

University of Adelaide, Department of Physics

Experimental PX III

Cs Hyperfine Structure – assessment questions

Name : Andre Repanich Student No: a1764037 Date: 26/10/23

- 1) Does the ratio of heights of the two absorption dips (or peaks) agree with the degeneracy ratio of the ground hyperfine states? Explain briefly.

Yes the max found for the first peak over the max of the second peak was calculated as 1.2991. The theoretical ratio based on degeneracy was 1.2838 using Boltzman probability distribution

$$\text{i.e. } \frac{P(E_2)}{P(E_1)} = \frac{9}{7} \exp\left(\frac{-6.096 \times 10^{-24}}{k_B \times 300}\right) = 1.2838.$$

- 2) What is the experimental evidence for the ground state of Cs being an S-state?

The S-state is comprised of two degenerate ground states whereas the p-state would have six. We see the two spectral lines corresponding to the two degenerate states of the S-state. 6 spectral lines would suggest a ground state being a P-state.

- 3) What does the experiment tell you about any hyperfine splitting of the upper P-state? In terms of the different nature of S- and P- wavefunctions, why should P-state hyperfine splitting be less?

Hyperfine energy differences correspond with the angular momentum of an electron and that of the nucleus. The weaker the interaction, the smaller the energy differences are. Therefore, for electrons in the upper p-state, i.e. further away from the nucleus, the weaker the interaction between the electron and the nucleus. Therefore, smaller differences in the degenerate energies. This becomes harder to resolve as the width of the absorbed light (in this case due to equipment limitations) would be greater than the energy difference.