Volovik Effects of the ±S-wave state in the Iron-based Superconductors

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We studied the field dependencies of specific heat coefficient $\gamma(H) = \lim_{T\to 0} C(T,H)/T$ and thermal conductivity coefficient $\lim_{T\to 0} \kappa(T,H)/T$ of the ±s-wave state in the mixed state. We showed that the Doppler shift of the quasiparticle excitations (Volovik effect) will produce a strongly field dependent low energy excitations in this fully gapped ±S-wave state when the gap sizes are different, $|\Delta_+| \neq |\Delta_-|$. It is, however, proportional to H in contrast to the $\sqrt{H}$ dependence of the d-wave state. Impurity scattering effect on the ±s-wave state makes this generic H-linear dependence to sublinear approaching to the $\sqrt{H}$ behavior. Our calculations of $\lim_{T\to 0} \kappa(T,H)/T$ successfully fit the experimental data of Ba(Fe$_{1-x}$Co$_x$)$_2$ As$_2$ with different Co-doping x by systematically varying the gap size ratio $R = |\Delta_+|/|\Delta_-|$. We also resolved the dilemma of a substantial value of $\gamma(H \to 0)$ but very small value of $\lim_{T\to 0} \kappa(T,H \to 0)/T$, observed in many pnictide superconductors. [1]

[1] Yunkyu Bang, Phys. Rev. Lett. **104**, 217001 (2010).

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