Oscillating Cantilever-Driven Adiabatic Reversal Technique with a Single Spin $S > 1/2$

Thomas Fan and Vladimir I. Tsifrinovich

Physics Department, Polytechnic Institute of NYU, New York

The oscillating cantilever-driven adiabatic reversal technique (OSCAR) has been invented by Dan Rugar et al. for the first detection of a single spin ½ below the surface of a non-transparent solid [1,2]. In this work we have extended the theory of the OSCAR technique to spin $S > 1/2$. We have used the classical equation of motion for the cantilever tip (CT) and the Schrodinger equation for a spin. The spin experiences the permanent external magnetic field, the rotating (microwave) field, the dipole field produced by the ferromagnetic particle on CT and the crystalline field, which causes the uni-axial anisotropy.

We present the following results of our computations:

1. The OSCAR signal (the frequency shift of the CT vibrations) does not depend on the value of S as well as on the initial state of the spin.
2. If the measurement time is smaller than the relaxation time the OSCAR technique provides the measurement of the spin quantum state.
3. If the measurement time is greater than the relaxation time the OSCAR signal reduces by a factor up to $2/(2S+1)$ and provides detection of the spin without measurement of its state.
4. We have found an analytical estimate for the half-width of the OSCAR signal $\Gamma=2^{1/2}\gamma GA$, where γ is the electron gyromagnetic ratio, G is the magnetic field gradient at the spin location, and A is the CT vibration amplitude. The value of Γ does not depend on S and the initial spin state.

1. D. Rugar, R. Budakian, H. J. Marin, B.W. Chui, *Single spin detection by magnetic resonance force microscopy.* Nature, Vol 430, 329, (2004).
2. G.P. Berman, F. Borgonovi, V. Gorshkov, and V.I. Tsifrinovich, *Magnetic Resonance Force Microscopy and a Single-Spin Measurement,* World Scientific, 2006.