An energetically competitive $\tau_3 B_{1g}$ pairing in a $t - J_1 - J_2$ model with orbital differentiated exchange couplings: implications for superconductivity in alkaline iron selenides

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— The pairing state in the alkaline iron selenides remains a challenge to our understanding. We address this issue in the incipient Mott picture based on the bad-metal behavior [1] of these materials. In conjunction with this picture, the multi-orbital effect is amplified, with two studied possibilities being the orbital-selective Mott transition [2] and the orbital-dependent pairing [3]. Here we carry out calculations in a five-orbital $t - J_1 - J_2$ model, in which the orbital-dependent correlations are directly encoded in the exchange couplings. Specifically, we consider intra-orbital exchange couplings for $d_{xz}$, $d_{yz}$, and $d_{xy}$ but allow varying the ratio $r_o = J_{xz;yz}/J_{xy;xy}$. For $r_o < 1$, we find a regime in the phase diagram where the leading pairing channel is an unusual $\tau_3 s^{B_{1g}}_{x^2-y^2}$. This state has a full gap on the Fermi surfaces at both the zone boundary and center, with the pairing function changing sign between the two electron pockets. We propose this pairing state as a viable candidate for superconducting alkaline iron selenides. [1] R. Yu et al., Nat. Commun. 4:2783 doi:10.1038/ncomms3783 (2013). [2] R.Yu and Q.Si, Phys. Rev. Lett. 110, 146402 (2013). [3] R. Yu, J.-X. Zhu, and Q. Si, Phys. Rev. B 89, 024509 (2014).