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Book Review

"Void: The Strange Physics of Nothing" by James Owen Weatherall, Yale, $26, 196 pages

The Nothing That Is

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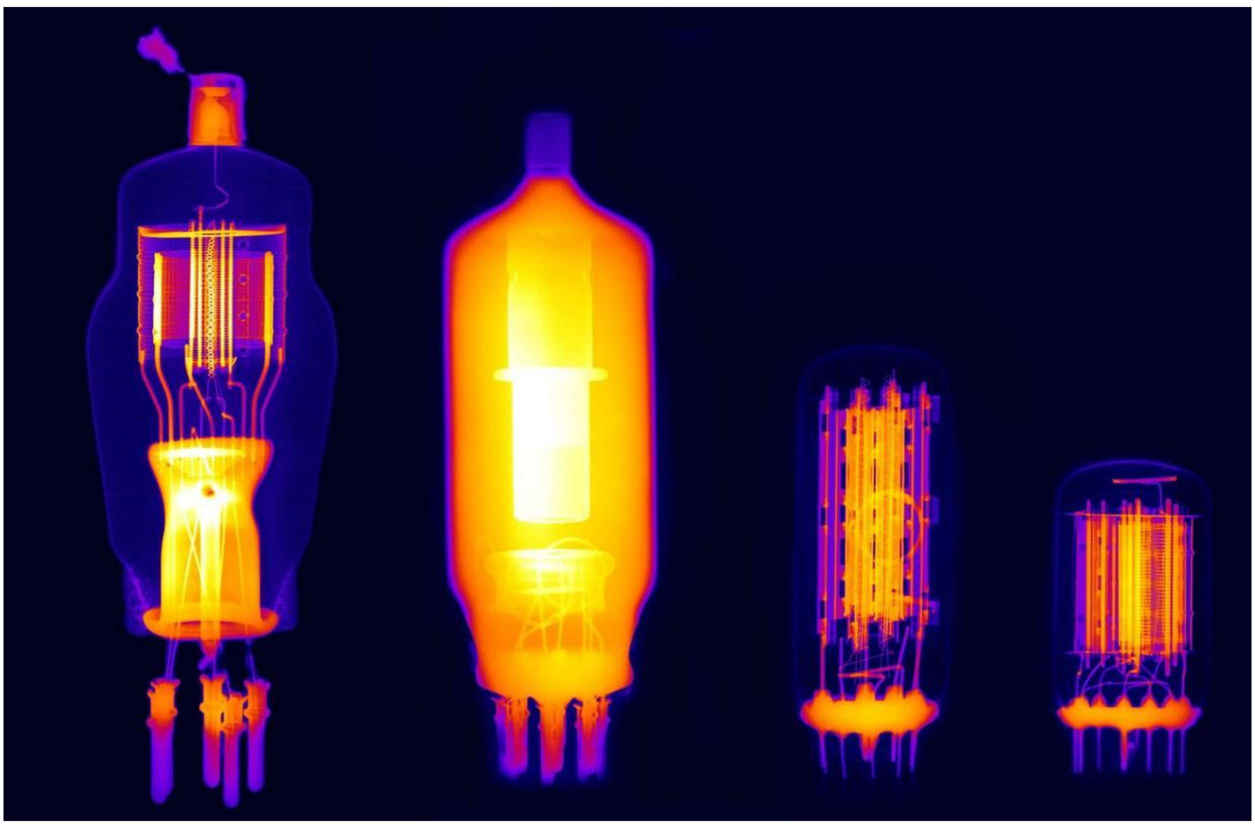

Analog glow Photo: Ted Kinsman

by Peter Pesic

'Nothing will come of nothing," King Lear says, but modern physics is even odder than that. The problem of the vacuum goes back more than 2,000 years and continues into the present. In "Void: The Strange Physics of Nothing," James Owen Weatherall, a philosopher at the University of California, Irvine, gives a wide-ranging and concise account of this remarkable story.

The concept of "nothing"—a total void or vacuum—has given rise to all kinds of questions, beginning with the ancient Greeks. What is left when the air is removed from a container? How do we know that there is really "nothing" there, rather than, say, an ever more attenuated gas? And if we conclude that "nothing" is indeed there, what would we mean by *there*, where there is nothing?

These issues weren't settled by the ancient Greeks' introduction of the concept of atoms, which just transferred such questions to the submicroscopic realm. Aristotle argued against the existence of atoms because, adrift in the void, unconnected to surrounding matter, they would have no way of knowing in which direction to move. It is good to see Mr. Weatherall treat Aristotle's acute arguments respectfully, though briefly. But he concentrates more on Isaac Newton's argument that, in addition to the relative space defined by the distances between bodies, there was an absolute space, completely empty and at rest—"an infinite, otherwise empty container," as Mr. Weatherall writes.

Newton's great rival, Gottfried Leibniz, thought that this concept of absolute emptiness went far beyond the evidence of our senses. Imagine shifting everything in the universe one meter in one direction, presumably moving everything equally in absolute space: Nothing would have changed, indicating that absolute space was unobservable, hence nonexistent. Drawing on the current-day philosopher Howard Stein, Mr. Weatherall notes that the real problem is what the "same place" means at different times if it is not stationary but moving around the solar system: My house has moved many thousands of miles since yesterday with respect to the distant stars.

Albert Einstein's special theory of relativity at first seemed to reinstate the void by denying the existence of an aether, a highly attenuated medium that the great 19th-century physicist James Clerk Maxwell and others thought necessary to transmit light and other electromagnetic waves. But if there is no such medium, what then is vibrating? Mr. Weatherall answers that "the electromagnetic field itself is a new kind of stuff." He points out that "the whole universe has a steady, low level of electromagnetic radiation pulsing through it, known as the Cosmic Microwave Background. So in a sense, we have left the aether behind but replaced it with a different kind of 'aetherial substance' that also pervades all of space."

Even were there a region with zero field strength—no electromagnetic signal—that would not mean that there is no field at all. Mr. Weatherall evokes a baseball stadium filled with fans doing "the wave," making regular patterns by standing and moving their arms: "Sometimes, though, there would be no wave — that is, no one standing. The wave strength would be zero. But this doesn't mean the stands are empty. Similarly, no field strength need not mean no electromagnetic field.” Likewise, in Einstein’s later general theory of relativity, space-time becomes an omnipresent field that even in a universe empty of matter can have many possible configurations, including the gravitational waves whose recent discovery (via a “chirp” transmitted over billions of light-years) touched the world.

The fields used in modern quantum theory take on even more vivid life, in Mr. Weatherall’s recounting. Paul Dirac, the laconic visionary of the new quantum theory, predicted in 1931 the existence and properties of antimatter before it was discovered the following year. The symmetry between matter and antimatter has amazing consequences for the nature of the vacuum. Just as Maxwell’s electromagnetic theory could have a zero field—rather than no field at all—Dirac realized that “even the zero field” of his new quantum theory “is very much a kind of stuff,” as Mr. Weatherall puts it.

Even a vacuum state in which no particle is observed in the whole universe, it turns out, can be consistent with the observation of local fluctuations caused by “virtual particles”—offsetting pairs of matter and antimatter particles—slipping into and out of existence. “You might think of static on an old TV or on a radio between stations: there is no signal to speak of—no persistent particles—and yet there isn’t silence either. There’s just white noise: random, incoherent background. . . . In a classical theory, it would be the blackness of a turned-off TV; in quantum field theory, it’s the static of no channel.” Remarkably, these vacuum fluctuations have measurable effects: The electron in a hydrogen atom observably trembles as it passes through this subtly seething vacuum, leading to slight shifts in its energy levels.

Against the plethora of popular writers who cast science as a series of incomprehensible wonders, Mr. Weatherall stands out by combining philosophical sophistication with an admirable ability to explain difficult concepts in plain, direct terms without oversimplifying. He presents cogent arguments, not just surprising results. Above all, he is aware of the importance of deep questions, which remain urgent and consequential even in the aftermath of powerful theories or explanations.

Mr. Weatherall offers his readers real food for thought, including excellent notes for those who want to go further into these questions. For instance, the cosmological data on our universe is consistent with our being in a vacuum state, so that our world may be a fluctuation of that cosmic vacuum, nothing more. Perhaps that realization will comfort those who, in dark times, seem to gaze into the very abyss.

—Mr. Pesic, director of the Science Institute and musician in residence at St. John’s College in Santa Fe, N.M., is the author of “Music and the Making of Modern Science.”