Title: Type-II thin film superconductors studied by terahertz radiation
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Abstract: Utilization of type-II superconductors for future practical applications such as fluxonics requires detailed knowledge of their physical properties, especially at high frequencies within the THz spectral region. We have investigated interactions of thin-film NbN samples deposited on Si substrate and of a high quality epitaxial film of the NbN superconductor grown on a birefringent R-cut sapphire substrate with monochromatic linearly polarized laser beam both below and above the critical temperature T_c. For photon energies lower than the optical gap, detailed measurements of transmission in zero field provide BCS-like temperature curves with a pronounced peak below T_c which disappears as the energy of incident radiation is increased above the gap. In externally applied magnetic fields up to 10 T oriented perpendicularly to the sample, i.e., in the Faraday experimental geometry, the temperature behavior of transmission is modified because the gap is suppressed and vanishes at the upper critical field and, additionally, the presence of quantized vortices changes the shape of the temperature curves. In the parallel Voigt geometry, significant differences are found between transmitted intensities of beams linearly polarised parallel with and perpendicular to the direction of applied magnetic field that fixes the vortex axes direction in the superconducting thin NbN film. A thorough analysis of the data, especially of the temperature and frequency dependence of the complex conductivity of the type-II superconductor has been performed in frame of the developed models, accounting for birefringent properties of the substrate. A precise polarization converting device fully tunable in a broad range of THz frequencies has been designed, developed and tested. It is now fully functioning for linear-to-circular polarization conversion and available for magneto-optical experiments with a FIR/THz gas laser source. It was used for measurements of the transmission of the circularly polarized THz beam through superconducting YBaCuO thin films in magnetic fields. The data reveal the presence of circular dichroism, most likely caused by the motion of the vortex lattice and allows one to estimate the effective vortex mass for this material.

Keywords: superconductivity, THz transmission, vortex mass, HTSC