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Geometric phases of quantum dots and topological designs of nucleic acid nanostructures

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Recent experimental results on universal geometric quantum gates have highlighted the importance of geometric phases and topology in determining and controlling properties of low dimensional nanostructures. Among them, quantum dots (QDs) are playing a prominent role due to a wide range of current and potential applications. In the first part of this contribution, we focus on the geometric Berry phase in QDs and analyze its high sensitivity to electric fields coming from the interplay between the Rashba and Dresselhaus spin-orbit couplings. We demonstrate that the accumulated geometric phase in QDs can be induced from other available quantum states that differ only by one quantum number of the corresponding spin state [2]. Moreover, the sign change in the g- factor can be reflected in this phase. We carry out the analysis for typical spatial scales in such situations, namely for spin-orbit length, hybrid orbital length, and orbital radius, and determine the key characteristics of the Berry phase in QDs, specifically for these scales. Among a series of new effects reported, it is shown that the superposition effect can be observed during the adiabatic transport of quantum dots. Applications of the observed effects are discussed. The second part of this contribution is devoted to several important aspects of nuclic acid nanotechnology, focusing on the topological designs and properties of RNA nanostructures. The remarkable flexibility and efficient self-assemblies of these biomolecular objects have moved them to the forefront of many applications in bionanotechnology and biomedicine. Our exemplifications here are based on RNA nanotubes where we provide further insight into their properties through recently developed molecular dynamics and coarse grained procedures [3].

1. *Prabhakar S., Melnik R., Bonilla L.L.* Gate control of Berry phase in III-V semiconductor quantum dots // Phys. Rev. B.-2014.- **8**,.- 245310.
2. *Badu S.R., Melnik R., Paliy M., Prabhakar S., Sebetci A., Shapiro B.* Modeling of RNA nanotubes using molecular dynamics simulation // Eur. Biophys. J. Biophy.-2014.-**43**,- P.555-564.