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About the photoacoustic signal of magnetic materials

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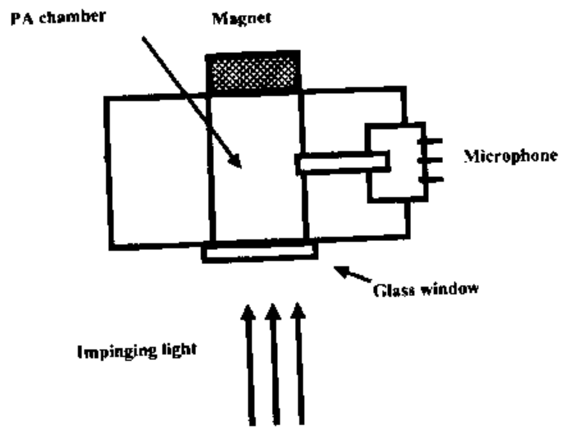
Abstract. The photoacoustic signal of magnets was measured in the presence of external magnetic fields, through the presence of intense magnets. It was observed that the intense magnetic field at the surface of a rare earth magnet can change the photoacoustic signal of a weak ferrite magnet. A possible explanation for the PA signal change is discussed.

1. INTRODUCTION

The photoacoustic signal is the result of the conversion of electromagnetic energy of modulated amplitude in modulated thermal energy, through non-radiative decays in the absorbing matter. It depends on the thermal properties of the sample, as the thermal diffusivity, effusivity and conductivity. This enables photoacoustic and photothermal techniques to study optical and thermal properties of solid matter. The photoacoustic phenomena has been used to study magnetic materials, as microwave absorption in ferromagnetic resonance [1], the photoacoustic spectroscopy of magnetic semiconductors [2] and magnetic fluids [3], the absorption of X rays by magnetic materials [4], and the monitoring of magnetite formation in heated iron (III) hydroxide acetate [5]. It is observed that none of those studies explores the possible existence of magnetic contributions to the photoacoustic signal and its detection through photoacoustic techniques. A recent theoretical report by Kabychenkov [6] admits that light pulses can modify sublattice magnetizations and effective magnetic fields in magnets. This means that the non-radiative decays that are the energy source to the photoacoustic signal can also contribute to local magnetization changes in magnets, changing the photoacoustic signal in these materials. In this report, the photoacoustic signal of a magnet was monitored during its interaction with another magnet.

2. MATERIAL AND METHODS

The PA setup was composed by a Tungsten arc lamp (150 W), a mechanical chopper, a PA cell and a lock-in amplifier. Light was chopped at 17 Hz. As figure 1 shows, the PA cell was one with two faces, where one face was closed with a glass window and the other was closed with the sample. Light incidence was frontal. The magnet used in this study was a disk of ferrite (1.6 cm diameter and 2 mm thick) and it interacted with another disk of rare earth magnet, that produces surface magnetic fields of about 0.1 T. The photoacoustic signal before and after the interaction was monitored for 5 minutes. At 2.5 minutes, two situations were analyzed: the proximity of the rare earth magnet and the contact between them. In the first case, the ferrite magnet senses the dipolar magnetic field of the rare earth magnet. In the second case, the contact between the magnets must change the magnetic domain distribution in the ferrite disk, because of the high magnetic field of the rare earth magnetic disk.



'igure 1. PA cell scheme for measurements with magnet disks.

i. RESULTS AND DISCUSSION

'igures 1 and 2 show the photoacoustic signal when the rare earth magnet is close to the ferrit nagnet and when both are in contact, respectively. As it can be seen, the presence of an externa nagnetic field do not change significantly the PA signal; on the other hand, when magnets are i :ontact, the PA signal increases abruptly.

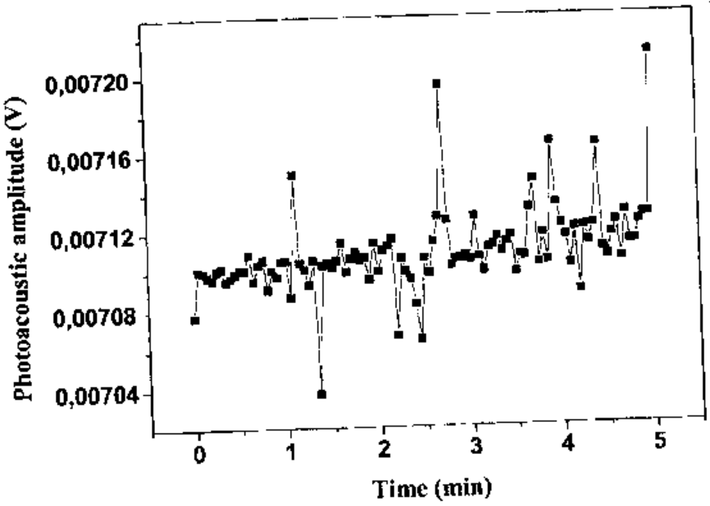


Figure 2. Photoacoustic signal as a function of time in the case of the presence of an external magnetic field starting at 2.5 minutes.

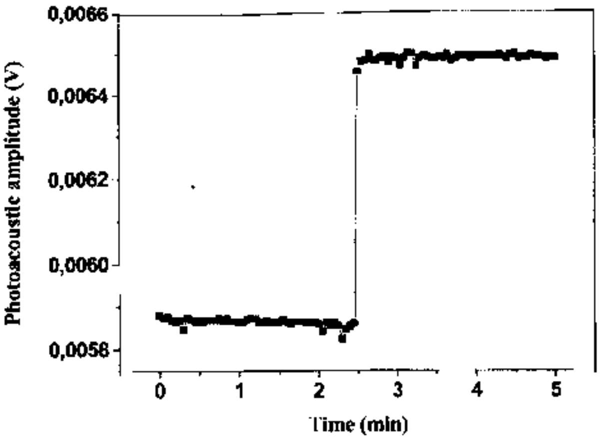


Figure 3. Photoacoustic signal as a function of time in the case of contact between both magnets starting at 2.5 minutes.

As figure 1 shows, the external magnetic field produces a signal disturbance that is rapidly corrected. In contrast, the direct interaction between the two magnetic dipoles at the magnets and the rearrange of the magnetic domain distribution produce an increase in the signal, implying that this situation favors modulated heat production. These results could be explained as follows: as the ferrite magnetic disk is black, more light is absorbed at the surface. As light is absorbed, the local magnetic dipoles suffer vectorial changes and during the following dark period they return to their original direction. To change the direction of the magnetic dipoles, light energy must be higher than the magnetic interaction between magnetic dipoles and the exchange field in the ferrite magnet. As the magnetic domain distribution changes because of the presence of external magnetic fields, the internal magnetic fields also change, increasing or decreasing the internal magnetic energy. This must also decrease or increase the photoacoustic signal, because less or more energy must be used to change the surface dipole arrange after the domain configuration change.

4. CONCLUSION

In conclusion, it was shown for the first time that the photoacoustic signal of magnetic materials can be affected by the presence of intense external magnetic fields. Our hypothesis is that the observed signal behaviour occurs because the magnet magnetic domain arrange changes after its interaction with intense magnets. More experiments will be necessary to prove its veracity.

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