Books

QED: The Strange Theory of Light and Matter

by Richard P. Feynman

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"While I am describing to you *how* Nature works, you won't understand *why* Nature works that way but you see, nobody understands that. I can't explain why Nature behaves in this peculiar way."

So the author introduces his attempt to make understandable the theory of quantum electrodynamics — QED — a theory that allows physicists to calculate the results of interactions between light and electrons; and this includes chemistry and biology, materials and structures, mirrors and lenses, rainbows and sunsets — in short, ourselves and our world. In fact, the only things not included are gravity (a stubborn outsider, resisting the efforts to bring together the forces of nature) and interactions within the atomic nucleus, although the last chapter explains the frustration physicists have encountered in their seemingly reasonable attempts to extend QED to this latter domain.

The book is based on a series of four lectures — the Alix Mautner Memorial Lectures at UCLA — and is intended as an explanation of QED for a non-technical audience. How well does it come off? Indeed, there is little demand placed on the reader's technical or mathematical knowledge. Addition, subtraction, and multiplication are all that are required. The word "vector" is left unused. Instead we are told about arrows and how to manipulate them: how to point them (rotate them) in the right direction; how to add them, nose-to-tail like circus elephants, making sure that we slide them across the paper without changing their direction; and how to find the result, connecting the tail of the first to the point of the last.

He tells us how to analyze an event, how to look at all the possible ways in which that event might have happened, how to calculate an arrow for each way and then add them up for the final arrow. And then comes the magic of quantum mechanics: We measure the length of that final arrow and square it. What do we get? The probability that the event we were looking at would actually happen; for example, the percentage of light particles (photons) that would go through a piece of glass versus the percentage that would be reflected back. He then goes on to explain how to put together the arrows for events that happen in succession and once again calculate — from the length of the final arrow — the probability of the sequence.

The next step is to look at interactions between two different kinds of things: photons and electrons. There are special ground rules for adding up all the different ways that such interactions could take place. The very useful technique of "Feynman" diagrams is brought in, although the author doesn't call them that.

It is a beautiful demonstration of how the mathematically complex can be made mathematically simple; but not intellectually simple. You may find yourself frequently putting your finger in the book to mark the page and staring off into space. The theory is, as the title states, "strange." Beams of light and material objects don't *really* behave that way, do they? It seems to defy common sense, which Einstein is purported to have described as the set of prejudices we acquire by the age of 18. Why isn't it more sensible, like the theory of gravity, for instance? But then, the theory of gravity is simply a technique for determining the motion of two bodies pulling on each other — the moon and the earth, the planets and the sun, and so on. We have become so accustomed to it that we seldom stop to think that this theory is really only a set of rules for making calculations — whether we use Newton's rules or Einstein's update. The theory of gravity doesn't tell us what gravity *really is*. In fact, when it was first put forward there was much objection to the apparently nonsensical notion of "action at a distance." Somehow, over the centuries, we've gotten used to that. But most of us aren't quite ready for QED.

So, when you have gone through this delightfully written book (complete with footnotes expanding on some of the simplifications), you may feel somewhat frustrated. You have learned how to use simple mathematics, and a considerable amount of careful thinking, to calculate the outcome of the most basic processes that control the material world you deal with on a day-to-day basis. But you don't understand why it works that way. Well, he warned you. □

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