TECHNISCHE UNIVERSITÄT DRESDEN

IFMP Institut für Festkörper- & Materialphysik

IFMP Seminar

Date: Tuesday, June 29, 2021, at 14:50

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Speaker: **Yoshihiko Ihara**

Hokkaido University

Title: **NMR observation of valence skipping phenomena in superconducting $In_xGe_{1-x}Te$**

Abstract: The valence states of ions are strongly connected with the physical properties of materials. To control conductivity, for instance, we frequently replace an element with another element with a different valence state. For some elements with large atomic numbers, their own valence state can change without replacement, donating (accepting) electrons to (from) the conduction bands. This spontaneous doping effect is most significant for a valence-skipping element, which donates/accepts two electrons at the same time. Indium is one of these valence skipping elements — the trivalent In^{3+} ($5s^05p^0$) and monovalent In^{1+} ($5s^25p^0$) states are preferred over the divalent state. Here we focus on the In-doped superconducting telluride $In_xGe_{1-x}Te$, in which valence skipping is introduced as a function of In doping x.

The In-free end member GeTe is ideally a narrow-gap semiconductor. In reality, however, a small amount of hole doping by defects is inevitable. At low In doping levels, In enters as In^{3+}, donating 3 electrons to the conduction bands and filling the small hole pockets. Upon further doping, the In valence changes to In^{1+}, the 5*s* orbital in the valence band extracting 2 electrons from the conduction band, creating holes again. This change in the valence state of In was observed previously by photoemission spectroscopy, which suggests a gradual change in valence across the critical doping of $x \sim 0.3$. [1] In this study we have performed ^{115}In-NMR spectroscopy to directly detect the local valence state. Interestingly, we find that the nuclear spin-spin relaxation time T_2 has a significant doping dependence. We suggest that the RKKY interactions between nuclear spins, which are mediated by conduction electrons, are modified by the change in the valence state of In. We will also discuss the possibility of mixed valence for the high-doping side with the shortest T_2.

[1] M. Kriener *et al.*, Phys. Rev. Lett. **124**, 047002 (2020).

Host: D. Inosov