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A Liquid-Helium Neutron Polarimeter

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A large-volume liquid-helium neutron polarimeter has been constructed and tested successfully for use in low energy (p,n) and (d,n) experiments. The polarimeter assembly is shown in Fig.1. The neutron scatterer is liquid helium contained in a 350cc stainless steel cup coupled to 3ℓ reservoir. Scattered neutrons are detected by two pairs of NE213 scintillators(not shown). Scintillation signals from both liquid helium and NE213 are used to give time and pulse-height information of recoiling helium and scattered neutrons.

The inner wall of the stainless steel cup is coated with reflector(NE560) and 100μm thick wavelength shifter(diphenylstilbene, DPS). Scintillation light from liquid helium is detected by a 2" photomultiplier(PMT) through a quartz window, whose inner surface is coated with 10 μm thick DPS and outer surface with indium oxide. The latter is to cut off infrared rays flowing into liquid helium. A PMT with SbCs or multialkali photocathode is used, since large resistivity of bialkali photocathode at low temperature makes commonly used PMT unsuitable for the helium scintillator. The intrinsic time resolution of the helium scintillation is measured to be less than 1 ns. The light output of helium has been measured using neutrons from the $^{9}Be(p,n)^{9}B$ reaction. Figure 2 shows the relation between the incident neutron energy E_n, which is determined by the time of flight method, and the maximum light output corresponding to the maximum recoil energy of helium. The light output is found to be proportional to helium recoil energy and about 60% of that for Compton-scattered electrons of the same energy.

Two 5" x 5" NE213 scintillators are placed at scattering angles of ±123° and 30cm from the scatterer. Another pair of NE213 , 8" x 2", is placed at ±61°. Compton-scattered γ rays are eliminated with the aid of pulse shape information of the NE213 output and flight-time between He and NE213. The analyzing powers of the polarimeter have been calculated at several neutron energies with a Monte Carlo code using the known n-^{4}He phase shifts[1). The calculated analyzing power at 123° (61°) is 0.66(-0.36) for 18-MeV neutrons.

The system has been tested for the $^{2}H(d,n)^{3}He$ reaction. The polarization of the outgoing neutrons at E_d=18 MeV measured with the present polarimeter is compared with the data by Hardekopf et al.[2)] in Fig. 3. An excellent agreement between the two sets of data is seen.

Preliminary results of the polarization measurement in the $^{12}C(p,n)^{12}N(1^{+},0.0)$ reaction are shown in Fig.4. The solid line shows DWBA calculation.

References

1) B.Hoop and H.H.Barschall, Nucl. Phys. 83 (1966) 65.
2) R.A.Hardekopf, T.C.Rhea, P.W.Lisowski and R.L.Walter: Nucl. Phys. A191 (1972) 460.

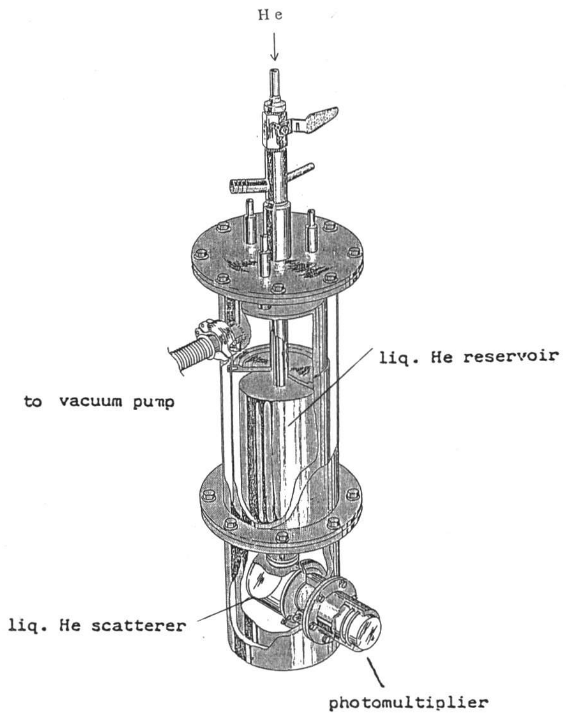

Fig. 1 Liquid-helium neutron polarimeter.

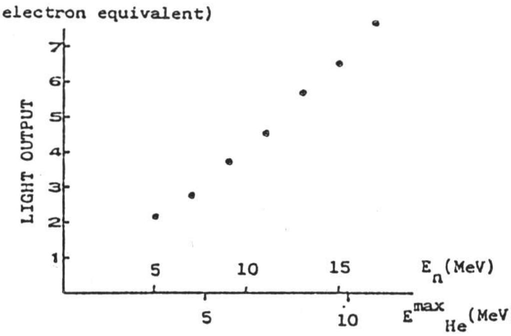

Fig. 2 Relation between the maximum light output of helium scintillation and the incident neutron energy.

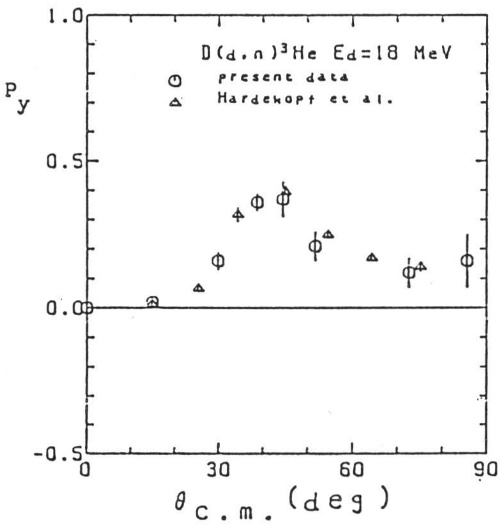

Fig. 3 Polarization for the $^2H(d,n)^3He$ reaction. Circles are present data. Triangles are previous data by Hardekopf et al.

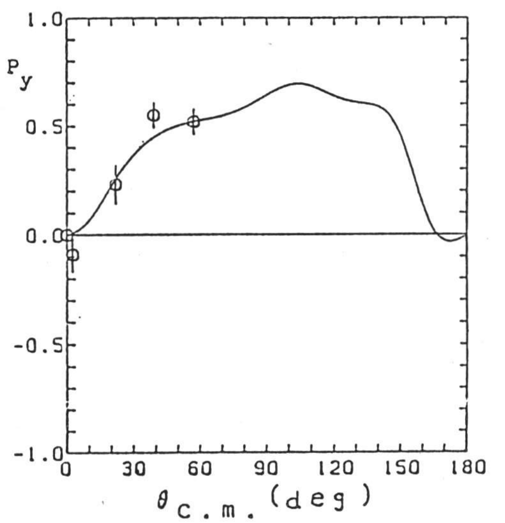

Fig. 4. Polarization for the $^{12}C(p,n)^{12}N(1^+,0.0)$ reaction. Solid line shows DWBA calculation.