Determining the Width of the Apparent Exotic Baryon Seen in K^+ Collisions With Xenon

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The Diana Collaboration reports a resonance in the K^+n channel observed in a xenon bubble chamber.[1] The mass is given as 1539 ± 2 MeV and the width with less than 9 MeV. At this mass, the only open channels are K^+n and K^0p so scattering is either elastic or charge exchange. In this note we deduce an estimate of the intrinsic width of the resonance. The data, given as a histogram in $m(K^0p)$ show a peak two bins wide, with a background of about 22 events per bin and 20 events above background in the first signal bin and 6 events in the second signal bin.

To estimate the width we assume a Breit-Wigner line shape

$$\sigma(m) = BR(K^+n)\, BR(K^0p)\, \sigma_0 \left[\frac{\Gamma^2/4}{(m-m_0)^2+\Gamma^2/4}\right] \tag{1}$$

where $BR(K^+n)$ and $BR(K^0p)$ are the branching ratios of the resonance to the entrance and exit channels and where

$$\sigma_0 = \frac{2J+1}{(2s_1+1)(2s_2+1)}\frac{4\pi}{k^2} = \frac{2}{2}\frac{4\pi}{(0.269\text{ GeV})^2}\cdot 0.389\text{ mb GeV}^2 = 65\text{mb} \tag{2}$$

We have assumed the spin of the resonance is $J = 1/2$ in accord with the theoretical prediction [2] cited by the authors of the experimental paper. If we integrate over the resonance we have

$$\begin{aligned}\int_{-\infty}^{\infty} dm BR(K^+n)\, BR(K^0p)\sigma_0 \left[\frac{\Gamma^2/4}{(m-m_0)^2+\Gamma^2/4}\right] &= BR(K^+n)\, BR(K^0p)\frac{\pi\Gamma}{2}\sigma_0 \\ &= \frac{1}{2}\cdot\frac{1}{2}\cdot 68\text{ mb}\frac{\pi\Gamma}{2} \end{aligned} \tag{3}$$

We have assumed the resonance to be isoscalar.

Now we need to compare this to the data. If we look at *A Compilation of K^+N Cross-Sections Below 2 GeV/c* [3] we find the cross section for the charge exchange process $K^{=}n \to K^0 p$ at 480 MeV is about 5 mb. We interpret the background in the xenon bubble chamber experiment, which measured the final state $K_S p$ with an incident K^+ beam, as due to charge exchange. Thus 22 events per 5-MeV bin is equivalent to a 5 mb cross section. Now the integrated resonant cross section is 26 events, which is then equivalent to 5 mb $\times$ 5 MeV $\times$ (26/22) = 30 mb MeV. Altogether, then

$$\begin{aligned} 30 \text{ mb MeV} &= \frac{1}{2} \cdot \frac{1}{2} \cdot 68 \text{ mb} \frac{\pi \Gamma}{2} \\ 1.1 \text{ MeV} &= \Gamma \end{aligned} \tag{4}$$

This is an exceedingly small width, especially if the spin is $J = 1/2$ and an s-wave decay is allowed. While it seems improbable that such a resonance could have escaped detection in the study of K^+d collisions, it is of some interest to take literally the results of the K^+ xenon study and a photoproduction experiment that finds a similar result[4].

References

[1] V. V. Barmin et al., hep-ex/0304040v2.

[2] D. Diakonov, V. Petrov, and M. Polyakov, *Z. Phys.* **A359**, 305 (1997).

[3] CERN/HERA 75-1, CERN, Geneva, 1975, pp. 40-41.

[4] T. Nakano et al. hep-ex/0301020.