Abstract: This paper is a brief review of recent measurements performed on \( \text{Eu}_{x}\text{Sr}_{1-x}\text{S} \) just below and above \( x_c \approx 0.51 \), i.e. within the ferromagnetic to spin glass crossover regime where quite interesting and novel effects are observed. Spin-glass freezing below \( x_c \) is studied in the high-frequency region and in dependence on a magnetic field. Neutron-diffraction experiments measure the spin correlations directly and provide evidence for a re-entrant ferromagnetic phase boundary above \( x_c \), which can be explained in terms of random-field effects.

I. Introduction

Disordered magnetic systems with competing interactions have attracted a great deal of attention in recent years. Non-conventional magnetic order phenomena found in such random alloys have been studied systematically in \( \text{Eu}_{x}\text{Sr}_{1-x}\text{S} \) \cite{1} where the ferromagnetic insulator \( \text{EuS} \) is diluted with \( \text{SrS} \). There is the advantage that the unique properties of \( \text{Eu}_{x}\text{Sr}_{1-x}\text{S} \) can be described quantitatively by a realistic site-disorder model of a Heisenberg system with well-known short-range competing interactions between well-localized spin-only moments of \( \text{Eu}^{2+} \) ions \cite{2}, namely a ferromagnetic nearest-neighbor exchange, \( J_1 \), and an antiferromagnetic next-nearest neighbor exchange interaction, \( J_2 \), with the ratio \( J_2/J_1 = -0.5 \).

Figure 1a shows the magnetic phase diagram of \( \text{Eu}_{x}\text{Sr}_{1-x}\text{S} \): long-range ferromagnetic order (FM) is unstable against dilution already at concentration \( x_c = 0.51 \), far above the percolation threshold \( x_p \approx 0.13 \), and spin-glass (SG) behavior is observed for \( 0.13 < x < 0.65 \). Insulating spin glasses \( \text{Eu}_{x}\text{Sr}_{1-x}\text{S} \), similar to metallic alloys like \( \text{AuFe} \), exhibit a freezing transition to some new type of local magnetic order, the nature of which is still heavily debated. It is well established, however, that both disorder (due to the dilution effect) and frustration (due to the competition of exchange interactions of opposite sign) are considered as necessary and essential ingredients for a spin glass. Here, we are interested in studying the evolution of spin-glass behavior from the ferromagnetic phase by increasing the magnetic dilution in \( \text{Eu}_{x}\text{Sr}_{1-x}\text{S} \). Our results in the crossover regime can be explained by the interplay between ferromagnetic and spin-glass type of order phenomena.

First, we present experimental data of \( \text{Eu}_{x}\text{Sr}_{1-x}\text{S} \) as function of composition which provide evidence of a significant change of magnetic behavior in the diluted ferromagnets when approaching the ferromagnetic to spin glass boundary. As shown
Fig. 1: (a) Magnetic phase diagram of Eu$_x$Sr$_{1-x}$S.
(b) Specific heat of four dilute ferromagnets Eu$_x$Sr$_{1-x}$S /3/
(c) Plot of C$_M$/T versus temperature, C$_M$ = magnetic specific heat.