

Diffusion lab

Physics 3705: Spring 2016

Objective: To measure the exponent associated with diffusion by studying a dye diffusing in a wetted wick and salt diffusing in a thin pipe filled with water.

Theory: As your instructor will show you in class, the concentration $C(x, t)$ of a diffusant at a distance x from an initial spike of concentration delivered at time $t = 0$ goes as

$$C(x, t) = \frac{A_0}{t^{d/2}} e^{-x^2/(4Dt)} \quad (1)$$

where D is the so called diffusion constant and A_0 is an overall constant. In this expression, d is simply the number of spatial dimensions that the diffusion occurs in.

Eq.(1) can be boiled down to the following observation; the size $\sqrt{\langle x^2 \rangle}$ of a diffusing spot will grow as

$$\sqrt{\langle x^2 \rangle} = B_0 \sqrt{Dt} \quad (2)$$

where B_0 is an overall constant. We will aim to test both of these expressions directly, in two different ways.

Method 1: Onto a wetted scott towel a drop of dye is placed...and at regular intervals of time the size (radius) of the spot is recorded. This is relatively quick (10 minutes) but may need to be repeated a few times to get a good, representative dataset.

Method 2: A thin glass tube is illuminated in two locations by green LEDs. Across the tube from the LEDs are intensity sensors. The tube is filled with room temperature water and a water+salt filled “sock” is placed at one end. The salt used is Cobalt Carbonate. As this salt diffuses down the tube, the two sensors placed along the tube register the opacity change of the tube. The relation between the transmission percentage and the concentration is exponential one (called Beer’s law);

$$T = \exp(-bC) \quad (3)$$

Where b is a constant. Thus, by measuring transmission and taking its logarithm you will have a quantity that is proportional to the concentration.

Analysis: For method 1, plot the distance versus time and fit those data with a power law (or maybe a modified power law ... a power law with an constant term added) and determine the exponent and compare what you get with the expected exponent.

For method 2, take the log of your intensity signal (i.e. the concentration) and plot that versus time and try to fit it with the above equation expected for diffusion in one spatial dimension ($d = 1$). From your two different positions (x 's) can you use your data to determine

- (1) Does the Eq.(1) 'work' for your data?
- (2) Can you determine the diffusion constant D from your data?