

# Magnetic properties and spin kinetics of a heavy-fermion Kondo lattice

Kochelaev B.

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

## Abstract

A review of peculiarities of magnetic properties and spin kinetics of a heavy-fermion Kondo lattice revealed by electron spin resonance (ESR) experiments and their theoretical analysis is given. Among the issues discussed in some detail are the renormalization of spin kinetics coefficients due to the Kondo effect, formation of the collective spin modes of the Kondo ions and wide-band conduction electrons, unexpected behavior of ESR parameters as functions of temperature and magnetic fields. Special attention is focused on the possible role of the Kondo effect for the ESR signal existence at low temperatures.

<http://dx.doi.org/10.1063/1.4974187>

## References

- [1] P. Gegenwart, Y. Tokiwa, T. Westerkamp, F. Weickert, J. Custers, J. Ferstl, C. Krellner, C. Geibel, P. Kersch, K.-H. Müller, and F. Steglich, *New J. Phys.* 8, 171 (2006).
- [2] J. Sichelschmidt, V. A. Ivanshin, J. Ferstl, C. Geibel, and F. Steglich, *Phys. Rev. Lett.* 91, 156401 (2003).
- [3] J. Sichelschmidt, J. Wykhoff, H.-A. Krug von Nidda, J. Ferstl, C. Geibel, and F. Steglich, *J. Phys.: Condens. Matter* 19, 016204 (2007).
- [4] J. Sichelschmidt, T. Kambe, I. Fazlishanov, D. Zakharov, H.-A. Krug von Nidda, J. Wykhoff, A. Skvortsova, S. Belov, A. Kutuzov, B. I. Kochelaev, V. Pashchenko, M. Lang, C. Krellner, C. Geibel, and F. Steglich, *Phys. Status Solidi B* 247, 747 (2010).
- [5] J. Wykhoff, J. Sichelschmidt, G. Lapertot, G. Knebel, J. Flouquet, I. I. Fazlishanov, H.-A. Krug von Nidda, C. Krellner, C. Geibel, and F. Steglich, *Sci. Technol. Adv. Mater.* 8, 389 (2007).
- [6] J. Sichelschmidt, J. Wykhoff, H.-A. Krug von Nidda, I. I. Fazlishanov, Z. Hossain, C. Krellner, C. Geibel, and F. Steglich, *J. Phys.: Condens. Matter* 19, 016211 (2007).
- [7] T. Gruner, J. Wykhoff, J. Sichelschmidt, C. Krellner, C. Geibel, and F. Steglich, *J. Phys.: Condens. Matter* 22, 135602 (2010).
- [8] U. Schaufuss, V. Kataev, A. A. Zvyagin, B. Buchner, J. Sichelschmidt, J. Wykhoff, C. Krellner, C. Geibel, and F. Steglich, *Phys. Rev. Lett.* 102, 076405 (2009).
- [9] A. A. Zvyagin and A. V. Makarova, *J. Phys.: Condens. Matter* 17, 1251 (2005).
- [10] A. A. Zvyagin, V. Kataev, and B. Buchner, *Phys. Rev. B* 80, 024412 (2009).
- [11] E. Abrahams and P. Wolfle, *Phys. Rev. B* 78, 104423 (2008).
- [12] P. Wölfle and E. Abrahams, *Phys. Rev. B* 80, 235112 (2009).
- [13] P. Schlottmann, *Phys. Rev. B* 79, 045104 (2009).
- [14] D. L. Huber, *J. Phys.: Condens. Matter* 21, 322203 (2009); 24, 226001 (2012); D. L. Huber, *Mod. Phys. Lett. B* 26, 1230021 (2012).
- [15] D. V. Vyalikh, S. Danzenbacher, Yu. Kucherenko, K. Kummer, C. Krellner, C. Geibel, M. G. Holder, T. K. Kim, C. Laubschat, M. Shi, L. Patthey, R. Follath, and S. L. Molodtsov, *Phys. Rev. Lett.* 105, 237601 (2010).

- [16] A. S. Kutuzov, A. M. Skvortsova, S. I. Belov, J. Sichelschmidt, J. Wykhoff, I. Eremin, C. Krellner, C. Geibel, and B. I. Kochelaev, *J. Phys.: Condens. Matter* 20, 455208 (2008).
- [17] A. S. Kutuzov and A. M. Skvortsova, *Magn. Reson. Solids* 11, 7 (2009).
- [18] A. S. Kutuzov and A. M. Skvortsova, *J. Phys.: Conf. Ser.* 324, 012039 (2011).
- [19] A. Abragam and B. Bleaney, *Electron Paramagnetic Resonance of Transition Ions* (Clarendon Press, Oxford, 1970).
- [20] O. Stockert, M. M. Koza, J. Ferstl, A. P. Murani, C. Geibel, and F. Steglich, *Physica B* 378-380, 157 (2006).
- [21] Q. Si, S. Rabello, K. Ingersent, and L. Smith, *Nature* 413, 804 (2001).
- [22] P. Gegenwart, Y. Tokiwa, J. Custer, C. Geibel, and F. Steglich, *J. Phys. Soc. Jpn.* 75(Suppl), 155 (2006).
- [23] B. I. Kochelaev, S. I. Belov, A. M. Skvortsova, A. S. Kutuzov, J. Sichelschmidt, J. Wykhoff, C. Geibel, and F. Steglich, *Eur. Phys. J. B* 72, 485 (2009).
- [24] S. I. Belov, A. S. Kutuzov, and B. I. Kochelaev, *J. Phys.: Conf. Ser.* 324, 012017 (2011).
- [25] S. I. Belov, A. S. Kutuzov, B. I. Kochelaev, and J. Sichelschmidt, *J. Phys.: Condens. Matter* 24, 365601 (2012).
- [26] S. I. Belov and A. S. Kutuzov, *Magn. Reson. Solids* 14, 12103 (2012).
- [27] S. I. Belov and A. S. Kutuzov, *Magn. Reson. Solids* 16, 14103 (2014).
- [28] S. I. Belov and A. S. Kutuzov, *Appl. Magn. Reson.* 45, 1179 (2014).
- [29] S. I. Belov and A. S. Kutuzov, *Magn. Reson. Solids* 17, 15104 (2015).
- [30] S. I. Belov and A. S. Kutuzov, *J. Low Temp. Phys.* 185, 641 (2016).
- [31] K. N. R. Taylor and M. I. Darby, *Physics of Rare Earth Solids* (Chapman and Hall, London, 1972).
- [32] S. E. Barnes, *Adv. Phys.* 30, 801 (1981).
- [33] B. I. Kochelaev and A. M. Safina, *Phys. Solid State* 46, 226 (2004).
- [34] A. A. Abrikosov, *Physics* 2, 5 (1965).
- [35] P. W. Anderson, *J. Phys. C* 3, 2436 (1970).
- [36] N. N. Bogolubov and S. V. Tyablikov, *J. Exp. Theor. Phys.* 19, 251 (1949).
- [37] K. Wilson, *Rev. Mod. Phys.* 47, 773 (1975).
- [38] O. Trovarelli, C. Geibel, S. Mederle, C. Langhammer, F. M. Grosche, P. Gegenwart, M. Lang, G. Sparn, and F. Steglich, *Phys. Rev. Lett.* 85, 626 (2000).
- [39] U. Köhler, N. Oeschler, F. Steglich, S. Maquilon, and Z. Fisk, *Phys. Rev. B* 77, 104412 (2008).
- [40] T. S. Altshuler, I. A. Garifullin, and E. G. Kharakhashyan, *Phys. Solid State* 14, 263 (1972).
- [41] C. Rettori, D. Davidov, P. Chaikin, and R. Orbach, *Phys. Rev. Lett.* 30, 437 (1973).
- [42] N. E. Alekseevsky, I. A. Garifullin, B. I. Kochelaev, and E. G. Kharakhashyan, *JETP Lett.* 18, 189 (1973) [*Pisma Zh. Eksp. Teor. Fiz.* 18, 323 (1973)].
- [43] B. I. Kochelaev, E. G. Kharakhashyan, I. A. Garifullin, and N. E. Alekseevsky, in 18th AMPERE Congress, Nottingham, 1974.
- [44] A. A. Kosov and B. I. Kochelaev, *Phys. Solid State* 74, 148 (1978).