Due: Thursday, 03/02

7. Beautiful experiments demonstrating that Laguerre-Gaussian light modes are associated with certain orbital angular momentum of the light have been done in the following way. Laser light was focused on small particles suspended in water. Due to absorption of the light with angular momentum, because of angular-momentum conservation, the particles are set in rotational motion. This can be observed in a microscope.

a. How can one do an experiment with this general setup to demonstrate both the spin and orbital angular momentum of the light beam, and to verify that the minimum-magnitude non-zero angular momentum per photon is the same as photon spin ($\hbar$)?

b. Make "first-path" estimates of what it would take to do such an experiment: suggest a reasonable size of the particles, light intensity, etc.; how fast will the particles rotate. Make sure your experiment is "doable." (You can check the literature, if you want, to see what the parameters were in actual experiments.)

8. Best commercially available crystalline polarizers give extinction ratio on the order of 10^{-6}. This means that, upon propagation through one such polarizer, light is mostly of a particular linear polarization, with the intensity of the "wrong" linear polarization $\sim 10^6$ times weaker (corresponding to $\sim 10^3$ weaker electric-field amplitude). Assuming that the "wrong" field component is at random phase with respect to the "legitimate" electric field in the transmitted beam, estimate the magnitude of the normalized third Stokes parameter (P_3) which characterizes the difference in intensity of the two opposite circular polarizations in the beam. (This problem was suggested by Arman Cingoz.)

9. As demonstrated during the "field trip" to our laboratory, a variable retarder (for example, a $\lambda/2$ or a $\lambda/4$ plate) can be constructed from a cuboid (a.k.a. rectangular parallelepiped) made out of fused silica by mechanically squeezing it perpendicularly to a pair of opposite-facing sides. Without squeezing, the element is optically isotropic; anisotropy (linear birefringence) is induced by squeezing. Assuming the thickness of the element is 2 cm, and the other two dimensions are both 5 cm, estimate the force that is needed to make a $\lambda/4$ plate for the light from a He-Ne laser (λ=632.8 nm). What is the maximal retardance that can be achieved before the element breaks?