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Measurement of the Quadrupole Interaction of Long-Lived States in Liquid Metals

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Investigations of the quadrupole interaction of excited nuclear states with lifetimes from 10^{-5} to 10^{-1}s have not yet been reported with the exception of the work done by Sugimoto *et al.*[1] on light nuclei, where the quadrupole interaction is extremely small. Such experiments are usually impossible in solid targets, since lattice perturbations caused by the recoils and the beam particles give rise to quadrupole relaxation times generally short compared to 10 μs. We therefore studied the quadrupole interaction in liquid metals by measuring the relaxation time τ_R, which typically ranges from 10 μs to 100 ms.

The 20 ms, $9/2^+$ state in ^{71}Ge and the 160 μs, $11/2^-$ state in ^{115}Sn were excited by the (p, n) reaction in liquid targets of Ga and In with a pulsed beam from the 7 MeV Van de Graaff in Berlin. Relaxation times were determined by observing the time dependent γ-ray anisotropy in successive time windows covering the range of τ_R.

In liquid metals the relaxation rate is composed of a magnetic contribution essentially described by the Korringa relation and a quadrupole part τ_Q^{-1} due to the time dependent field gradient q caused by diffusive motion of the ion cores.

The separation of these two contributions was possible by measuring the temperature dependence of τ_R over a wide temperature range as shown in Fig. 1 for the system ^{71}Ge in liquid Ga. The quadrupole part, curve (b), is described by[2] $\tau_Q^{-1} \propto (qQ)^2\tau_c$. The temperature dependence is completely assigned to the correlation time $\tau_c \propto \exp(Q_A/k_BT)$. The activation energy results as $Q_A = 1.6$ kcal/mol, very close to the value 1.8 kcal/mol from diffusion rate measurements for Ga in liquid Ga. This agreement is encouraging to compare τ_Q^{-1} for the systems ^{71}Ge($9/2^+$) and ^{69,71}Ga

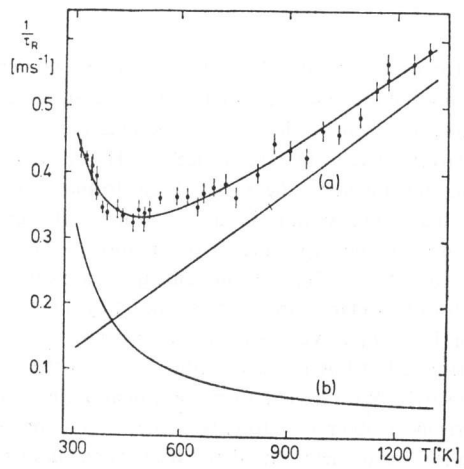

Fig. 1. Relaxation rate τ_R^{-1} of excited ^{71}Ge nuclei in liquid Ga as a function of temperature. (a) magnetic part of τ_R^{-1}, (b) quadrupole part of τ_R^{-1}.

(stable),[3] in liquid Ga and to extract the quadrupole moment Q. Assuming that τ_c and q are equal within 30% for the two systems, we get $|Q(9/2^+, {}^{71}\text{Ge})| = 0.28 \pm 0.1$ barns. An analogous analysis of the measurements with the 160 μs state of ^{115}Sn in liquid In results in $|Q(11/2^-, {}^{115}\text{Sn})| = 0.8 \pm 0.3$ barns.

References

1) K. Sugimoto *et al.*: in *Hyperfine Interactions in Excited Nuclei*, Vol. 1, p. 167.
2) A. Abragam *et al.*: Phys. Rev. **92** (1953) 943.
3) D. A. Cornell: Phys. Rev. **153** (1967) 208.