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*The Concepts of Physics*
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# THE SELF-AWARE UNIVERSE

## HOW CONSCIOUSNESS CREATES THE MATERIAL WORLD

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# *Chapter 3*

# QUANTUM PHYSICS AND THE DEMISE OF MATERIAL REALISM

ALMOST A CENTURY AGO, a series of experimental discoveries was made in physics that called for a change in our worldview. What started showing up were, in the words of philosopher Thomas Kuhn, anomalies that could not be explained by classical physics.[1] These anomalies opened the door to a revolution in scientific thought.

Imagine that you are a physicist at the turn of the century. One of the anomalies you and your colleagues are interested in understanding is how hot bodies emit radiation. As a physicist of Newtonian vintage, you believe that the universe is a classical machine consisting of parts that behave according to Newtonian laws that are almost all completely known. You believe that once you have all the information about the parts and have figured out the few remaining glitches about the laws, you will be able to predict the future of the universe forever. Still, those few glitches are troubling. You are not prepared to answer such questions as, What is the law of emission of radiation from hot bodies?

Imagine, as you puzzle over the question, that your loved one is comfortably seated beside you in front of a glowing fire.

YOU (*muttering*): I just can't figure this out.
LOVED ONE: Pass the nuts.



YOU (*while passing the nuts*): I just can't figure out why we are not getting a good tan right now.
LO (*laughing*): Well, that would be nice. We could even justify using the fireplace in the summertime.
YOU: You see, theory says that the radiation from the fireplace should be as rich in high-frequency ultraviolet as sunlight is. But what makes sunlight and not fireplace light rich in these high frequencies? Why aren't we tanning in an ultraviolet bath right now?
LO: Wait a minute, please. If I am going to listen to this seriously, you'll have to slow down a little and explain. What's frequency? What's ultraviolet?
YOU: Sorry. Frequency is the number of cycles per second. It's the measure of how fast a wave wiggles. For light, that means color. White light is made up of light of various frequencies, or colors. Red is low-frequency light, and violet is high-frequency light. If the frequency is even higher, it's invisible black light, what we call ultraviolet.
LO: Okay, so light from both burning wood and the sun should give out plenty of ultraviolet. Unfortunately, the sun follows your theory, but burning wood doesn't. Maybe there's something special about burning wood. . . .
YOU: Actually, it's even worse than that. All light sources, not just the sun or burning wood, should give off copious amounts of ultraviolet.
LO: Ah, the plot thickens. The inflation of the ultraviolet is ubiquitous. But isn't all inflation followed by a recession? Isn't there a song, what goes up must come down? (*Your loved one starts humming.*)
YOU (*exasperated*): But how?
LO (*holding out the bowl of nuts*): Nuts, dear?

(The conversation ends.)

## PLANCK TAKES THE FIRST QUANTUM JUMP

Many physicists in the late nineteenth century were frustrated until, finally, one of them broke rank: Max Planck, of Germany. In 1900, Planck took a bold conceptual leap and said that what the old theory needed was a quantum jump. (He borrowed the word *quantum*,