

Widths of the 14·32 and 14·40 MeV Levels in ^{16}O

P. D. Clark, A. Johnston and T. R. Ophel

Department of Nuclear Physics, Research School of Physical Sciences,
Australian National University, P.O. Box 4, Canberra, A.C.T. 2600.

Abstract

By means of measurements of the $^{14}\text{N}(\alpha, d)$ reaction, the widths of the 14·32 and 14·40 MeV levels in ^{16}O have been determined to be 34 ± 12 and 27 ± 5 keV respectively. No evidence was found for resonances corresponding to these levels in the $^{15}\text{N}(p, \alpha\gamma)$ reaction.

Studies of various transfer reactions have suggested the existence of relatively narrow levels in ^{16}O in the region of excitation between 14·3 and 14·4 MeV (Rivet *et al.* 1966; Meier-Ewert *et al.* 1968; Bassani *et al.* 1971). In general, determination of the locations and widths has been limited by experimental resolution. However, two measurements of the $^{14}\text{N}(\alpha, d)$ reaction have identified a level at $14\cdot40 \pm 0\cdot030$ MeV with a width of 30 ± 30 keV (Zisman *et al.* 1970) or at $14\cdot400 \pm 0\cdot003$ MeV with a width of < 30 keV (Lowe and Barnett 1972). Lowe and Barnett also found evidence for a level at $14\cdot320 \pm 0\cdot020$ MeV (width < 30 keV). Neither level has been observed in $^{12}\text{C} + \alpha$ resonance reactions and this fact, coupled with the exclusive ($> 96\%$) decay of the 14·40 MeV level by α -particle emission to the first excited state of ^{12}C (Artemov *et al.* 1971), implies that the 14·40 MeV level is the 5^+ member of the triplet with a $(p_{1/2})^{-2}(d_{5/2})^2$ configuration (Zuker *et al.* 1968).

Observation of the levels as resonances in the $^{15}\text{N}(p, \alpha\gamma)$ reaction would provide a possible means of determining J^π assignments. However, although the decay channel is favoured (at least for the 14·40 MeV level), the probable high spin and the relatively low incident proton energy required ($\sim 2\cdot4$ MeV) make it unlikely that the resonances would be other than very weak. The present work included an attempt to observe the resonances. To ensure that appropriate experimental conditions (beam energy spread, target thickness and energy span) prevailed during the resonance search, a remeasurement of the deuteron spectrum from the $^{14}\text{N}(\alpha, d)$ reaction was made with a magnetic spectrometer to establish better width estimates.

The deuteron spectrum from the $^{14}\text{N}(\alpha, d)$ reaction was measured with an Enge split-pole spectrograph, instrumented with a 53 cm long, ionization-type focal plane detector (Ophel and Johnston 1978). A beam energy of 30 MeV was used and the angle of observation was 15° . The target of natural adenine, $100 \mu\text{g cm}^{-2}$ thick on a thin carbon backing, was stable if the beam intensity was kept below 100 nA. Deuterons from the $^{12}\text{C}(\alpha, d)$ reaction dominated the spectrum, one group in particular overlapping with the group corresponding to the known broad level in ^{16}O at 14·81 MeV (see Fig. 1). The experimental resolution was taken as the width of this $^{12}\text{C}(\alpha, d)$ group, and was determined to be 21 keV by fitting the two overlapping groups with

gaussian distributions. (The same resolution was obtained for the group when the adenine target was replaced by a thin carbon target and for deuterons of the same energy (~ 9.8 MeV) obtained by inelastic scattering of a deuteron beam by carbon.) Similar fits were made to the groups corresponding to the 14.32 and 14.40 MeV levels after subtraction of the underlying background due to broad levels. Their widths were calculated assuming quadrature combination with the experimental resolution.

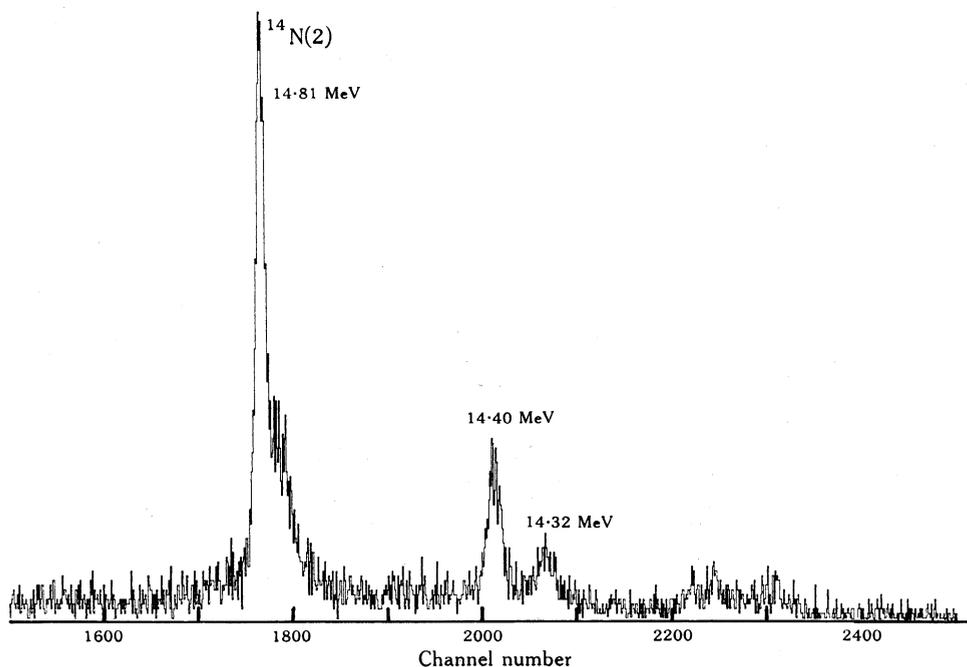


Fig. 1. Portion of the deuteron spectrum from the $^{14}\text{N}(\alpha, d)^{16}\text{O}$ reaction showing the 14.32, 14.40 and 14.81 MeV levels in ^{16}O . The beam energy is 30 MeV and the observation angle is $\theta_{\text{lab}} = 15^\circ$.

Table 1. Summary of measurements of level widths in ^{16}O

E_x (MeV)	Γ_{cm} (keV)	Source*	Γ_{cm} (keV)	Source*	Γ_{cm} (keV)	Source*
14.31 ± 0.01	34 ± 12	P	< 30	L		
14.40 ± 0.01	27 ± 5	P	< 30	L	30 ± 30	Z
14.81	70 ± 8	P	65 ± 9	M		

* References are as follows: P, present work; L, Lowe and Barnett (1972); Z, Zisman *et al.* (1970); M, average of measurements summarized by Martin and Ophel (1973).

Though the extracted widths depend on the estimate of the underlying background, it is apparent that the observed widths of both the 14.32 and 14.40 MeV levels exceed the experimental resolution. The results for the centre-of-mass level widths Γ_{cm} are summarized in Table 1.

The measurements of the yield of $^{15}\text{N}(p, \alpha\gamma)$ reaction were made using a shielded 12.7×10.2 cm² sodium iodide detector in close geometry at 90° to the incident beam direction. The target was prepared by evaporating ^{15}N -enriched melamine onto a

thin carbon backing, its thickness being $100 \mu\text{g cm}^{-2}$ and corresponding to 14 keV for 2.4 MeV protons. No evidence was found for a resonance in either of the energy regions corresponding to the 14.32 and 14.40 MeV levels.

Thus the assignment of definitive spin-parity values for the 14.32 and 14.40 MeV levels is extremely unlikely. Particle-particle correlation methods would be possible for the 14.40 MeV level, but they are complicated by the fact that the decay is to the 2^+ level in ^{12}C rather than to the ground state. No information concerning the decay of the 14.32 MeV level is available, though confirmation of the existence of the level has recently been obtained from high-resolution studies of the $^{14}\text{N}(^3\text{He}, \text{p})$ (Fortune *et al.* 1978) and $^{12}\text{C}(^6\text{Li}, \text{d})$ reactions (K. Kemper and T. R. Ophel, to be published).

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