Weak ferromagnetic ordering in the anomalous field-insensitive heavy-fermion state in $SmOs_4Sb_{12}$

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Quite rare Sm-based heavy-fermion (HF) state has been revealed recently in the filled-skutterudite $SmOs_4Sb_{12}$ at low temperatures[1,2]. One of the most striking features is its anomalous insensitivity against magnetic field[1]. The largely-enhanced electronic specific-heat-coefficient ($\gamma = 0.82$ J/K^{2}mol) and the T^2 coefficient (A) of electrical resistivity ρ do not show any significant decrease in applied fields, in contrast with ordinary Ce-based HF compounds, suggesting an unconventional origin of the heavy-quasiparticle formation. The ratio $A\gamma^{-2}$ is one order of magnitude smaller than the ordinary Kadowaki-Woods ratio of HF materials, probably associated with the orbital[3] or other[4] degrees of freedom of 4f electrons.

In the HF state, an extremely weak ferromagnetic ordering sets in below ~ 3 K. In order to investigate the nature of the weak ferromagnetic ordering, we have performed μSR measurements on single crystalline samples of $SmOs_4Sb_{12}$ down to 20 mK. In ZF-μSR spectra, we have observed clear oscillation developing in the ordered state. From the oscillation frequency, the ordered Sm magnetic moment has been determined to be 0.16 μ_B/Sm, combining with the hyperfine coupling constant of 760 Oe/μ_B determined in TF-μSR measurements. The strongly suppressed ordered moment compared with the expected values of 0.71 (0.52) μ_B/Sm for free Sm^{3+} ion (Γ_{67} quartet CEF ground state[5]) suggests that the 4f electrons are strongly hybridized with conduction electrons in the HF state.

[1] S. Sanada, et al., J. Phys. Soc. Jpn. **74** (2005) 246.
[2] W.M. Yuhasz, et al., Phys. Rev. B **71** (2005) 104402.
[3] N. Tsujii, et al., Phys. Rev. Lett. **94** (2005) 057201.
[4] for example, H. Kotegawa, et al., Phys. Rev. Lett. **99** (2007) 156408.
[5] Y. Aoki, et al., Physica B **378-380** (2006) 54.
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