A11.1. The preferred basis problem.

In Ch. 11, we argued that quantum mechanics, by itself, implied one and only one classical version of reality was perceived. But there are many physicists who contend that is incorrect. They claim that a 'preferred basis' has been chosen in the argument, and that a more thorough analysis shows the observer can be aware of more than one classical version of reality. We will show here that that is incorrect provided we are willing to accept a certain restriction—communicability—on 'perception.'

No basis is used to arrive at the final state.

To illustrate, we use the half-silvered mirror argument of Ch. 6. At first, we have the observer not look at the readings on the detectors, so the wave function is

$$\begin{array}{c}(.6)\ |\text{Det H,yes}\rangle|\text{Det V,no}\rangle \\ \quad |\text{Obs sees nothing}\rangle \\ \oplus \\ (.8)\ |\text{Det H,no}\rangle|\text{Det V,yes}\rangle \\ \quad |\text{Obs sees nothing}\rangle\end{array} \qquad (1)$$

When the observer looks at the detectors, she sees the readings by means of the light emitted by them. But as we argued in Ch. 10 and A10.1, a photon emitted in one universe cannot be detected or perceived in another. Because of this, the version of the observer on the 'yes,no' branch can only perceive the 'yes,no' reading version of the detectors, and similarly for the vertical branch. None of the photons emitted by the 'yes,no' version of the detectors ever reach the version of the observer on the 'no,yes' version of reality. Thus after perception, with the observer writing what she perceives, the wave function becomes

$$\begin{array}{c}(.6)\ |\text{Det H,yes}\rangle|\text{Det V,no}\rangle \\ \quad |\text{Obs sees H,yes, V,no, writes "I see only yes,no"}> \\ \oplus \\ (.8)\ |\text{Det H,no}\rangle|\text{Det V,yes}\rangle \\ \quad |\text{Obs sees H,no, V,yes, writes "I see only no,yes"}\rangle\end{array} \qquad (2)$$

This result is **absolutely required** by the mathematical laws of quantum mechanics, which include the interactions between the original photon and the detectors, between the detectors and the photons they send out, and between those sent-out photons and the observer. **No basis was chosen or used in deriving this result.** Thus we see that in this 'no-basis' result, no version of the observer ever says "I see two versions of reality," or "I see something other than a single, 'classical' version of reality," where 'classical' here means just what we normally expect to see in everyday life. Thus, by the testimony of the versions of the observers, quantum mechanics forbids the perception of a mixture.

Linear combination objection.

Now the counter-argument says that we don't know the correspondence between the observer state vectors in Eq. (2) and what we perceive. Suppose that instead of the two possible states of the observer being |Obs sees H,yes, V,no> and |Obs sees H,no, V,yes>, we stipulate that the two possible states of the observer are linear combinations, for example,

$$|\text{Obs }+\rangle = b[|\text{Obs sees H,yes, V,no}\rangle + |\text{Obs sees H,no, V,yes}\rangle] \text{ and} \qquad (3)$$
$$|\text{Obs }-\rangle = b[|\text{Obs sees H,yes, V,no}\rangle - |\text{Obs sees H,no, V,yes}\rangle], \quad b=1/\sqrt{2}.$$

If these are taken as the possible observer states, then it certainly looks like the observer is perceiving two classical versions of reality—yes,no and no,yes—at the same time.

The observer never writes "I see something other than a classical version."

But the counter-counter-argument is to include what is written, as in Eq. (2). "Sees yes,no" in these states means the neural firing pattern of that particular observer version of reality corresponds to the perception of a yes,no image. And then the written response—remembering from A10.1 that each ket evolves in time as if the others weren't there, and noting that the response of each ket must agree with the perceptions registered in the brain for that ket—the written response is

$$\begin{gathered}[b|\text{Obs sees H,yes, V,no, writes "I see } \textbf{only} \text{ yes,no."}\rangle + \\ b|\text{Obs sees H,no, V,yes, writes "I see } \textbf{only} \text{ no,yes."}\rangle] \\ \text{and} \\ [b|\text{Obs sees H,yes, V,no, writes "I see } \textbf{only} \text{ yes,no."}\rangle \\ b|\text{Obs sees H,no, V,yes, writes "I see } \textbf{only} \text{ no,yes."}\rangle]\end{gathered} \qquad (4)$$

That is, even when we choose a particular ('non-preferred') basis, the observer still never writes that she sees anything other than a classical version of reality. Thus there is no 'preferred basis problem' because there is no basis in which there is communicable perception of a superposition of versions of reality. (A physicist who claims the preferred basis problem is really a problem can never construct a situation in which a version of the observer writes "I see something other than a single, classical version of reality." And so their claim cannot be substantiated; the time evolution will not allow it.)

An informal way of explaining this result is to say that the 'yes,no' and 'no,yes' versions of the observer's brain are in different universes. Thus there can be no 'awareness,' in the usual sense, of both results at once.