Experimental Practical Session at M15 (Aug.15-18, 2011)

Apparatus: LAMPF (Los Alamos Meson Proton Facility) Spectrometer, Miss Piggy (Quantum Design) Helium Gas Flow Cryostat

Sample: $BaFe_2As_2$ Crystal – with the crystalline *c*-axis perpendicular to the big face with the beam inciding on the sample in the *c* direction of the crystal.

Objective: Study the magnetism of this compound with ZFmuSR

At the start: What is the incident muon rate per second? This is the rate of light pulses in the thin muon counter that give a signal sufficient to trigger the discriminator. Record this rate in the logbook provided. It is important to get into the habit of recording important status indicators and observations in the logbook. This makes it much easier to troubleshoot or to identify problematic data or to reproduce conditions later. Estimate the uncertainty in the muon rate per second.

What is the current sample temperature? How much power is being applied to the resistive electrical heaters to balance the cooling power of the cryostat? There are two heaters in the cryostat: one in the helium "diffuser" (resistance 40 Ohms) and one on the sample tube (55 Ohms). What is the needle valve setting for the liquid Helium flow into the cryostat? What steps will you take to cool the sample?

What direction is the muon's spin in the current setup? Hint: Check the values of the separator voltages to see if they are being operated as spin rotators.

Procedure:

1. Apply a weak horizontal (L/R) field by sending a current of 14 Amps through this set of transverse coils. Note there is another set of coils (vertical) that we won't use. This should result in a field of about 20 G. What will this do to the muon's spin? Take data for 20 minutes. Does the F/B asymmetry look as you would expect?

What is the amplitude A_0 of the signal? What is the value of alpha (see handout titled: "Basic Definitions for μSR Data")? What does this mean? (Hint: requires fitting) Are there oscillations in the U/D asymmetry? Why?

2. Turn the transverse field off, so that the sample is once again in zero magnetic field. Take 20 minutes of data. What do you see?

3. Now rotate the muon spin polarization and take another run of about 20 minutes. This involves turning on (up) the high voltages and the magnetic field on the 2 separators (2 plates and one magnet current each) and going to "Argon mode" where a low pressure Ar gas is used to suppress discharges caused by the high electric field.

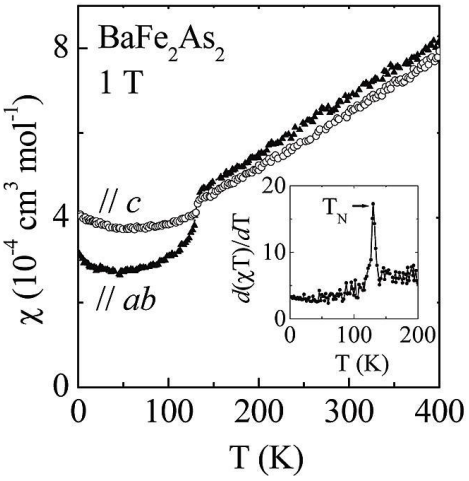
4. Cool the sample to 135 K and repeat the ZF measurement with the spin rotated, i.e. with transverse muon spin polarization.

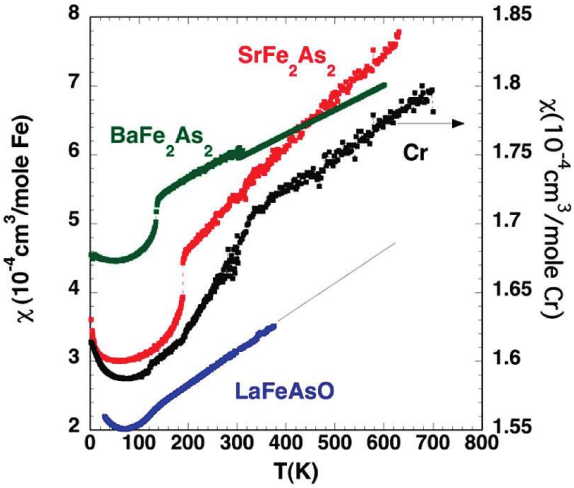
5. Cool to 10 K and take two runs one with longitudinal muon spin polarization and one with transverse. Allow the latter to accumulate significant statistics.

Monitor both the U/D and F/B asymmetry as a function of time by plotting it and also by Fourier transforming it.

What does the data tell you about the magnetic properties of $BaFe_2As_2$? -see G.M. Luke's lectures.

Combined with the macroscopic SQUID susceptibility χ (below), what does this tell you about the magnetism in this material?





The magnetic susceptibility of a single crystal of $BaFe_2As_2$ with a 1Tesla magnetic field applied along the crystal *c*-axis and within the *ab*-plane as a function of temperature from Mandrus et al., Chem. Mater. 2010, **22**, 715–723.