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(KU Leuven)

## **Confinement of electrons and phonons in nanoscale superconductors**

When reducing the dimensions of superconductors, confinement effects can lead to strong modifications of their properties compared to bulk. In this seminar, phonon and electron confinement effects will be illustrated in superconducting systems with dimensions ranging from the microscopic down to the subnanometer scale.

Phonons are of crucial importance in phonon-mediated superconductivity. In particular, the phonon density of states (PDOS) directly determines key parameters such as the electron-phonon coupling strength and the critical temperature  $T_C$ . There remains however a clear need for improving our fundamental understanding of the phonon related properties for materials with reduced dimensionalities, in particular because atomic vibrations are difficult to access at this scale. During the first part of the seminar, recent measurement of the PDOS of Sn nano-islands and cluster-assembled systems by nuclear inelastic scattering of synchrotron radiation which specifically probes the  $^{119}\text{Sn}$  isotope [1] will be presented. Clear modifications are found compared to the PDOS of a reference bulk Sn sample, such as an energy redistribution of the phonon modes due to phonon damping and scattering at grain ( $\sim 50\text{nm}$ ) and sample boundaries. Moreover,  $T_C$  enhancements well above 10% are detected, which are mainly explained by the phonon confinement.

When reducing the dimensions of superconductors down in the nanometer scale and below, electron confinement becomes dominant. Due to the discretization of the electronic density of states,  $T_C$  is strongly modulated as a function of the dimensions of the superconductor. Recently, strong electron pairing up to temperatures above 100K has been predicted in small metallic clusters made of a few atoms due the presence of highly degenerated electronic shells [2]. A review on the current status of the search for superconductivity in small clusters will be given. Investigation of electron confinement effects in Co nano-islands and small Co clusters performed using scanning tunneling microscopy will be presented. Finally, a prospective for the search of superconductivity in small metallic clusters made of a countable number of atoms will be discussed.

[1] S. Couet, H. Peelaers, M. Trekels, K. Houben, C. Petermann, M.Y. Hu, J.Y. Zhao, W. Bi, E.E. Alp, E. Menéndez, B. Partoens, F.M. Peeters, M.J. Van Bael, A. Vantomme, K. Temst, Phys. Rev. B 88, 045437 (2013).

[2] V.Z. Kresin and Y.N. Ovchinnikov, Phys. Rev. B 74, 024514 (2006).

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