Nuclear Theory

η photoproduction on the quasi-free nucleons in the chiral quark model

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A chiral quark-model approach is adopted to study the η photoproduction off the quasi-free neutron and proton from a deuteron target. Good descriptions of the differential cross sections, total cross sections and beam asymmetries for these two processes are obtained in the low energy region. For $\gamma p\rightarrow \eta p$, the dominant resonances are $S_{11}(1535)$, $S_{11}(1650)$, $D_{13}(1520)$, $D_{13}(1700)$ and $P_{13}(1720)$. While for the $\gamma n\rightarrow \eta n$ process, the dominant resonances are $S_{11}(1535)$, $S_{11}(1650)$, $D_{13}(1520)$, $D_{15}(1675)$ and $P_{13}(1720)$. Furthermore, the u channel backgrounds have significant contributions to the η photoproduction processes. The configuration mixings in the $S_{11}(1535,1650)$ and $D_{13}(1520,1700)$ can be extracted, i.e. $\theta_S\simeq 26^\circ$ and $\theta_D\simeq 21^\circ$. It shows that the narrow bump-like structure around $W= 1.68$ GeV observed in $\gamma n\rightarrow \eta n$ can be naturally explained by the constructive interferences between $S_{11}(1535)$ and $S_{11}(1650)$. In contrast, the destructive interference between $S_{11}(1535)$ and $S_{11}(1650)$ produces the shallow dip around $W= 1.67$ GeV in $\gamma p\rightarrow \eta p$. The S wave interfering behaviors in the proton and neutron reactions are correlated with each other in the quark model framework, and no new exotic nucleon resonances are needed in these two reactions.

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