10. Each quantum version of reality is an isolated, classically if-then universe.

In Part II, we will consider two of the mysteries (Ch. 2) of quantum mechanics. We will show in this chapter that each quantum version of reality is completely isolated from each other version, and that each obeys classical if-then logic. Then in Ch. 11, we will show that the mathematics of quantum mechanics prevents **perception** of more than one version of reality even though several may exist in the wave function. The rest of Part II concerns the mystery of wave-particle duality, while the third mystery, probability, is considered in Part III. The fourth mystery, on the nature of physical reality, is examined in Part IV.

Isolation of the branches.

To illustrate the reasoning, we again use the half-silvered mirror example of Ch. 6, with yes indicating detection and no, no detection. We start after the photon wave function in the .6, .8 coefficient case has been split into two parts, but before detection. The wave function is

$$\begin{array}{c}(.6)|\text{ph H}\rangle|\text{Det H,no}\rangle|\text{Det V,no}\rangle \\ \oplus \\ (.8)|\text{ph V}\rangle|\text{Det H,no}\rangle|\text{Det V,no}\rangle\end{array} \tag{1}$$

Then, as we said in Ch. 6, the mathematical rules of quantum mechanics dictate that the H part of the photon wave function can only interact with the H detector, changing its reading from no to yes; the H part of the photon cannot affect the V detector, so its reading stayed at no on the H version of reality. And similarly for the vertical version. Thus after detection and the annihilation of the photon, the wave function is

$$\begin{array}{c}(.6)|\text{Det H,yes}\rangle|\text{Det V,no}\rangle \\ \oplus \\ (.8)|\text{Det H,no}\rangle|\text{Det V,yes}\rangle\end{array} \tag{2}$$

where we call the top line the H version of reality and the bottom line the V version.

One can then show, as is done in A10.1, that the linear mathematics implies the two versions of reality are totally isolated from each other. Each version of reality behaves as if—that is, evolves in time as if—the other version was not there. The two versions of reality thus correspond to **completely different, totally isolated, non-communicating universes**. They are not just far away from each other, they are in *different universes*. No signal or information can be passed from one universe to another. A photon emitted by the version of one of the detectors in the H version of reality, for example, can never hit the versions of the detectors in the V version of reality; the photon emitted in the H version of reality stays within the H version.

The classical, if-then property.

In each version of reality, classical if-then logic holds. To illustrate, we will use the half-silvered mirror Schrödinger's cat experiment. After the mirror but before detection, the wave function/state vector consists of two branches, an H branch and a V branch;

$$\begin{gathered} |\text{ph H}\rangle|\text{Det H,no}\rangle|\text{Det V,no}\rangle|\text{circuitry not activated}\rangle \\ |\text{cyanide bottle unbroken}\rangle\,|\text{cat alive}\rangle \\ \oplus \\ |\text{ph V}\rangle|\text{Det H,no}\rangle|\text{Det V,yes}\rangle|\text{circuitry not activated}\rangle \\ |\text{cyanide bottle unbroken}\rangle\,|\text{cat alive}\rangle \end{gathered} \qquad (3)$$

After the versions of the photon have been detected and are annihilated, but before the circuitry has been activated, the state is

$$\begin{gathered} |\text{Det H,yes}\rangle|\text{Det V,no}\rangle|\text{circuitry not activated}\rangle \\ |\text{cyanide bottle unbroken}\rangle\,|\text{cat alive}\rangle \\ \oplus \\ |\text{Det H,no}\rangle|\text{Det V,yes}\rangle|\text{circuitry not activated}\rangle \\ |\text{cyanide bottle unbroken}\rangle\,|\text{cat alive}\rangle \end{gathered} \qquad (4)$$

So the photon-detector interactions guarantee that **if** |Det H,yes ⟩, **then** |Det V,no ⟩ and **if** |Det H,no ⟩, **then** |Det V,yes ⟩.

Next consider the results of the detector-circuitry and circuitry-bottle interactions. The state becomes

$$\begin{gathered} |\text{Det H,yes}\rangle|\text{Det V,no}\rangle|\text{circuitry not activated}\rangle \\ |\text{cyanide bottle unbroken}\rangle\,|\text{cat alive}\rangle \\ \oplus \\ |\text{Det H,no}\rangle|\text{Det V,yes}\rangle|\text{circuitry activated}\rangle \\ |\text{cyanide bottle broken}\rangle\,|\text{cat alive}\rangle \end{gathered} \qquad (5)$$

The interactions guarantee that **if** |Det V,yes⟩, **then** |circuitry activated ⟩|cyanide bottle broken ⟩, and similarly for |Det V,no⟩. And the final step is the cat. The cyanide-cat interactions guarantee that **if** |cyanide bottle broken⟩, **then** |cat dies⟩ (and similarly for the other branch). Thus one can see that, because of the inter-object interactions, if-then logic is built into the quantum mechanics time evolution of systems. **Within each version, classical if-then logic holds**. (One never has a quantum version containing |cyanide bottle broken⟩ |cat alive ⟩ for example.)

See also Ch. 15 for if-then logic in trajectories.

Evaluation.

No problems here. All physicists would agree.