Crystal-field magnetic background for the superconductivity in $CeCoIn_5$ and $CeFeAsO_{1-x}F_x$

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Existence of the discrete electronic structure (in meV energy scale) and the role played by the crystal field (CEF) in compounds containing $3d/4f/5f$ atoms/ions both in ionic and intermetallic compounds have been under strong discussion by last 40 years. In this contribution we analyze the localized crystal-field states in two Ce compounds: $CeFeAsO_{1-x}F_x$ and $CeCoIn_5$. The uniqueness of $CeFeAsO_{1-x}F_x$ relies in a fact that also in the superconducting state (T_{sc} of 41 K for x =0.16) well-defined crystal-field states have been found at 18.7 and 57 meV. $CeCoIn_5$ becomes superconducting at normal pressure at T_{sc}=2.3 K despite of strong increase with lovering temperature of the paramagnetic susceptibility. Revealed well defined CEF excitations, of 9 and 30 meV energy, are fingerprints of the Ce^{3+} ions with 3 Kramers doublets. By fitting temperature dependence of the paramagnetic susceptibility we have evaluated the low-energy electronic structure of the Ce^{3+} ions. In the J=5/2 basis the ground state Kramers doublet takes a form: $\Gamma_7^1 = 0.863|\pm 3/2> - 0.501|\mp 5/2>$. It yields a small spin value of 0.1 being a reason for difficulties in the formation of the AFM state.

The successful revealing of the Ce^{3+} crystal-field (CEF) states confirms the Quantum Atomistic Solid State Theory (QUASST) worked out by Radwanski *et al.* [1,2]. QUASST was the only theory, which has claimed from 1992 the existence of the discrete low-energy, below 10 meV, CEF electronic structure and the Kramers doublet ground state in heavy-fermion intermetallics. One notices that our atomistic approach is in full contrast to presently-in-fashion "the *ab initio* approaches to unconventional superconductivity of $CeCoIn_5$

We are convinced that the detailed description of normal-state properties will help in uderstandings of the origin of the superconductivity. According to us weakly-magnetized Ce-In planes in $CeCoIn_5$ become background for the superconducting flow. In $CeCoIn_5$ the superconductivity appears at the AFM edge.

References

[1] R.J. Radwanski *et al.*, Acta Phys Pol. B **31**, 3079 (2000).
[2] R.J. Radwanski, Acta Phys. **7-8** (2007).