in color and strength and in the length in time during which visible light is emitted.

At the end of this chapter, let us revisit the fundamental question that stood at the outset of our discussion concerning the wave-particle duality: Are particles and waves really two completely unrelated phenomena? Seen conceptually, they probably are. But consider (2.9) and its discussion. Both waves and particles are *mathematically* described essentially by the same equation, i.e., the former by setting $\Delta\omega$ and $\Delta k = 0$ and the latter by making $\Delta\omega$ and Δk large. Thus, waves and particles appear to be interrelated in a certain way. It is left to the reader to contemplate further on this idea.

Problems

1. Calculate the wavelength of an electron which has a kinetic energy of 4 eV.
2. What should be the energy of an electron so that the associated electron waves have a wavelength of 600 nm?
3. Since the visible region spans between approximately 400 nm and 700 nm, why can the electron wave mentioned in Problem 2 not be seen by the human eye? What kind of device is necessary to detect electron waves?
4. What is the energy of a light quantum (photon) which has a wavelength of 600 nm? Compare the energy with the electron wave energy calculated in Problem 2 and discuss the difference.
5. A tennis ball, having a mass of 50 g, travels with a velocity of 200 km/h. What is the equivalent wavelength of this "particle"? Compare your result with that obtained in Problem 1 above and discuss the difference.
6. Derive (2.9) by adding (2.7) and (2.8).
7. "Derive" (2.3) by combining (1.3), (1.5), (1.8), and (2.1).

*8. *Computer problem.*
   (a) Insert numerical values of your choice into (2.9) and plot the result. For example, set a constant time (e.g. $t = 0$) and vary Δk.
   (b) Add more than two equations of the type of (2.7) and (2.8) by using different values of $\Delta\omega$ and plot the result. Does this indeed reduce the number of wave packets, as stated in the text? Compare to Fig. 2.3.