Comment on 'Bismuth-induced increase of the magneto-optical effects in iron garnets', 14, 6957 (2002)

2003 J. Phys.: Condens. Matter 15 2227

(http://iopscience.iop.org/0953-8984/15/13/309)

INSTITUTE OF PHYSICS PUBLISHING JOURNAL OF PHYSICS: CONDENSED MATTER

J. Phys.: Condens. Matter **15** (2003) 2227–2228 PII: S0953-8984(03)54506-4

COMMENT

Comment on 'Bismuth-induced increase of the magneto-optical effects in iron garnets', 14, 6957 (2002)

Lars Egil Helseth

Department of Physics, University of Oslo, PO Box 1048 Blindern, N-0316 Oslo, Norway

E-mail: l.e.helseth@fys.uio.no

Received 9 October 2002
Published 24 March 2003
Online at stacks.iop.org/JPhysCM/15/2227

Abstract

In a recent paper, Zenkov and Moskvin (2002 *J. Phys.: Condens. Matter* **14** 6957) analysed the influence of bismuth on magneto-optical effects in iron garnets, questioning the validity of previous approaches (Dionne and Allen 1993 *J. Appl. Phys.* **73** 6127; 1994 *J. Appl. Phys.* **75** 6372, Allen and Dionne 1993 *J. Appl. Phys.* **73** 1630, Helseth *et al* 2001 *Phys. Rev.* **64** 174406). In this comment I point out that these claims apparently have no foundation.

(1) Zenkov and Moskvin [1] do not mention that a self-consistent molecular orbital analysis was presented in [4]. In this paper reasonable transitions and values for the spin–orbit splitting are found without resorting to numerical analysis. I confess that I do not see why the analysis of [1] contradicts that of [4]. Therefore, if the authors of [1] think [4] contains any errors, I urge them to spell them out (i.e. not to talk about 'questionable assignments' without quantifying such claims). On the other hand, I agree with the authors of [1] that it would be much more pleasing to have an exact molecular basis for the magneto-optical effects. Ideally, such an approach should be able to predict the electronic structure (in particular the bismuth distribution within the lattice), the oscillator strengths as well as the linewidth broadening. This is definitely not an easy task, and cannot be achieved with the models of [1, 4].

(2) Zenkov and Moskvin [1] do not mention that several studies have used a large number of transitions (both paramagnetic and diamagnetic, without giving a reasonable background), in order to explain the Faraday spectra, without much luck (see [5] for references). According to [1], the large number of degrees of freedom should make it easy to fit curves to the experimental data. In practice this does not seem to be the case, and it is highly unlikely that this is only due to poor fitting procedures. On the other hand, the studies of [2–6] are based on the reasonable molecular orbital approach of [4], and our assignment of transitions should therefore not be 'trivial'.

(3) The analysis of [4] put constraints on the values that the spin–orbit splitting and resonance frequencies can take (for the tetrahedral and octahedral transitions). In [5, 6] the theory of [2, 4] was extended and used to interpret the Faraday rotation spectra in a certain wavelength range for varying bismuth and gallium contents. In these studies the experimental results were given in a limited wavelength range with a limited resolution (note also that possible interference oscillations are averaged out from the curves), and would therefore be unsuitable for testing the correctness of a full theory. That is, the wavelength range should ideally have been much larger, but this was unfortunately limited by the monochromator available at that time (and the fact that we concentrated on the wavelength range of interest for magneto-optic imaging). However, I believe that the experimental data provide a verification of the underlying theory, at least within the given wavelength range. Moreover, our data seem to indicate that in the case of (100) films as well the Faraday rotation increases linearly with the bismuth content and decreases almost linearly with the gallium content (one cannot tell from the experimental data whether the Faraday rotation versus gallium content is linear or slightly nonlinear). An explanation of this dependence should be included in a complete theory. Naturally, there are uncertainties in interpreting the spectra, which can be seen by the fact that [5] and [6] present slightly different values for the microscopic parameters. However, as pointed out before, some of the parameters are restricted by the underlying theory, and are therefore not allowed to vary too much (admittedly, it is difficult to tell what is 'too much'). From a practical point of view it is seen that small changes in the microscopic parameters alter the spectra significantly, at least on the scale studied in our experimental papers. Moreover, it should be pointed out that only two transitions (and therefore a very limited number of free parameters), are used to fit the spectra in [5, 6]. Thus, this is the 'minimal' approach to fitting the curves, and is very suitable for experimental studies such as those of [5, 6].

(4) In [1], an analysis of a single set of measurement data for films with a small bismuth content was provided as evidence for their theory. However, I think it should be tested on several data sets before such claims can be presented. Moreover, they do not discuss why there is a deviation between the theory and experiment below 2.3 eV.

(5) Finally, I would like to point out that to date no theory exists which completely explains the experimental data. For example, the following features are not explained (at least not quantitatively):

   (A) When the bismuth content is large, the Faraday rotation saturates, and a red-shift of the spectra occurs.

   (B) Films grown on differently oriented substrates show similar bismuth-dependence/Faraday spectra, despite the fact that the bismuth ordering is expected to be different (as seen from measurements of K_u versus bismuth and temperature for example).

References

[1] Zenkov A V and Moskvin A S 2002 *J. Phys.: Condens. Matter* **14** 6957
[2] Dionne G F and Allen G A 1993 *J. Appl. Phys.* **73** 6127
[3] Allen G A and Dionne G F 1993 *J. Appl. Phys.* **73** 6130
[4] Dionne G F and Allen G A 1994 *J. Appl. Phys.* **75** 6372
[5] Helseth L E, Hansen R W, Il'yashenko E I, Baziljevich M and Johansen T H 2001 *Phys. Rev.* B **64** 174406
[6] Helseth L E, Solovyev A G, Hansen R W, Il'yashenko E I, Baziljevich M and Johansen T H 2002 *Phys. Rev.* B **66** 064405