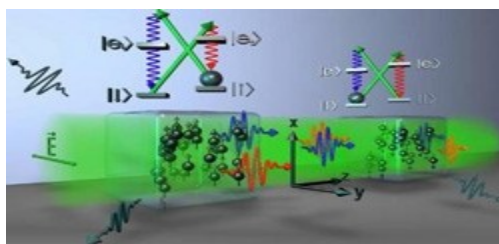


CHALLENGES IN FUTURE NANO-SCIENCE

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<http://www.rdmag.com/News/2011/08/Information-Tech-Physics-Quantum-optical-link-sets-new-time-records/>

Future development of Nanotechnology also includes fundamental rethinking of understanding of basic chemical-physical concepts; this is a consequence of the deep changes of the properties in the nano-scale dimension.

Materials in the micrometer scale mostly exhibit physical properties the same as that of bulk form; however, materials in the nanometer scale may exhibit physical properties distinctively different from that of bulk. For bulk materials, certain fundamental properties, such as electrical and thermal conductivity, colour, melting point, elasticity, electronic structure and so on are intrinsic to the material structure and composition.

In nano structured materials some of these fundamental properties are associated to the nano-length scales and, as a consequence, the properties may themselves be experimentally controlled. For example, nano-crystals have a melting point very low, the difference can be as large as about 1000°C.

Those changes are the consequence of the number of surface atoms or ions that becomes a significant fraction of the total number of atoms or ions in nano-structures and for this modification the surface energy plays a significant high tension that change the role of nano-materials in the thermal stability. Crystal structures stable at elevated temperatures are stable at much lower temperatures in nanometer sizes, so ferroelectrics and ferromagnetics may lose their ferroelectricity and ferromagnetism when the materials are shrunk to the nanometer scale. Bulk semiconductors become insulators when the characteristic dimension is sufficiently small (in a couple of nanometers). Although bulk gold does not exhibit catalysis properties, Au nanocrystal demonstrates to be an excellent low temperature catalyst. Also in the organic nano compounds as in the bidimensional graphene the catalytic properties are enhanced during the progressive changes of electronic properties starting from a single graphene sheet to graphite.(1)

Today emerge the need to advance in a good understanding of the origin of these changes of properties in nanostructure materials, because it is essential to ameliorate the fabrication and process of utilization of nano-materials (2) The above complex changes of nano-structured matter requires an innovative conceptual research and to open a debate on developmental themes of trans-disciplinary nanoscience. Especially it become in evidence the need to understand deeply the new scientific and technological challenges in order to connect the nano-size dependence with the electro-chemical and physical modification, including magnetic and optical properties melting points, specific heats, chemical reactivity and catalytic activity etc...

As a matter of facts seems that most of those variations probably are depending from the plasticity of the of chemical bonds at the nano-scale dimensions. (3) There are various types of chemical bonds – ionic, covalent, metallic, Van der Waals', hydrogen bonds, donor-acceptor ones, etc, so that some scientists accept that chemical bond, in regard to cases dealing with nano-structures interpretations, loose their definitiveness and significance, this because such great variation of properties at a first approximations seems only relative to the external shape and size of nanoscale systems. (4)

Nowadays the new challenge of nanoscience characterization will overcome the previous approximation limiting to the size and shape the knowledge of the peculiar properties of nano-particles. So that the challenge of nanoscience is now focused in advance an innovative interpretation about the changes that happen in modifying the size of nano-materials understanding the basis of the modification of traditional parameters of structure and composition of matter an energy when the bulk-matter is progressively going forward the nano-scale or viceversa.

Carbon-based nanomaterials are a very important case of nanostructured compounds, that are linked together by means a network of covalent bonds, as graphene, fullerene and nano-tubes, so that can be important to understand how change the co-organization of bonding properties of nano-structured carbonium atoms, in relation to the amazing changes in their electronic and thermal properties of such nano-compounds. At this proposal it is important to remember that in relation to the covalent bond, **Lynus Pauling** underlined the dependence of such bonds on the system's size.

Pauling (Nobel Prize in Chemistry 1954) observed the high decrease in the inter-nuclear distance and a consequent increase of the bond energy between the two atoms, participating to the molecular bond, and interpret them as **quantum effects, resulting from the overlapping of the inner electrons when is forming a chemical covalent bond**. These assumption are confirmed experimentally through the studies of chemical

reaction induced by lasers and measured in femto-seconds. In fact inner electrons increase their fluctuation in the range of 500 to 800 femto-seconds around the nucleus, changing as a consequence the binding values of energy from 3.5 to 5.0 eV .

The difference of frequency fluctuations and energy emission measured in femto-seconds, permits to go beyond the approximation of the size and shape dependence of the changes of properties from bulk to nano-structured matter. In fact the binding energy change with the decreasing of size and form of nano-structured matter this because a delocalized contribution of internal electron's shell modify the valence of external binding electrons to a value that is much more sensitive in magnitude in relation of the nucleus action force.

This result theoretical and experimental results go in deeper to the traditional theories of sharing of electrons in covalent bonds before considered as a simple effect of electronegativity asymmetry between external bonding electrons and without any contribution of the core-shell where it exists.

Besides, over recent years, chemists have found lots of examples of hydrogen bonding that don't quite fit the classic Molecular Orbital (MO) or Valence Bond (VB) theory definitions (5), in fact novel bonding modes can be conceived through understanding the action of "quantum entanglement" in nanostructured materials. Introducing the *entanglement effect* an important relationship can be predicted considering the probability of the increase of bond-strength, through the enlargement of the extension of "physical" overlapping of electron orbitals. (6)

In classic approach of *chemical bond orbitals* represent the electronic probability of configuration of electron cloud, but if we think at the *physical overlapping of such electron clouds*, in that case the *entanglement of electron orbitals* will be the cause of the *quantum effect*, (as suggested by L.Pauling), in governing the changes of the orbital's *rehybridization* both in geometrical and electronic properties of nanostructured materials. (7)

Chemical bonds are typically 0.2 nm long for catalytic nano particles are 3/6 nm in size, the bonding electrons in such typical nano dimensions *are becoming "non-local entities"*, so that bond electrons through the *quantum entanglement* can exist in many positions at the same time. One of the consequences of this *non-locality* is that the electrons as quantum objects can co-exist together in the same "*quantum entangled state*" even if separated by a relatively variable bond-distance.

This fact implies the effective existence of an invisible link between two distant quantum bodies as can be considered the coupled of covalent bond-electrons, so that whatever happens to one of them simultaneously affects the other linked in the covalent bond. Therefore in a *non local system of entangled electron clouds*, the delicate balance of energy bond changes, become extremely sensitive to the extension of the size and shape especially in strongly correlation system as they are nanomaterials .

--> In conclusion the experimentally interesting but not only theoretically annoying studies of "entangled quantum states" will be a crucial endeavour for understanding the foundations of FUTURE NANO-SCIENCE (8)

("Spectrally resolved quantum tomography of polarization-entangled states").



<http://www.nanowerk.com/news/newsid=20777.php>
http://nanopatentsandinnovations.blogspot.com/2011_03_01_archive.html

<Light from a nonlinear crystal is emitted over a range of emission angles (as indicated by the concentric circles) and energies (as indicated by the different colors) with various levels of quantum entanglement.>

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