

Introduction

We are used to a universe made of things. Atoms make materials, stars gather into galaxies, and each object seems to occupy its own place in space and time. It is a useful picture. Much of physics begins by identifying those things and describing what they do. This book asks whether their existence might depend on something more basic than the objects themselves.

My starting thought is that a physical thing may be an organisation of relations that can sustain itself through change. Its identity would then belong to the pattern that continues, even while interactions alter its circumstances. Phase Differential Theory, or PDT, explores that possibility through phase relations.

Phase is already familiar in physics. It describes a position within a cycle, and comparisons of phase help explain how waves combine. Two contributions can reinforce one another or partly cancel according to their relationship. PDT asks whether this capacity for comparison and composition points towards a deeper foundation. Perhaps phase is one of the ingredients from which a physical state is built, rather than simply a property assigned to a state we have already assumed.

That is a substantial proposal. Giving phase a more fundamental role would only be useful if it helped explain why physical structures have the character we observe. The book develops my reasons for pursuing it. I am interested in how an object persists, how a definite event occurs and whether these might be aspects of a shared process.

Quantum mechanics is complex, both mathematically and conceptually. PDT asks whether its familiar rules can be understood from a more basic account of relations and persistence. The foundations derive key features of quantum probability and reversible evolution under explicitly stated physical assumptions. Those assumptions matter. The derivation is conditional, and the work of selecting the particular physical laws remains open. The book explains both the result and its limits.

Quantum mechanics is sometimes taught in the spirit of the phrase “Shut up and calculate!” David Mermin used those words in 1989 to characterise an attitude towards its interpretation. The emphasis is on applying the equations and checking their predictions against experiments. Mermin later criticised his own phrase as too dismissive. For me, successful calculation also invites the question of why the rules take the form they do. This book explores that question through PDT, while keeping the distinction between established results, stated assumptions and proposed explanations clear.

The question of a definite event is particularly important. Quantum theory can describe alternatives and calculate their probabilities with extraordinary success. In an experiment, a detector leaves a particular record. We can use that record to make another measurement or to change what we do next. I want a physical account of how it became part of the world's history.

In PDT, phase snap is the name given to the proposed process of realisation. The idea is that physical conditions restrict which continuations remain possible. In the unique survivor account, an event becomes definite when one admissible continuation remains. Here admissible means permitted by the physical law governing the situation. It cannot simply mean the continuation that we later happen to observe.

This brings the event and the persistent object into the same inquiry. A record matters because it lasts long enough to affect something else. Matter matters, in this picture, because its organisation can survive a range of interactions. I am asking whether the conditions for continued existence can also help explain the occurrence of a particular outcome.

The observer belongs within that world. A detector can register an event without a person watching it. When someone reads the detector, a further physical interaction takes place with the

record already present. The account therefore begins with the physical formation of records. Conscious experience raises further questions, which should not be confused with the workings of a measuring instrument.

The same relational outlook runs through the discussions of time, gravity and the universe as a whole. Time raises the question of how changes are ordered and compared. Gravity asks how the behaviour of matter and the geometry used to describe it belong together. Cosmology asks whether the world's present organisation can be understood as part of a common physical history. These subjects give the proposal its scope, while each brings demands that a detailed theory must meet.

I have written for a reader who wants to follow the ideas without first learning their mathematical machinery. Equations appear where they make a relationship clearer. The figures help make unfamiliar connections easier to picture. The six appendices offer different ways to look more closely at the argument. They can be read alongside the chapters or returned to after the main narrative.

Appendix A sets out the core commitments and the conditions under which an indispensable part of PDT would have to be abandoned. Appendix B examines the demands of quantum mechanics, including probabilities and measurement. Appendix C considers general relativity, gravity, inertia and curvature. Appendix D turns to cosmology and the observations that a proposed account must explain. Together, these appendices make the proposal more exact and give the reader grounds on which to question it.

Appendix E explores the philosophical connections between PDT, consciousness and Alan Watts. His reflections on the individual and the surrounding world help illuminate the relational picture that interests me. The appendix distinguishes that interpretation from a mathematical or physical demonstration. Its additional premises about experience remain visible, so that an account of physical records is not mistaken for a completed explanation of consciousness.

Appendix F is a brief mathematical introduction to the PDT Foundations papers R00 through R13. It introduces the notation, explains a few central results and provides a route through the research papers without repeating their full proofs. It also explains the review suite's more precise treatment of relational phase and the scope of the axioms. Readers who want to understand how the mathematics supports and limits the proposal may find it useful to read Appendix F before returning to the technical comparisons in Appendices A to D.

Some of what follows is established physics. Some is mathematics developed within the PDT foundations. Some is my interpretation of the physical world that those foundations might support. A conditional result remains conditional, and a proposed explanation still has to earn its place through calculation and observation. The R00 to R13 suite provides explicit structures and conditional physical models. It does not yet establish one independently selected physical law that produces all the observed phenomena discussed in this book.

The purpose of the book is to give the reader a coherent view of the possibility I am exploring. It does not require belief in PDT before the argument can be understood. I hope it offers a way to look again at familiar questions and to consider whether the apparent independence of things conceals a more fundamental dependence on one another.

Before proceeding to Chapter 1, please make sure you have fully understood the starting point set out in this introduction. If anything remains unclear, read or listen to it again. Be clear about what PDT means by relations, persistence and a realised event, and about the distinction between an assumption and a derived result. The chapters that follow build on these ideas, so taking time with them now will make the argument easier to follow.

Reference for the quotation: N. D. Mermin, "Could Feynman Have Said This?", *Physics Today* 57(5), 10–11 (2004). doi:10.1063/1.1768652.