Can We Trust $^{26}Al^m$? A Search for Competitive Decay Branches

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An upper limit of 2×10^{-4} per disintegration was found for any possible β- or γ-decay branch of ^{26}Al competing with its superallowed β decay.

[RADIOACTIVITY $^{26}Al^m$ [from $^{23}Na(\alpha,n)$]; measured I_γ, I_{CE} upper limit.]

There has been much hard work in precision measurements of β transition strengths in pure "Fermi" superallowed transitions. After corrections of electromagnetic origin, negligible or known with sufficient accuracy (e.g., Ref. 1; cfr., however, the unexpected results of Ref. 2), the "vector" coupling constant extracted from these measurements provides the most precise test of the universality hypothesis "à la Cabibbo."[2,3]

Without attempting to discuss the many ups and downs of this work in recent years,[1-3] let us stress only, that among the numerous candidates, the decay of $^{26}Al^m$ was selected not only as being one of the most accurately measured, but also as having the fastest transition rate.[1-3] The fastest transition is believed to be the most reliable because it is least hampered by slowing down from isospin impurities in the nuclear states.[1] Unfortunately, the transition appears to be *too fast* for the requirement of universality if the conventional K_{l3} form factors are used for the $\Delta S=1$ part of the weak hadronic current.[3]

At this point one should note, however, that the transition will effectively appear *too fast* if a competitive decay channel of the 223-keV $^{26}Al^m$ state escapes observation. In spite of this fact, to our knowledge, no methodic search for such decay channels has been undertaken, as yet, at the required 10^{-4} accuracy. (In 1955 an upper limit of 10^{-4} for an eventual second-forbidden β branch to the 1809-keV 2^+ level of ^{26}Mg was reported[4]; on the basis of systematics, however, this branch is expected to be entirely negligible for our purpose.)

The reason for this is the absence of any known state which could drain a competitive decay branch of sufficient intensity. We would need either a low-spin state (0^+ or 1^+) at rather low excitation energy in ^{26}Mg (typically under 2000 keV), or a high-spin state (3^- or 4^+) near the 5^+ ground state of ^{26}Al (Fig. 1).

We may dismiss the possibility of a low-lying 1^+ state in the even-even ^{26}Mg and that of a 3^- level in the midst of the positive-parity $(d_{5/2})^{-1}{}_\nu(d_{5/2})^{-1}{}_\pi$ states of ^{26}Al, but let us discuss briefly the two other possibilities.

There is a 0^+ level in ^{26}Mg at 3589 keV,[5] much too high for our purposes; one cannot exclude, however, the possibility that the two-phonon 0^+ state lies, in reality, somewhere between the two-phonon and one-phonon 2^+ levels (2938 and 1809 keV) and has escaped observation either because it is very weakly fed in nuclear reactions or because it is situated too near the first 2^+ level. The

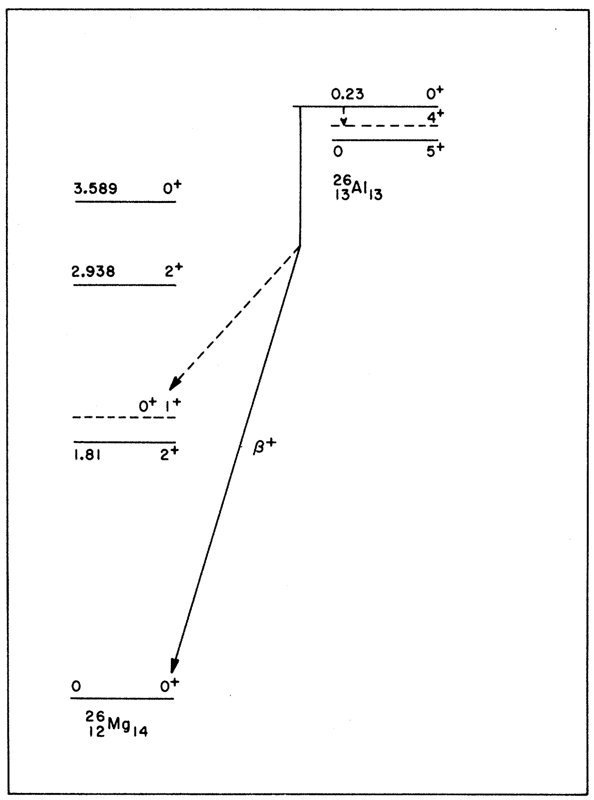

FIG. 1. Decay scheme of $^{26}Al^m$ indicating eventual competitive decay branches.

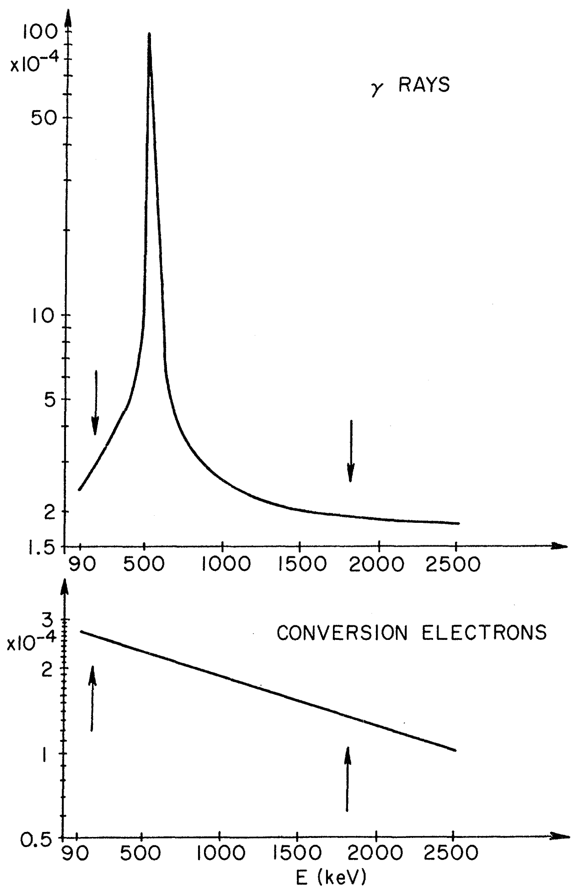

FIG. 2. Upper limit (number per disintegration) for γ rays and conversion electrons as a function of their energy. The arrows indicate the position where events due to competitive decay branches may have been expected.

second alternative, that of a 4^+ level, is also tentative only: The 4^+ member of the $(d_{5/2})^{-2}$ multiplet should lie much higher in ^{26}Al[6] and some indications from (τ, α) reactions seem to indicate that it is at 4.7-MeV excitation energy.[7] It may lie, however, too near the 5^+ ground state, to be resolved and if so, an exceptionally strong $E4$ decay to this state ($\approx$30 W.u.) might provide a dangerous drain for the 0^+ ^{26}Al^m mother state.

The possibilities we invoke are rather artificial and the eventuality of competitive decay branches, even at the 10^{-4} level, seems rather remote. Considering the importance of the issue, we felt nevertheless, that an experimental search for such a decay channel would be of interest.

^{26}Al^m was produced by 12-MeV α particles incident on sodium fluoride. The energy spectrum and time dependence of the γ emission was observed using a 4-cm^3 or a 35-cm^3 Ge(Li) detector; that of possible conversion-electron emission by the use of a 1-cm-thick Si(Li) one. No electrons or γ rays (other than the annihilation radiation) were observed with the ^{26}Al^m or comparable lifetime.[8]

We summarize in Fig. 2 the upper limits of intensity (90% confidence level), compatible with our results, both for conversion electrons and γ rays. As shown, the upper limits, in the energy region of interest, are $2-3\times10^{-4}$ per disintegration. Consequently any competitive decay branch would be too weak to influence the ^{26}Al^m ft value within its measured accuracy ($\approx1.5\times10^{-3}$).

In conclusion, our result allows one to confidently rely on the measured rate of this superallowed "Fermi" transition.

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