Comment on ”Narrow Structure in the Excitation Function of η photoproduction off the Neutron”

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In a recent letter, observation of a narrow structure was reported in photoproduction of η mesons off neutrons bound in 3H and 3He [1]. The data from both data sets agree well, hence we restrict the discussion to the results using deuterons. The structure had been observed before [2, 3] and is listed in the Review of Particle Properties as one–star resonance [4]. The new data exceed the earlier data both in quality and in statistics. In the new experiment, the hit proton or neutron was detected, and hence the Nη invariant mass was reconstructed without smearing due to the Fermi motion. These experimental achievements greatly enhanced the visibility of the narrow structure. The contributions from η production were determined by two different methods; the differences were used to estimate the systematic error. In the analysis below, we added both errors (quadratically).

In [1], the structure was tentatively interpreted as a narrow nucleon resonance at \( W = (1670 \pm 5) \) MeV mass and \( \Gamma = (30 \pm 5) \) MeV width. The product coupling of the hypothesized resonance given by its helicity amplitude \( A^0_{1/2} \) and the branching ratio for its neutron-η decay \( b_\eta \) was determined to \( \sqrt{b_\eta A^0_{1/2}} = (12.3 \pm 0.8) \times 10^{-3} \text{GeV}^{-1/2} \). The structure is exciting since a \( P_{11} \) resonance with precisely these properties is predicted as the non-strange member of an anti-decuplet [5].

The authors of [1] admitted that the older less precise data could be described without introducing a new nucleon resonance with exotic properties. In this comment we confirm that also the new and precise data are well described by the interference within the \( S_{11} \) wave. Moreover, the data are incompatible with the existence of a nucleon resonance with the reported properties.

The data were fitted within the Bonn-Gatchina partial-wave analysis. Masses, widths, decay couplings of resonances were all frozen by a fit to \( \pi N \) elastic and inelastic reactions and to data on photoproduction off protons (see [6, 7] for the data included). Here, only the helicity amplitudes for photoproduction of nucleon resonances off neutrons and contributions from \( t- \) and \( u- \) channel exchange were used as free parameters. To constrain the data on \( \gamma n \rightarrow \eta n \) further, we included GRAAL data on the beam asymmetry for this reaction and data on \( \gamma n \rightarrow \pi N \). These additional data were described well and have no impact on the conclusions; hence we retain from a more detailed discussion of those data.

Fig. 1 shows the total cross section for \( \gamma p \rightarrow \eta p \), for \( \gamma n \rightarrow \eta n \) and - as insert - the ratio \( \sigma_n/\sigma_p \), and our fit to the data. Overall, the description of all angular distributions is excellent, with \( \chi^2 = 95 \) for 200 data points in the \( (1610 - 1710) \) MeV mass range (or 620 if statistical errors only are used). If a resonance with properties from [1] is enforced, the \( \chi^2 \) increases by 257 units. Just acceptable solutions – with an increase in \( \chi^2 \) of about 25 – are obtained for \( (-3 < \sqrt{b_\eta A^0_{1/2}} < 5) \times 10^{-3} \text{GeV}^{-1/2} \).

The reason for the peak structure in \( \eta \) and dip structure in \( \eta p \) lies in the opposite relative sign of the helicity amplitudes for the two resonances \( N(1535)S_{11} \) and \( N(1650)S_{11} \). The helicity amplitudes (in units of \( 10^{-3} \text{GeV}^{-1/2} \)) as derived in the fits are listed below.

\[
\begin{array}{cccc}
N(1535)S_{11} & N(1650)S_{11} \\
p & 0.105 \pm 0.010 & 0.033 \pm 0.007 \\
n & -0.095 \pm 0.006 & 0.019 \pm 0.006 \\
\end{array}
\]

Summarizing, we have shown that the narrow structure observed in the new data on photoproduction of η mesons off neutrons does not support the existence of a nucleon resonance with exotic properties.

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