

More line broadening: Figure 6.2 shows data from measurements of the homogeneous linewidth of the  $D_1$  ( $6p^2P_{1/2} \rightarrow 6s^2S_{1/2}$ ) and  $D_2$  ( $6p^2P_{3/2} \rightarrow 6s^2S_{1/2}$ ) transitions in Cs at 894 and 852 nm respectively.

In addition to the homogeneous broadening, inhomogeneous broadening is caused by the thermal motion of the atoms. This so-called Doppler broadening has a Gaussian lineshape with a full-width at half-maximum linewidth given by,

$$\Delta\nu_D = \sqrt{8 \ln 2} \sqrt{\frac{k_B T}{M c^2}} \nu_0.$$

where  $T$  is the temperature of the atoms,  $M$  their mass, and  $\nu_0$  the frequency emitted on the transition by a stationary atom.

- (a) Calculate the Doppler width in MHz of these transitions assuming that the temperature of the Cs vapour is 21 °C, and comment on the relative magnitudes of the inhomogeneous and homogeneous linewidths.
- (b) The radiative lifetimes of the  $D_1$  ( $6p^2P_{1/2}$ ) and  $D_2$  ( $6p^2P_{3/2}$ ) levels are 34.75 and 30.41 ns respectively. What is the natural linewidth of the  $D_1$  and  $D_2$  transitions? Is your calculated value consistent with Fig. 6.2?
- (c) Use the data presented to deduce the rate of increase in the homogeneous linewidth in units of MHz Torr<sup>-1</sup> for each of the two transitions. Explain briefly the cause of this increase in homogeneous linewidth with pressure.
- (d) What is the mean collision time at a He pressure of 100 Torr for He-Cs collisions?

[The molar mass of Cs is 132.9 g.]

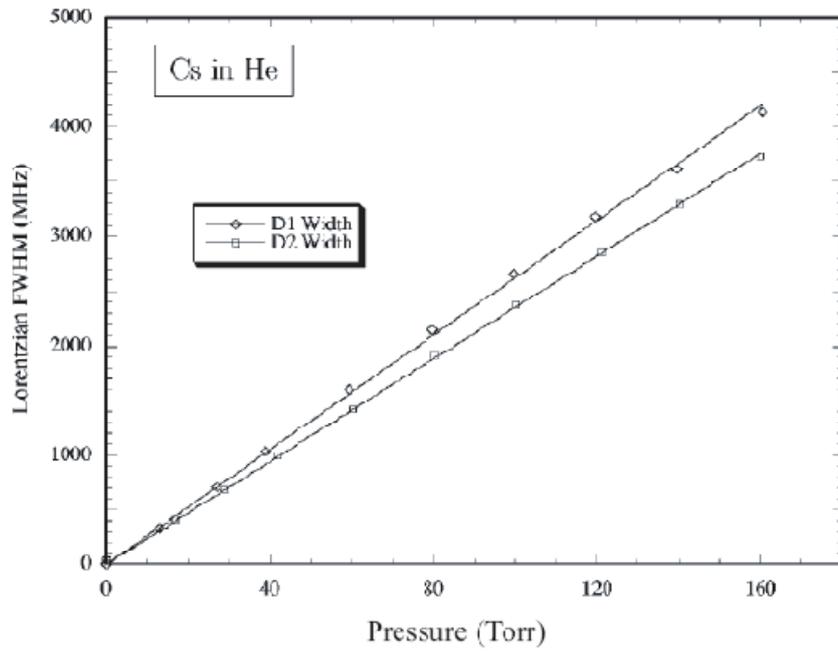


Figure 6.2: Measured full width at half maximum of the homogeneously broadened component of the  $D_1$  and  $D_2$  lines of Cs as a function of the pressure of helium (data from A. Andalkar and R. B. Warrington *Phys. Rev. A* **65** 032708 (2002)).