Lévy Statistics for Random Single–Molecule Line Shapes in a Glass

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Experimental advances have made it possible to measure the spectral line shape of a single dye molecule embedded in different types of glassy materials. Because each individual molecule is in a unique static and dynamic environment, the line shapes of chemically identical single molecules varies from molecule to molecule. Thus single molecules serve as local probes for dynamics and statics of the glassy system. We examine the statistical properties of line shapes of single molecules (tetra-tert-butylterrylene) in a low temperature ($T = 2$K) glass (polyisobutylene ). For low-temperature glasses the fundamental question is: Is the standard tunneling model (STM) valid for glasses? Experimental data shows that most single molecules are coupled to two level systems (TLS) as expected from the STM, a few single molecules (10%) show non standard behaviors (e.g. single molecule coupled to three level system). A detailed theoretical and experimental analysis shows that statistical properties of the random line shapes are described by L’evy statistics. This behavior is a manifestation of long range interactions between the TLSs and the single molecule. A universal amplitude ratio is investigated which shows that the STM assumptions are compatible with the experimental data. 1. E. Barkai, A. V. Naumov, Yu. G. Vainer, M. Bauer, L. Kador Phys. Rev. Lett. 91 075502 (2003).

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