Measurement of Longitudinal and Transverse Polarization Transfer in the T($\vec{p},\vec{n}$) Reaction at Low Energies*

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In this paper we present results from recent measurements of the longitudinal ($K_z^{z'}$) and transverse ($K_y^{y'}$) polarization transfer coefficients at zero degrees for the T($\vec{p},\vec{n}$) neutron production reaction at low energies. The results verify a striking resonance behavior in $K_z^{z'}$ that we recently predicted from R-matrix calculations for the mass four system. The resonance occurs at about 800 keV neutron energy and is a clear manifestation of the 0^- level in ^{4}He.[1] Data previously available for $K_z^{z'}$ extended no lower than 4 MeV proton energy.[2]

Eight measurements of $K_z^{z'}$ were made using a polarized proton beam incident on a tritium target. Proton energies ranged from 1.3 to 2.8 MeV; the proton beam polarization was determined by p-^{4}He elastic scattering measurements. The neutron polarization was determined by measuring the transmission asymmetry through a dynamically polarized proton target. Figure 1 shows a schematic of the transmission experimental setup.

The target was cooled to 500 mK in a 2.5 Tesla magnetic field and polarized to 65% with microwaves.[3] The longitudinal spin-dependent n-p cross section difference, $\Delta\sigma_L$, at these low energies is well known and can be used to determine the polarization of the neutron beam. As compared to elastic scattering of the neutrons in a polarimeter, this is a much faster method of measuring neutron beam polarization, allowing measurements at several energies.

To confirm the absolute value of $K_z^{z'}$ at a proton energy of 1.62 MeV, we also carried out a separate measurement using a high-pressure ^{4}He scattering polarimeter of known analyzing power. For this purpose the polarization of the neutron beam was precessed from the longitudinal to the transverse direction in a magnetic field located after the neutron production cell. This absolute measurement was then used to calibrate the eight transmission measurements. Calibrated results are given in Figure 2 and in Table 1. A measurement of $K_y^{y'}$ at zero degrees was also performed at 1.62 MeV.

The results are consistent with a longitudinal polarization transfer approaching 96% at a neutron energy of 750 keV. At the same energy the transverse polarization transfer

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was measured to be 9%. Without changing any of the resonance parameters the R-matrix parameters of Ref. 1 provide quite a good fit to the longitudinal $K_z^{z'}$ data. The low value of $K_y^{y'}$ is also predicted from the resonance parameters. The $T(\vec{p},\vec{n})$ reaction is a copious source of longitudinally polarized neutrons and the data for $K_z^{z'}$ show clear evidence for the presence of the 0^- level in ^{4}He.

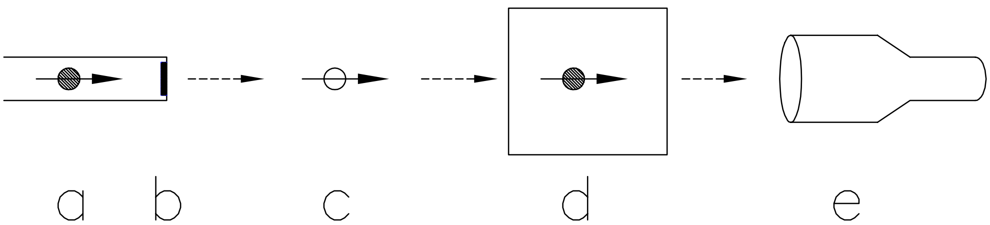

Figure 1: Experimental layout for neutron transmission measurements. (a) Longitudinally polarized proton beam incident on (b) the tritiated titanium neutron production target produced a (c) beam of longitudinally polarized neutrons. The neutron beam traveled through a (d) dynamically polarized proton target used as a neutron polarization analyzer. (e) A liquid scintillator and photomultiplier tube were used for neutron detection at zero degrees to measure the neutron transmission asymmetry.

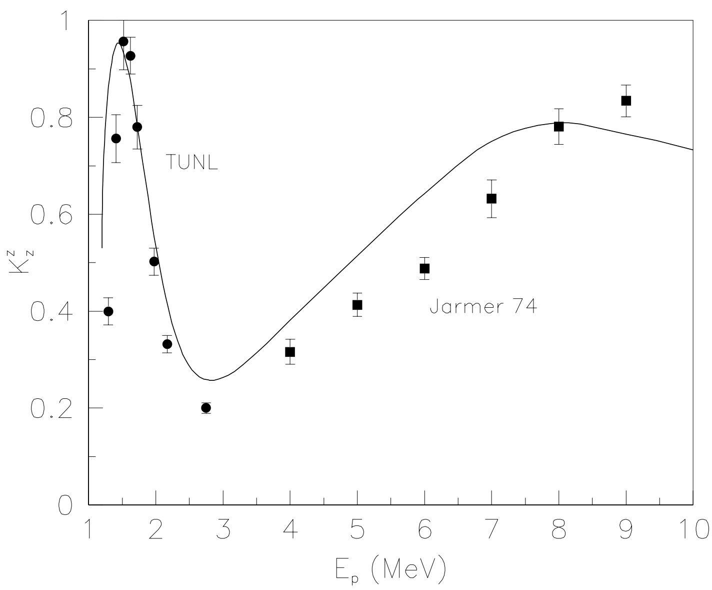

Figure 2: Comparison of experimental data (TUNL) for $K_z^{z'}(0°)$ with previous data (Jarmer 74) and an R-matrix calcualtion.

E_p (MeV)	K_z^z
1.29	0.40 ± 0.03
1.41	0.76 ± 0.05
1.52	0.96 ± 0.06
1.62	0.93 ± 0.04
1.72	0.78 ± 0.05
1.97	0.50 ± 0.03
2.17	0.33 ± 0.02
2.75	0.20 ± 0.01

Table 1: Experimental data for $K_z^{z'}(0°)$.

1. Tilley DR *et al.*, Nucl. Phys. **A541** (1992) 1.
2. Jarmer JJ *et al.*, Phys. Lett. **B48** (1974) 215.
3. Seely ML *et al.*, Nucl. Inst. and Meth. **A356** (1995) 142.