## A14.2 The Smeared-out Baseball Problem.

**Quantum mechanics implies the perception of the baseball will always be sharp.**

Typically the wave function for the center of mass (c.m.) of a macroscopic object spreads out in time. So after the passage of a suitable amount of time, or in some peculiar circumstance, the wave function could be smeared out over a macroscopic distance. According to many physicists, the implication is that quantum mechanics does not always lead to the perception of sharply localized macroscopic objects. But that is not correct; using essentially the same reasoning as in the localized perception case (Ch. 14, A14.1), one can show that quantum mechanics always leads to the perception of a sharply localized macroscopic object.

**The uncertaintly principle is negligible here.**

Before starting the analysis, consider the uncertainty principle for a macroscopic object of mass *m* about 1 kg and an observation time (as it cuts across one's field of view) of about .01 sec. Then the spread in the c.m. coordinate during that time is gotten from

$$\Delta x \Delta p = \Delta x m \Delta x / \Delta t \cong \hbar \qquad (1)$$

which implies a $\Delta x$ of about $10^{-18}$ meters, and that is negligible in this context.

**Observation of a baseball.**

We first observe a *localized*, stationary baseball with a telescope at some distance and suppose the mounting of the telescope is calibrated in such a way that it gives a different angular reading each time the localized baseball is moved .01 mm.

Suppose we now have, in quantum mechanics, a baseball which has its c.m. coordinate spread out over 1 meter and we perceive it with the telescope. We can, without serious error, change the c.m. wave function to a sum, with the c.m. of each term in the sum being localized to within, say, .01 mm.

$$|\Psi\rangle = \int dx \psi(x)|x\rangle = \sum \int_{x(i)}^{x(i+1)} dx \psi(x)|x\rangle \equiv \Sigma\, |\varphi(x(i))\rangle\,, \quad x(i+1)-x(i) = .01\text{ mm}. \qquad (2)$$

The observer focuses the telescope on the baseball and looks at the angular reading. After observation, our system consists of N versions of: the baseball; the baseball-to-telescope photons; the telescope with its readings; and the observer, with the observer's neural firing patterns being different for each reading of the telescope;

$$\begin{aligned} |\Psi\rangle = \Sigma\, &|\varphi(x(i))\rangle\, |\text{photons corresponding to } x(i)\rangle \\ &|\text{telescope with reading } r(i) \text{ corresponding to } x(i)\rangle \\ &|\text{obs neural pattern } n(i) \text{ corresponding to reading } r(i)\rangle \end{aligned} \qquad (3)$$

**Each version of the observer sees a sharply defined, localized baseball.**

Each version of the observer will see a baseball with its c.m. localized to within .01 mm. And each version will see a baseball with sharp edges and features because feature and edge locations *in each version* are, in the quantum mechanical description, sharply defined (to, say, $10^{-9}$m) relative to the localized c.m. in each version. Thus, using the reasoning in Ch. 11 (more than one version of reality is never perceived), we see that anything other than a sharply defined, localized baseball will never be perceived.

The spreading of the wave function means that if the experiment is exactly repeated, the observed location of the c.m. will change on different runs, but it does not imply that a *smeared-out* baseball will be perceived on a given run of the experiment.