Microscopic model of the Knight shift in anisotropic superconductors

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Previous works on the development of a microscopic model of the Knight shift in anisotropic and correlated metals [1] and superconductors [2] have been extended to construct a fully Lorentz-invariant model of an anisotropic superconductor with one or more ellipsoidal Fermi surfaces. This new model exhibits equivalent Landau-level and Zeeman-energy splittings for all magnetic induction directions. In these models, the leading contribution to the Knight shift arises from the hyperfine interaction of the probed nucleus with one of its orbital electrons, which then enters one of the conduction bands and returns to orbit the same probed nucleus [1,2]. Thus, electrons that enter open orbits have a very low probability of returning to the same nucleus, and therefore do not contribute to the Knight shift, even in the normal state.

The fully Lorentz-invariant version of this model shows that quasi-one-dimensional superconductors such as $(TMTSF)_2PF_6$ should have very weak Zeeman energy splittings, and consequently little temperature dependence to the Knight shift in the superconducting state. Similarly, for the field parallel to the layers of a quasi-two-dimensional material such as Sr_2RuO_4, the Knight shift is likely to be independent of the temperature as it decreases below the superconducting critical temperature. Although the case of the applied field normal to the layers of a layered superconductor has not yet been analyzed theoretically, experiments on the singlet pair-spin superconductors $YBa_2Cu_3O_{7+\delta}$ and LiFeAs have shown that anomalous, temperature-independent behavior in the superconducting state, arises when the applied field is sufficiently strong. This model has profound implications for many Knight shift measurements that may have been misinterpreted in the literature.

References

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