Radiative width of the 2.31-MeV level in ^{14}N†

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(Received 21 April 1975)

By observation of the resonant scattering of bremsstrahlung, the width of the 2.31-MeV level of ^{14}N has been measured as 6.2 ± 0.6 meV. This is somewhat smaller than previous values and in disagreement with inelastic electron scattering results and the prediction of the conserved vector current theory from the shape of the $^{14}O \rightarrow {}^{14}N$ β^+ spectrum.

[NUCLEAR REACTIONS $^{14}N(\gamma,\gamma)$, $E=2.31$ MeV; measured $\sigma(96°)$ and $\sigma(126°)$; deduced Γ; natural target.]

Many years ago, the major problem in the $A=14$ triad was the long life of ^{14}C, some five orders of magnitude longer than other allowed Gamow-Teller transitions. It has long been accepted that this is the result of an accidental cancellation of matrix elements. A recent discussion of wave functions for mass 14 which result in the required transition amplitudes is given by Rose, Häusser, and Warburton.[1] In particular, they show that it is of importance to consider also certain electromagnetic transitions in ^{14}N.

One of these is from the first excited state of ^{14}N, the 2.31-MeV $(J^\pi, T)=(0^+, 1)$ analog of the ^{14}C ground state, to the ^{14}N ground state. The recent lifetime compilation of Endt and van der Leun[2] gives 80 ± 10 fs for the mean life of this level, only one order of magnitude slower than the most probable isospin allowed $M1$ transition listed in this compilation.

Two values from the literature are not included in the Endt and van der Leun value. Sidhu and Gerhart[3] measured the shape of the 0.6% ground state branch of the ^{14}O β^+ spectrum. As for the ^{12}B-^{12}N case, conserved vector current (CVC) then predicts the strength of the corresponding electromagnetic transition. For ^{14}N they find 33 ± 3 fs. In their text, they also mention a further correction which would increase their value to 43 ± 4 fs, and suggest that this is as large a value as is consistent with their data. The recent electron scattering measurements of Ensslin *et al.*[4] give, by extrapolation to the photon limit, 41 ± 12 fs. The authors seem to feel that the apparent discrepancy reflects the difficulty of the extrapolation.

If one goes to the Ajzenberg-Selove compilation[5] and the additional references in the Endt paper,[2] one finds several Doppler shift attenuation method (DSAM) measurements and resonance fluorescence measurements which cluster nicely around 83 fs. However, it is well known that DSAM results can be wrong by a factor of 2, and the resonance fluorescence measurement from this laboratory was clearly a difficult one, publishable only because it was one to two orders of magnitude more precise than the then existing lifetime data for this level. It thus seemed desirable to remeasure this lifetime using our present bremsstrahlung source for nuclear resonance fluorescence.

Our experimental procedures in observing the nuclear resonant scattering of bremsstrahlung have been described in previous publications.[6] Two scatterers were used. One consisted of a Plexiglas ($C_5H_8O_2$) container, of inside dimensions 5.71 cm diam×1.63 cm long, filled with 67.3 g of AlN.[7] The other, also Plexiglas, with inside dimensions 7.62 cm diam×6 cm long, was filled with 303.7 g of melamine.[8] These both seem to be very stable compounds which are not hydroscopic. Initial measurements were made with 294 g of melamine from a batch which had been around our laboratory for 12–14 years, and they do not differ appreciably from those made with a fresh batch. The larger scatterer is about as large as can be used with our "standard" shielding without risk of vignetting.

The first results were obtained with the AlN scatterer, which has the advantage that one sees, at the same time, scattering via the 2.21-MeV level of ^{27}Al for which the width is well known. The counts in the 2.31-MeV line, after correction for scattering from atmospheric nitrogen, corresponded to a mean life of 103 ± 14 fs. The nontrivial (~20%) correction for air scattering was made using the results of a separate experiment performed with a matching AlF_3 scatterer.

Subsequent data were taken with the melamine scatterer, for which the air correction is not more than 1% and was not made. Typical data

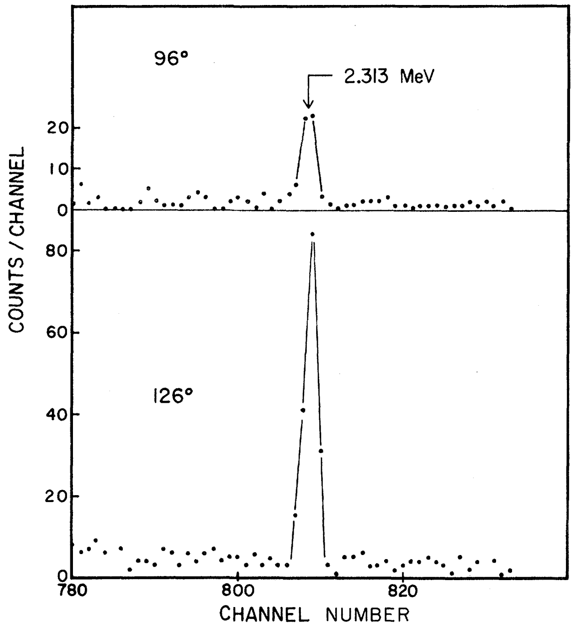

FIG. 1. Partial spectra of the bremsstrahlung scattered by a melamine scatterer. The upper spectrum is with a 30 cm^3 Ge(Li) detector at a 96° scattering angle; the lower with a 45 cc detector at 126°.

are shown in Fig. 1. The contrast with our 1961 data[9] is striking, and undoubtedly reflects three factors—the greater photon flux from bremsstrahlung compared to ^{14}N(p,p'), the better resolution of Ge detectors (compared to NaI), and the reduced neutron background.

Alternate runs were made with 7.62 cm diam Al and Mn scatterers to determine scattering via the reference 2.21 and 2.56 MeV levels. From the best data—although inclusion of all data would not change our result by more than about 3%—we find $\Gamma = 6.1 \pm 0.6$ MeV, or $\tau = 108 \pm 11$ fs, where the error includes an estimate of all known uncertainties. The weighted mean of our two values is $\tau = 106 \pm 10$ fs.

The disagreement with the inelastic electron scattering result, 41 ± 12 fs, and the ^{14}O result, 33 ± 3 fs, is marked. Theorists with whom we have discussed this seem to feel that the inclusion of higher order terms in the wave functions and consideration of meson exchange could explain the ^{14}O-CVC discrepancy. For the electron scattering,[4] one must accept the statement of the authors that extrapolation to the photon point is difficult. It thus would appear that there are unsolved theoretical and/or experimental problems in the mass-14 triad.

As a check of the melamine scatterer, we ran for a short time with the electron energy at 3.19 MeV and observed resonant scattering via the 3.086-MeV level of ^{13}C. After allowing for ^{13}C in the container, the scattered intensity corresponds to a width for this level of 0.39 ± 0.06 eV, in agreement with our previous value[10] of 0.44 ± 0.04 eV.

We are indebted to Dr. H. A. Primakoff, Dr. S. Pittel, and Dr. T. -S. H. Lee for enlightening discussions.

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†Work supported in part by the National Science Foundation.

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