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Molecular Low-Dimensional and Nanostructured Materials

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he main motivation of this Workshop is the general ongoing trend toward electronics miniaturization. Going on from low-dimensional materials to nanostructures and molecules the quantal nature of the atomic world is revealed. Quanta of electric and thermal conductance have been seen in nanowires, atoms can be manipulated "by hand" with the scanning electron microscopy, one-molecule diodes and transistors already work, Coulomb blockade has been seen electron-by-electron in quantal dots, electron-transfer in large molecule writes up bits of information, and nanomachines and nano(ro)bots are imagined, which, one day will repair living organisms, and will go out and replicate themselves to do any imaginable functions of the human race, including food delivery from nanotech matter compilers. All this because "there is plenty of room at the bottom", according to Feynman. Carving up solid surfaces, or essembling atomic aggregates below the 100nm limit of today (the size of the aminoacids), either by pushing further the photolitography and soft litography, or by "atomic writing" with the scanning tunneling microscope, or by gauged chemical reactions, would open the gate toward the genuine nanoworld. We are not "out of our minds with joy", because in science nothing is impossible (except for the non-sense). We are living not one of, but "the best possible world" indeed.

Electro-luminiscent devices made out of one or two organics slices sticked together with different metallic contacts get injected electrons from one contact and holes from the other (which drains out electrons); electrons and holes inside combine each other to give visible light. This raises a fundamental question about the validity of the energy-band concept in solid state physics.[1]

Molecular dipoles in complex molecules, whose strength and orientation are controlled by light, or electric fields, respond, optically, non-linearly. Electric-field gradients by photoconductivity, or conformational changes in photochromic molecules, give rise to light-driven organized molecular movements and arrangements, leading to gratings of refractive index, holograms, polarization holograms, photoinduced birefringence and dichroism, as a consequence of the non-linear optical activity of such molecules (especially in polimers and liquid crystals).[2] Quantal states of a charge carrier in an electric dipole potential are not done yet, nor their effect upon the lifetime of the charge carriers, their mobility, etc.[3] In particular, the non-linear response of a variable electric dipole to the electromagnetic field is not worked out, especially in connection with the Holstein polaron, nor the ionic-neutral phase transition investigated in the donor-acceptor dimer model of Holstein.[4] Electron-phonon interaction in this context is worthstudying.[6]

Grinding together two crystalline insulators new, composite conducting materials are obtained.[8] New features are to be expected in two-species atomic clusters as compared with the corresponding component (pristine) clusters.[9]

Magneto-oscilaltions are worthnoting, both Shubnikov-de Haas magnetoresistance oscillations and de Haas-van Alfven magnetisation oscillations, in quasi-two-dimensional organic metals, especially their angle dependence at low temperature and high magnetic field.[**?**] Organic crystals like salts of BEDT-TTF with acceptors like iodine, are among the purest crystals. Their electronic structure is quasi-two-dimensional, with a weakly warped cylindrical Fermi surface. Magneto-oscillations provide information about this Fermi surface. For pure crystals such an information is accurate, it may resolve uncertainties in quasi-two-dimensional Fermi surfaces, while electronic behaviour in two dimensions is long suspected of treasuring surprises. On the other hand, it would be worth observing the quantum Hall effect in natural layered structures, like these crystals (not fabricated two-dimensional metal-oxide-semiconductor MOS). The magneto-oscillations theory in two and quasi-two dimensions is not done yet.[10]

The ferromagnet-superconductor interface is a host of complex phenomena. There, Andreev reflection of an electron entails an opposite spin and impedes a parallel spin, so that the current can be controlled by controlling the spin polarization of the injected electrons. The latter may be sensitive to an applied magnetic field, but spin-orbit coupling as well as the ubiqutuos proximity effects are also present. The spin-polarized transport through a superconducting interface is not yet done.[11]

Nanowires are sometimes modelled by (quasi-) one-dimensional Luttinger liquids where the excitations are exhausted by collective charge- and spin-density oscillations.[12] However, thin metallic nanowires are unstable, while electrons may move on surface in carbon nanotubes. The transport in Luttinger liquid however is a long-waiting subject.[13]

Transport through nanostructures or molecules implies ballistic transport, as distinct from thermal, diffusive transport, as well as the intermediary regime of an incoherent-coherent transport; the incoherent transport is of a one-electron type, with Coulomb blockade, or resonant tunneling through a molecule (which acts this way like an Esaki diode); while the coherent transport interferes with localized states as in Fano's resonance (or Kondo's for a magnetic moment).[14] The main problem is that contacts may change everything. The nanotransport is not yet done, in spite of many interesting insights.[15]

Cluster-essembled materials exhibit an interplay between a long-range order parameter from cluster to cluster and a short-range order parameter inside each cluster, the latter being viewed as ordered large defects with their own dynamics. Such materials are also clusters deposited on surfaces, or endohedral functionalized clusters macroscopically essembled. They are new materials, and even new phases.[16] Carbon-nitrogen clusters have again recurred, due to their unusual hardness.

Superconducting organic crystals are, in range, $(TMTSF)_2X$ (X=halogen), quasi-one-dimensional (at least structurally), with $T_c < 2$K, BEDT-TTF salts, two-dimensional, with $T_c = 12$K, A_3C_{60} (alkali fullerides), three-diemnsional, with $T_c = 35$K, and, recently, hole-doped C_{60} fullerene, with $T_c \sim 52$K. A systematic procedure of synthesizing such organic superconductors has also been presented.[17] As well as molecular nanowires,[18] or molecular magnets,[**?**] based on TTF. TTF is tetrathiafulvalene, BEDT is bis-ethylenedithio.

The old point-contact spectroscopy, which gets the electron-phonon interaction from the current-voltage characteristics of a pointlike contact (hole), has been discussed,[19] as well as an electrochromic cell on starch extracted from potatoes.[20]

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