TT 30: Poster Session: Disordered Quantum Systems

Time: Monday 15:00–19:00 Location: Poster B

TT 30.1 Mon 15:00 Poster B

On the relation between chicken eyes and superconducting vortex lattices — •Jose Benito-Llorens[1,2], Anton Fente[1,2], Edwin Herrera[1,2], Hermann Suderow[1,2], and Isabel Guillamón[1,2] — [1]Laboratorio de Bajas Temperaturas y Altos Campos Magnéticos, Unidad Asociada UAM, CSIC, Departamento de Física de la Materia Condensada — [2]Instituto de Ciencia de Materiales de Madrid Nicolás Cabrera and Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, Spain

The arrangements of cells in a chicken eye are not randomly disordered, but are instead hyperuniform. Hyperuniformity is also observed in superconducting vortex lattices, even when vortex pinning centers are arranged randomly.

Here we analyze images of disordered superconducting vortex lattices taken with a scanning tunneling microscope. We analyze the potential that creates the disorder influencing the vortex lattice and present two limiting cases, random pinning and uncorrelated long range disorder created by a 1D potential at an angle with the vortex lattice. The latter is a hyperuniform potential in a somewhat trivial way, because it is a discommensuration between two ordered lattices.

We find that in both cases, the structure factor of the vortex lattice decreases to zero for large wavelengths with power laws. We discuss imaging experiments showing vortex motion and their relevance for the proposed phenomena.

Work supported by Spanish MINECO, ERC, Starting Grant and CIG Marie Curie program.

TT 30.2 Mon 15:00 Poster B

Dielectric measurements of the dynamics of atomic tunneling systems in thin-film AlO_x — •Saskia M. Meissner, Arnold Seiler, and Georg Weiss — Physikalisches Institut, Karlsruher Institut für Technologie

From the study of glasses atomic tunneling systems (TS) are well known to dominate the low temperature properties of disordered materials. They also appear in thin-film dielectrics of superconducting circuits, where AlO_x is a common material for the fabrication of Josephson junctions.

We present a broadband study of the dynamics of TS contained in thin-film disordered AlO_x ranging from kHz to GHz frequencies. The TS' density of states is probed at kHz frequencies by capacitance measurements as well as in the GHz range by tracking the resonance frequencies of superconducting microstrip resonators with embedded plate capacitors. This geometry creates a homogeneous electric field which is concentrated in the dielectric AlO_x reducing the influence of the native oxide on the surface of the Al structures.

The large bandwidth of excitation frequencies allows to verify the standard tunneling model but contrary to the predictions we measured an increasing density of TS with increasing temperature. Moreover, our observations reveal that the relaxation rates of TS are not only caused by their interaction with phonons and other TS as expected in dielectrics but also by quasiparticles penetrating the AlO_x from the superconducting Al plates.

TT 30.3 Mon 15:00 Poster B

Interaction of electrons with atomic tunneling systems in a Zr-basedsuperconducting metallic glass — •Arnold Seiler, Saskia M. Meissner, and Georg Weiss — Physikalisches Institut, Karlsruher Institut für Technologie

The low temperature properties of amorphous materials are known to be dominated by tunneling systems (TS) formed by atoms or groups of atoms that can tunnel between different configurations. Despite the success of the standard tunneling model in describing the properties of disordered dielectrics, its predictions for metallic glasses still appear incomplete.

In this work we investigate a Zr-based metallic glass by means of ultrasonic waves where the interaction of TS with quasiparticles or conduction electrons can be switched on and off by suppressing the superconductivity by a magnetic field. The onset of the relaxation process gives a clear indication of the energy relaxation rate of TS and allows to separate the underlying interactions and their coupling strength. Taking into account the temperature dependence of the finite linewidth and relaxation rate of TS in numerical calculations allows to reproduce the appearance of a crossing point of the sound velocity between normal and superconducting state.

Contrary to the expectation of a frequency-independent, logarithmic increase of the sound velocity with temperature, we found a frequency dependence of the temperature variation in the normal conducting state when changing the frequency of ultrasonic excitation from 1 GHz to 2 GHz.

TT 30.4 Mon 15:00 Poster B

Thin-film piezoelectric ZnO transducers for studies of tunneling systems in disordered materials with ultrasonic waves — •Axel Gullasch, Saskia M. Meissner, Arnold Seiler, and Georg Weiss — Physikalisches Institut, Karlsruher Institut für Technologie

The ultrasonic pulse propagation technique is a standard method for the study of fundamental properties of solids. Electron-phonon coupling in metals or semiconductors, spin-phonon interactions in magnetic systems as well as phonon coupling to collective excitations and sound propagation effects near phase transitions are a number of applications.

Ultrasonic methods are also an important tool to study atomic tunneling systems (TS) which often dominate the low temperature properties of disordered materials. In superconducting metallic glasses mechanical deformations are the method of choice to study TS and their interaction with conduction electrons.

For all these methods thin film 0.3-1 μm piezoelectric transducers are fabricated to be able to produce acoustic sound waves in the range of 0.5-2 GHz. ZnO is deposited by physical vapor deposition utilizing RF-magnetron sputtering. The quality of our ZnO-films is analyzed with an ultrasonic pulse-echo method using a probe station for lateral scanning of the piezoelectric transducers.

TT 30.5 Mon 15:00 Poster B

Low Frequency Acoustic and Dielectric Measurements of a Polymer Glass Containing Nuclear Quadrupole Moments — •Patrick Schygulla, Andreas Reiser, Annina Luck, Benedikt Frey, Nicole Assmann, Andreas Fleischmann, and Christian Enss — Kirchhoff-Institut für Physik, Universität Heidelberg, INF 227, D-69120 Heidelberg

Recent studies of glasses with nuclear electric quadrupole moments such as N-KZFS11 and HY-1 have revealed deviations in the dielectric function from the predictions of the standard tunneling model (STM), in particular an additional relaxational contribution.

We used a double paddle oscillator for acoustic and a capacitance bridge for dielectric measurements in order to investigate the elastic and dielectric susceptibility respectively at temperatures ranging from 7 to 700 mK and at frequencies between 60 Hz and 16 kHz. The examined polymer glass, FR-122P, has an atomic bromine content of 11 % with a well defined hyperfine level splitting of $\nu_Q \approx 250$ MHz. While at higher temperatures one-phonon processes can explain the data, below the temperature of the maximum the resonant contribution to the change of sound velocity is hardly visible and in the loss data a constant contribution was found in contrast to the expected T^3-dependence. The measured results are compared to numerical calculations of different extensions to the STM accounting for the presence of quadrupole moments. Also, first results are discussed from a newly designed experimental setup allowing for selectively saturating the quadrupolar transition of the nuclei during the measurement.

TT 30.6 Mon 15:00 Poster B

Influence of Nuclear Quadrupole Moments on Dielectric Polarization Echoes — •Andreas Schaller, Marcel Haas, Robert Haase, Anna Pollithy, Sergey Tsurkan, Matthias Sinnwell, Andreas Fleischmann, Andreas Reiser, and Christian Enss — Kirchhoff-Institute for Physics, Heidelberg University, D-69120 Heidelberg

Many low temperature properties of amorphous solids are well described by the phenomenological standard tunneling model. However, measurements of the dielectric constant, sound velocity, and dielectric polarization echoes of glasses containing atoms carrying nuclear quadrupole moments revealed unexpected characteristics, such as magnetic field dependencies, which are not observed in glasses without

nuclear quadrupole moments.

We present new results of dielectric two-pulse polarization echo measurements carried out on different multicomponent glasses and polymers containing large nuclear quadrupole moments. For all these samples the two-pulse-echo decay occurs on a comparably short timescale and we observe a dependency of the echo amplitude on the electric field strength of the excitation pulses which is weaker than for glasses without large nuclear quadrupole moments. In order to probe the echo decay at sub-μs times we developed microstructured superconducting planar resonators for which the quality factor can be determined by design. We show the results of first test measurements.

TT 30.7 Mon 15:00 Poster B

Dielectric Properties of a Brominated Molecular Glass at Low Frequencies and Low Temperatures — •Nicole Assmann, Annina Luck, Benedikt Frey, Andreas Fleischmann, Andreas Reiser, and Christian Enss — Kirchhoff-Institute for Physics, Heidelberg University, D-69120 Heidelberg

The low temperature behavior of amorphous solids is determined by atomic tunneling systems and can be described by the phenomenological standard tunneling model (STM). In the last two decades, several deviations from STM-like behavior have been observed which triggered a number of refinements of this model taking microscopic details of the tunneling entity and motion as well as the presence of nuclear moments into account. In order to study particularly the effect of large nuclear quadrupole splittings on the structure and dynamics of atomic tunneling systems we investigated brominated Bisphenol A diglycidether (BrDGEBA). This simply structured molecule contains about 5 % bromine which carries a very large quadrupole moment. In addition to its vitreous behaviour and well known quadrupole splitting of 250 MHz, it provides the possibility of adjusting the bromine concentration of the sample by mixing it with its unbrominated version. As a first attempt we measured the dielectric properties of an undiluted sample between 60 Hz and 16 kHz at temperatures down to 10 mK and ascertained large deviations from the STM at low frequencies combined with low temperatures.