Electronic correlation on carbon nanotubes and nano-graphite ribbons

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Recently, graphite-based one-dimensional materials with nanometer sizes, such as carbon nanotubes (CNs) and nano-graphite ribbons (NGRs), have been attracting much attention in both the fundamental sciences and the application sides, and the properties of these materials have been intensively studied both experimentally and theoretically. It has been well known that physical properties of the one-dimensional interacting electron systems cannot be described by conventional Fermi-liquid-theory. In the present work, we discuss the effects of the electronic correlation on the properties of these materials.

At first, we discuss the CN, which is composed of a coaxially rolled graphite sheet as is shown in Fig.1 and it's actual length is of the order of $1\mu m$ or less than it.

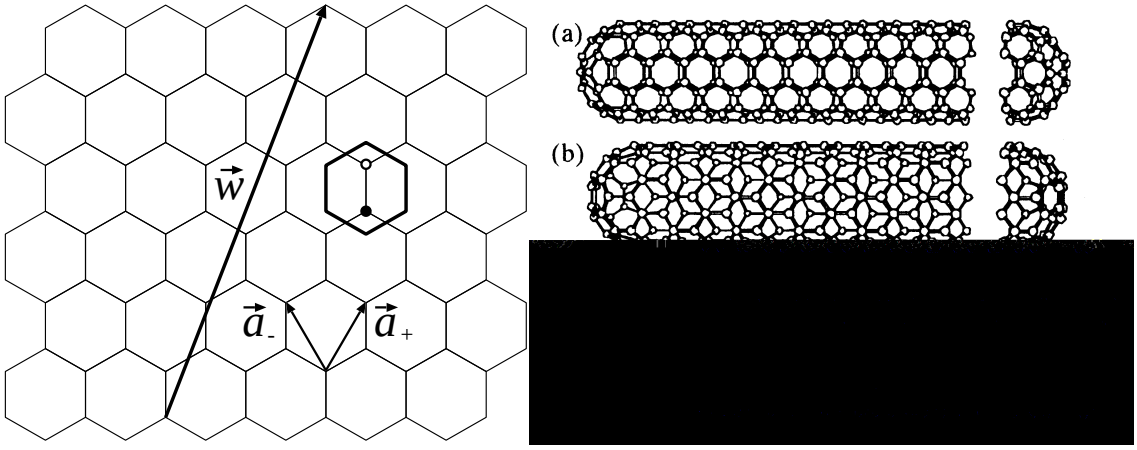

Fig.1 : The structures of the graphite sheet (left) and the CNs (right). In the left figure, the black (white) circle shows the A (B) sublattice and $\vec{a}_\pm$ express the two primitive lattice vectors. The CN is made by rolling up the sheet along the wrapping vector $\vec{w} = N_+\vec{a}_+ + N_-\vec{a}_- \equiv (N_+, N_-)$. In the right figure, (a), (b) and (c) express the armchair CN with (N, N), the zigzag CN with $(N, 0)$ and the chiral CN.

The CN is characterized by two integers, (N_+, N_-), corresponding to a wrapping vector along the waist, $\vec{w} = N_+\vec{a}_+ + N_-\vec{a}_-$, where $\vec{a}_\pm$ are primitive lattice vectors of the graphite sheet. When $N_+ - N_- = 0 \bmod 3$, the metallic one-dimensional dispersions appear near the center of the bands. The low energy properties less than v_0/R (v_0 : Fermi velocity, R : radius of the tube) are well described by taking into account only the metallic one-dimensional dispersions. Thus, the metallic CN is the typical one-dimensional conductor and Tomonaga-Luttinger liquid (TLL) state is realized due to the mutual interaction. We investigate the properties of the semi-infinite (N, N) armchair CN based on the TLL theory of the CN with open ends. The space distribution of the charge and the local density of states (LDOS) are discussed. In case of $\mu = 0$ (μ : chemical potential), *i.e.*, there are no carrier doping, the oscillation of the charge distribution does not happen. When $\mu \neq 0$, the oscillation appears. The mount of the injected carriers become smaller compared to the

non-interacting case corresponding to the suppression of the charge susceptibility. As a result, the amplitude near an edge become smaller, but that far from the edge is enhanced by the interaction. The LDOS consists of the two parts. One is the spatially slowly varying component and the other shows the rapid oscillation in space. It is shown that the both components in the LDOS at the energy $\omega = \mu$ vanish for the absolute zero temperature. The LDOS is discussed comparing with that in the absence of the interaction.

Next the properties of the NGR, which is the nano-meter size graphite fragment, are discussed. We concentrate on the NGR with the zigzag edges and the width N (number of the zigzag lines from one side to the other) as is shown in Fig.2.

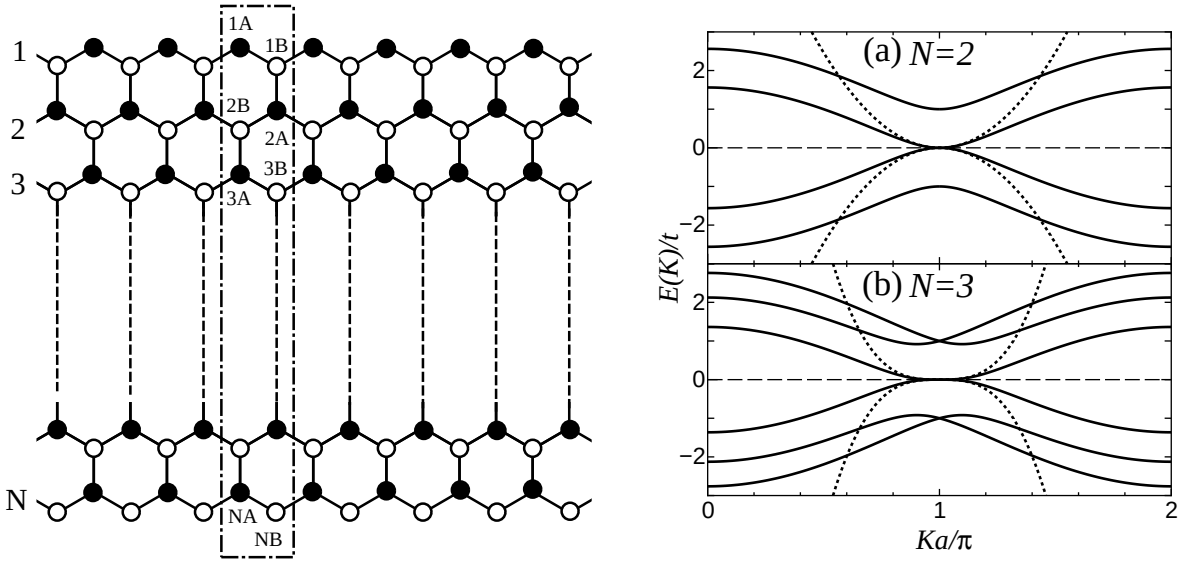

Fig.2 : The structure (left) and the dispersion relation (right) of the zigzag NGR with the width N. In the left figure, the black (white) circle shows the A (B) sublattice and the rectangle with the dashed-dotted line indicates the unit cell. The band structure in the right figure are