Low-temperature magnetic state of Ho_7Rh_3 studied by neutron diffraction and AC magnetic susceptibility

A.A. Vaulin[1], A.F. Prekul[1], T. Tsutaoka[2], N.V. Baranov[1,3], A.F. Gubkin[1,3]

[1]*M.N. Mikheev Institute of Metal Physics, Ural Branch of the Russian Academy of Sciences, Ekaterinburg, Russia,* [3]*Graduate School of Education, Hiroshima University, Higashi-Hiroshima, Japan,* [2]*Institute of Natural Sciences and Mathematics, Ural Federal University, Ekaterinburg, Russia*

artavaulin@gmail.com

Binary rare-earth intermetallic compounds of R_7Rh_3 type possess complex magnetic phase diagrams and rich variety of magnetic phase transitions. In particular, three temperature induced magnetic phase transitions were observed at T_N = 32 K, T_{t1} = 21 K, and T_{t2} = 9 K [1, 2]. In this work, a comprehensive study of the low-temperature magnetic state of Ho_7Rh_3 was carried out using neutron diffraction and nonlinear AC magnetic susceptibility.

Analysis of the neutron diffraction data and both the linear and non-linear AC magnetic susceptibility $\chi_{n\omega}'(T)$ and $\chi_{n\omega}''(T)$ (n = 1, 2, 3) (Fig. 1) showed that the magnetic phase transition at a temperature T_N = 32 K is associated with emergence of an incommensurate magnetic structure of spin density wave type described by the magnetic superspace group *Cmc*2₁1'(00g)0*sss*. Upon further cooling below the temperature T_{t1} ~ 21 K, a "squaring-up" process begins reflecting evolution of the amplitude modulated incommensurate magnetic structure towards a rectangular structure of the "antiphase domains" type. At $T<T_{t2}$, the magnetic structure can be described by the magnetic supersymmetry groups $Cm'c2_1'(00g)ss0$ or $Cmc'2_1'(00g)000$, which are subgroups of index i = 2 of the $Cmc2_11'(00g)0sss$ magnetic superspace group. Symmetry breaking associated with loosing of {1'|0 0 0 1/2} operation at the transition allows the emergence of a spontaneous magnetization confined in the basal plane of the hexagonal structure while magnetic structure keeps its incommensurate character. Measurements of the linear and nonlinear AC magnetic susceptibility revealed that emergence of the weak spontaneous magnetization in the sample are accompanied by pronounced anomalies in the temperature dependencies of the 2nd and 3rd harmonics ascribed to a symmetry breaking due to the loss of the time inversion symmetry {1'|0 0 0 1/2}.

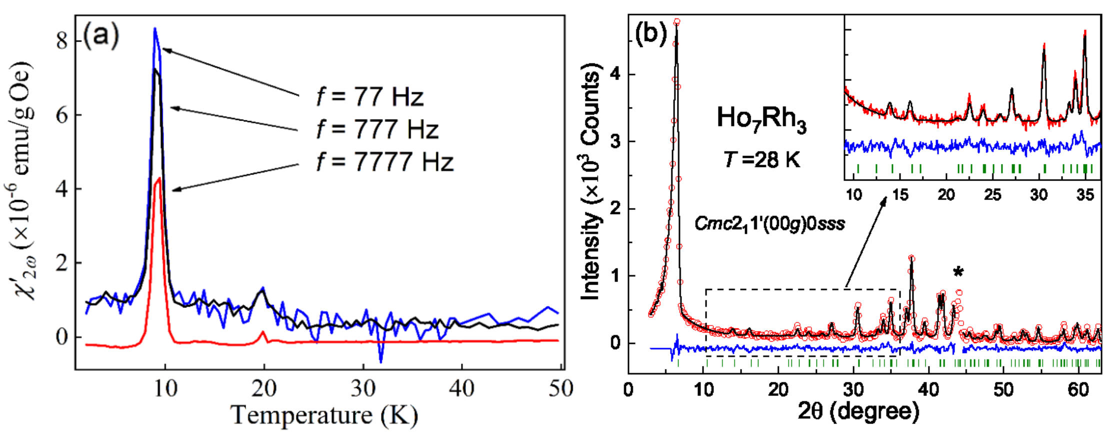

Figure 1. (a) Temperature dependence of the real component $\chi_{2\omega}'(T)$ of the ac harmonics of the magnetic susceptibility. (b) The best fit result of the neutron powder diffraction pattern measured at T = 28 K using the model of the magnetic superspace group $Cmc2_11'(00g)0sss$

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[2] Tsutaoka, T., et al, (2016). *J. of Alloys and Compounds*. **654**, 126-132.

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