ANL-HEP-CP--91-47 the
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1991

STATUS OF NP SPIN-DEPENDENT TOTAL CROSS SECTIONS AND SPIN-SPIN CORRELATION PARAMETERS†

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ABSTRACT

New measurements of $\Delta\sigma_L(np)$, $C_{LL}(np)$, $C_{SL}(np)$, and $C_{SS}(np)$ will add over 200 new data points to the world's np database. A combination of almost final and final results, the first in the neutron beam kinetic energy range 484–788 MeV, are presented for an extended c.m. angular region. The $\Delta\sigma_L(np)$ data are consistent with that from PSI (below 500 MeV) and Saclay (above 800 MeV).

CROSS SECTION DATA

Measurements of $\Delta\sigma_L(np)$, the difference between the total cross sections for beam and target spins antiparallel and parallel to the beam momentum, were performed at LAMPF for the five energies 484, 568, 634, 720, and 788 MeV.[1] As shown in Fig. 1, these data are consistent with measurements made at PSI[2] and Saclay.[3] The early Argonne $\Delta\sigma_L(pn)$ data[4] seems to be at variance with the newer Saclay results.

The isospin-0 ($I = 0$) component of $\Delta\sigma_L(np)$ was extracted for all data using

$$\Delta\sigma_L(I=0) = 2\Delta\sigma_L(np) - \Delta\sigma_L(pp), \quad (1)$$

where an interpolation curve was used for $\Delta\sigma_L(pp)$ in Eq. 1 above. The resulting $I = 0$ component is also plotted in Fig. 1. The curves shown are phase-shift solutions of Arndt et al.[5] and Hoshizaki et al.[6]

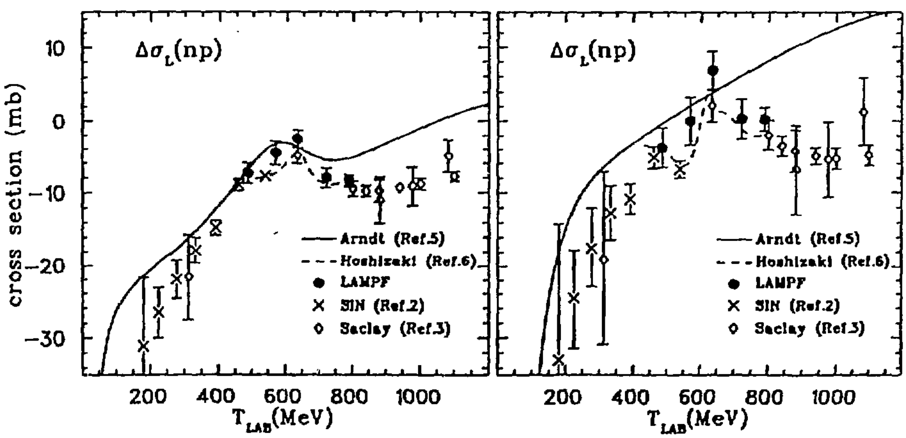

Figure 1: Plot of $\Delta\sigma_L(np)$ and $\Delta\sigma_L(I=0)$ data.

It is curious to note that the energy dependence of $\Delta\sigma_L(I = 0)$ is strikingly similar to that of $\Delta\sigma_L(pp)$, which is an independent channel. The $I = 0$ channel is mostly elastic at these energies and it becomes difficult to explain the structure in terms of inelastic thresholds (N^* threshold > 1 GeV) or other channels (πd and $N\Delta$ are not allowed by isospin conservation). In Ref. 1, an analysis by Kroll indicates that the structure in $\Delta\sigma_L(I = 0)$ may be due to a resonance in either a spin-singlet or spin-triplet partial wave. A determination of the partial wave responsible for the observed structure requires $\Delta\sigma_T(np)$ data, which are scarce in this energy region. Kroll's resonance parameters are mass = 2213 MeV, width = 75 MeV, and elasticity $(2J+1)\Gamma_{el}/\Gamma = 0.9$.

SPIN–SPIN CORRELATION PARAMETERS

The spin-spin correlation parameters are asymmetries in the differential cross sections for fixed beam and target polarizations. The orthogonal spin directions are: L (longitudinal), N (normal to scattering plane) and S (in scattering plane). The parameters measured at LAMPF were $C_{LL}(np)$ and $C_{SL}(np)$,[7] as well as $C_{SS}(np)$[8] for the three neutron beam kinetic energies 484, 634, and 788 MeV, and c.m. angular ranges from about 30° to 180°. Refs. 7 and 8 report the results of analysis for only a portion of the total data.

The present spin-spin correlation parameters, obtained through analysis of most of the remaining data, are shown grouped together in Fig. 2, and are considered almost final. Phase-shift solutions by Arndt et al. (solid line) and Hoshizaki et al. (dashed line) are represented by the curves in Fig. 2.

At 484 and 634 MeV, $C_{SL}(np)$ is consistent with zero, as it is for backward angles at 788 MeV. Note however, for forward angles at 788 MeV, $C_{SL}(np)$ is nonzero. Also note that the One–Pion Exchange model is not sufficient in explaining the $C_{LL}(np)$ data, since the model predicts all of the C parameters to be zero at 180° c.m., where $C_{LL}(np)$ is several standard deviations from zero.

The parameter $C_{SS}(np)$ was derived from the measured mixed parameter $C_{\sigma\sigma}(np)$, which is a combination of various C parameters (Ref. 8),

$$C_{\sigma\sigma} = aC_{SS} + bC_{NN} + dC_{LL} + eC_{SL}, \tag{2}$$

due to a spin rotation by the magnetic field of the polarized proton target magnet. In Ref. 8, $b = d \sim 0$, $a \sim 0.5$ and $e \sim 0.8$ for Eq. 2 above. The $C_{SS}(np)$ data was extracted using data from Ref. 7 for Eq. 2.

In addition to those data shown, there are data at c.m. angles 30° to 80° that will be analyzed in the near future. The extensive coverage of the c.m. angles 30° to 180° by these data should considerably constrain future phase-shift analyses.

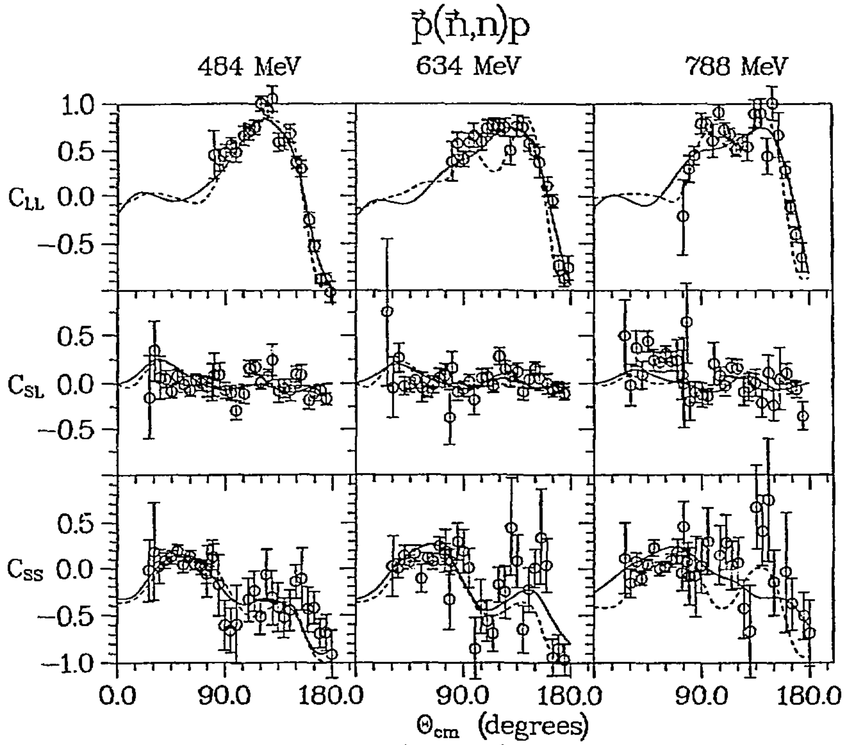

Figure 2: Plot of C_{LL}(np),C_{LS}(np), and C_{SS}(np), as a function of c.m. angle for three different energies.

CONCLUSIONS

These data taken at LAMPF used a monoenergetic neutron beam produced in the charge-exchange reaction $d(\vec{p},\vec{n})X$ for incident longitudinally polarized proton beam and unpolarized deuterium target. The polarization of the neutrons through spin-transfer was equal to K_{LL} times the polarization of the incident protons. The normalization of these data are affected by the K_{LL} value. New measurements of K_{LL} at LAMPF for 788 MeV neutrons indicate that it is probably 15% larger in magnitude than previously published values.[9] This does not change the conclusions on the zero values for C_{SL}, but any future measurements of K_{LL} at other LAMPF energies may alter statements about $\Delta\sigma_L(I=0)$ structure.

Inclusion of the LAMPF data presented here (as well as other np observables) have enabled Hoshizaki et al.[6] to identify resonant-like behavior in the $I = 0$ $^1P_1$ partial wave. The mass of this resonance is 2168 MeV and its width is 25 MeV. This narrow resonance lies upon a large background, and has elasticity 0.2.

Such a resonance should manifest itself in the total np reaction cross section, which to date are not known well enough to determine whether any structure is present. Hoshizaki et al. also predict a large narrow peak (~10 mb enhancement) in $\Delta\sigma_T(I=0)$ at 630 MeV and a somewhat broader bump (~4 mb enhancement) in $\sigma^{tot}(I=0)$ near 700 MeV. Unfortunately, data for $\Delta\sigma_T(np)$ and $\sigma^{tot}(np)$ either do not exist or are too sparse to confirm or disprove these predictions.

REFERENCES

† Work supported by U. S. Department of Energy (Contracts. No. W31-109-ENG-38, No. DE-AS05-76ER-04449, and No. DE-AS04-76ER-03591, and Grants No. DE-FG05-88ER-40399 and No. DE-FG04-88ER-40403).

§ M. Beddo, T. S. Bhatia, G. Burleson, V. Carlson, R. Damjanovich, M. Devereux, W. R. Ditzler, J. A. Faucett, C. A. Fontenla, S. Gardiner, R. Garnett, G. Glass, D. P. Grosnick, J. C. Hiebert, D. Hill, J. Hoftiezer, J. J. Jarmer, R. H. Jeppesen, K. F. Johnson, R. Kenefick, P. Kroll, G. Kyle, D. Lopiano, S. Nath, L. C. Northcliffe, Y. Ohashi, S. Penttilä, M. Rawool, T. Shima, H. Shimizu, H. Spinka, R. Stanek, G. E. Tripard, D. Underwood, R. Wagner, A. Yokosawa.

1. M. E. Beddo et al., Argonne report ANL-HEP-PR-90-116, Los Alamos report LA-UR-90-40100, accepted by Phys. Lett.; M. E. Beddo, Ph. D. thesis, Los Alamos report LANL-11905-T, 1990.
2. R. Binz et al., PSI preprint PSI-PR-90-36, 1990.
3. F. Lehar et al., Nucl. Phys. A478, 533c (1988); F. Lehar (private communication).
4. I. P. Auer et al., Phys. Rev. Lett. 46, 1177 (1981); The Argonne data have since been revised and new values are available (private communication, D. Underwood, ANL).
5. R. A. Arndt et al., Phys. Rev. 35D, 128 (1987).
6. N. Hoshizaki et al., unpublished, 1991.
7. M. W. Rawool, Ph. D. thesis, Los Alamos report LANL-11387-T 1988.
8. R. W. Garnett et al., Phys. Rev. 40D, 1708 (1989); R W. Garnett, Ph. D. thesis, Los Alamos report LA-11491-T, 1989.
9. P. J. Riley et al., Phys. Lett. 103B, 313 (1981); J. S. Chalmers et al., Phys. Lett. 153B, 235 (1985).