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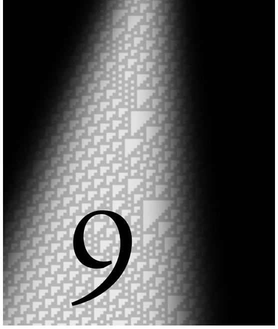
A NEW KIND OF SCIENCE

SECTION 9.1

The Problems of Physics



Fundamental Physics

The Problems of Physics

In the previous chapter, we saw that many important aspects of a wide variety of everyday systems can be understood by thinking in terms of simple programs. But what about fundamental physics? Can ideas derived from studying simple programs also be applied there?

Fundamental physics is the area in which traditional mathematical approaches to science have had their greatest success. But despite this success, there are still many central issues that remain quite unresolved. And in this chapter my purpose is to consider some of these issues in the light of what we have learned from studying simple programs.

It might at first not seem sensible to try to use simple programs as a basis for understanding fundamental physics. For some of the best established features of physical systems—such as conservation of energy or equivalence of directions in space—seem to have no obvious analogs in most of the programs we have discussed so far in this book.

As we will see, it is in fact possible for simple programs to show these kinds of features. But it turns out that some of the most important unresolved issues in physics concern phenomena that are in a sense more general—and do not depend much on such features.

And indeed what we will see in this chapter is that remarkably simple programs are often able to capture the essence of what is going on—even though traditional efforts have been quite unsuccessful.

Thus, for example, in the early part of this chapter I will discuss the so-called Second Law of Thermodynamics or Principle of Entropy Increase: the observation that many physical systems tend to become irreversibly more random as time progresses. And I will show that the essence of such behavior can readily be seen in simple programs.

More than a century has gone by since the Second Law was first formulated. Yet despite many detailed results in traditional physics, its origins have remained quite mysterious. But what we will see in this chapter is that by studying the Second Law in the context of simple programs, we will finally be able to get a clear understanding of why it so often holds—as well as of when it may not.

My approach in investigating issues like the Second Law is in effect to use simple programs as metaphors for physical systems. But can such programs in fact be more than that? And for example is it conceivable that at some level physical systems actually operate directly according to the rules of a simple program?

Looking at the laws of physics as we know them today, this might seem absurd. For at first the laws might seem much too complicated to correspond to any simple program. But one of the crucial discoveries of this book is that even programs with very simple underlying rules can yield great complexity.

And so it could be with fundamental physics. Underneath the laws of physics as we know them today it could be that there lies a very simple program from which all the known laws—and ultimately all the complexity we see in the universe—emerges.

To suppose that our universe is in essence just a simple program is certainly a bold hypothesis. But in the second part of this chapter I will describe some significant progress that I have made in investigating this hypothesis, and in working out the details of what kinds of simple programs might be involved.

There is still some distance to go. But from what I have found so far I am extremely optimistic that by using the ideas of this book the most fundamental problem of physics—and one of the ultimate problems of all of science—may finally be within sight of being solved.