2.2. RESONANT ABSORPTION AND FLUORESCENCE

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ABSORPTION

In the classical experiments on resonant absorption of γ-rays from (p,γ) reactions [see e.g. ref.[1]], the radiation was always absorbed in the same nucleide, and excited the same resonance level, as that emitting the radiation. Last year it was for the first time successfully demonstrated that it is possible to excite nuclear states (also bound states) by absorption of γ-rays emitted by the decay of a (p,γ) resonance in a different nucleus [2]. In this experiment the 7.06 MeV level of ^{208}Pb was excited by γ-rays from the E_p = 1974 keV resonance in the $^{34}S(p,\gamma)^{35}Cl$ reaction. This cross-excitation method is suitable for measuring lifetimes of bound states in the range τ_m = 1 as – 1 fs.

In the experiments discussed below, the slit-system was positioned under computer-control (Laben-70) by a small-step motor allowing a precision exceeding 0.01°.

^{11}B. The very strong E_p = 1417 keV resonance in the $^{23}Na(p,\gamma)^{24}Mg$ reaction, with $(2J+1)\Gamma_p\Gamma_\gamma/\Gamma$ = 38 ± 10 eV, decays 93% to the second excited state of ^{24}Mg, providing an intense 8925 keV γ-ray in an unusually clean spectrum. This γ-ray has been used to excite the 8.92 MeV level of ^{11}B at the slightly backward angle θ = 93.3°. In this case the high yield obviated the usual precise energy calibrations. The dip could easily be located in a trial run notwithstanding the fact that the 60 cm^3 Ge(Li) detector was placed at a distance of 30 cm from the target and was shielded by lead bricks except for the 1 mm wide slit filled with boron powder.

A preliminary analysis gives a width of Γ = 1.9 ± 0.3 eV, a factor of 2.5 lower than the value found from two independent inelastic electron scattering experiments [3].

^{28}Si. The precision energy measurements described in the section on capture reactions indicated that the transition from the E_p = 1684 keV $^{27}Al(p,\gamma)^{28}Si$ resonance level to the first-excited state could be used to excite the semi-bound J^π = 1^+, T = 1 level of ^{28}Si at E_x = 11.45 MeV. The measured absorption integral implies a width of Γ = 9 ± 2 eV, again considerably lower than the values Γ = 23 ± 4 eV and 21 ± 4 eV obtained from resonance fluorescence and electron scattering, respectively, suggesting some sort of systematic discrepancy.

^{35}Cl. Ground-state radiation from the E_p = 2.79 MeV $^{34}S(p,\gamma)^{35}Cl$ resonance was used to excite the same resonance level, at 9.08 MeV, in a classical resonant absorption experiment. The transmission as a function of the collimator angle is given in fig. 1. Analysis of these data leads to a resonance width of Γ = 65 ± 20 eV and Γ_γ = 2.3 ± 0.4 eV. These data can be reconciled with the resonance strength measurements, if the strength of the calibration resonance at E_p = 1.21 MeV is taken as $(2J+1)\Gamma_p\Gamma_\gamma/\Gamma$ = 9.7 ± 0.7 eV [4], as compared to 21 ± 3 eV found in previous work [5].

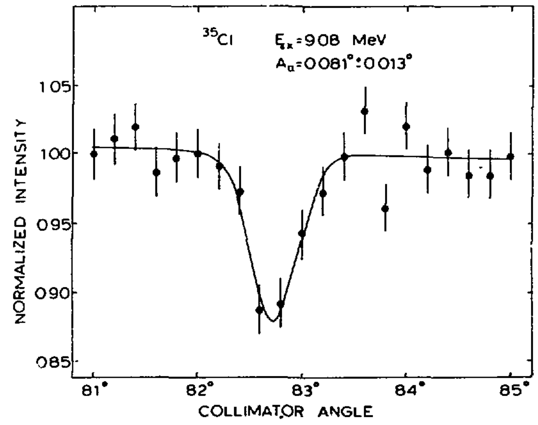

Fig. 1. Intensity of the 9.08 MeV γ-rays from $^{34}S(p,\gamma)^{35}Cl$ at E_p = 2.79 MeV transmitted through a CCl_4-NaCl absorber plotted vs the collimator angle.

FLUORESCENCE

The kinematically broadened 6.92 and 7.12 MeV lines from the reaction $^{19}F(p,\alpha\gamma)^{16}O$, which have a width of about 130 keV at E_p = 2 MeV, have been used in resonance fluorescence experiments. Though the set-up was built originally for measuring precise excitation energies (a prerequisite for the resonant absorption measurements described above), it has also been used to measure several transition strengths.

$^{16}O(\gamma,\gamma)^{16}O$. To check the procedure, the partial widths were measured of the 6.92 and 7.12 MeV states of ^{16}O. Our values of Γ_o = 94 ± 10 and 60 ± 10 meV, respectively, are in good agreement with previous determinations [6].

$^{23}Na(\gamma,\gamma)^{23}Na$. Large discrepancies occur in the excitation energies of ^{23}Na levels at $E_x \approx 7$ MeV as deduced from (γ,γ) and (p,γ) work [refs.[7,8]]. Our preliminary values are E_x = 7066 ± 2, 7084 ± 2 and 7135 ± 2 keV. A level at E_x = 7156 ± 2 keV, reported in ref.[7], does not exist.

$^{40}Ca(\gamma,\gamma)^{40}Ca$. The 6.95 MeV ($1^-$, T = 0 → 0^+, T = 0) ground-state transition in ^{40}Ca is the strongest known isospin-forbidden E1 transition in nuclei with A < 45. The unusual strength, which is based on a single experiment [9], has been questioned on the basis of recent electron scattering data. It was therefore decided to remeasure the strength in a resonance scattering experiment. A partial width was found of Γ_o = 0.41 ± 0.08 eV, in agreement with the previously published [9] value.

$^{54}Fe(\gamma,\gamma)^{54}Fe$ and $^{208}Pb(\gamma,\gamma)^{208}Pb$. The results of these experiments have been published in refs.[10] and [2], respectively.

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