Due: Thursday, 03/23

10. If you had a femtosecond frequency comb in your lab, what would you do with it? (Give a brief description of a measurement or application.)

11.

a. Consider an electric-dipole (E1) transition between states of total angular momenta $F = 1/2$ and $F'=3/2$. Draw and/or list all possible $M \longrightarrow M'$ transitions and indicate their relative strength. Explain, which type of plane-wave light (polarization, propagation direction) is needed to drive each of the transitions.

b. Same but for an electric-quadrupole (E2) transition.

12. Consider the following set of angular-momentum probability surfaces [figure from E. B. Alexandrov *et al*, Dynamic effects in nonlinear magneto-optics of atoms and molecules; in a Special Issue of JOSA B on Nonlinear and Integrated Magneto-Optics; JOSA B **22**(1), 7-20 (2005)]. Looking at these surfaces, predict the character of optical anisotropy corresponding to some of the representative cases, and discuss an experimental arrangement where such anisotropy can be detected. Which polarization moments (PM) can be detected by weak probe light? What are the symmetry properties of the angular-momentum probability surfaces corresponding to these PM?

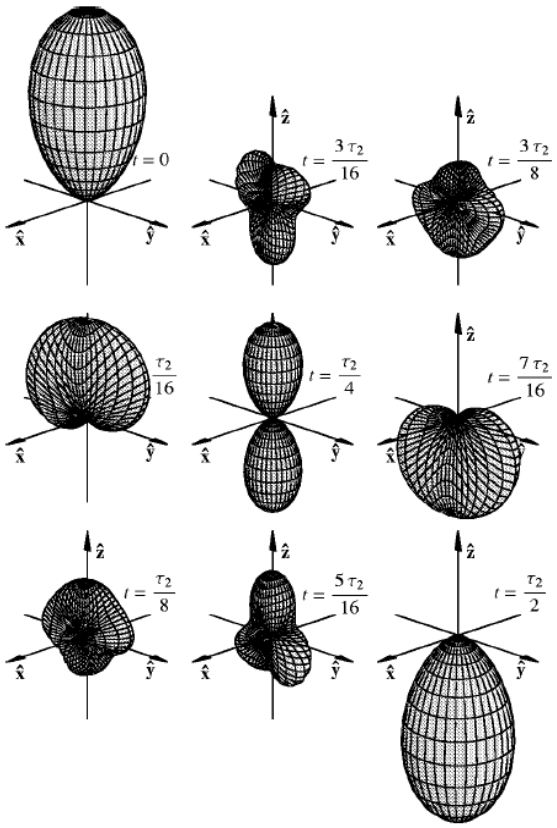

Fig. 1. Quantum beats in Cs illustrated with surfaces representing the probability of finding the system in the state with maximal projection $m = F$ in a given direction.[8,9] This sequence is "stroboscopic" in the sense that the surfaces correspond to times chosen to have the same phase of the fast Larmor precession around the direction of the magnetic field $\hat{\mathbf{x}}$. From the symmetry of the plots one clearly sees that orientation present in the initial state collapses and revives in the process of the temporal evolution. Temporal variation of higher polarization moments gives rise to higher-order-symmetry contributions to the probability surface (see also Fig. 3).

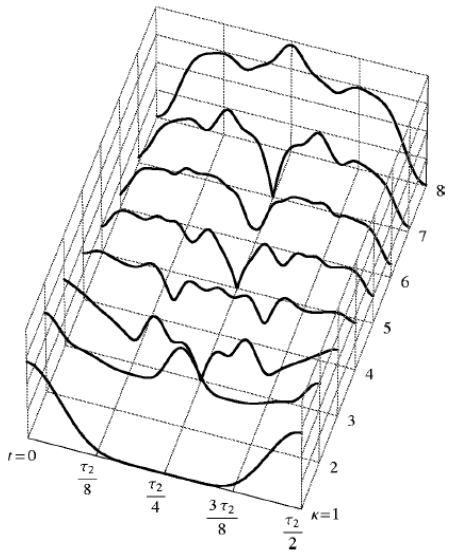

Fig. 3. Temporal evolution of the norms of various polarization moments of ranks κ of the $F = 4$ ground state of Cs corresponding to the case of Figs. 1 and 4. The initial stretched state is dominated by the lowest-order moments; at $t = \tau_2/4$ the state is composed only of even-order moments.