Polarization THz Spectroscopy in High Pulsed Magnetic Fields in Voigt and Faraday Geometries

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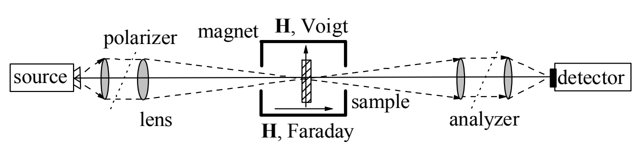
Abstract— **The paper presents the design and the performance of a pulsed magnetic field system for quasi-optical polarization THz (100 - 1000 GHz) spectroscopy capable to obtain 50 T at room temperature in Voigt and Faraday geometries, using backward wave oscillators as radiation sources. The developed facility is compact and relatively cheap. This allows one to realize the spectroscopy in magnetic fields up to 50 T in scientific communities with restricted financial and personnel opportunities.**

I. Introduction And Background

In this paper the design, performance, and application of a pulsed magnetic field system capable to obtain 50 T at room temperature for polarization THz spectroscopy are described.

In the developed design of the solenoid, the advantages of a pulsed power feed with pulses of duration about 100 μs are realized. The basic element of the solenoid is a multi-turn rectangular helix made of Beryllium bronze. The solenoids have an inner diameter of (1-2) cm and a length of (3-8) cm. The coil is connected directly to a 2000 μF, 5 kV banks of conventional capacitors by means of a vacuum switch. The discharge is oscillatory with a half-period of 100 μs.

To realize polarization THz measurements in magnetic fields (**H**) we use the quasi-optical method to control the radiation polarization (**h,** high frequency magnetic field**)** in a simple transmission scheme:

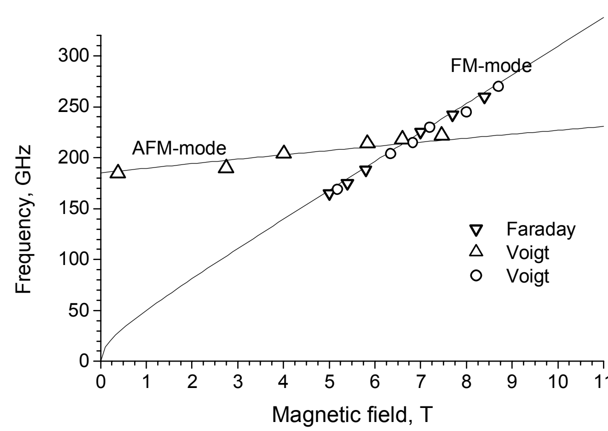


To cover the frequency range (100-1000) GHz backward wave oscillators are employed as sources of monochromatic radiation. The wire grids are used as polarizers and analyzers and provide a degree of polarization up to 99.99%. A beam of polarized monochromatic THz radiation is focused by Teflon or polyethylene lens on a plane-parallel sample located inside the coil. The passed radiation is analyzed with a wire-grid analyzer and is focused on a fast semiconductor detector.

II. Results

The demonstration of spectrometric measurements in pulse magnetic field made with several test samples has been carried out. The measurements of magnetic resonances in yttrium-iron garnet $Y_3Fe_5O_{12}$, antiferromagnets hematite α-Fe_2O_3 and orthoferrite $YFeO_3$ have demonstrated the possibilities of polarization measurements at THz frequencies (submillimeter wavelengths) in pulsed fields and the efficiency of the quasi-optical measurement scheme. A capability of the separate excitation (with respect to polarization of the radiation) of the quasi-antiferromagnetic (AFM-mode) and quasi-ferromagnetic (FM-mode) modes in the Voigt geometry is shown by using the easy-plane antiferromagnet α-Fe_2O_3 as a model magnetic material. A comprehensive computer simulation of the transmission spectra were carried out which made it possible to describe the observed evolution of the resonance line shape as a function of the frequency and polarization of the radiation.

The frequency-magnetic field dependences for antiferromagnetic resonance modes in hematite (**H** lying in the easy-plane), obtained by polarization measurements in pulsed field in Voigt and Faraday geometries at room temperature are given on the figure below. The AFM-mode is optically active for **h**||**H**, and the FM-mode – for **h**⊥**H**. Both, the AFM- and the FM-modes are optically active in Voigt geometry and only one FM-mode is active in Faraday geometry.



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