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# Impact of Magneto-optical Properties Depending on the Orientation in the Plane of Cobalt Ferrite Locked in a Silica Matrix

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author NL designed the study performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors DA, AMN, DB and TJ managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

In this work, we discuss the magneto-optical properties according to the orientation of 15nm-sized cobalt ferrite blocked in a silica matrix in comparison to the study done on 20nm-sized cobalt ferrite. This measurement shows that it is possible to increase the remanence of the Faraday effect by creating a magnetic orientation in the solid matrix, which is interesting for the production of self-polarized components. In addition, this remanence is greater for 15 nm than for 20 nm.A gelation field applied perpendicular to the plane of the layer therefore produces a preferential orientation of the magnetic moments in the direction of the field applied during the measurement.

*Keywords: Magnetic liquids; thin layers; cobalt ferrite; sol-gel; Faraday rotation.*

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## 1. INTRODUCTION

Having particular magnetic and physical properties, many studies are done on cobalt ferrite nanoparticles in research laboratories for the past twenty years. The development of thin films based on cobalt ferrite and the mastery of this technique have made it possible to achieveenormous progress in the production of self-polarized components. Our choice to develop thin layers of cobalt ferrite by sol-gel processis that this technique preserves the stoichiometry, and requires a combination of good quality and low cost.. In this work, we are interested in the impact of magneto-optical properties according to orientation in the plane of cobalt ferrite blocked in a silica matrix [1,2].The general objective is to confirm the gelation obtained during previous work in the laboratory and to improve the persistence under gelation.

## 2. MATERIALS AND METHODS

### 2.1 Materials

The silica matrix ($SiO_2$ / $ZrO_2$) used was produced by the sol-gel route according to the protocol [3,4] obtainedat the LaHCLaboratory. Then the sol will be doped with the 15 nm-sized cobalt ferrite nanoparticle [5]. The nano particle is obtained according to the protocol of R. Massart [6] by co-precipitation and an additional hydrothermal treatment at the PHENIX Laboratory. The study focused on thin films doped with cobalt ferrite nanoparticles of size 15 nm. More specifically, in each case it concerns:

• a thin layer obtained outside the magnetic field: i.e. justafter the deposition, the layer hasundergo a heattreatment for one hourthen UV treatment for 20 minutes (reference sample)

• a thin layer produced and treat edunder the influence of a perpendicular magnetic field of amplitude 0.7T or 7000 Oe. This isobtained through an electro magnetlarge enough so that the printing machine canbeplaced in the air gap.

• a thin layer produced and treatedunder the influence of a perpendicular magnetic field

### 2.2 Methods

The spectral polarimetricbench in Fig. 1 was used for the characterization of the samples. The Faraday rotation is achieved by sending unpolarized light from a lamp. Then the light is linearly polarized after exiting the polarizer; and after the sample it is elliptically polarized. All the rest of the elements then makeit possible to determine these two parameters: the ellipticity and the Faraday rotation.

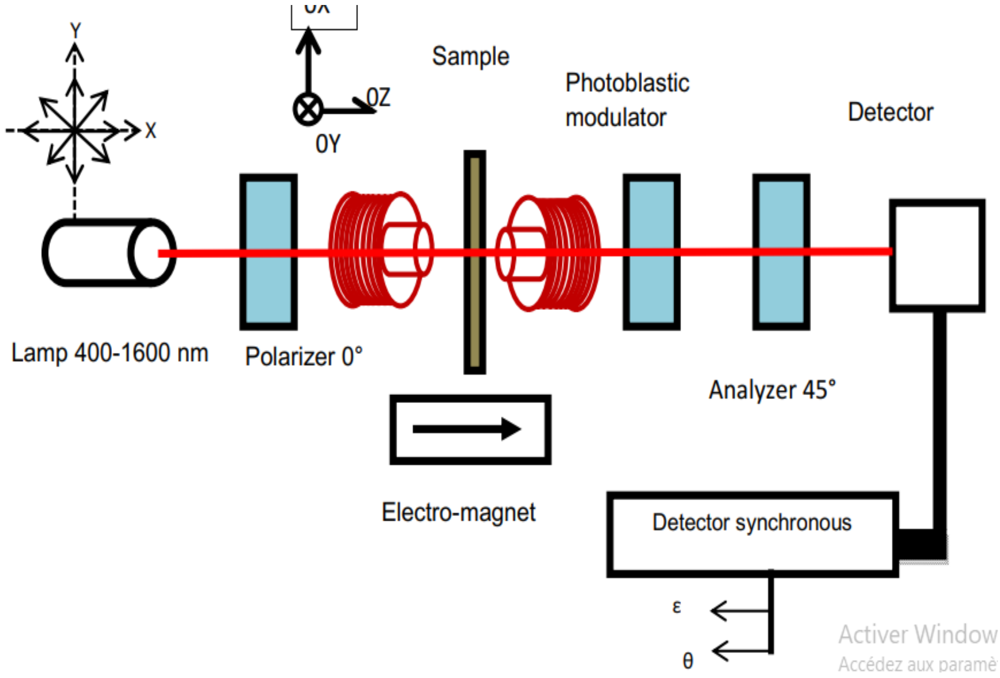


**Fig. 1.Spectral polarimetric setup using the modulatorphoto-elastic**

We explain it this way: aluminous vibration from the light is sent to the sample via a polarizer. The magneticfieldapplied to the sampleinducesanisotropy in the middle. This transforms the incident rectilinear state into an elliptical state. The modulator causes the ellipse to oscillateat the frequency f = 50 kHz by an angle $\Theta_F$.[7 − 10]

## 3. RESULTS AND DISCUSSION

The Faraday effect measurements made on each of these samples are shown in Fig. 2 and the Faraday rotations of the three samples are shown. These figures show that the magneticbehavior of the three types of samples is different. A perpendicular to the magnetic field applied during gelation induces a increase in remanence and co ercive field. The opposite istrue for the. The fieldapplieduring the product an orientation of the magnetic moments therefore axes of easymagnetizationsince the particles are then able to move within the host matrix still saturated with solvent. In addition, here the remanence is greater than that observed on the 20 nm size [1]. The measurementswere made at the wavelength of 820 nm.

By comparison, we have plotted in Fig. 3, the orientation effect for the 20 nm-sizednanoparticleobtained by simple co-precipitation; and in Fig. 4 the orientation effectdemonstrated by F. Choueikani during his work at the Laboratory [11]. These are 12 nm size cobalt ferrite nanoparticles obtained by simple co-precipitation and without hydrothermal treatment.

The orientation effect is there for emuchgreater, which seems confirm that simple co-precipitation leads to the production of rather uniaxial nanoparticles, while the addition of hydrothermal treatment leads to the production of particleswith multi-axis (cubic) anisotropy.

Ultimately, to maximize the effect of self-polarized components, itisnecessary to orient the nanoparticles during matrix gelation, use large size particles and favor that obtained by simple co-precipitation.

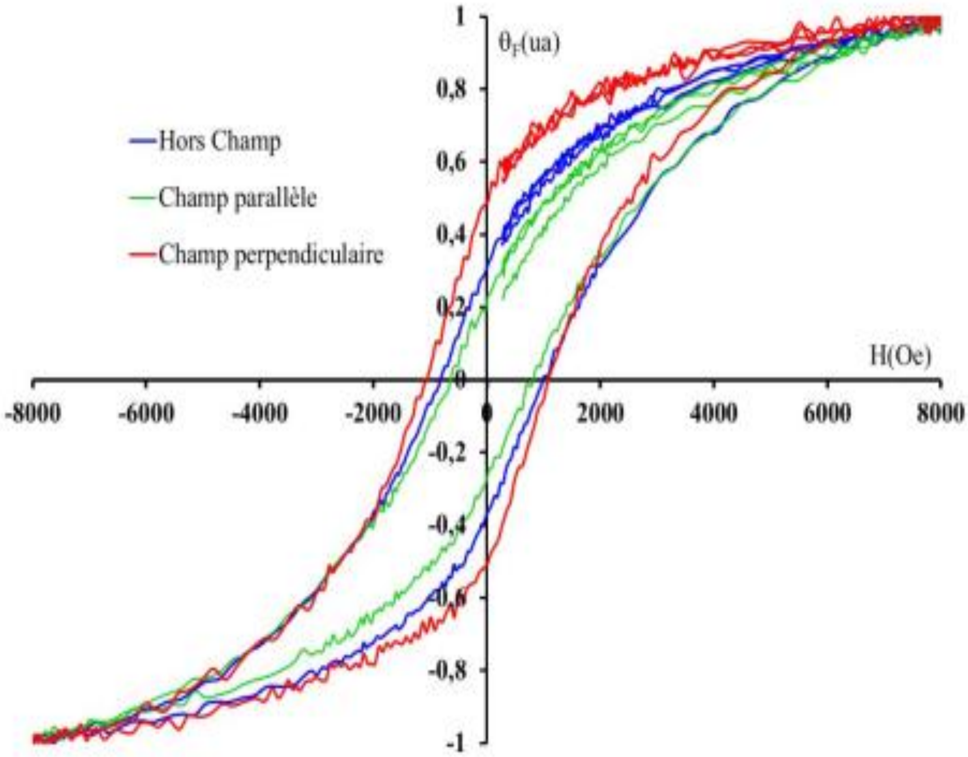


**Fig. 2. Comparison of the normalized Faraday rotation between a thin film performed out of field, one under the influence of a magnetic field parallel to the plane of the layer, and one under the influence of a perpendicular field**

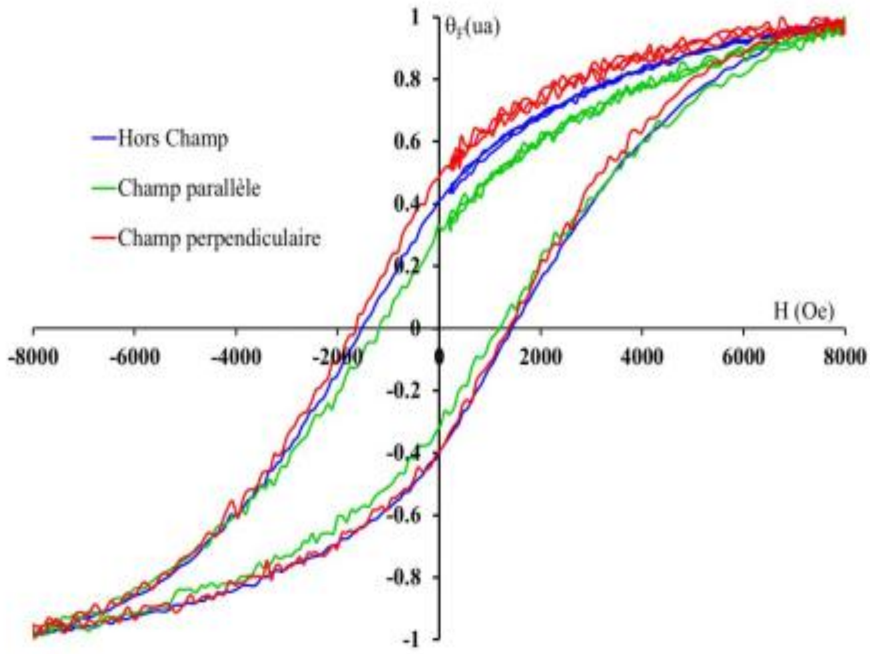


**Fig. 3. Comparison of the normalized Faraday rotation between a thin film performed out of field, one under the influence of a magneticfieldparallel to the plane of the layer, and one under the influence of a perpendicularfield. Sample: S487, size 20 nm [1]**

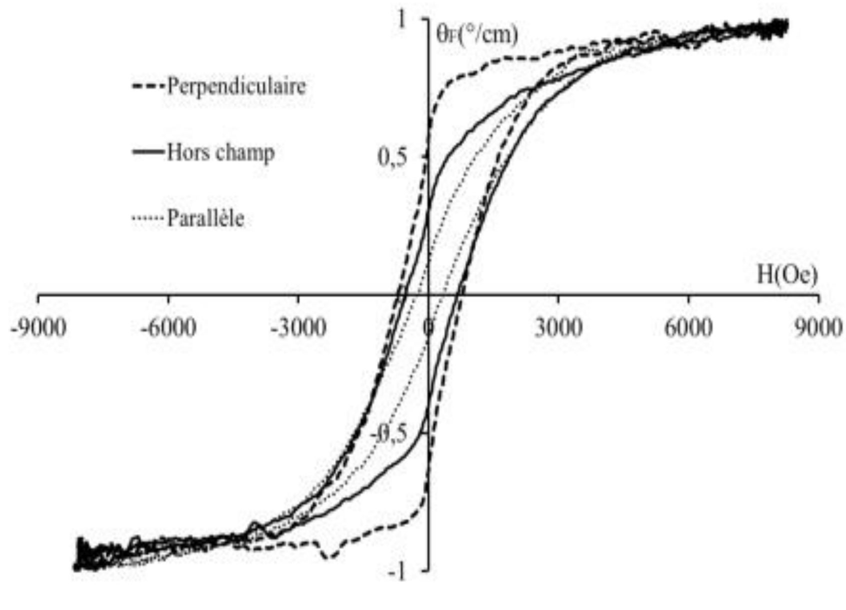


**Fig. 4. Orientation effect on Faraday rotation [11]**

## 4. CONCLUSION

We have illustrated in this work the magneticbehavior of the Faraday effectproduced by Cobalt ferrite nanoparticles.In the case of magneto-optical applications based on the use of solid composite material, the following elements can be retained:

• To promote the low fields ensitivity of a magneticfieldbasedsensoron using the Faraday effect, an average size of 10nm is most appropriate.

• To promote the remanence of the self-polarized components, itisnecessaryto increase the size of the particles, and to generate a preferential magnetic orientation. In this case, the hydrothermal treatment does not necessarily seem the mostadequate.

In general, itis more advantageous to use cobalt ferrites obtained by co-precipitation.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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