21COE 物質階層融合科学セミナー

物性コロキュウム

日時：１月２３日（金） １６：３０－１８：００
場所: 理学部 総合研究棟７４５号室(大学院講義室Ｉ)
講師：Z.K. Tang (Department of Physics, Hong Kong University of Science & Technology)
題目：Novel Properties of ultra-small single-walled carbon nanotubes formed in the channels of AlPO4-5 zeolite single crystals

Abstract：
In 1993, Iijima's group as well as Bethune's group found that the use of transition-metal catalysts could lead to nanotubes with only a single wall. The diameter of each freestanding single-walled carbon nanotube (SWNT) ranges from 0.7 nm to a few tens nanometers with a maximum length of about 1 micron. Although theoretical calculations have predicted the stability of a SWNT with diameter as small as 0.4 nm, the existence of free-standing SWNTs with a diameter smaller than that of C60 fullerene (0.7 nm) has been in doubt for quite a while because of the extreme curvature and reactivity of these structures. Smaller carbon nanotubes can exist in a spatially confined environment. Carbon nanotubes with diameters of as small as 0.5 nm, and 0.4 nm have been observed existing in the centre of multi-walled carbon nanotubes. It is still not clear, however, that whether these small nanotubes are stable in free space. Recently, we have shown that 0.4 nm-sized SWNTs can be produced by means of paralysing hydrocarbon molecules in 1 nm-sized channels of AlPO4-5 (AFI) single crystals. These 0.4 nm SWNTs have the same size of the smallest possible fullerene C20, they are stable inside the AFI channels but not very stable when they are in free standing. These small nanotubes perhaps constitute the best example of one-dimensional (1D) quantum wires. In this lecture, we report the novel properties of the ultra-small SWNTs. Because these SWNTs are highly aligned and uniform in size, they show interesting optical and electrical transport properties. Local density functional calculations indicate that when the diameter of the SWNT is smaller than 0.5 nm, strong curvature effects induce strong sigma-pi mixing of the unoccupied orbitals. In this regime, metallicity can no longer be predicted by the simple band-folding picture, and these small-radius SWNTs generally have finite density of states at the Fermi level. These small SWNTs behave a good polarizer. It has strong absorption for the light polarized parallel to the tube direction, and is nearly transparent for the light polarized in perpendicular direction. The optical dipole selection rules are discussed, and the absorption bands are assigned to the dipole transitions between the van-Hove singularities. Investigation of the magnetic and transport properties of these SWNTs revealed that at temperatures below 20 K, the 0.4 nm tubes exhibit superconducting behavior manifest as an anisotropic Meissner effect, with a superconducting gap and fluctuation supercurrent. The measured superconducting characteristics display smooth temperature variations owing to one-dimensional fluctuations, with a mean-field superconducting transition temperature of 15 K.

湯先生は、COEの招聘研究者として東北大学にお呼びいたしました(1/21-27)。湯先生は、東北大学出身で光物性研究でも多くの優れた研究があります。２月には、ZnOの研究で中国政府より自然科学賞を受賞することになっています。今回は、直径0.4nmのナノチューブの合成から、超伝導についての発見者として、お話いただきます。招聘期間中ご議論を歓迎します。スケジュール調整は齋藤がしますので、 斉藤までご連絡ください。

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☆ 16:15 よりコーヒー、紅茶、お菓子を用意します。カップを持ってお集まり下さい。

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