



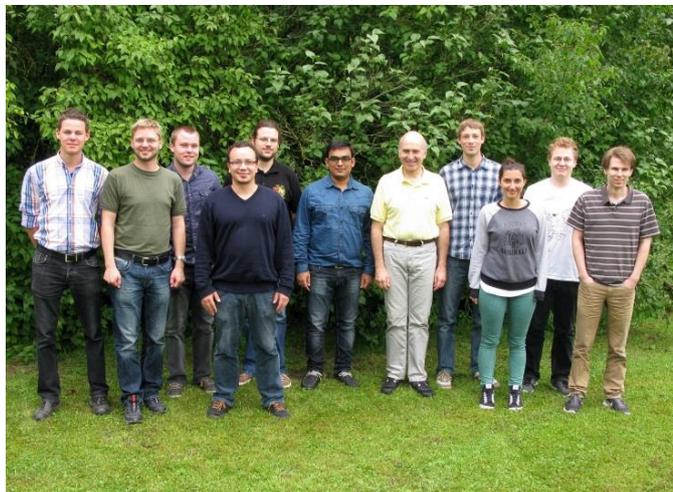
Bachelor / Master Theses

Superconductivity and phase transitions in novel materials

Research in condensed matter physics is driven by the discovery of novel materials. Unexpected properties and functionalities usually spark broad theoretical and experimental interest. Therefore, superconductivity at high transition temperatures, spin and charge order or metal-insulator transitions are among the most vibrant research fields. We study materials such as MnSi, [cuprates](#), [rare earth tri-tellurides](#) or the recently discovered [iron based superconductors](#).

The Raman group at the Walther-Meissner-Institut focuses on the study of many-body interactions in these systems and is integrated in the [research area superconductivity](#). Our fields of interest include the search for the interactions at the origin of Cooper pairing and phases in competition with superconductivity.

We use [Raman spectroscopy](#) to study the spin and carrier dynamics, fluctuations, and the superconducting gap. The method is very powerful and can be applied under extreme conditions such as high pressure and/or field.

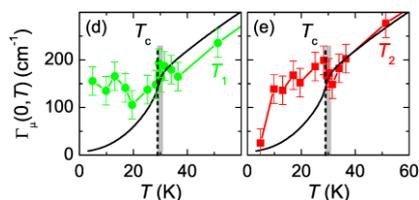


A current list of subjects for Bachelor / Master Thesis topics can be found on the following page.

If you are interested in one of these topics, please contact Andreas Baum (andreas.baum@wmi.badw.de), Thomas Böhm (thomas.boehm@wmi.badw.de) or [Dr. Rudi Hackl](#) (hackl@wmi.badw.de, phone 089 289 14218) for additional information.

Theses

Bachelor/Master



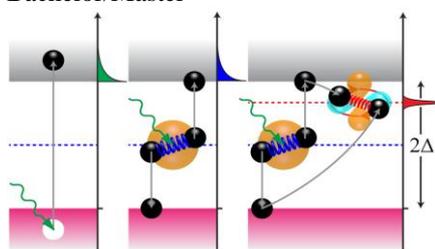
Static relaxation rates (inverse lifetimes) $\Gamma_{\mu}(0, T)$ for (left) T_1 (chiral spin excitations) and (right) T_2 (conduction electrons) symmetry of MnSi. The magnetic ordering temperature $T_C=29\text{K}$ is marked by a dashed line. H.-M. Eiter *et al.*, [PRB 90, 024411 \(2014\)](#), Fig. 9.

Study of the interaction between spin, lattice and charge degrees of freedom in *d*- and *f*-electron systems without inversion symmetry

In systems without inversion symmetry such as [MnSi](#) spin, charge and lattice are generally coupled. This opens a window into the direct manipulation of the magnetization by electric fields, for instance. In the intended work, the influence of the various spin ordering phenomena on the electronic and lattice properties shall be studied using [inelastic light \(Raman\) scattering](#) as the major experimental tool. As shown in the figure left, spin and charge excitations, selected by appropriate light polarizations, relax in fact differently close to and in the magnetically ordered phase. It is planned to study the various phase boundaries in magnetic fields and with applied pressure. The work will be performed in collaboration with the group of [Christian Pfleiderer](#).

We offer a thorough introduction into low-temperature physics and experimental techniques. These include optics, spectroscopy, magnetometry, transport, diamond-anvil pressure cells, He cryostats, and superconducting magnets.

Bachelor/Master



Gap excitation, pair breaking and excitonic states as observed by Raman scattering in $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}_2$.

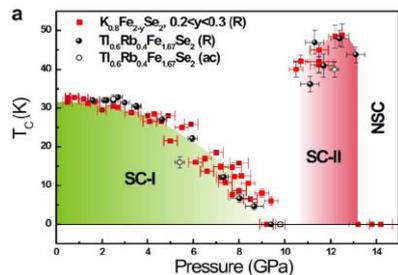
F. Kretschmar *et al.*, [PRL 110, 187002 \(2013\)](#)
T. Böhm *et al.*, [PRX 4, 041046 \(2014\)](#)

Study of the superconducting phase diagram in $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}_2$

[Iron-based compounds](#) such as BaFe_2As_2 with and without elemental substitution are a new class of superconductors with transition temperatures T_c above 50 K. Similar to the record-holding cuprates magnetism and superconductivity are in close proximity and believed to be interrelated. This obviously fundamental question can be studied in BaFe_2As_2 and related compounds in which the phase boundaries can be tuned by substitution and by uniaxial or hydrostatic pressure. It is planned to scrutinize the energy gap and bound states using [inelastic light \(Raman\) scattering](#) in order to identify and quantify potential contributions to Cooper pairing.

We offer a thorough introduction into low-temperature physics and experimental techniques. These include optics, spectroscopy, diamond-anvil pressure cells, He cryostats, and superconducting magnets.

Bachelor/Master



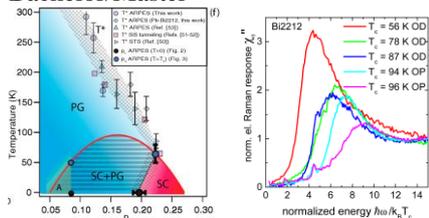
P-T phase diagram of FeSe compounds. Liling Sun *et al.*, [Nature 483, 67 \(2012\)](#)

Search for new phases in iron-based compounds

Several new superconducting phases of [iron-based compounds](#) such as FeSe have been discovered at elevated pressure. This not only opens a window toward a better understanding of the interplay of carrier doping and structural changes upon atomic substitution but also paves the way towards new superconductors. In collaboration with the group of [Dirk Johrendt](#), new Fe-based compounds will be studied in the diamond anvil cell. The major tool for characterization will be the magnetic susceptibility.

We offer a thorough introduction into low-temperature physics and experimental techniques. These include optics, spectroscopy, diamond-anvil pressure cells, He cryostats, and susceptometry.

Bachelor/Master



Phase diagram and Raman spectra of $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$ for $p>0.15$.

I. Vishik *et al.*, [PNAS 109, 18332 \(2012\)](#)
N. Munnikes *et al.*, [PRB 84, 144523 \(2011\)](#)

Magnetic and electronic phases in copper-oxygen compounds

The understanding of superconductivity in the [copper-oxygen compounds](#) remains one of the major challenges in condensed matter physics. The highly ordered samples available since recently provide new insight into the intrinsic properties. It is planned to study the electronic properties of single crystalline $\text{YBa}_2\text{Cu}_3\text{O}_{6+x}$ and $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$ at various oxygen concentrations with [light scattering](#). The data will be analyzed in collaboration with the group of [T.P. Devereaux](#).

We offer a thorough introduction into theoretical data analysis, low-temperature physics, and experimental techniques. These include optics, spectroscopy, pressure cells, He cryostats, and susceptometry. In addition, advanced techniques for sample preparation will be used.