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Change of the Charge Modulation at Critical Temperature in Iron-based Superconductors as Seen by Mössbauer Spectroscopy

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Iron-based superconductors $\text{Ba}_{0.6}K_{0.4}\text{Fe}_2\text{As}_2$ [1] belonging to the ‘122’ family (critical temperature $T_c = 38$ K) and $\text{SmFeAsO}_{0.91}\text{F}_{0.09}$ [2] belonging to the ‘1111’ family ($T_c = 47$ K) were investigated by Mössbauer spectroscopy versus temperature with particular attention paid to the region of superconducting transition. Spectra display quasi-continuous distribution of quadrupole doublets in the whole temperature range. A distribution is caused by the spatial modulation of the electric field gradient, i.e., by the electric field gradient wave (EFGW), the latter being a consequence of the incommensurate modulation of the charge density on the iron nuclei, i.e., the charge density wave (CDW). CDW is seen as the line broadening. Shape and amplitude of EFGW and CDW are strongly perturbed at the superconducting transition. Namely, all modulations strongly vary at critical temperatures due to the superconducting gap opening and subsequent formation of the Cooper pairs. Dispersion of the CDW and EFGW shape behave in the opposite ways for these two superconductors. These differences follow the manner of doping above compounds to achieve superconductivity. The ‘122’ superconductor is hole doped, while the ‘1111’ superconductor is electron doped. Hence, the Fermi surface moves opposite way for above cases and it seems that $d$ electrons contribute significantly to the Cooper pair formation in both compounds as EFGW is perturbed within the temperature region of the superconducting gap formation.

References