Spin Fluctuation Difference in Even Electron Metal Particles and Odd Electron Metal Particles

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Introduction

Recent NMR study on Ag nanoparticle revealed that there are two distinctive nuclear spin-lattice relaxation (NSLR) components (**Fig.1**) originating from even electron and odd electron particles.[1] With this motivation, an Au nanoparticle specimen was investigated with NMR and, similarly, two distinctive NSLR components were observed. The phenomena seem to be quite universal for metal nanoparticles.

Experimental

^{1}H NMR study on Au nanoparticle (Average Particle Size (APS) = 5 nm) capped with PVP (Polyvin ylpyrrolidone) has been performed. The measurements were done at 30 K as a function of field, and as a function of temperature at 4.1 T. A 12 T superconducting sweeping magnet and a FFT NMR spectrometer developed at NHMFL were extensively utilized.

Results and Discussion

Transverse relaxation rate is measured to be almost constant (~20μs). The most interesting observation is the double exponential type relaxation behavior in longitudinal relaxation (NSLR) of ^{1}H NMR. The field dependence and the temperature dependence of NSLR show bifurcation between slow and fast relaxing components as the temperature or the field is lowered. (**Fig.2 and Fig.3**) Those temperature dependence and field dependence of NSLR are interpreted as the results of different electron spin fluctuations in metal nanoparticles and the data are fitted against the quantum statistical calculations on finite size metal particles with even number of and odd number of electrons respectively. Preliminary analysis deduced that the average level spacing of the discrete energy level scheme of Au nanoparticle is about 100K. The average level spacing can be converted to the size of about 3 nm which is quite smaller than average particle size (5 nm). Similar correlation was found in Ag nanoparticle experiments where one could interpret the average level spacing originating from the domains and not from the whole particle. Further investigations (XRD to check the average domain size, magnetic susceptibility measurement with SQUID, etc) are on-going for comprehensive understanding of the phenomena.

Conclusions

Preliminary analysis revealed that Au nanoparticles are composed of even electron particles and odd electron particles and those particles are discernible with different NSLR. The behavior is explained with quantum statistical calculations on finite size systems. Further experimental and theoretical investigations are on-going for comprehensive understanding of the experimental results.

Acknowledgements

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References

[1] Jang, Z. H. *et al*., manuscript in preparation

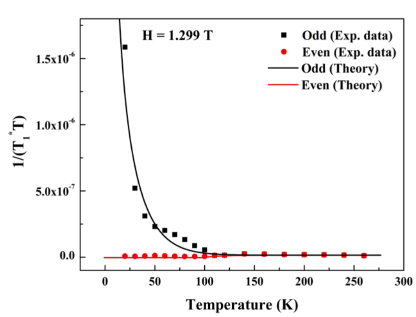

Fig.1 Temperature dependence of $1/(T_1^*T)$ of Ag nanoparticle measured at 1.33 T.

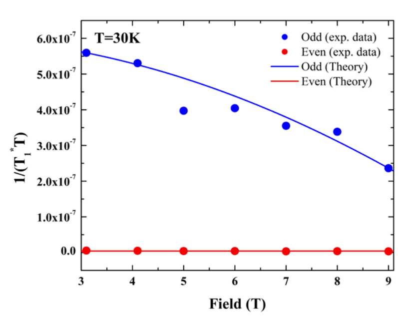

Fig.2 Field dependence of $1/(T_1^*T)$ measured at 30 K.

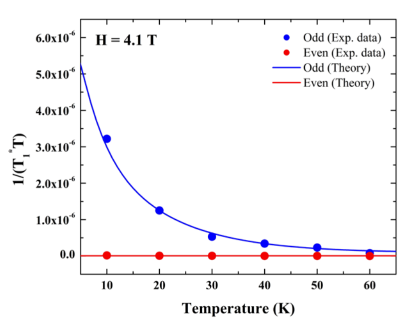

Fig.3 Temperature dependence of $1/(T_1^*T)$ measured at 4.1 T.