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Some Philosophy inputs for Muon Physics

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Introduction

Philosophy

Philosophy [...] is something intermediate between theology and science.

*Like **theology**, it consists of speculations on matters as to which definite knowledge has, so far, been unascertainable; but like **science**, it appeals to human reason rather than to authority, whether that of tradition or that of revelation.*
All definite knowledge [...] belongs to science; all dogma as to what surpasses definite knowledge belongs to theology.

But between theology and science there is a No Man's Land, exposed to attack from both sides; this No Man's Land is philosophy.

Russell B. (1945). *A History of Western Philosophy, Introductory.* George Allen & Unwin Ltd

Do we need philosophy? (I)

So many people today - and even professional physicists - seem to me like someone who has seen thousands of trees but has never seen a forest.

Knowledge of the historical and philosophical context gives the kind of independence from the prejudices of one's own generation that most scientists suffer from.

This independence created by philosophical insight is, in my opinion, the mark of distinction between a mere craftsman or specialist and a true seeker of truth.

A. Einstein, *Letter to Robert A. Thornton*, 7 December 1944

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Do we need philosophy? (II)

1. Scientists themselves are the practitioners best able to conduct science and do not need advice from philosophers

2. Scientists are not particularly adept at taking a step back from their work and describing and characterizing the nature of that work

3. Scientists are typically good at making scientific progress, but not particularly good at articulating what that progress consists of

Chalmers, A. (1976). *What is this thing called science?* Univ. of Queensland Press

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Philosophical Method

Physics $\Leftrightarrow$ Philosophical point of view

1. Thought experiments
2. Epistemology and Logic (theory of knowledge)
3. Studies of the historical and social contexts

Objectivity: all about experiments and calculations?

- Physics is based on observable *facts* obtained through direct sensory experience
- This observations are objective and indisputable

$\rightarrow$ Strong and reliable definition of physics
$\rightarrow$ Unveiling the objective natural world

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Challenging the objectivity of Physics

Objectivity or interpretation?

- Kuhn: Scientific Paradigms and *Normal Science* vs. *Scientific Revolution*

Kuhn, T. (1970). *The Structure of Scientific Revolutions.* Univ. of Chicago Press.

- Feyerabend: Methodological rules are themselves influenced by theoretical perspectives. A strong adherence to them my hinder scientific progresses by suppressing alternatives viewpoints. ⇒ Everything is permitted

Feyerabend, P. K. (1975). *Against Method: Outline of an Anarchistic Theory of Knowledge.* New Left Books.

- Theory-laden ⇒ When we observe phenomena, how can we be sure that we are perceiving the objective reality and not an interpretation, influenced by our own prior knowledge and theoretical commitments?

Chalmers, A. (1976). *What is this thing called science?* Univ. of Queensland Press.

The Galileo case: a misunderstanding about observations

It was not so much the observations and experiments which Galileo made that caused the break with tradition as his attitude to them. For him, the facts based on them were taken as facts, and not related to some preconceived idea...

The facts of observation might, or might not, fit into an acknowledged scheme of the universe, but the important thing, in Galileo's opinion, was to accept the facts and build the theory to fit them.

Anthony, H. D. (1948). *Science and Its Background.* Macmillan

The Galileo case: a misunderstanding about observations

The scholastic professors (teacher of Aristotle's philosophy)
→ blamed for preferring *a priori speculation* to observation and experiment

→ Not totally correct

Kenny, A. (2010). *A New History of Western Philosophy - Part 3.* Oxford Univ. Press.

Aristotle affirmed the primacy of fact over speculation:
'We must trust observation rather than theory,
and trust theories only if their results conform with the observed phenomena'

Aristotle, *On the Generation of Animals* 3. 10. 760^b28–31

Critique to Empiricism and Positivism

- A.J. Ayer and Neopositivism: only empirically or logically verifiable statements are even meaningful

- Kuhn: our sense organs are not merely passive receptors of external stimuli, but their responses to stimuli are actively interpreted by brain...

- Pure empiricism: the technological progress and the highly accurate predictions of the observed phenomena are undeniable

- Underdetermination of various models that can describe the data

Quine, W.V.O. (1951). *Two Dogmas of Empiricism.* The Philosophical Review. 60 (1): 20–43. Reprinted in his 1953 From a Logical Point of View. Harvard Univ. Press.

Massimi M. (2022). *Perspectival Realism.* Oxford Univ. Press.

Critique to Empiricism and Positivism

- Observations true, but provisional, facts about the world: tentative brushstrokes on an expansive canvas (scientific knowledge)
- observer's biases and limitations, due to the current theoretical understanding

$\Rightarrow$ Theory laden

A little story to reflect on

A physicist of the pre-Einsteinian era takes Newton's law of gravitation, the initial conditions, and calculates the path of a newly discovered small planet, p.

But the planet deviates from the calculated path.

Does she consider that the deviation forces her to refute Newton? No.

There must be a hitherto unknown planet p^1, which perturbs the path of p. [...] However p^1 is too small, she cannot observe it...

She applies for a research grant to build a bigger telescope [...] But she cannot observe it.

Does she abandon Newton's theory and her idea of the perturbing planet? No.

She suggests that a cloud of cosmic dust hides the planet from us [...] But the cloud is not found

Is this regarded as a refutation of Newtonian physics? No.

Either yet another ingenious auxiliary hypothesis is proposed or... the whole story is buried in the dusty volumes of periodicals and the story never mentioned again

Lakatos, I. and Musgrave, A. (eds) (1970). *Criticism and the Growth of Knowledge.* Cambridge: Cambridge Univ. Press

Some important points to reflect on

- The convergence of independent observations leads to reliable knowledge over time
- *Widely accepted* interpretations can still be overturned

- The notion of physics as purely derived from objective observables facts is a oversimplification
- Theoretical models, human cognition shape the scientific knowledge → nuanced understanding of scientific objectivity

- Possible that some scientific models remain 'buried' and therefore, dramatically, some *natural laws* are never discovered scientifically... ?

Dialogue about the nature of objectivity and subjectivity in physics

Implications for the Muon g-2(?)

Personal thougths

- The ongoing saga on $g_\mu - 2$ provides important information on the research processes in physics (perhaps even more than dark matter and cosmological issues)

- More than 60 years of rich history of high precision physics $\rightarrow$ test the Standard Model at $<$0.5 ppm precision

Idea/Proposal:
As part of the Leverhulme *Muon Precision Physics Program* a philosophical/epistemological study on the Muon g-2 case

Main points

Some initial idea that fascinated me and to be discussed

1. Technological end methodological endeavours
   - → Studies on the CERN experiments, and the Brookhaven and the FermiLab experiments
   - → The various theoretical approaches: Lattice and Dispersive approach, Radiative returns and τ data
2. The desire of freedom from biases
   - → Communication among different collaborations
   - → Blind analysis
3. The role of a 'regulating' community
   - → The goal of independent observations to converge leads to reliable knowledge over time. Does this approach require a 'superior' institution?
   - → Widely accepted interpretations can still be overturned

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Keep the discussion on-going

THANK YOU!