Why the Laws of Experimental Physics are Not Time Symmetric

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https://youtu.be/2QnRpinVmo4&lc=UgyqEvRHfPP42vca3a14AaABAg

A Comment on the Big Think post:
The physics of time, entropy, and immortality | *Sabine Hossenfelder* (Feb 10, 2023)
https://youtu.be/2QnRpinVmo4

0:12 "Laws for… particles… work the same way forward in time as… backward." One of the more impactful features of the Copenhagen ("wave collapse") interpretation of quantum mechanics is Bohr's insistence on an either-or view of the wave-versus-particle issue. In the resulting maths, an electron can behave *exactly* like a particle or *exactly* like a wave, but not both. Thus, an electron can self-interfere like a wave when it passes through two slits or land like a point particle on a screen placed after the slits.

Splitting the maths into wave and particle views creates two sets of time-symmetric equations. Not surprisingly, wave maths dominate quantum mechanics while particle maths dominate classical mechanics.

Here's the rub: These wave and particle equations are time-symmetric only in isolation. Anything that mixes the two falls back into the "wave collapse" category. That's a problem since, pretty much by definition, wave collapse cannot be made time-symmetric.

The other problem is that experimentally, the ideal of "pure" waves and "pure" particles *never* describes what happens. A Schrödinger wave requires infinite time to form since its boundaries are light-speed limited, and a purely point-like electron requires infinite energy due to quantum uncertainty. As Feynman elegantly explains in his lecture on "Watching the electrons" [1], actual double-slit electron interference experiments produce a complex interplay between the momentum wavelengths of the probes (photons) and the resulting *mix* of wave and particle behaviors.

Thus while it's not popular among many theorists, detailed Feynman-style applications of standard quantum mechanics to problems such as the two-slit particle self-interference *do not* support the belief that reality is time-symmetric. Actual experiments always produce transitions between *mixes* of particle and wave states. None of these mixes fall into the time-symmetric extrema of pure particles or pure waves.

Partial collapses or, even better, scale changes in wave packets provide better models of what happens in experiments. You never see point-like particles since those require infinite probe energy, but you also never get perfect wave states. Each detection event instead results in a new and initially compact Schrödinger state whose boundaries spread no faster than the speed of light: a wave packet.

Finally — and from here on, it's just Terry talking, so you can safely stop reading now :) — the more insightful solution is to model time and causality as bottom-up, emergent, and fractal. What's going on is that undifferentiated, Lorentz invariant time-space separations between particles and probe split into local-only time and space interpretations whenever the probe and particle exchange a bit of linear momentum. That's the more physically meaningful way of saying the particle is "observed" by the probe.

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[1] Feynman Lectures II, Chapter 1, Section 6, *Watching the electrons*
https://www.feynmanlectures.caltech.edu/III_01.html#Ch1-S6