Report
on the thesis by **Lezova Irina Evgenievna**
titled "**Heat capacity and magnetocaloric properties of series of rare-earth garnets, aluminates and pentaphosphates**"
for the degree of Candidate of Physical and Mathematical Sciences,
Scientific specialty 1.3.8. - Condensed matter physics

While now many efforts are focused on nanostructured substances, single crystalline and polycrystalline materials play the most important role in modern applied physics and techniques. In accordance with the great demand and popularity of bulk crystalline materials, studies of their physical properties are crucial and extremely essential for designing devices and facilities with improved features, which could meet new challenges. The crystals of garnets, aluminates, and pentaphosphates are widely used in many areas of microelectronics and quantum optics. Some of them were also suggested as very promising materials for application in magnetic refrigerators due to relevant and stable characteristics. Nevertheless, the thermodynamic properties of the above mentioned crystals, first of all, the heat capacity within large temperature ranges and under strong external magnetic fields, are poorly known. Moreover, these properties were investigated only for quite limited number of crystal compositions. For instance, there is information about the heat capacity in the garnet family only for most known samples with simpler composition. The thesis of Lezova is just aimed to eliminate this drawback.

In introduction, Lezova poses the problems and discusses their importance. The aim of the thesis was formulated. Also, the main necessary experiments are described.

First chapter of the thesis offers a short review of the theory of heat capacity in solids with magnetic ions, which is important for better understanding the further content of the thesis. The impact of magnetic field is discussed. The structure and some properties of the garnets, aluminates, and pentaphosphates are presented.

Second chapter presents experimental data and their treatment for the erbium doped gallium-gadolinium garnet in comparison with the relevant data for the undoped sample. The measurements in the doped garnet were conducted for the first time. They evidenced some advantages of doping to get better magnetocaloric properties for applications.

Third chapter presents data for the heat capacity and the effect on the heat capacity of magnetic field for the family of the yttrium-dysprosium aluminum garnets. The temperature dependences of the heat capacity at zero field were modeled taking into account the phonon contributions and the contribution of dysprosium in agreement with modern theoretical treatment. The Schottky anomalies due to dysprosium ions were evaluated. A model was suggested to treat the splitting of the lower Kramers doublet by local magnetic fields from neighbor dysprosium ions. The Debye temperatures were calculated. It was also demonstrated that measurements of the heat capacity at magnetic fields can provide information about substitution order in solid-solution crystals. Magnetic entropy was obtained and the magnetocaloric properties depending on dysprosium composition were discussed. The g-factors were also evaluated and compared with electron paramagnetic resonance results when they are available.

Fourth chapter presents results for crystalline pentaphosphates and for some glass samples. Experimental data obtained at zero field allowed estimating the Debye temperatures and the

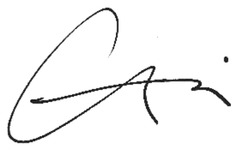
Stark splitting due to modeling the temperature dependences of the heat capacity on the base of theoretical treatment of different additive contributions. The difference in the crystalline and glass pentaphosphates was revealed and ascribed to two-level centers in glass. The g-factors were calculated. The magnetic entropy was evaluated. It was used to estimating the application of pentaphosphates in magnetic refrigerators.

Fifth chapter presents results of studies of the heat capacity in the mixed crystals of yttrium-erbium aluminates. To treat the heat capacity at zero magnetic field at low temperatures, a model of the ground doublet splitting was suggested similar to that used in other chapters. The values of the first Stark levels and the Debye temperatures were obtained. The measurements in various magnetic fields gave the values of the g-factor. The magnetic entropy was calculated for the aluminates family that was used to discuss the magnetocaloric properties.

All results presented in the thesis are unique. Among the samples studied, some fragmentary information about the heat capacity was previously published only for pure dysprosium and yttrium aluminum garnets. The data obtained in the thesis are obviously very important for physics and different applications of crystalline garnets, aluminates, and pentaphosphates. The theoretical models used in the thesis seem to be convincing. The idea concerning the impact of the substitution order in the solid solutions on the heat capacity is well motivated. The results of the thesis are presented in 4 publications in the high quality journals and were reported at conferences. The thesis is written clear and well structured. However, I have found some misprints and bad sentences in the English version of the thesis.

Based on the high quality of research contents and writing skill, I claim that the thesis titled “Heat capacity and magnetocaloric properties of series of rare-earth garnets, aluminates and pentaphosphates” by Lezova Irina Evgenievna deserves to be awarded the degree of Candidate of Physical and Mathematical Sciences.

26.09.2024



Guorong Li
Professor, Head of Functional Ceramics and Devices,
Key Lab. of Inorganic Functional Materials and Devices,
Shanghai Institute of Ceramics, Chinese Academy of Sciences
Shanghai, P.R. China
Tel: +86-21-69163700
Fax: +86-21-69906700
E-mai: grli@mail.sic.ac.cn