

# AP 217

## Problem Set 5

Consider a spherical Bose-Einstein condensate trapped by an electromagnet in a 3D symmetric harmonic oscillator potential. For large condensates ( $N \geq 10^3$  or  $10^4$ ) the density distribution of the condensate is parabolic:

$$n(\vec{r}) = n_0 \left( 1 - \left( \frac{r}{r_0} \right)^2 \right), \quad r \leq r_0$$

$$n(\vec{r}) = 0, \quad r > r_0$$

Assume that  $r_0 = 25 \mu\text{m}$  and  $n_0 = 10^{14}$  atoms/cm<sup>3</sup>.

Let the condensate consist of Na atoms. Illuminate it from the side with a laser beam tuned close to the sodium resonance line discussed in the last problem set: electric field =  $\vec{e}(\vec{r}, t) = E_0 \hat{e}_z e^{i(ky - \omega t)}$  in vacuum before the light beam enters the cloud. Ignore local field effects.

For the laser tuned on

1. resonance
2. 10 MHz above, and
3. 10 MHz below resonance

calculate and show in a figure a set of light ray paths through the condensate.

Find the phase of each path in a plane (perpendicular to the original propagation direction of light rays) right after the condensate. Find the absorption of each ray.

To start out, plot  $\epsilon_1$ ,  $\epsilon_2$ , and  $\epsilon_2/\epsilon_1$  as a function of frequency. It will be helpful for you to have these plots as a reference.

And remember, the radial frequency  $\omega$  (rad/s) is  $2\pi$  times the frequency  $f$  (Hz).