

Sixth homework assignment tentatively due on Wed 6 May.

1. Compute the matrix element of the third component  $z$  of the position operator  $\mathbf{r}$  between the  $3p$  state with  $m = 0$  and the ground state of atomic hydrogen:

$$\langle 100|z|310\rangle. \quad (1)$$

2. Compute the rate of transitions from the  $3p$  state with  $m = 0$  (directly) to the ground state of atomic hydrogen. What is the partial lifetime of the  $3p$  state, excluding decays to the  $2s$  state?

Some useful relations for atomic hydrogen:

- $R_{10}(r) = \frac{2}{a_0^{3/2}} e^{-r/a_0}$
- $R_{21}(r) = \frac{1}{\sqrt{3}} \frac{1}{(2a_0)^{3/2}} \frac{r}{a_0} e^{-r/(2a_0)}$
- $R_{31}(r) = \frac{8}{9\sqrt{6} a_0^{3/2}} \left(1 - \frac{r}{6a_0}\right) \frac{r}{a_0} e^{-r/(3a_0)}$
- $Y_0^0 = \frac{1}{\sqrt{4\pi}}$
- $Y_1^0 = \sqrt{\frac{3}{4\pi}} \cos \theta$