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Single energy partial wave analyses on eta photoproduction – experimental data

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Abstract. Free, unconstrained, single channel, single energy partial wave analysis of η photoproduction is discontinuous in energy. We achieve point-to-point continuity by enforcing fixed-t analyticity on model independent way using available experimental data, and show that present database is insufficient to produce a unique solution. The fixed-t analyticity in the fixed-t amplitude analysis is imposed by using Pietarinen's expansion method known from Karlsruhe-Helsinki analysis of pion-nucleon scattering data. We present an analytically constrained partial wave analysis using experimental data for four observables recently measured at MAMI and GRAAL in the energy range from threshold to $\sqrt{s} = 1.85$ GeV.

1 Introduction

In another contribution of our group [1] to the Mini Workshop, we applied iterative procedure with the fixed-t analyticity constraints to a partial wave analysis of eta photoproduction pseudo data. In this paper we apply our method to a partial wave analysis of experimental data considering some limitations due to use of real data instead of idealised pseudo one. Presently, we have an incomplete set of experimental data consisting of differential cross section σ_0, single target polarisation asymmetry T, double beam-target polarisation with circular polarized photons F, and single beam polarisation Σ. Statistical and systematic errors of experimental data are much larger than 0.1% used in our analysis with pseudodata. There is also limitation in kinematical coverage. Unpolarized differential cross section has the best coverage in energy and scattering angles. Good coverage is also available for the polarisation data (Σ, T, F) up to total c.m. energy $W = 1.85 GeV$. More details about formalism and our method may be found in ref. [2].

* Talk presented by J. Stahov

2 Input preparation and results

The list of data which we used in our PWA analysis with experimental data is given in Table 1.

Table 1. Experimental data from A2@MAMI and GRAAL used in our PWA.

Obs	N	E_{lab} [MeV]	N_E	θ_{cm} [^{0}]	N_θ	Reference
σ_0	2400	$710-1395$	120	$18-162$	20	A2@MAMI(2010,2017) [3,4]
Σ	150	$724-1472$	15	$40-160$	10	GRAAL(2007) [5]
T	144	$725-1350$	12	$24-156$	12	A2@MAMI(2014) [6]
F	144	$725-1350$	12	$24-156$	12	A2@MAMI(2014) [6]

As it may be seen from the table, in our data base we have data for differential cross sections at much more energies then for polarisation observables. To perform partial wave analysis, all observables are needed at the same kinematical points. Experimental values of double-polarisation asymmetry F, target asymmetry T, and beam asymmetry Σ for given scattering angles have to be interpolated to the energies where the σ_0 data are available (fixed-s data binning). We have used a spline smoothing method as a standard method for interpolation and data smoothing [7] (Fortran code available on request). In the Ft AA part of our method, we have to build a data base at fixed t-values using measured angular distribution at a fixed value of variable s (fixed-t data binning). This has been done using again spline interpolation and smoothing method. We have performed Ft AA at t-values in the range $-1.00GeV^2 < t < -0.09GeV^2$ at 20 equidistant values. When working with real data, uniqueness means that the partial wave solution does not depend on starting solution. We start with two different MAID solutions: Solution I (EtaMAID-2016, [8]) and Solution II (EtaMAID-2017, [3]). Although significantly different, both solutions describe experimental data very well as might be seen in Figure 1 for two values of variable t (predictions from these two solutions can not be distinguished in the plots).

In our truncated PWA we fitted partial waves up to L_{max}=5. As in the case of pseudo data, procedure has converged fast. Resulting multipoles up to L=2, obtained after three iterations, are shown in Figure 2. Almost no differences can be observed for the dominant S waves, what is to be expected while this wave is similar in both starting solutions. Other partial waves are consistent within their error bands. Considerable differences still exist in certain kinematical regions, mainly at higher energies. It is a strong indication that for some multipoles a unique solution in this kinematical regions was not achieved (See ImE_{1+}, ImE_{2-} , and ReM_{2-} for example). There are different reasons for nonuniqueness observed. First of all, we have as an input an incomplete set of four observables. Secondly, our fixed- t constraint loses its constraining power at higher energies, especially at larger scattering angles. In addition, less kinematical points are experimentally accessible for higher negative t- values. From partial wave analysis

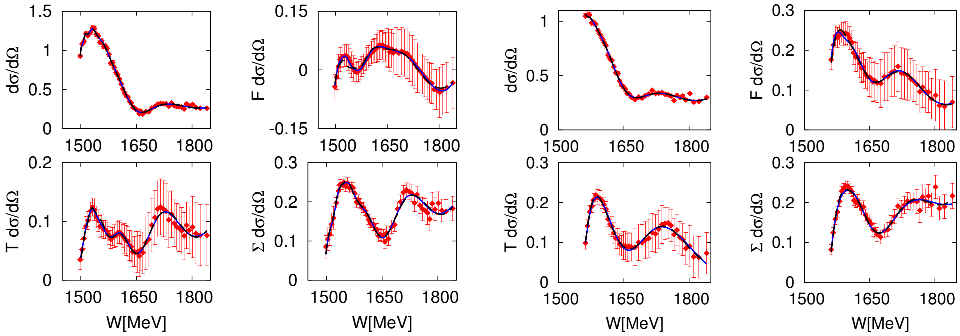

Fig. 1. Pietarinen fit of the interpolated data at $t = -0.2\,\mathrm{GeV}^2$ and $t = -0.5\,\mathrm{GeV}^2$. The dashed (black) and solid (blue) curves are the results starting with solutions I and II respectively and are on top of each other.

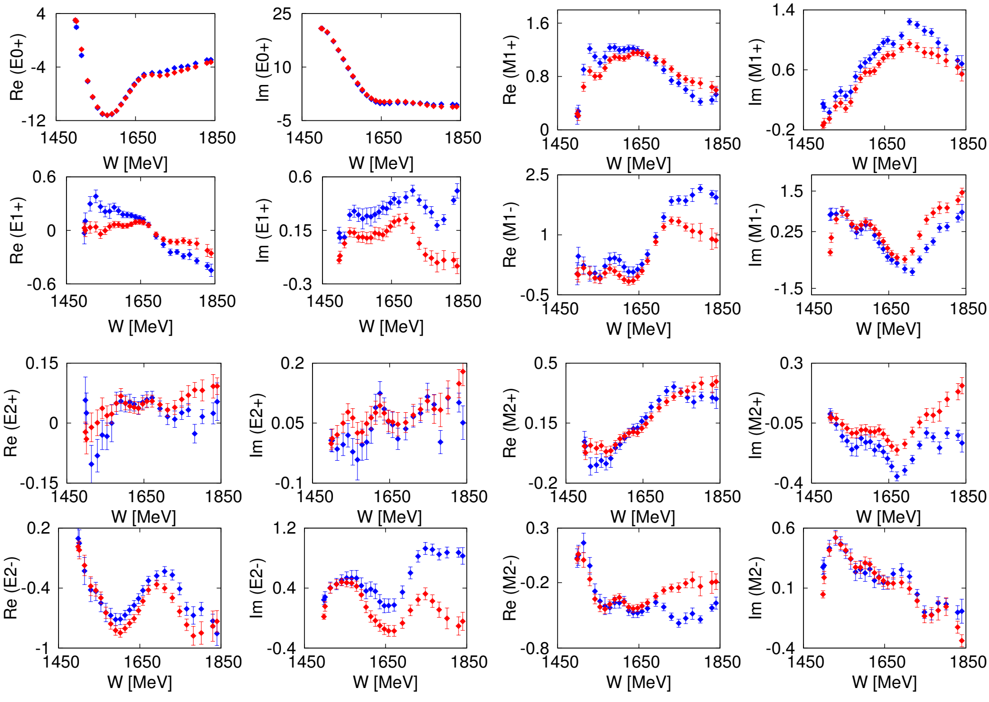

Fig. 2. (Color online) Real and imaginary parts of the S-, P- and D-wave multipoles obtained in the final step after three iterations using analytical constraints from helicity amplitudes obtained from initial solutions I (blue) and II (red).

of pseudo data we learned that a complete set of data results in unique solution. From that reason, we presume that new data from ELSA, JLAB and MAMI, which are expected soon, will help to resolve remaining ambiguities.

3 Conclusions

We applied iterative procedure with the fixed-t analyticity constraints to a partial wave analysis of eta photoproduction experimental data. In truncated PWA we obtained multipoles up to L_{max}=5. Ambiguities still remain in some multipoles, mainly at higher energies. New data, expected soon, will significantly expand our database, improve reliability of our results, and resolve remaining ambiguities.

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