Experimental Technique For Nuclear Moment Measurements By the β-NMR Method Using Spin Polarized RI Beams via Projectile Fragmentation Reaction

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A static electric quadrupole moment (Q-moment) is a sensitive probe for investigating nuclear deformation, and often provides information about where and how rapidly the structure changes as the neutron to proton ration *N/Z* increases. In the Q-moments measurement for unstable nuclei, we employ the β-NMR method taking advantage of spin polarization produced by the fragmentation reaction.

The measurement of Q-moments of unstable nuclei consists of three processes; 1) production of spin-polarized radioactive nuclei using the projectile fragmentation reaction, 2) implantation in a solid substance with the polarization preserved and 3) the β-NMR measurement on the implanted nuclei.

The spin-polarized fragments are introduced into the β-NMR apparatus. The stopper material, to which a static magnetic field B_0 is applied, must be chosen so as to provide a long spin-lattice relaxation time compared with the β-decay lifetime. An oscillating magnetic field is applied to the stopper in the direction perpendicular to B_0. The adiabatic fast passage method of NMR is useful for the experimental efficiency. The frequency of the oscillating field is swept over a region. If the region includes the resonance frequency, spin reversal would takes place. In the presence of an electric field gradient *eq*, the each resonance frequency $\nu_{m,\, m+1}$ between magnetic substate with $\Delta m = \pm 1$ is given by

$$\nu_{m,\ m+1} = \frac{g\mu_N B_0}{h} - \frac{3e^2 qQ\left(3\cos^2\theta - 1\right)}{8I\left(2I-1\right)h}\left(2m+1\right),$$

where g and eQ denote the g-factor and the Q-moment, respectively. θ indicate the angle between B_0 and the crystalline c-axis. I, μ_N and h denote nuclear spin, nuclear magneton, and Planck's constant, respectively. In an experiment, the θ is set 90° for searching a Q-moment in an initial measurement and 0° for a precise measurement. .