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LAMPF NUCLEON-NUCLEON PROGRAM

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Abstract - NN activities at LAMPF are summarized. Measurements with p+p are now focusing on inelastic spin transfer and spin correlations. There should be good coverage of np spin correlations by 1986. Additional facilities are outlined for polarized beam nucleon and nuclear physics.

Résumé - Le programme Nucléon-Nucléon réalisé à LAMPF est résumé. Les efforts ont porté sur les réactions p+p inélastiques pour l'étude des transferts et des corrélations de spin. Nous espérons avoir une bonne couverture des corrélations de spin dans les réactions élastiques n+p en 1986. Les nouvelles installations prévues pour les expériences nucléon-nucléon et nucléon-noyau avec les faisceaux polarisés sont également présentées.

Since our last summaries in 1981-82,^{1,2} the facilities available at LAMPF have changed only a little: (1) the BR channel was restored to a neutron beamline with a liquid deuterium source target, (2) another polarized target system has been assembled by a Japanese-American collaboration. The accelerator with a Lamb-shift polarized H⁻ ion source delivers ~20nA average beam at 800 MeV (9% duty) or 7nA at lower energies down to 212 MeV (3% duty). The beam is shared among three beamlines with fairly complete precession equipment available. The beam current is generally adequate for proton experiments but is marginal for production of the polarized neutron beam.

Table I lists LAMPF NN experiment activities since ~1981, covering experiments which have reported activity through publications, preprints, and LAMPF Progress Reports.³ The table is organized by number of particles observed and number of spins measured. Nucleon experiments with pion beams are discussed elsewhere.

In the pp channels, the total cross section experiments $\Delta\sigma_L$ and $\Delta\sigma_T$ over 300-800 MeV are close to completed analysis; preliminary results have been informally reported.³ The pp and pd parity measurements at 800 MeV are complete.

Results from many pp elastic scattering experiments from 500-800 MeV are published^{2,4,5} or available in preprint. Generally, there is a sufficient variety of measurements to overconstrain a phase shift solution. The less-accessible in-plane spin rotation parameters as well as normal depolarization have been measured in spin transfer experiments with error bars usually under 0.03. Other experiments focus on specialized features such as forward-angle Coulomb-nuclear interference.

There is one other pp reaction with a two-body final state, $pp + d\pi$, that has been well covered in cross section and analyzing power;⁶ spin transfer to the deuteron has been sampled more sparsely.⁷ In the latter experiment, a deuteron

dissociator was placed in the center of the precession and analyzing magnet to give a unique signature of dissociation as the charged particle momentum is cut in half. The results are nearly ready for publication.

An intensive set of measurements on spin transfer in $pp \rightarrow NN\pi$ has just been finished; this experiment uses a two-arm detection system.⁸ A recent publication⁹ on cross section and analyzing power also used two coplanar arms. These two experiments present data as a function of analyzed proton momentum in several angular bins. A remarkable feature of the momentum spectrum dN/dp is the enhancement at small invariant np energy, a final-state effect.

There are pd elastic experiments also with good coverage of energy, angle, and proton spin transfer.¹⁰ The thrust of this program has been to develop a model of the deuteron with nucleon input amplitudes; the spin measurements are essential to proceed beyond a simple Glauber picture. Reports are in press.

The np elastic measurements are less complete. An early np experiment¹¹ at LAMPF was initial-state normal-direction spin correlation; this experiment was done with a broadband neutron beam polarized by production at 20° . Only recently has a reasonably complete angular cross-section measurement been published;¹² other spin measurements¹³ tend to be limited in angular coverage. However, an extensive program of initial-state in-plane spin-correlation measurements is underway even though the available flux of polarized neutrons is limited to about $10^4/s$ on target. A spin-difference total cross section measurement may follow perhaps in two years. Other free-neutron measurements are likely to wait until a more intense polarized neutron beam is available.

Proton scattering on quasifree neutrons in deuterium has been used as a supplement to np scattering with free neutron beams, particularly to extend the angular range to small CM angles. Quasifree/free-deuterium/hydrogen comparisons are made by using the pp reaction,¹⁴ and by overlapping free np data. Limits to the validity of the quasifree substitute are not clearly established.

A plan¹⁵ has been sketched out for facility development over the next few years which would have benefits for both the NN and nucleon-nucleus programs. A key element is improvement of the BR channel neutron beam. A factor of 10-100 increase in intensity will be achieved, hopefully in 1987, probably by installation of a more intense polarized ion source, or possibly by incremental improvements to the existing source and BR channel. A 100-ns beam buncher will be installed with the new source or perhaps before then to enable neutron energy measurements by time of flight. Even with present beam intensities, the buncher would permit additional valuable measurements such as np spin-difference total cross sections. A medium-resolution spectrometer (MRS), $\Delta E \sim 1$ MeV, will be built in the External Proton area. This spectrometer with focal-plane polarimetry will enable further NN small-angle measurements and will be the principal equipment in a program in few-body physics. The MRS will have a non-magnetic pivot to facilitate mounting of a new, large-volume polarized target; the target system is intended to permit frozen-spin H or D operation with any orientation. The primary beam line might eventually be equipped with a lithium target cell which could deliver monoenergetic polarized neutrons on the spectrometer target. These changes would permit broad evolution of the nucleon-beam physics program at LAMPF.

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TABLE I

LAMPF NUCLEON-NUCLEON EXPERIMENT ACTIVITY 1981-84
Published, preprinted, or progress report since Jan. '81

Reaction	Measurement	Chan. No.	Comment	CM°(Lab°)	Energies
p + p	$\Delta\sigma_T$	B504			300,...800
	$\Delta\sigma_L$	E498			300,...800
	Parity	E792,...			800
pp + pp	σ	H563,760		6-90	500,650,800
	A_{SS}	E512	also $\Delta\sigma_T$	20-90	500,650,800
	σ, A_N	H385	QF/F	10-47	800
	A_{NN}, A_{LL}	H709		5-30	650,800
	A_{NN}, A_{LL}	B517,518		50-90	500,...800
	D_{ij}	E636,194		20-130	500,...,800
	D_{ij}	H392		5-24	500,800
pp + $d\pi^+$	A_N	H508		4-170	550,...800
	D_{ij}, A_N	E637	dissociator	30-60	500,650,800
	A_{ij}	B517			500,...800
	A_{ij}	H790		small	
pp + pX	σ, A_N	H642		(5-20)	800
pp + NN π	σ, A_N	E336			500,650,800
	A_{NN}, A_{LL}	B518			650,800
	D_{ij}	E708		(5-25)	650,733,800
pd + pd	σ, A, D	H540	N,S,L, beams	(5-50)	500,650,800
	D_{ij}, A_N	E635		(30-60)	500,650,800
	A_{ijk}	H685	in progress	small	800
np + np	$\sigma(\theta)$	B56	F	60-180	800
	σ, A_N	H385	QF	14-75	800
	A_N, A_{NN}	B65-66	Wideband n	70-170	400-700
	A_N	B457	QF	20-90	800
	D_{NN}	B590	QF and F	20-90	800
	K_{NN}	B403	F	168-177	800
np + np	A_{LL}, A_{SS}, A_{LS}	B770	in progress	40-160	500,650,800
pp + NN π	A_{ij}	E815	1985		650,800

S,N,L = x,y,z

ij = several

 A_{ij} = initial state spin correlation