Detection of Villari effect in $FeSe_{1-x}S_x$ (x=0.075)

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Acoustoelectric transformation (AET) is a new method that has made it possible to obtain various information about piezomagnetic and electromagnetic effects in studied media. In particular, it permits to study the temperature and magnetic field dependence of the AE response of the systems with superconducting ordering. Recently, at temperatures below the temperature of the structural phase transition T_s the AE transformation revealed the hidden magnetism in FeSe.

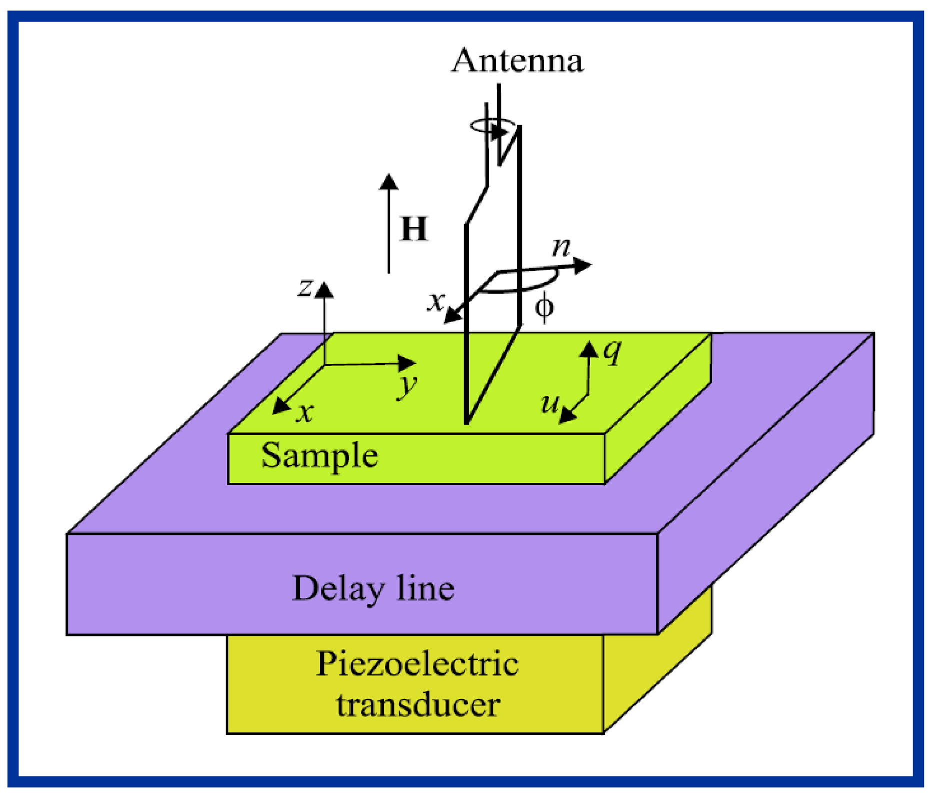

Fig. 1. Geometry of the AET experiment

In piezomagnets, an elastic wave propagating in the sample excites oscillations of the magnetic moment in it, which cause oscillations of the electric field. A measurement of the amplitude and phase of the AET signal at different orientations of the antenna, different polarization of the elastic mode, and in the presence of the external magnetic field make it possible to study the qualitative and quantitative characteristics of magnetoelastic effects.

The scheme of the AET experiment is shown in Fig. 1. The shear deformation of a given polarization, generated by the piezoelectric transducer, is introduced into the sample through an acoustic delay line. The electromagnetic field, arising in the sample under deformation, is radiated into free space and registered by a frame antenna placed near the sample. The interface radiating surface is orthogonal to the wave vector of the sound mode.

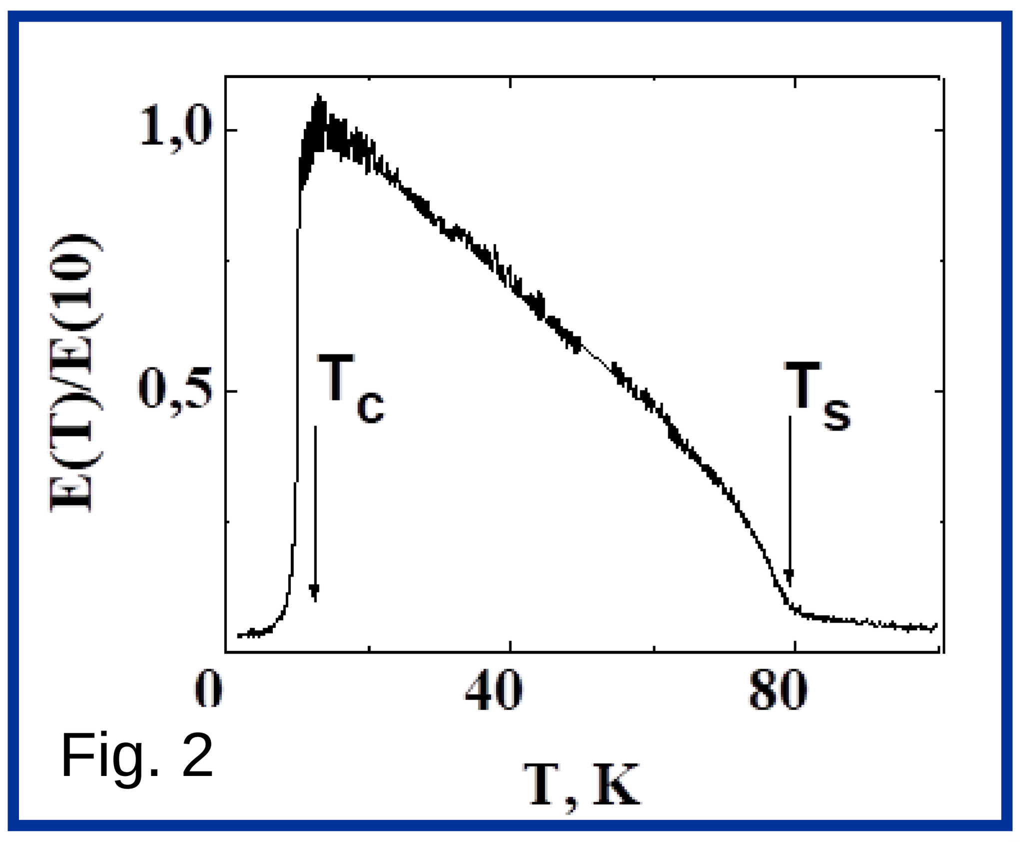

Fig. 2

The temperature dependence of the amplitude of the radiation field obtained in the experiment is shown in Fig. 2. T_s is the temperature of the structural transformation. T_c is the superconducting transition temperature.

The AET signal increases rapidly below T_s, but at the point of the superconducting transition T_c, it sharp decreases almost to zero. This fact allows us to assume that this signal exists only in the normal state.

This work is devoted to the study of magnetoelastic interactions in single crystals of $FeSe_{1-x}S_x$ (x=0.075) in an external magnetic field. The rotation diagrams were studied in the absence (Fig. 3) and in an external magnetic field (Fig. 4), which give the dependence of the amplitude (E) and phase (φ) of the signal on the angle of rotation of the antenna (ϕ).

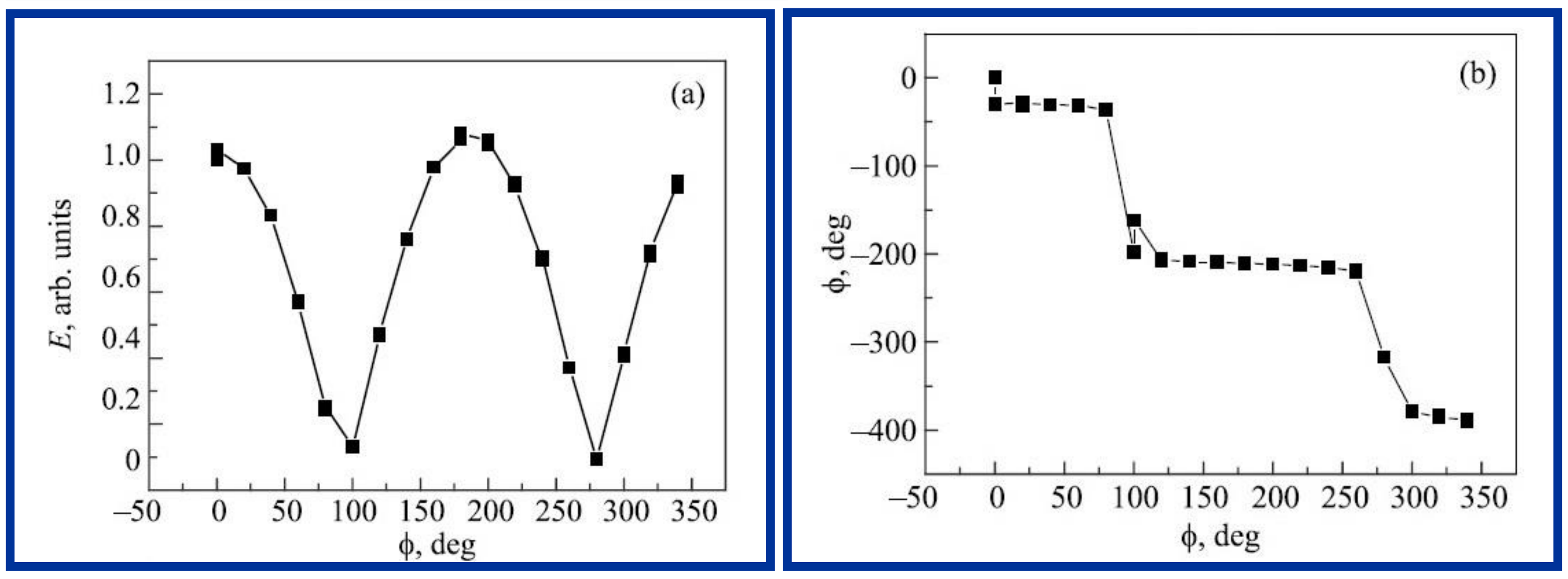

Fig. 3. The polarization diagram for the AET signal at T = 20 K in zero magnetic field

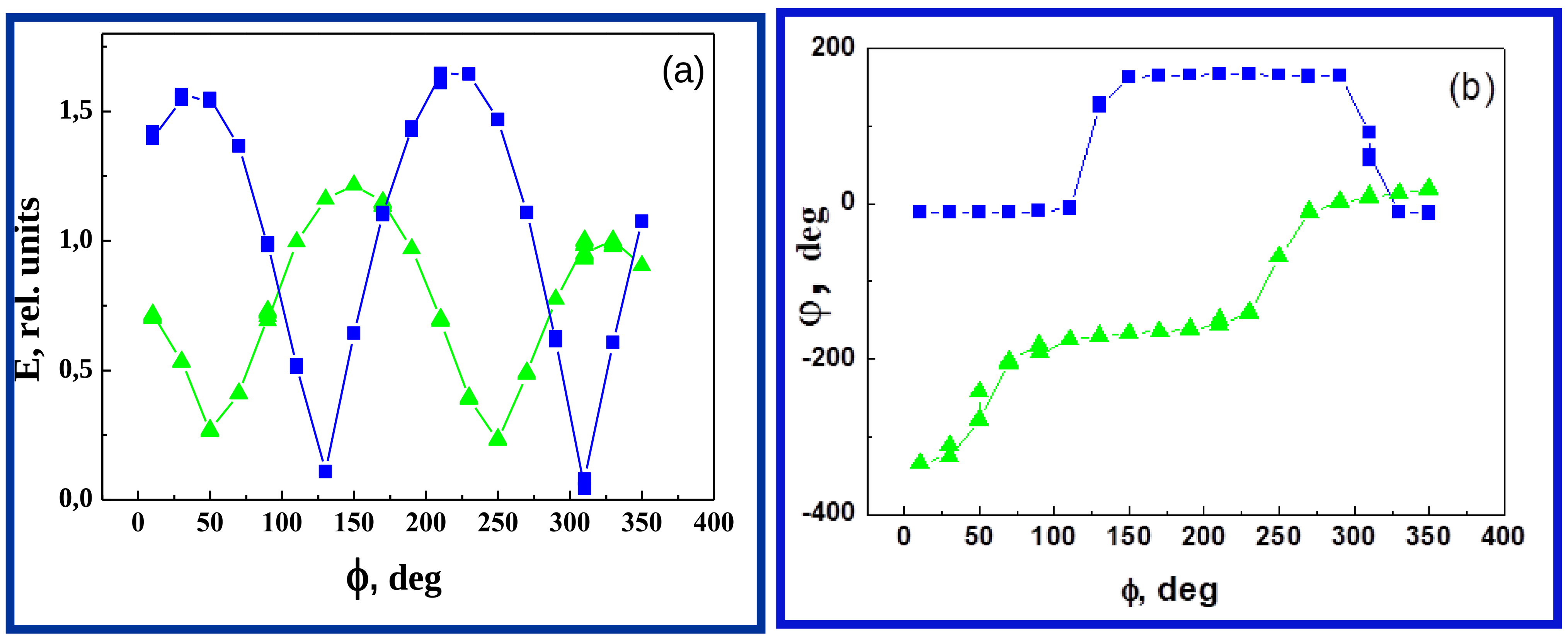

Fig. 4. The amplitude (a) and the phase (b) of the AET signal at T=15K and H =3T.
The blue squares and green triangles are the experimental points that correspond to two opposite directions of the field **H** (parallel and antiparallel to the z-axis).

It was found that **in the magnetic field, the plane of polarization of the emitted electromagnetic wave rotates, and the sign of the rotation angle corresponds to the sign of the applied magnetic field.**

The physical mechanism of the studied feature is that the elastic deformation leads to the appearance of a non-diagonal component of the magnetic susceptibility and to the generation of an additional alternating magnetic moment perpendicular to the external magnetic field and to the elastic displacement.

The observed features are interpreted as a manifestation of the **Villari effect, that is, a change in magnetization under the action of elastic deformation.**

The following results were obtained:

The AET in the normal state of superconducting chalcogenides based on FeSe has been studied.

- The main experimental result is that the **applied magnetic field leads to a rotation of the polarization plane of the emitted wave**. It reveals itself in a shift of the maximum of the amplitude of AET signal in the rotation diagram.
- The physical mechanism that causes this behavior is a manifestation of the **Villari effect,** that is, a change in magnetization under the elastic deformation. The observed effect indicates that the symmetry of the low-temperature phase FeSe1-xSx belongs to the triclinic syngony.
- The presence of piezomagnetism in FeSe1-xSx crystals indicates the existence of hidden magnetic order with an odd order parameter relative to the spin variables.