M1-TRANSITION IN V^{51} AND THE SENIORITY QUANTUM NUMBER

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As shown by Neudachin[1] the measurement of M1-transition probability in nuclei in which the $1f_{7/2}$ shell is being filled should allow us to answer the question of the accuracy of the seniority quantum number v for this type of nucleus. If v is a good quantum number, then, under certain conditions, the matrix element for M1 transitions in such nuclei could be equal to zero. In particular, if outside the filled shell there are only neutrons or only protons characterized by the configuration j^n, only those M1 transitions will be allowed that occur without a change in v. In V^{51} there is a filled neutron shell (N = 28) and three protons outside the shell Z = 20. The configuration of the ground state is $(f_{7/2})^3_{7/2}$, v = 1, and for the first excited state (321 kev) $(f_{7/2})^3_{5/2}$, v = 3. Thus, for the 321-kev M1 transition there is a change in the quantum number v (Δv = 2), therefore this transition must be forbidden if v is a good quantum number.

In the present work the lifetime of the 321 kev excited state of V^{51} is measured by the resonance scattering of γ quanta. Cr^{51} in the compound $CrCl_2O_2$ (chromyl chloride, an easily evaporated liquid) was the source of the γ quanta. We observed the scattered radiation from V_2O_5 and (for comparison) Cr_2O_3 scatterers with a scintillation spectrometer. The methods of measuring and handling the experimental data are analogous to those used in references 2—4. A source was prepared in which chromyl chloride evaporated completely at 110° C. This permitted us to measured the dependence of the resonance scattering effect on vapor pressure in the source up to nearly atmospheric pressure. The comparison of the measured dependence with that theoretically calculated (from the known dependence of density of chromyl chloride vapor on temperature) showed that atomic collisions in the source practically do not affect the magnitude of the effect up to temperatures of about 30—40° C. The lifetime measurements were made with a source of smaller mass at 10—18° C. The high specific activity of the source and the improved geometry allowed us to obtain a higher resonance scattering counting rate than Schopper did.[2]

The value $\tau = (3.1 \pm 0.8) \times 10^{-10}$ seconds was obtained for the lifetime of the 321-kev level of V^{51}. Taking into consideration data on the Coulomb excitation of V^{51},[5] this corresponds to a partial lifetime for M1 components of the mixed M1-E2 transition at 321 kev of 3.4×10^{-10} sec. The lifetime measurement in the present experiment exceeds by a factor of two the value obtained by Schopper using the method of resonance scattering of γ quanta, but is about the same magnitude as obtained using the delayed coincidence method[6] ($\tau = 4 \times 10^{-10}$ sec). The lifetime 3.4×10^{-10} sec corresponds to a forbiddenness of M1-transition in comparison with a single proton transition (Weisskopf formula) by 300 times. We note that the magnitude of forbiddenness (and consequently the magnitude of the transition matrix element) was the same as for l-forbidden transitions.[7] However, we must recognize this as mere coincidence since in this case l-forbiddenness cannot occur. The result we obtained has its natural explanation as a forbiddenness because of the seniority quantum number. Evidently, the 321-kev transition in V^{51} is the first known case of such forbiddenness. The forbiddenness is not rigorous, which indicates a proximity to the nuclear model used by Neudachin in calculations. The presence of the noted collective effects appearing in the considerable intensity of the E2 component in the 321-kev transition,[5] also explains that the forbiddenness because of the quantum number v does not have to be rigorous.

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