Comment on "Comparison of Phase-Shift-Analysis Solutions to π^-p Scattering Data"

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Criticism by Brody *et al.* of the CERN-I πp phase-shift analysis is answered.

IN a recent paper,¹ Brody *et al.* claim that the CERN-I phase-shift solution "is not a good representation of the measured π^-p elastic scattering data." The captions on our graphs² state that "the solid squares are our phases and elasticities, the solid lines are our dispersion-relation fits." Thus the CERN-I phase-shift solution is what Brody *et al.* refer to as CERN-EXPT, which they admit "describes the data well." The solid lines, which they call CERN-TH or CERN I, are not our solution—they are not even an organic entity, but a set of independent fits to the different partial waves using dispersion-theoretic parametrizations.³ Most of these latter fits are quite good, but a few (S_{11} , D_{13} , F_{15}) are definitely bad. This is clearly visible on the graphs in our papers.^{2,4} Since they do not fit our phase shifts, it is hard to understand why anybody should suppose these solid curves would fit the original experiments. It has been pointed out at least twice previously in the literature^{5,6} that they do not.

The reason that these dispersion-relation fits are bad in S_{11} , D_{13} , and F_{15} , is that the parametrization used is biased against narrow resonances. This has also been pointed out in our previous paper.⁷ A small narrow resonance like $S_{11}(1525)$ may get lost altogether, while a large moderately narrow one like $F_{15}(1690)$ tends to get pulled out sideways somewhat. This is why we placed big errors on the dispersion-relation fits and fed them back as additional data in the phase-shift analysis,

instead of considering them as a solution. Actually, even with S_{11} , D_{13} , and F_{15} omitted altogether, the remaining dispersion-relation fits would have been more than sufficient to resolve all phase-shift ambiguities. Of course, our new resonances may also have been biased by these dispersion-relation data, but any such bias will be on the conservative side—dispersion-relation fits tend to *flatten* resonances. For the isospin- $\frac{3}{2}$ waves, it has already been shown, without using dispersion relations, that the CERN-I structure is required by the experiments.⁸ Reference 2 only announced new resonances in cases where the experimental phase shifts and dispersion-theoretic fits agreed well. The remark of Brody *et al.* about the published resonance parameters being obtained from "CERN-TH" is thus irrelevant.

The experiment of Brody *et al.* actually does not give much of a test of any solution, since it agrees with earlier data included in all the phase-shift analyses. A far more remarkable fact is that the new Bristol-RHEL π^-p differential cross sections at higher energies, which are in considerable conflict with the ones used in the CERN-I analysis, so far from eliminating any of our new resonances, actually enhance some of them.⁹ This shows how the overdetermined fits, resulting from the addition of dispersion relations to the experimental data, give stability against wrong measurements. It also illustrates a point not yet appreciated by most people—if existing πp phase-shift analyses need future correction, it will much more probably be because they *underestimated* new structure than because they overestimated it. If a solution to the accurate angular and polarization data really existed, containing only those resonances familiar from total cross sections, it would certainly have been found years ago.

¹ A. D. Brody, D. W. G. S. Leith, B. S. Levi, B. C. Shen, D. Herndon, R. Longacre, L. Price, A. H. Rosenfeld, and P. Söding, *Phys. Rev. Letters* **22**, 1401 (1969).

² A. Donnachie, R. G. Kirsopp, and C. Lovelace, *Phys. Letters* **26B**, 161 (1968).

³ C. Lovelace, in *Pion-Nucleon Scattering*, edited by G. L. Shaw and D. Y. Wong (Interscience, New York, 1969).

⁴ C. Lovelace, in *Proceedings of the Heidelberg International Conference on Elementary Particles*, edited by H. Filthuth (North-Holland Publishing Co., Amsterdam, 1968), pp. 100, 103, and 105.

⁵ F. Bradamante, S. Conetti, M. Giorgi, A. Penzo, L. Piemontese, F. Sauli, P. Schiavon, G. Fidecaro, and M. Fidecaro, *Nuovo Cimento Letters* **1**, 177 (1969).

⁶ J. Baacke, *Nucl. Phys. B9*, 324 (1969).

⁷ See Ref. 4, p. 86.

⁸ C. Lovelace and F. Wagner, quoted by A. Donnachie in *Proceedings of the Fourteenth International Conference on High-Energy Physics, Vienna, 1968* (CERN, Geneva, 1968), p. 139.

⁹ A. T. Lea, G. Oades, D. L. Ward, I. M. Cowan, W. M. Gibson, R. S. Gilmore, J. Malos, V. J. Smith, and M. A. R. Kemp, *Phys. Letters* **29B**, 584 (1969).