Theoretical Physics

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Outline

1. References

Introduction

Don't listen to his words, examine his achievements.
– Albert Einstein

Theoretical physics is shaped not just by logic, but by creative principles guided by experience.

Reason and Experience

- Knowledge starts and ends with experience.
- Reason structures the system; experience validates it.
- Parallel with Euclidean geometry: axioms vs. empirical content.

Invention vs. Derivation

- Basic laws are not derivable from experience.
- They are free inventions of the human mind.
- Goal: simplest possible basis that still fits all phenomena.

Development of Theoretical Method

- Greece: pure logical systems.
- Galileo: experience as foundation of knowledge.
- Newton: uneasy balance between empirical and absolute concepts.

Theory and Reality

- Theories must match experience, not derive from it.
- Relativity shows multiple conceptual bases can fit reality.
- Logical derivation alone is insufficient.

The Role of Mathematics

- Mathematics enables discovery of physical laws.
- Simplicity and elegance are guiding principles.
- Mathematical constructs precede empirical verification.

Examples: General Theory

- Riemannian metric ⇒ Einstein's field equations.
- Antisymmetric tensor ⇒ Maxwell equations.
- Spinor field ⇒ Dirac's electron theory.

Quantum Theory and Atomism

- Born's interpretation: probability, not representation.
- Heisenberg: no absolute localization.
- Continuum theory can still imply atomism via integrals.

Conclusion

- Theoretical physics is a fusion of thought and reality.
- Mathematics is the creative core, experience the judge.
- Future theories must unify depth with simplicity.

References

References

[1] Albert Einstein. **“On the Method of Theoretical Physics”.** In: *Philosophy of Science* 1.2 (Apr. 1934), pp. 163–169. ISSN: 1539-767X. DOI: 10.1086/286316.

Thank you!

Questions or comments?