Stripline-based resonant microwave spectroscopy at cryogenic temperatures

Marc Scheffler, Christian Fella, and Martin Dressel

1. Physikalisches Institut, Universität Stuttgart, 70550 Stuttgart, Germany

Optical spectroscopy can directly probe electronic excitations and dynamics if the frequency of the radiation is tuned to the characteristic energy scales of the material under study. For exotic conductors, such as strongly correlated metals and superconductors, this often means frequencies below 30 GHz (≈ 1 cm^{-1} ≈ 124 μeV), i.e. the microwave range, and temperatures below 10 K are required. In recent years, there has been substantial experimental progress to perform microwave spectroscopy on metals and superconductors at cryogenic temperatures, but the techniques have so far been limited (e.g. no phase information or only thin film samples).
Here we present a spectroscopic technique that employs microwave stripline resonators, where one of the ground planes is replaced by the (bulk) sample under study. Due to this resonant approach, we are sensitive enough to resolve the microwave losses of single crystals of metals and superconductors. Furthermore, the one-dimensional stripline geometry allows us to use several modes of the resonator to obtain frequency-resolved information. Although we have also employed metallic striplines, we focus on superconducting stripline resonators which are particularly sensitive. We present experimental results both on metallic samples (such as high-quality single crystals of heavy fermions) as well as superconductors, for frequencies between 2 GHz and 10 GHz and for temperatures down to 1 K, and we discuss the observed frequency dependences both for well-known as well as previously inaccessible regimes.