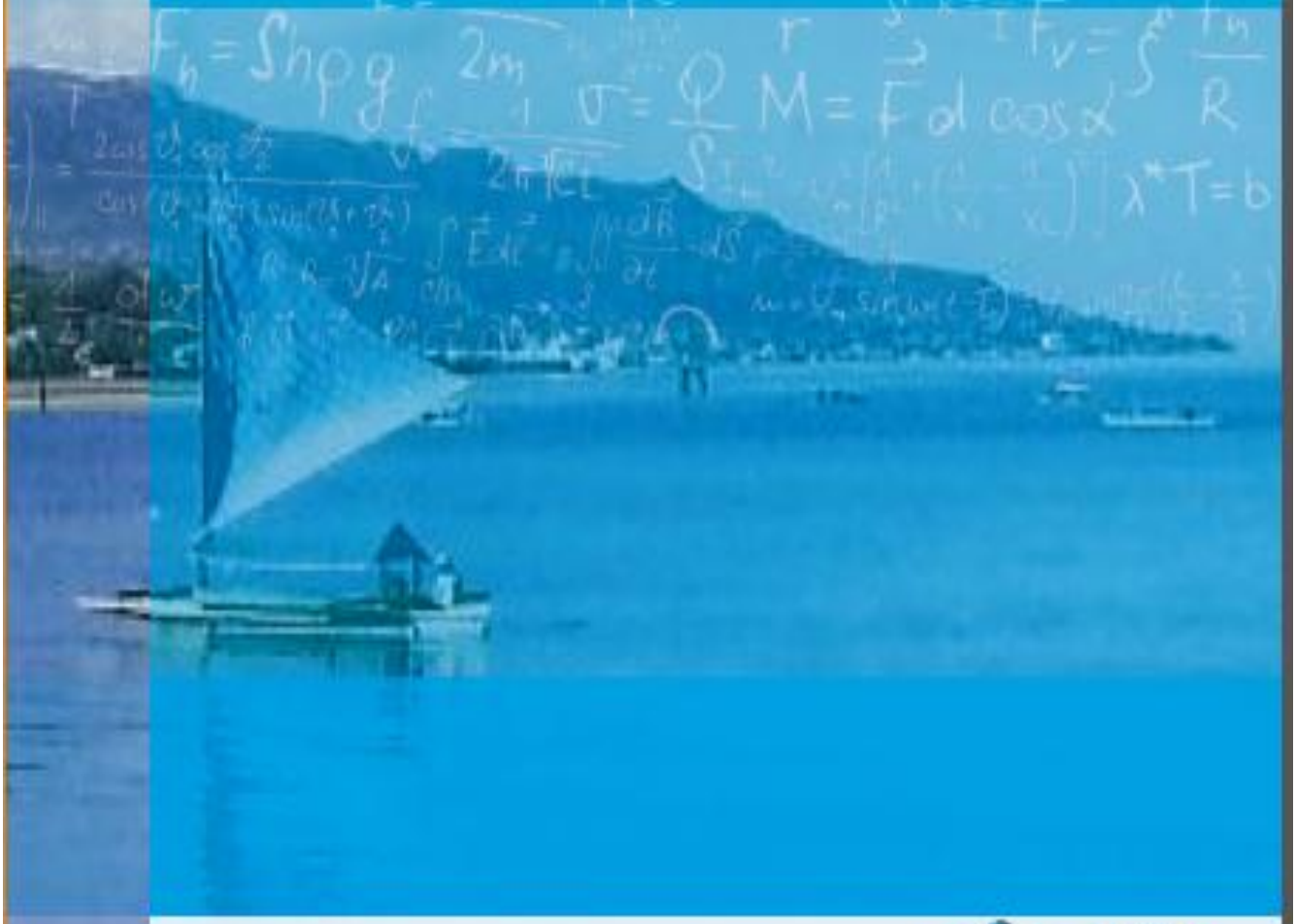
Basic Science
for Sustainable Marine Development

PROCEEDING
INTERNATIONAL SEMINAR 2015

Ambon, 3-4 June 2015



Organized by
Faculty of Mathematics and Natural Sciences
Pattimura University

PROCEEDINGS

1st International Seminar of Basic Science, FMIPA Unpatti - Ambon
June, 3rd – 4th 2015

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Welcoming Address by The Organizing Committee

The honorable, the rector of Pattimura University

The honorable, the vice rector of academic affair, Pattimura University

The honorable, the vice rector of administration and financial affair, Pattimura University

The honorable, the vice rector of planning, cooperation and information affair, Pattimura University

The honorable, all the deans in Pattimura University

The honorable, the key note speakers and other guests.

We have to thank The Almighty God for the blessings that allow this International seminar can be held today. This is the first seminar about MIPA Science in which the Faculty of MIPA Pattimura University becomes the host. The seminar under the title Basic Science for Sustainable Marine Development will be carried out on 3 June 2015 at Rectorate Building, the second floor. There are 250 participants from lecturers, research institute, students, and also there are 34 papers will be presented.

This International seminar is supported by the amazing people who always give financial as well as moral supports. My special thanks refer to the rector of Pattimura University, Prof. Dr. Thomas Pentury, M.Si, and the Dean of MIPA Faculty, Prof. Dr. Pieter Kakissina, M. Si. I also would like to express my deepest gratitude to Dr. Kotaro Ichikawa, the director of CSEAS Kyoto University, Prof. Bohari M. Yamin, University of Kebangsaan Malaysia, Prof. Dr. Budi Nurani Ruchjana (Prisident of Indonesian Mathematical Society/Indo-MS), Dr. Ir. A. Syailatua, M.Sc (Director of LIPI Ambon), and Hendry Ishak Elim, PhD as the key note speakers. We expect that this international seminar can give valuable information and contribution especially in developing basic science for sustainable marine development in the future.

Last but not least, we realize that as human we have weaknesses in holding this seminar, but personally I believe that there are pearls behind this seminar. Thank you very much.

Chairman

Dr. Netty Siahaya, M.Si.

Opening Remarks
By Dean of Mathematic and Natural Science Faculty

I express my deepest gratitude to The Almighty God for every single blessing He provides us especially in the process of holding the seminar until publishing the proceeding of International Seminar in celebrating the 17th anniversary of MIPA Faculty, Pattimura University. The theme of the anniversary is under the title Basic Science for Sustainable Marine Development. The reason of choosing this theme is that Maluku is one of five areas in Techno Park Marine in Indonesia. Furthermore, it is expected that this development can be means where the process of innovation, it is the conversion of science and technology into economic value can be worthwhile for public welfare especially coastal communities.

Having the second big variety of biological resources in the world, Indonesia is rich of its marine flora and fauna. These potential resources can be treated as high value products that demand by international market. Basic science of MIPA plays important role in developing the management of sustainable marine biological resources.

The scientific articles in this proceeding are the results of research and they are analyzed scientifically. It is expected that this proceeding can be valuable information in terms of developing science and technology for public welfare, especially people in Maluku.

My special thanks refer to all researchers and reviewers for your brilliant ideas in completing and publishing this proceeding. I also would like to express my gratefulness to the dies committee-anniversary of MIPA Faculty for your creativity and hard working in finishing this proceeding, God Bless you all.

Dean of Mathematic and Natural Science Faculty

Prof. Dr. Pieter Kakisina, M.Si.

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Spin Wave Excitation in $YFeO_3$ Crystal Investigated with Magnetic Component of Terahertz Pulse

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ABSTRACT

We report the observation of the magnetic dipole transition triggered with magnetic component of terahertz electromagnetic pulse in an antiferromagnetic YFeO3 crystal, which is manifested by a sharp absorption at the frequency of the quasiferromagnetic mode of the crystal. The rotating coherent macroscopic magnetization radiates circularly polarized emission at the frequency of the quasiferromagnetic resonance.

Keywords: Terahertz, spin wave, magnetic resonance

Terahertz time-domain spectroscopy (THz TDS) is a powerful tool for studying the response of materials to electromagnetic (EM) waves, through which information on both amplitude change and phase shift in a material can be obtained (Ferguson and Zhang, 2002; Ma et al., 2008; Tonouchi, 2007). THz spectroscopy has proved to be a very effective method to study the low-energy elementary excitations in solids, such as phonons (Dekorsy et al., 1993), excitons (Heberle et al., 1995), magnons (Satoh et al., 2006), etc. In most THz spectroscopy studies, only the electric-field component of the THz radiation is considered to excite electric dipole transitions in the desired materials, and the influence of the magnetic field component of the EM wave is normally neglected. In fact, the magnetic field component of the THz wave plays the dominant role during the interaction process through magnetic dipole transitions in magnetically ordered materials (Kamfrath et al., 2011; Nakajima et al., 2010; Yamaguchi et al., 2010). In this study, we investigate the magnetic response of a rare-earth orthoferrite, $YFeO_3$, crystal by using THz time domain spectroscopy. The interactions between the electric and magnetic fields of the THz wave with the $YFeO_3$ crystal are clarified. A sharp absorption at 0.299 THz is observed, which arises from coupling between the impulsive magnetic component of the THz wave and the quasiferromagnetic mode (F-mode) of the $YFeO_3$ crystal. The subsequent EM wave radiation at the same frequency as the F-mode comes from the free induction decay of the rotation of the macroscopic magnetization.

Figure 1(a) and 1(b) show the THz transmission spectra with the electric field of THz wave parallel and 45º with respect to the *a*-axis of the $YFeO_3$ crystal, respectively. These spectra are obtained from the Fourier transforms of the transmitted temporal waveforms from 10.5 to 55.5 ps (solid lines), and 20.5 to 55.5 ps (dashed lines), as shown in the insets of the figure, respectively. It can be seen that there are two absorption dips. The one at 0.299 THz shows a very narrow band, which does not depend on the polarization of the incident THz wave. The other one, centered around 0.43 THz, strongly depends on the direction of the THz electric-field: the absorption band disappears completely when the electric field is parallel (Fig. 1(a)) or perpendicular to the *a*-axis of the crystal, and it becomes most pronounced when the electric field is set at 45º with respect to the *a*-axis (Fig. 1(b)). The

broad high frequency absorption band (0.43 THz) is attributed to the birefringence of the crystal.

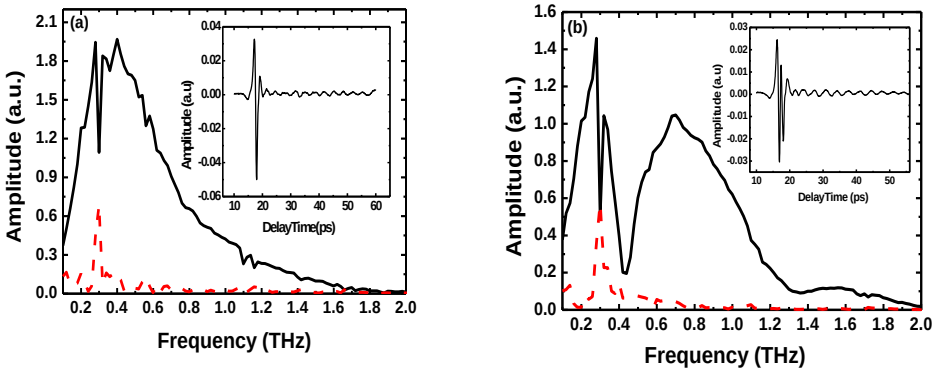

Fig. 1. THz transmission spectra of c-cut YFeO3 crystal with the electric field of the THz pulse parallel (a) and 450 (b) to the a-axis of the crystal, respectively. The insets show the corresponding transmitted temporal THz pulses. The solid lines represent the Fourier transform of the corresponding time-domain spectrum in the time range from 10.5 to 55.5 ps, and the dashed lines show the Fourier transform in the time range from 20.5 to 55.5 ps, respectively.

The narrow band absorption at 0.299 THz exhibits no dependence on the polarization of the incident THz wave, which can be assigned to the magnetic dipole transition due to the resonant coupling between the magnetic component of the THz wave and the F-mode of the crystal (Yamaguchi et al., 2010). In the excitation of the F-mode, the energy of the impulsive magnetic field is transferred to the spin system instantaneously, diminishing the amplitude of the incident electromagnetic wave. Phenomenally, when the impulsive magnetic field of the THz wave acts on the crystal, the magnetic moment experiences a Zeeman torque (T), which is proportional to the cross product of the magnetic moment (μ) and the impulsive magnetic field (H), $T=\gamma\mu\times H$, where γ is the gyromagnetic constant. As a result, the torque tilts the macroscopic magnetization of the crystal from the equilibrium. It is also noteworthy that the quasiferromagnetic resonance for $YFeO_3$ crystal is around 0.299 THz at room temperature (Kozlov et al., 1993), where the resonant mode agrees well with our observations from THz spectra.

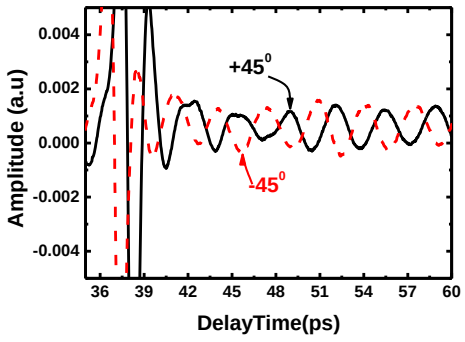

Fig. 2. Transmitted THz temporal waveforms with polarizer at +45° (solid) and -45° (dashed) from the horizontal direction, respectively

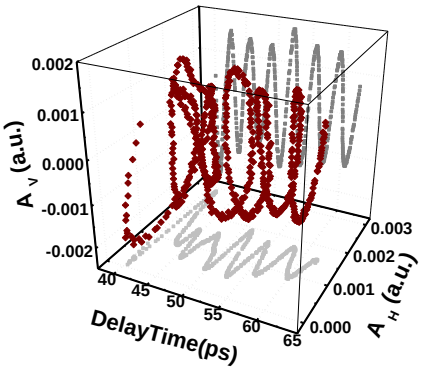

Fig. 3. Three-dimensional trajectory plot for the transmitted THz electric field in the $YFeO_3$ crystal with both horizontal and vertical components

In order to study the polarization of the emitted radiation at 0.299 THz, a THz polarizer is inserted before the detector and after the sample, and the polarizer is set to be +45 and -45 degrees to the horizontal, respectively. The measured results are shown in Fig. 2. The oscillation signals at both +45º and -45º originate from the rotating macroscopic magnetization excited by the impulsive THz magnetic field. It is obvious that the phase shift for the two curves is close to $\pi/2$, and the amplitudes are nearly the same, which indicate that the generated THz wave has a nearly circular polarization. The sum and difference of the two spectra give the horizontal and vertical electric field components, respectively (Nakajima et al., 2010). Figure 3 shows the three-dimensional trajectory plots of the horizontal and vertical components of the THz electric field for the $YFeO_3$ crystal and clearly demonstrates circular polarization. After tipping with THz pulses, the magnetization rotation around the effective magnetic field radiates a circularly polarized THz wave.

In summary, the impulsive magnetic component of a THz pulse is used to excite the magnetic dipole transition in $YFeO_3$ crystal. The sharp absorption at 0.299 THz in the THz spectrum originates from the excitation of the quasiferromagnetic mode of the orthoferrite, and the following EM radiation is demonstrated to arise from the free induction decay, which emits EM radiation at the same frequency as the absorption with circular polarization.

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