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SUBMILIMETER MAGNETOSPECTROSCOPY ON ZnFeSe

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We report FIR laser spectroscopy study of $Zn_{1-x}Fe_xSe$ ($x < 0.06$) Semimagnetic Semiconductor at the temperature range of 2–26 K and magnetic fields up to 18 T.

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One of the central problems of Fe-based Semimagnetic Semiconductor (SMSC) is the information about the energy structure of the Fe^{++} ion ground term (^5E, split into a singlet A_1, a triplet T_1, a doublet E, a triplet T_2 and a singlet A_2 [1]). A useful tool to study this structure is far infrared (FIR) spectroscopy [1, 2]. Recently, an investigation of Fe-type SMSC has been reported [3, 4], however it dealt with rather low Fe concentrations. In this paper we present complementary results of FIR laser spectroscopy for $Zn_{1-x}Fe_xSe$ ($x < 0.06$) in the temperature range $2 < T < 26$ K and magnetic fields up to 18 T.

In Fig. 1 we display resonant energies observed experimentally as a function of magnetic field. The previously observed [3, 4] transitions $A_1 - T_1$ and $A_1 - E$ are clearly visible also for higher x, although the spectra are broader than those obtained for low x. The experimental energies match well the calculated energy level differences for isolated, i.e. not interacting Fe^{++} ion (Fig. 1). We notice that the line observed at 14.3 cm^{-1} coincides with the lowest transition $A_1 - T_1$. However, this transition is only weakly dependent on the field and therefore should not be observed in laser spectroscopy as a resonance (fixed energy of laser line). In that respect the origin of 14.3 cm^{-1} line is still not clear.

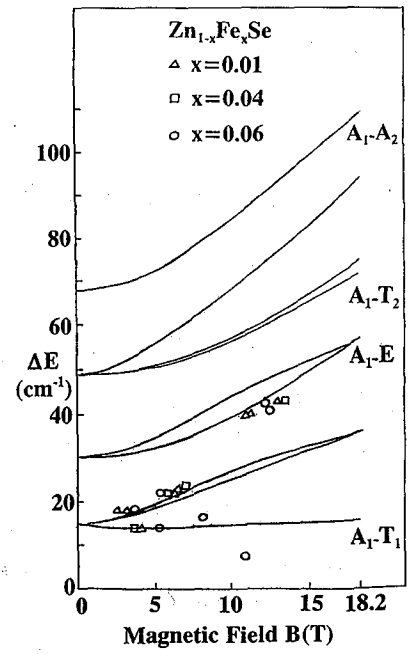

Fig. 1. The experimentally observed resonance energies as a function of magnetic field; the lines present calculated energies of transitions: solid lines – model from [1] with $Dq = 293$ cm^{-1} and $\lambda = -95$ cm^{-1}, dotted lines – model from [2] with $Dq = 294$ cm^{-1} and $\lambda = -88$ cm^{-1}; parameters were obtained by fitting to the zero-field energies of $A_1 - T_1$, $A_1 - T_2$ transitions as well as zero phonon line of $^5E - ^5T$ transition.

For $Zn_{0.94}Fe_{0.06}Se$ we observed a weak and broad line at 8.2 cm^{-1} (Fig. 1). This line disappears at temperatures $T > 5$ K and is not visible for lower Fe concentrations. We stress that the transition energy is roughly two times smaller than the lowest transition energy expected for isolated Fe ion. A possible candidate for the 8.2 cm^{-1} lines is the transition between the ground and the first excited states of a Fe–Fe pair coupled by exchange interaction. In ZnFeSe, calculated energy of this transition is about 8–9 cm^{-1} [5]. An increasing contribution of pair and larger clusters to FIR absorption should be expected for $x > 0.03$ and is indeed exhibited by the changes of FIR absorption spectra shape [6, 3] as well as by the temperature variation of the spectra (Fig. 2). We believe, however, that the available data are too preliminary to establish the nature of 8.2 cm^{-1} line.

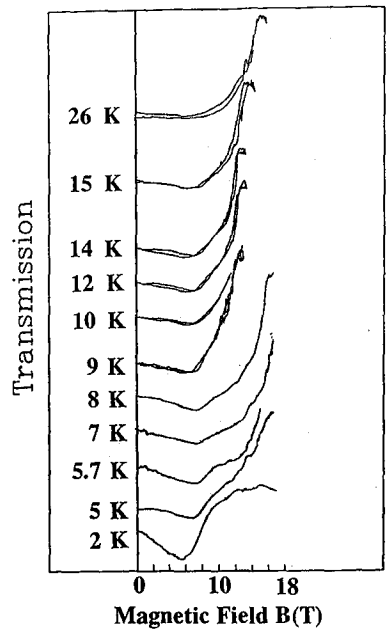

Fig. 2. The experimental FIR transmission spectra of $Zn_{0.94}Fe_{0.06}Se$ as a function of magnetic field for various temperatures. The laser energy was 21.2 cm^{-1}. Curves at $9 < T < 26$ K show results for upward and downward sweeps of magnetic field.

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