MEASUREMENTS AND ESTIMATES OF THE FUNDAMENTAL SYMMETRY BREAKING EFFECTS

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All the enhancements of the P-violation effects in γ-transitions between the compound-nucleus states were analyzed in the classical paper [1] by I.S. Shapiro. The source of these effects is the weak interaction V_W leading to the fact that the wave function Ψ_i of this state contains, besides the wave function of a definite parity Ψ_1, the small admixture Ψ_2 of the opposite parity state

$$\Psi_i = \Psi_1 + \Psi_2 \tag{1}$$

The effect is defined by the ratio of the P-forbidden transition normalized by the total transition value:

$$R = \frac{c(A_a \cdot A_f)}{(A_a + A_f)^2} \approx \frac{cA_f}{A_a} \equiv \frac{n}{d} \tag{2}$$

Here A_α and A_f are the amplitudes of the P-allowed and P-forbidden transitions. The review [1] indicates 3 types of enhancement: 1) kinematical enhancement, 2) structural enhancement and 3) dynamical enhancement. The kinematical enhancement appears when the allowed transition is the magnetic one which is smaller than the forbidden electric of the same multipolarity by the factor c/v ≈10. The structural enhancement appears when the allowed transition amplitude A_α comes to be unusually small due to some suppression caused by the structure of the initial and final states.

One should point that both the kinematical and structural enhancements arise because of the decrease of the denominator d in Eq. (2). Only the dynamical enhancement is caused by the increase of the admixture coefficient:

$$c = \frac{< \psi_2 | V_W | \psi_1 >}{| E_1 - E_2 |} \equiv \frac{v_p}{D}$$

in the numerator n of (2). Here v_p is the weak interaction matrix element, while the enhancement of the admixture for the high-lying exited states is caused by their strongly decreased level spacing.

It is assumed that the largest magnitude of the symmetry-breaking effect allows to measure it with the largest accuracy (i. e. with the smallest relative error). This assumption is shown to be often misleading. Indeed, the experimentally measured value (2) is the ratio of the normally distributed numbers of numerators n to denominators d. Taking their absolute errors to be σ and neglecting the correlation between them, one obtains for the relative error of the measured effect:

$$\frac{\sigma_R}{R} = \sqrt{\frac{\sigma^2}{n^2} + \frac{\sigma^2}{d^2}} \cong \frac{\sigma}{n}$$

We see that the dynamical enhancement of n decreases the relative error and indeed leads to the enhanced accuracy of the effect’s measurement. However, the other two enhancements lead only to the slight increase of the relative error and to the poorer accuracy of the effect’s measuring. Usefulness of the relative error approach to transmission measurements is also discussed.

1. I.S. Shapiro, Sov.Phys.Uspekhi. **95**, 647 (1968).