QUANTUM NANOMAGNETISM

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In my talk I will review the work done in the field of nanomagnts emphasizing the description of quantum phenomena detected in such small systems and their possible technological applications. I will start talking about the effect of quantum tunneling of magnetic poles in magnetic nanoparticles then I will move to the discovery of ressonant spin tunneling and finishing with the explanation of other exotic phenomena detected such as spin quantum interference, quantum magnetic deflagration, the emission of superradiance and the use of nanomagnets as qubits. For a large magnet the positions of north and south magnetic poles are fixed. As one reduces the size of the magnet the poles begin to interchange randomly due to thermal processes. It was widely believed that when temperature approaches absolute zero the thermal processes die out and the poles become frozen again. However, the theory [1] demonstrated that even at absolute zero temperature the poles can still interchange due to a purely quantum effect – tunneling. Inspired by this work several experimental groups started working on the search of the experimental elucidation of such effect. In early 1990s a number of experiments established with certainty the existence of non-thermal magnetic relaxation in arrays of magnetic nanoparticles. In essence these works demonstrated that when temperature goes to absolute zero the magnetic poles of tiny magnetic particles continued to interchange, thus providing the non-vanishing time dependence of the magnetization of the sample [2]. Related seminal research conducted by several groups in 1990s included quantum tunneling of domain walls, tunneling of vortices in superconductors, and spin tunneling in random magnets.

It was not until 1995, however, that tunneling of the magnetic moment in molecular magnets was firmly established in a seminal discovery of quantum magnetic hysteresis [3]. This experimental result was just followed by the experimental evidence of resonant spin tunneling by ac magnetic susceptibility data [4]. Since then, more than 3000 papers have been published in this field having some of them a very high impact in both science and technology.

References

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