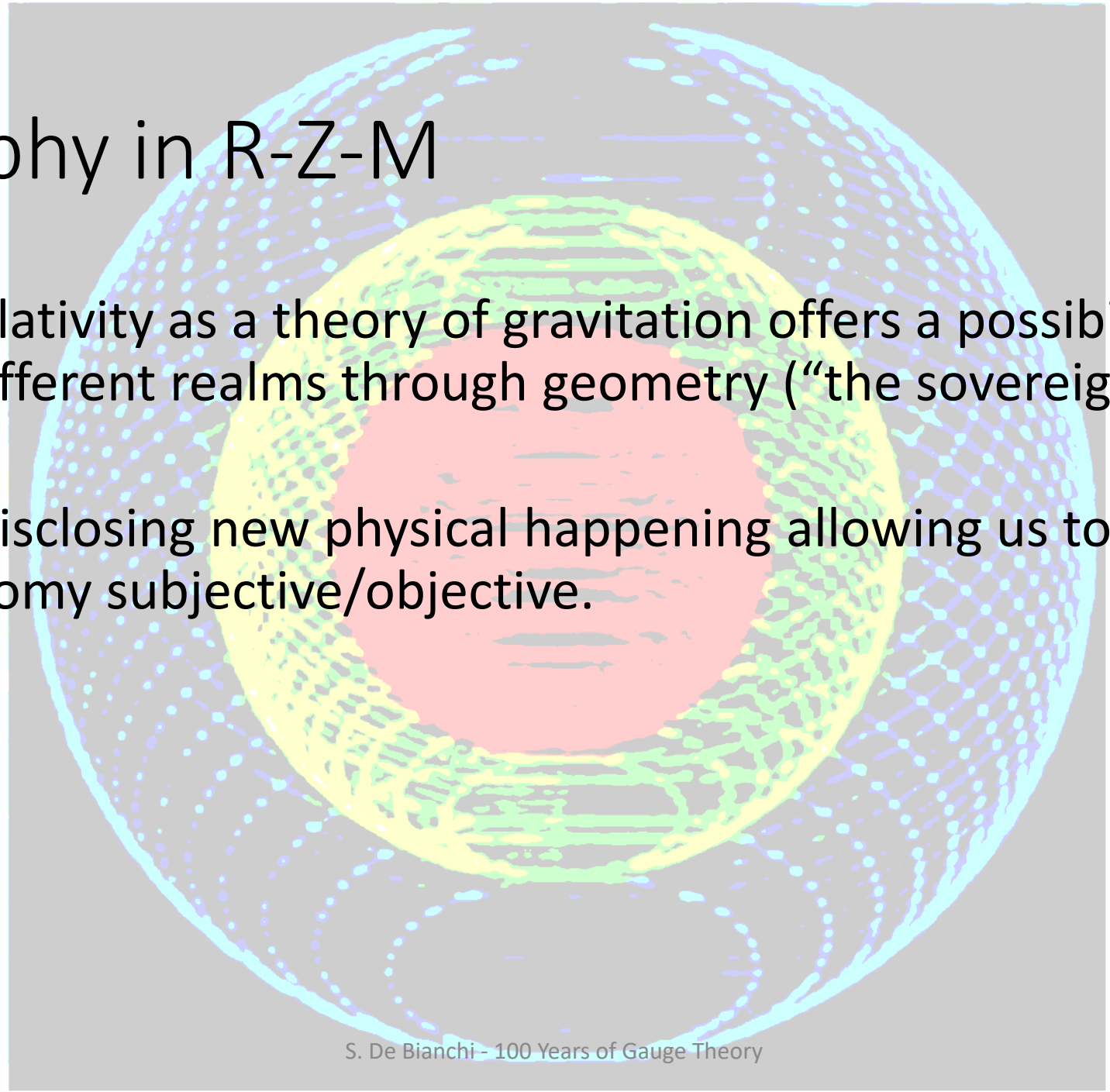
Geometry: Inclusion of the observations of measurements in constructing a theory of gravitation

Philosophy in R-Z-M



- General relativity as a theory of gravitation offers a possibility of unifying different realms through geometry (“the sovereignty of the intellect”)
- Principle disclosing new physical happening allowing us to overcome the dichotomy subjective/objective.

Philosophy in R-Z-M

- The transition from the special to the general theory of relativity is a purely mathematical process.
- To formulate physical laws so that they remain invariant for arbitrary transformations is a possibility that is purely mathematical in essence and denotes no peculiarity of these laws.
- A new physical factor appears only when it is assumed that the metrical structure of the world is not given a priori, but that the quadratic form is related to matter by generally invariant laws.

Weyl's philosophy of science

- To overcome dualism is the goal of scientific enquiry in order to be knowledge in the highest sense:

"The physical world-picture here described in its first outlines is characterised by the dualism of matter and field, between which there is a reciprocal action. Not till the advent of the theory of relativity was this dualism overcome, and, indeed, in favour of a physics based solely on fields".

(S-T-M, p. 68)

PART II

Hermann Weyl and the Philosophy of Science

Weyl's philosophy of science: scientific theories

Two ways in which we can portray a physical theory:

1. As a system (objectively)
2. Through symbolic construction (including the subjective within it)

The two views are not in contrast, only dogmatism counts them as opposite

Weyl's philosophy of science: holism

"We cannot merely test a single law detached from this theoretical fabric! The connection between direct experience and the objective element behind it, which reason seeks to grasp conceptually in a theory, is not so simple that every single statement of the theory has a meaning which may be verified by direct intuition. We shall see more and more clearly in the sequel that Geometry, Mechanics, and Physics form an inseparable theoretical whole in this way. We must never lose sight of this totality when we enquire whether these sciences interpret rationally the reality which proclaims itself in all subjective experiences of consciousness, and which itself transcends consciousness: that is, truth forms a system".

(S-T-M, p. 67)

Weyl's philosophy of science: levels of reality

World: four-dimensional continuum, which is neither "time" nor "space".

"Only the consciousness that passes on in one portion of this world experiences the detached piece which comes to meet it and passes behind it, as history, that is, as a process that is going forward in time and takes place in space. This four-dimensional space is metrical like Euclidean space, but the quadratic form which determines its metrical structure is not definitely positive, but has one negative dimension. This circumstance is certainly of no mathematical importance, but has a deep significance for reality and the relationship of its action".

(S-T-M, p. 217)

Weyl's philosophy of science: epistemology

- Within the natural sciences the conflicting philosophies of idealism and realism signify principles of method which do not contradict each other. We construct through science an objective world.

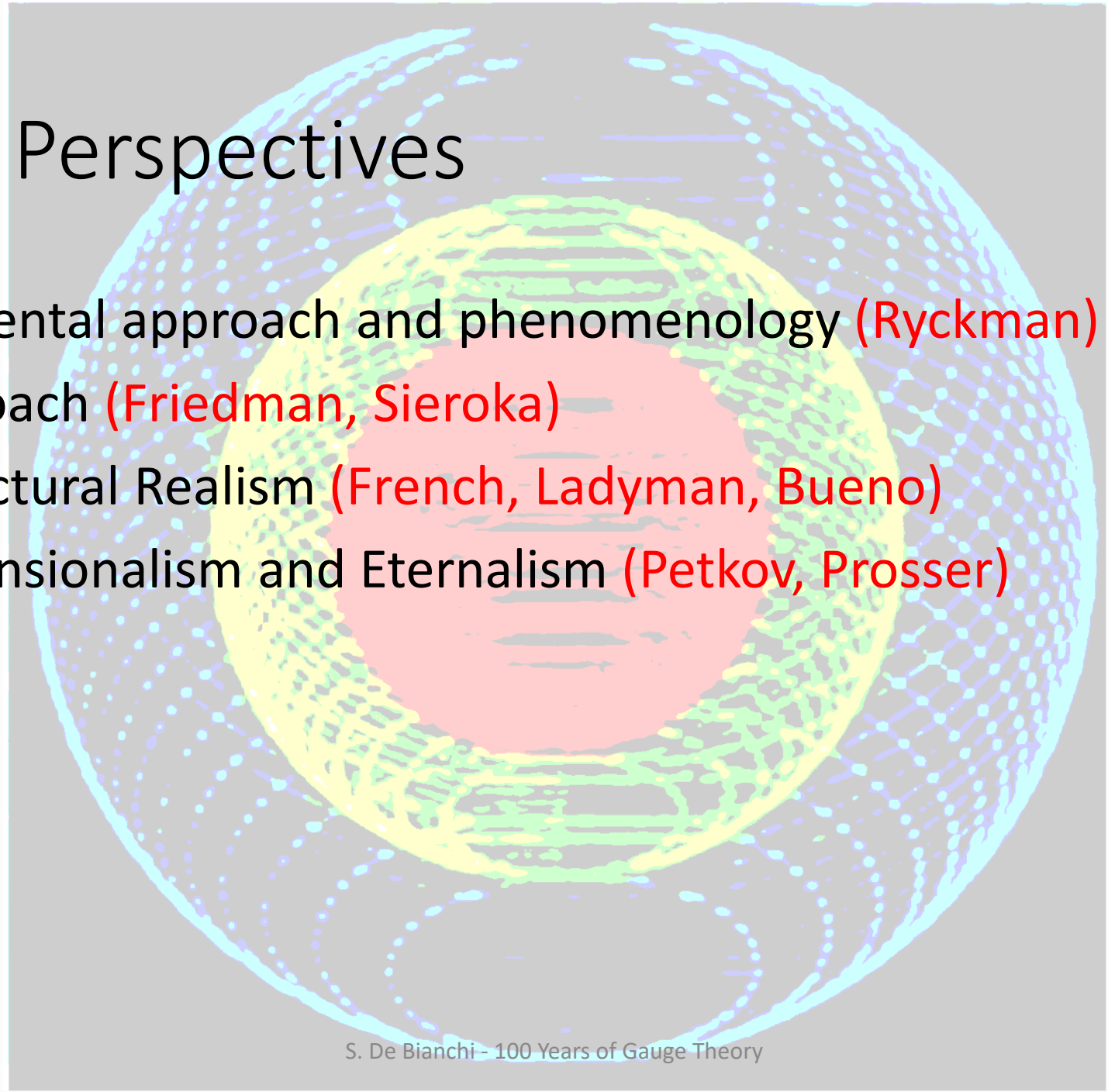
- Subjective/absolute
- Objective/relative

- "Whoever desires the absolute must take the subjectivity and egocentricity into the bargain; whoever feels drawn toward the objective faces the problem of relativity." (PMNS, p. 115)

Part III

Current and Future perspectives on Weyl

Current Perspectives



- Transcendental approach and phenomenology (Ryckman)
- iHPS approach (Friedman, Sieroka)
- Ontic Structural Realism (French, Ladyman, Bueno)
- Four-dimensionalism and Eternalism (Petkov, Prosser)

Future perspectives

Philosophy of Time (metaphysics):

- Overcome the dualism between presentism and eternalism

Philosophy of Science:

- Overcome the dualism between realism and antirealism
- Process of theory construction is complementary to system analysis

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