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Evidence of homogeneous intermediate valence coexisting with long-range magnetic order in $EuCu_2(Si,Ge)_2$

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The phase diagram of the intermediate valence (IV) system $EuCu_2Ge_2$ is investigated by measuring the temperature dependencies of the heat capacity and the electrical resistance as a function of pressure (P) up to 4 GPa. Measurements were done using "toroid", Bridgman Anvils (BA) and Diamond Anvil Cell (DAC) pressure cells Transition to the magnetic ordered state is observed at P up to 9 GPa.

The dependence of T_N on pressure according to the results of all above mentioned experiments is shown in Fig. 1. The inset in Fig. 1 shows the magnetic phase diagram of $EuCu_2(Si_xGe_{1-x})_2$ based on previous experiments [1–3].

The dependence of T_N on pressure, obtained in the present work qualitatively and quantitatively (by the value of T_N) reproduces the dependence of T_N on the concentration of Si () presented in the inset. This means that for $EuCu_2Ge_2$ system the effects of the hydrostatic and chemical (substitution of Ge for Si) pressure on Eu-valence are equivalent from the point of view of the transition to the antiferromagnetic ordered ground state. The identity of the dependences of T_N on both x and P proves that a homogeneous IV regime is realized in the $EuCu_2(Si,Ge)_2$ system similarly to $EuCu_2Ge_2$ under pressure, and the coexistence of the homogeneous IV and long range magnetic order for the RE sublattice is confirmed.

The magnetic phase diagram is presented as a function of Eu average valence. The probable background for the formation of the magnetically ordered intermediate valence state of Eu is considered basing on the analysis of the original neutron magnetic spectroscopy [4] data for f-electron excitations in the $EuCu_2(Si,Ge)_2$. There

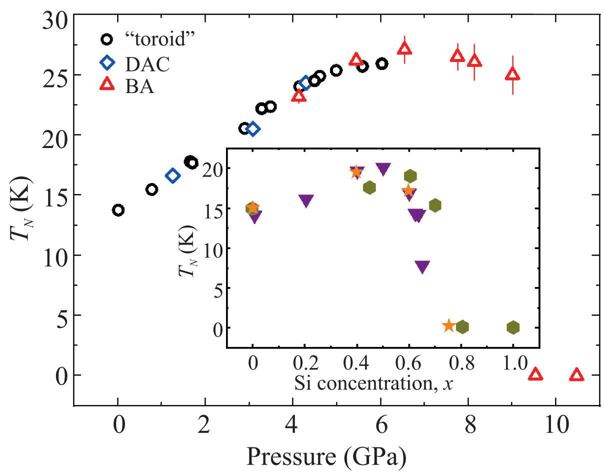

Fig. 1. (Color online) Pressure dependence of T_N for $EuCu_2Ge_2$ based on the results of the set of experiments (experiment titles correspond to the designations adopted in the text). Inset: magnetic phase diagram of $EuCu_2(Si_xGe_{1-x})_2$ based on the data from: heat capacity and resistivity measurements [1] – down triangles, [2] – stars, [3] – hexagons, magnetic neutron diffraction

is an indication that it develops on the basis of competition of the two magnetic configurations of Eu, one of which is formed on the base of initially nonmagnetic Eu^{3+} state. Therefore, some analogy can be suggested for coexistence of magnetic order and homogeneous intermediate valence with the case of TmSe [5, 6] intermediate valence system.

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