DIRECT RECONSTRUCTION OF np ELASTIC SCATTERING AMPLITUDES BETWEEN 0.80 AND 1.1 GeV

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Direct reconstruction of the neutron-proton elastic scattering amplitudes was carried out at six energies from 0.80 to 1.1 GeV. Complete sets of spin-dependent observables used in the reconstruction were measured in the Nucleon-Nucleon experimental program at SATURNE II. At 0.80 GeV LAMPF data were also used. The invariant amplitudes a, b, c, d, and e were fitted to the experimental data by the method of least squares. A search for solutions starting from random initial values was performed to determine different possible sets of amplitudes. The real and imaginary parts at several angles are shown and compared with the predictions of two phase shift analyses.

Puzikov, Ryndin and Smorodinskii [1] introduced the concept of "complete experiment" for the case of Nucleon-Nucleon (NN) scattering. A set of measured observables is complete if it contains sufficient information for a description of the interaction. It may be used to perform a direct reconstruction of scattering amplitudes (DRSA) without any theoretical input.

Complete sets of observables in np elastic scattering, consisting of eleven different spin-dependent quantities were measured at 0.84, 0.88, 0.94, 1.00, and 1.10 GeV at SATURNE II. The np differential cross sections, which provide absolute normalizations to amplitudes, were obtained from a fit to all existing data[2]. At 0.80 GeV DRSA was performed using the Saclay data together with published LAMPF results at 0.788 GeV (see Ref.[3]).

The np scattering matrix is a combination of the isosinglet and isotriplet matrices. Since the amplitude symmetry properties for each isospin are different, no symmetry relations for np elastic scattering amplitudes with respect to $90°CM$ exist. We determine the complex scattering amplitudes a, b, c,

d, and e, assuming parity conservation, time reversal invariance and isospin invariance throughout. The scattering matrix has the form [4]

$$M(\vec{k}_f, \vec{k}_i) = \tfrac{1}{2}[(a+b) + (a-b)(\vec{\sigma_1}, \vec{n})(\vec{\sigma_2}, \vec{n}) + (c+d)(\vec{\sigma_1}, \vec{m})(\vec{\sigma_2}, \vec{m}) \\ +(c-d)(\vec{\sigma}_1, \vec{\ell})(\vec{\sigma}_2, \vec{\ell}) + e(\vec{\sigma}_1 + \vec{\sigma}_2, \vec{n})] \qquad (1)$$

where $\vec{\sigma}_1$ and $\vec{\sigma}_2$ are the Pauli 2x2 matrices, $\vec{k}_i$ and $\vec{k}_f$ are the unit vectors in the direction of the incident and scattered particles, respectively, and $\vec{n}, \vec{m}$ and $\vec{\ell}$ are the c.m basis vectors.

Observables will be denoted as X_{srbt} with the subscripts referring to the polarization orientation of the scattered, recoil, beam, and target particles, respectively. Any observable can be expressed in terms of the five amplitudes from Eq. 1, for instance $d\sigma/d\Omega = [|a|^2 + |b|^2 + |c|^2 + |d|^2 + |e|^2]/2$, or a spin correlation $(d\sigma/d\Omega)A_{ookk} = -\Re e\ a^\star d \cos\theta + \Im m\ d^\star e \sin\theta + \Re e\ b^\star c$, where θ is the center of mass scattering angle (see Refs.[4,5]).

The observables, multiplied by the differential cross section, are bilinear combinations of real and imaginary parts of the amplitudes. One can express any amplitude A by its absolute value and phase: $A = |A| \exp i\phi_A$. The bilinear terms for each observable are invariant with respect to a rotation of the entire system. An arbitrary common phase cancels in all observable relations. We put $e = \Re e\ e = |e| \geq 0, \Im m\ e = 0, \phi_e = 0$. All phases are then relative to ϕ_e, and only 9 parameters are calculated.

The search for solutions was repeated several hundred times. One to three solutions remained at each angle and energy. The real and imaginary parts of amplitudes are shown in Fig. 1 at 6 energies; numerical values are given in Ref.[3]. They are compared with the amplitudes calculated by the Saclay-Geneva PSA [6] (dashed line) and by PSA of Arndt et al. [2] (solid line), including all measurements. For the majority of the solutions, a good agreement between the present results and PSA predictions was found. This amplitude analysis of $np \to np$ data represents a first attempt of direct reconstruction of the np scattering matrix.

References

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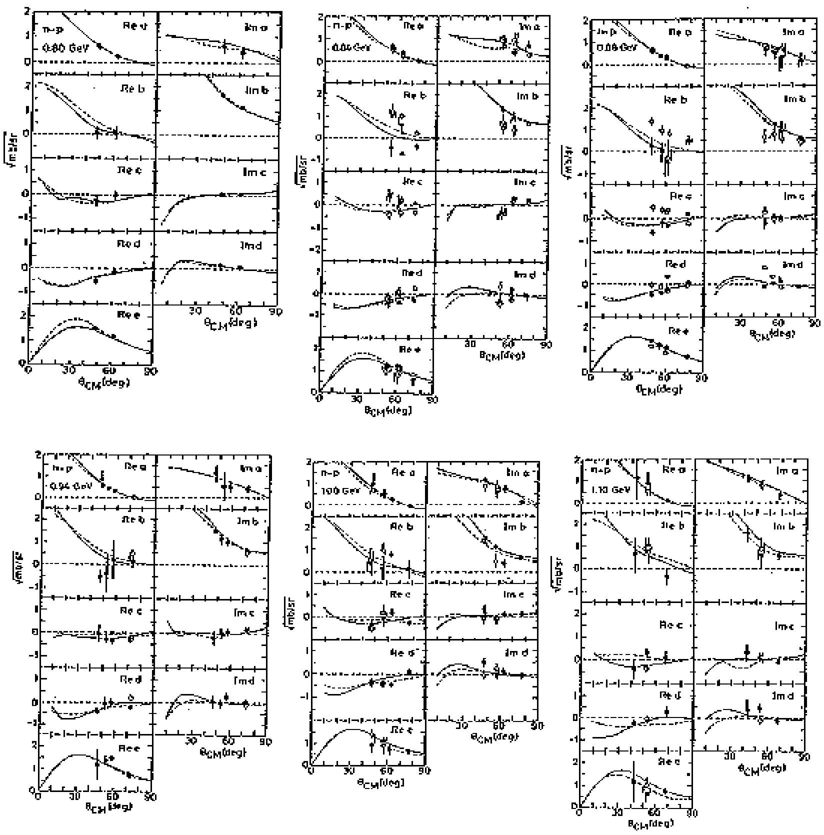

Fig. 1 Direct reconstruction of the scattering amplitudes at six energies shown as points. The solid and dashed lines are predictions from PSA analyses [2,6], respectively.