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Отзыв на автореферат диссертации Валерия Владимировича Соколова «Оптические и магнитооптические свойства алюмоборатов и ферроборатов эрбия и гольмия», представленной на соискание ученой степени кандидата физико-математических наук. Специальность 01.04.07 – Физика конденсированного состояния.

Report on synopsis of the PhD thesis "Optical and magneto-optical properties of alumoborate and ferroborates of Er and Ho" by Valeriy Vladimirovich Sokolov. The PhD thesis is to be defended in the field of Condensed Matter Physics (code 01.04.07).

PhD thesis by Valeriy Vladimirovich Sokolov titled "Optical and magneto-optical properties of alumoborate and ferroborates of Er and Ho" is dedicated to spectroscopic studies of rare-earth ions in four single crystals $ErFe_3(BO3)_4$, $ErAl_3(BO_3)_4$, $HoFe_3(BO_3)_4$ and $HoAl_3(BO_3)_4$. The reported results are novel, valid and timely. As mentioned by the author, the knowledge of optical properties of rare earth ions can be important for the development of magneto-optical modulators and lasers. In addition to these traditional areas of application of rare-earth ions, I would like to add that recent works in the field of quantum computing show that a rare-earth ion is a promising quantum bit (qubit) system (see, for instance, Nature Physics 16, 503–504 (2020)).

The author analyses the spectra of the ions in the range of wavelengths from 300 nm to 1200 nm for linearly and circularly polarized light. The measurements are performed in a broad temperature range from 300 K down to 90 K. In order to describe the experimentally obtained spectra the author has developed a model based on the Judd–Ofelt theory. The latter is known for its ability to describe the intensities of the f-f transitions in rare-earth ions. This is a very detailed research work that provides the whole set of parameters allowing to describe the spectra of the ions in the studied crystals. A special attention in this work is paid to the spectra of magnetic circular dichroism and optical activity. Revealing optically active transitions, understanding the selection rules and especially the role of spin-orbit coupling is of great interest for further development of rare-earth qubits.

The thesis consists of 6 chapters. The first chapter is dedicated to an overview of the properties of the studied single crystals. The second chapter describes the details of the employed experimental setup. In the third chapter the author reports experimental results obtained in spectroscopic studies of $ErAl_3(BO_3)_4$. In order to describe the spectra, the author employs the Judd–Ofelt theory. The fourth

chapter is about experimental study of the magneto-optical activity of the f-f transitions in $ErFe_3(BO3)_4$, $ErAl_3(BO_3)_4$, $HoFe_3(BO_3)_4$ and $HoAl_3(BO_3)_4$. In particular, the chapter reports about anomalous behaviour of the spectra as a function of temperature. For certain f-f transitions the measured magneto-optical activity changes sign. The author explains this anomaly in terms of interplay of several transitions whose intensities change with temperature. The fifth chapter reports about magneto-optical studies of $ErFe_3(BO3)_4$, $ErAl_3(BO_3)_4$, $HoFe_3(BO_3)_4$ and $HoAl_3(BO_3)_4$. The sixth chapter is about the phenomenon of optical activity in the crystals. Studying $ErAl_3(BO_3)_4$ and $HoAl_3(BO_3)_4$, the author defines which f-f transitions give the largest contribution into the phenomenon as well as reveals temperature dependencies of the contributions. Based on the results of the research, the author has published 8 papers and made several reports at international conferences.

I have a good overall impression about this work. A large amount of experimental data are presented in a systematic and a clear way. The reported results are novel, interesting and timely. Next to the report of interesting experimental data, the author has developed a theory allowing to describe the spectroscopic properties of the studied rare-earth ions and defined a set of parameters which will be important for further development of magneto-optical modulators, lasers and quantum computers. The work is, in principle, well written. However, I also would like to make several remarks

- I assume that for the measurements of the magnetic circular dichroism, reported in the thesis, the author applied an external magnetic field. Unfortunately, I could not find information about the orientation and the strength of the field. Also in Eq.2 quantity "H" seems to be undefined.
- A substantial part of the work is dedicated to the phenomena of magneto-optical and optical activity. However, I could not find information about the orientation of the studied crystals with respect to the wave vector of light. Consequently, it is not clear if the circularly polarized state of light is an eigen state of light in the crystal.
- I fully agree with the author that the reported study is very interesting and that further measurements at lower temperatures offer a plethora of new opportunities for fundamental research. However, I am wondering if the author has any long term (super)goal in his study. What is the most wanted result, so to say dream, in this research?

The remarks, however, must be considered as minor. They do not affect the reliability and significance of the reported results. This is a full-fledged research work, performed by the author at a high scientific level. The work and the author meet the standards for PhD degree in Europe and the degree of candidate of Science in Russia.

The author - Valeriy Vladimirovich Sokolov - deserves the degree of candidate of sciences in condensed matter physics (code 01.04.07).

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