Physics 491: Recitation #10
Nov. 11, 2016

The neutron interferemetry experiment (PhysRevLett.35.1053) is shown in Figure 1 from the paper. The unpolarized, spin-1/2 neutron interferes along the two paths, one path going through a magnetic field region. The neutron magnetic moment is $\vec{\mu} = g_N \mu_N \vec{S}/\hbar$ where the neutron g-factor is $g_N/2 = -1.91$ and the nuclear magneton is 3.15×10^{-14} MeV/T.

1. How does the electrically neutral neutron have a magnetic moment, and why is the nuclear magneton is so much smaller than the Bohr magneton (5.8×10^{-11} MeV/T).
2. For an unpolarized spin-1/2 particle we sum the probabilities (not the amplitudes) for spin up and spin down. Show that in either case, with the Hamiltonian $H = \omega_0 \hat{S}_z$, the counting rate at D should be proportional to $[1 + \cos(\omega_0 t/2)]$ predicting an oscillation period of $\omega_0 t = 4\pi$.

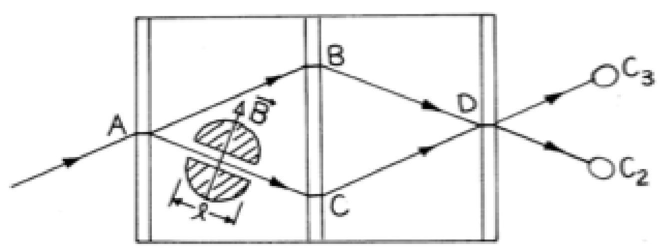

FIG. 1. A schematic diagram of the neutron interferometer. On the path AC the neutrons are in a magnetic field B (0 to 500 G) for a distance l (2 cm).

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3. The neutrons were selected via Bragg diffraction to have a wavelength of $1.445\mathring{A}$. The neutron mass is $Mc^2 = 940$MeV. Calculate the fractional phase shift $\omega_0 t/4\pi$ for path C using $\ell = 1$cm, $\lambda = 1\mathring{A}$ and $B = 100G$. Plank's constant is 4.1×10^{-21} MeV·s. (I get the time $t = 2.55\mu$s and $\omega_0 t/4\pi = 0.3742$.) In the paper, they say the "effective length" of the field region is 2.7 cm. Use the results of Figure 3 (B in Gauss) to confirm that a rotation by 4π gives zero interference. (I get $\omega_0 t/4\pi = 0.9$ which they claim is $= 1$ within experimental errors.)

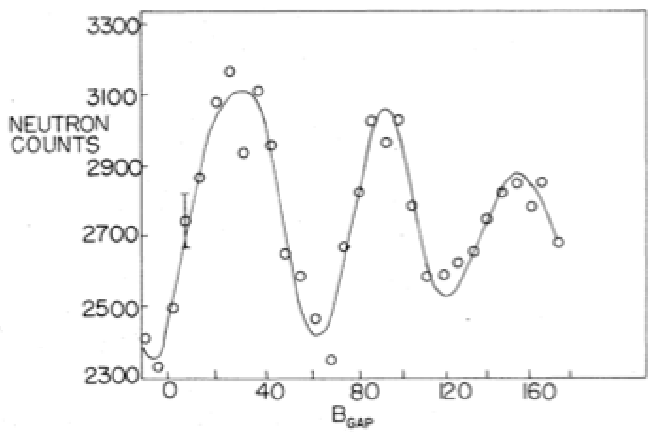

FIG. 3. The difference count, $I_2 - I_3$, as a function of the magnetic field in the magnet air gap in gauss. Approximate counting time was 40 min per point.