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New Narrow $N(1685)$ and $N(1726)$? Remarks on the Interpretation of the Neutron Anomaly as an Interference Phenomenon

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The observation of a narrow enhancement at $W \sim 1.68$ GeV in the $\gamma n \to \eta n$ excitation function [1–7] (the so-called "neutron anomaly") is one of the challenging findings in the domain of hadronic physics. It may signal a new nucleon resonance $N(1685)$ with unusual properties: the narrow ($\Gamma \leq 30$ MeV), strong photo-excitation on the neutron and the suppressed decay to the πN final state [8].

On the other hand, several groups explained this enhancement in terms of the interference in the photo-excitation of well-known resonances in S and P waves [9, 10]. For example, the Bonn-Gatchina (BnGa) group suggested that the interference of $S_{11}(1535)$ and $S_{11}(1650)$ may generate this peak [9]. The decisive identification of the neutron anomaly is a challenge for both theory and experiment.

Therefore there is a need to examine contradicting assumptions. The authors of Refs. [9, 10] focused on only the $\gamma n \to \eta n$ cross section, whereas the data base for the possible signals of $N(1685)$ is larger. Narrow structures at this energy were also observed in Compton scattering on the neutron $\gamma n \to \gamma n$ [11]. Furthermore, the recent data on the beam asymmetry for Compton scattering on the proton $\gamma p \to \gamma p$ [12], the precise data for the $\gamma n \to \eta n$ [13] and $\pi^- p \to \pi^- p$ [14] reactions revealed two narrow structures at $W \sim 1.68$ and $W \sim 1.72$ GeV.

Let us assume that the specific interference of wide ($\Gamma \sim 100 - 200$ MeV) resonances (for example $S_{11}(1535$ and $S_{11}(1650)$) generates a narrow ($\Gamma \leq 30$ MeV) peak in the $\gamma n \to \eta n$ excitation function. This reaction is governed by isospin-1/2 resonances only. In contrast, both isospin-1/2 and isospin-3/2 resonances are excited in Compton scattering. Could the interference of all these resonances also generate a peak at the same energy in $\gamma n \to \gamma n$?

Could the interference of wide resonances explain the second structure at $W \sim 1.72$ GeV? Could the BnGa and other solutions reproduce this structure in the $\gamma n \to \eta n$ cross section?

These questions should be answered prior the calculations from Refs. [9, 10] could be employed to achieve any meaningful conclusions.

More natural explanation of two observed phenomena would be the existence of one or two narrow resonances ($N(1685)$ and $N(1726)$). The properties of $N(1685)$, namely the narrow width $\Gamma \leq 30$ MeV, the strong photo-excitation on the neutron and the suppressed decay to the πN final state, do coincide well to those expected for the second member of the exotic anti-decuplet predicted in the framework of the Chiral Soliton Model [16] (pentaquarks). However, its decisive accusation requires in particular the identification of the second structure at $W \sim 1.726$ GeV.

Another assumption would be the sub-threshold virtual $K\Sigma$ and ωp productions (cusps). It is favoured by the fact that both structures are observed at the energies which correspond to the thresholds of these reactions.

In summary it looks questionable whether the interference phenomena could accomodate all experimental observations. Two other hypotheses, namely the existence of one or two narrow resonances or cusps, require further theoretical and experimental studies.

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