Superconducting α-FeSe studied by Mössbauer spectroscopy and magnetic measurements

Artur Błachowski[1], Krzysztof Ruebenbauer[1], Jan Żukrowski[2], Janusz Przewoźnik[2], Krzysztof Wojciechowski[3], Zbigniew M. Stadnik[4]

[1] *Mössbauer Spectroscopy Division, Institute of Physics, Pedagogical University PL-30-084 Cracow, ul. Podchorążych 2, Poland;* sfblacho@cyf-kr.edu.pl
[2] *Solid State Physics Department, Faculty of Physics and Applied Computer Science, AGH University of Science and Technology PL-30-059 Cracow, Al. Mickiewicza 30, Poland*
[3] *Department of Inorganic Chemistry, Faculty of Material Science and Ceramics, AGH University of Science and Technology PL-30-059 Cracow, Al. Mickiewicza 30, Poland*
[4] *Department of Physics, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada*

Recent discovery of the iron-based superconductivity resulted in the great scientific activity in similarity to the previous discovery of the high temperature superconductivity in cuprates. The simplest superconductor of this class belongs to the binary iron-selenium system. Superconductivity with the transition temperature T_c=8 K has been discovered for a compound being formed close to the FeSe stoichiometry with excess iron [1]. This compound has *P4/nmm* tetragonal structure at room temperature and transforms into *Cmma* orthorhombic phase between 100-80 K. There are several questions to be addressed for the tetragonal/orthorhombic $Fe_{1+x}Se$ system. The first point is concerned with the location of the excess iron. Another question is concerned with the electron spin density on iron.
Superconducting FeSe has been investigated by measurements of the magnetic susceptibility versus temperature and Mössbauer spectroscopy at various temperatures including strong external magnetic fields applied to the absorber. It was found that dominant defects for the sample having excess iron are iron atoms intercalated between iron selenium sheets. A transition from the *P4/nmm* to the *Cmma* structure lowers electron density on the intercalated iron atom by 0.86 electron a.u.$^{-3}$. Hence, two-dimensional character of the structure is enhanced in the *Cmma* structure in comparison with the higher temperature *P4/nmm* structure. Mössbauer measurements in the external magnetic field and for temperatures below transition to the superconducting state revealed null electron spin density within the unit cell. Hence, the compound behaves like Pauli paramagnet taking into account susceptibility data and Mössbauer results [2].

[1] F.C. Hsu *et al.*, arXiv:0807.2369, Proc. Natl. Acad. Sci. U.S.A. **105**, 14262 (2008).
[2] A. Błachowski *et al.*, arXiv:0907.0383 (2009).