$T=3/2$ Level in F^{19} at 9.07 Mev

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Contrary to previous reports, we have detected α particles emitted from the 9.07-Mev state of F^{19} formed by the reaction $O^{18}(p,\alpha)N^{15}$. The α-particle reduced width indicates that the isotopic spin of this state is $T=\frac{3}{2}$ with an admixture of about 15% of $T=\frac{1}{2}$. The spin of the state is determined to be $\frac{7}{2}$ from the α-particle angular distribution, while odd parity seems to be favored.

THE reactions $O^{18}(p,\gamma)F^{19}$ and $O^{18}(p,\alpha)N^{15}$ are both resonant at a series of bombarding energies up to 3 Mev.[1,2] The absence of a (p,α) resonance at the energy 1.169 Mev where the (p,γ) reaction is resonant, has been interpreted[1] as evidence for the $T=\frac{3}{2}$ character of the 9.07-Mev state of F^{19}. Considering the level density at this energy, it is surprising that the level should be purely $T=\frac{3}{2}$ and not mixed with a $T=\frac{1}{2}$ component by the Coulomb forces. We therefore searched for and found α particles from this resonance with the results given in Table I.

This reaction was studied with the 2-Mev Van de Graaff generator of the Ecole Normale Supérieure. Targets were 20-μg/cm^2 self-supporting Al_2O_3 foils prepared[3] by anodic oxidation of aluminum in an electrolyte containing 90% of O^{18}. Alpha particles were detected with p-n junctions prepared in n-type 75-ohm cm silicon.[4] The solid angle subtended at the target by the detector was 1.4×10^{-3} steradian. The resonant excitation curve was traced by varying the voltage applied directly to the target by means of a ±5-kev calibrated supply, in steps of 250 ev. The beam energy furnished by the accelerator itself was constant to better than 250 ev during a 20-minute run. By studying the reaction $Al^{27}(p,\gamma)$ at 993 kev ($\Gamma\leqslant140$ ev), the energy profile of the incident beam was found to be closely Gaussian with a half-width of 1 kev. The same resonance of $Al^{27}(p,\gamma)$ established the absolute energy scale, combined with the threshold of the $Li^7(p,n)$ reaction (1881 kev). The thickness of the target, which corresponds to a total stopping power of 10.8×10^{-15} ev cm^2 per atom of O^{18} at resonance, was measured to be 2.75 kev. By comparison with the excitation curve of $Al^{27}(p,\gamma)$ at 993 kev we determined the width of this resonance of $O^{18}(p,\alpha)$ to be $\Gamma\leqslant500$ ev. We measured simultaneously the γ-ray yield to verify that the same resonance is involved for the γ rays and α particles. The α-particle angular distribution was measured from 40° to 170° at 15° intervals, and the results normalized to a monitor p-n junction detecting the α particles at 170°.

It was very difficult to measure this angular distribution since the resonance is superposed on the large tails of neighboring resonances. For forward angles the resonance contributed 50% of the observed counting rate, and near 90° only 20%. However, the least-square analysis of the data gave a coefficient of P_6 equal to 0.57 ± 0.13.

A simple explanation of the narrow width of the resonance can result from high-orbital angular momenta for proton and α particle. The observed angular distribution is consistent with a spin of $\frac{7}{2}$ and parity odd or even within the experimental errors. Odd parity is preferred since it leads to a reasonable proton reduced width. This choice is further supported by the preferential γ-ray de-excitation[1] to the 2.78-Mev ($9/2^+$; $7/2^+$), the 1.35-Mev ($5/2^-$), and the 0.198-Mev ($5/2^+$) excited states of F^{19}. The angular distribution of the γ rays[1] leads to the choice of $9/2^+$ for the 2.78-Mev level of F^{19}, consistent with the collective model interpretation of this level scheme.[5]

By comparison with the systematics of α-particle reduced widths in light nuclei which range from 10° to 10^{-2}, we see that the present value of 4×10^{-4} indicates some hindrance of the α-particle transition. Probably, therefore, the state is mainly $T=\frac{3}{2}$ but with an amplitude of at most 15% of $T=\frac{1}{2}$.

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TABLE I. The parameters of the resonance in the reaction $O^{18}(p,\alpha)N^{15}$ measured in this experiment.

Energy at resonance	Γ_{res}	$\sigma_{max}\Gamma$	θp^2	$\theta_\alpha{}^2$	Spin scheme	Angular distribution[b]
1165.2 ± 1.0 kev	≤500 ev	6 ± 1.5 ev-barn	$\leq10^{-3a}$	$\leq4\times10^{-4}$	$\frac{1}{2}({}_3{}^2)\frac{5}{2}({}_2{}^3)\frac{1}{2}$ $\frac{1}{2}({}_4{}^3)\frac{7}{2}({}_3{}^4)\frac{1}{2}$	$1+(8/7)P_2(\cos\theta)+(6/7)P_4(\cos\theta)$ $1+(25/21)P_2(\cos\theta)+(81/77)P_4(\cos\theta)+(25/33)P_6(\cos\theta)$

[a] Fraction of Wigner limit evaluated for f-wave proton; g-wave proton leads to a reduced width exceeding this limit.
[b] Theoretical angular distribution. The presence of the $P_6(\cos\theta)$ term in the measured distribution leads to the choice of 7/2 for the level spin.

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