Comments and Addenda

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K_S^{0*} and its uses

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We point out that Primakoff conversion of K_L^0's produces K_S^{0*}'s. This makes possible a practical tagged K_S^0 beam. In addition one can test the recent suggestion that $I=1$ exchange effects necessitate large corrections to Primakoff measurements of vector-meson electromagnetic widths. It will also be possible to measure $\Gamma(K^{0*}\to K^0\gamma)$ in a manner independent of the alleged corrections.

In this note we point out certain interesting consequences of the fact that Primakoff excitation of a K_L^0 beam yields pure $K_S^0{}^*$. The process envisioned is shown in Fig. 1. That one-photon exchange from K_L^0 gives rise to $K_S^0{}^*$ is shown as follows.

Take

$$K_L^0=\alpha\,|K^0\rangle-\beta\,|\overline{K}^0\rangle\,,$$
$$K_S^0=\alpha\,|K^0\rangle+\beta\,|\overline{K}^0\rangle\,.$$

By strangeness conservation

$$\langle\overline{K}^{0}{}^*|\,T\,|K^0\gamma\rangle=\langle K^{0}{}^*|\,T\,|\overline{K}^0\gamma\rangle=0\,.$$

By C conservation

$$\langle K^{0}{}^*|\,T\,|K^0\gamma\rangle=-\langle\overline{K}^{0}{}^*|\,T\,|\overline{K}^0\gamma\rangle\equiv A\,.$$

Then we have

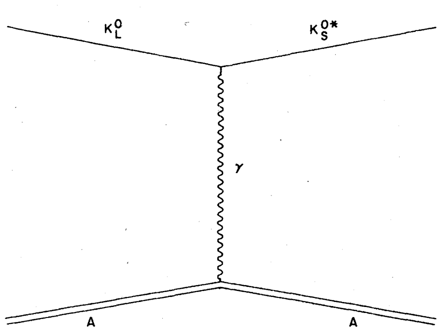

FIG. 1. Primakoff excitation of K^*.

$$\begin{aligned}|f\rangle=T\,|i\rangle&=T\,|K_L^0\gamma\rangle\\&=|K^{0}{}^*\rangle\langle K^{0}{}^*|\,T\,|K_L^0\gamma\rangle+|\overline{K^0}{}^*\rangle\langle\overline{K^0}{}^*|\,T\,|K_L^0\gamma\rangle\\&=\alpha\,|K^{0}{}^*\rangle\langle K^{0}{}^*|\,T\,|K^0\gamma\rangle-\beta\,|K^{0}{}^*\rangle\langle K^{0}{}^*|\,T\,|\overline{K^0}\gamma\rangle\\&\quad+\alpha|\overline{K^0}{}^*\rangle\langle\overline{K^0}{}^*|\,T\,|K^0\gamma\rangle-\beta|\overline{K^0}{}^*\rangle\langle\overline{K^0}{}^*|\,T\,|\overline{K^0}\gamma\rangle\\&=A(\alpha\,|K^{0}{}^*\rangle+\beta\,|\overline{K^0}{}^*\rangle)\\&=A\,|K_S^0{}^*\rangle\,.\end{aligned}$$

The cross section for Primakoff production of K^* is given by[1]

$$\frac{d\sigma}{dt}\approx 24\pi Z^2\alpha\,\frac{|F(t)|^2\Gamma(K^*\to K^0\gamma)M_{K^*}{}^3}{(M_{K^*}{}^2-M_K{}^2)^3}\times\frac{t'}{t^2}\,,$$

where $F(t)$ is the nuclear form factor $[F(0)=1]$, and $t'=t_{\min}-t$. The maximum of the expression occurs at $t'\sim|t_{\min}|$. Since

$$t_{\min}\sim-\left(\frac{M_{K^*}{}^2-M_K{}^2}{2p_K}\right)^2,$$

this process is already extremely forward peaked by $p_K\sim$ a few GeV/c. It is basically by this property that coherent γ exchange is distinguished from other production mechanisms. The leading "background" process at small t is coherent ω exchange. In fact from the point of view of this paper it is not really a background at all since being a $C=-1$ exchange it also produces $K_S^0{}^*$. The ω exchange cross section peaks at somewhat higher t', with $d\sigma/dt\propto t'\,|F(t)|^2$.

According to the results of Carithers *et al.*,[2] wherein $K^0{}^*$'s were excited off nuclear targets by a K_L^0 beam, these two processes account for vir-

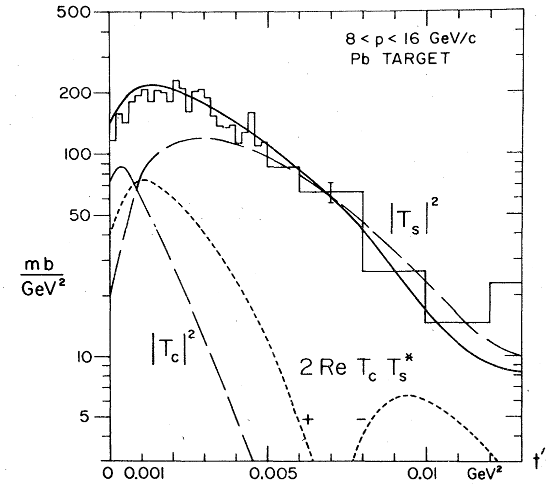

FIG. 2. Small-t' portion of the differential cross section for Pb. The dashed lines show the Coulomb, strong, and interference-term contributions, respectively. The solid line is the sum of these.

tually all of the K^{0*} production in the small t' [< .01 $(\mathrm{GeV}/c^2)^2$] region. This can be seen in Fig. 2 (reproduced from Ref. 2) which shows the fit of the lead data to a coherent sum of γ and ω exchange.

The yield is considerable: The cross section of Fig. 2 integrated from $t'=0$ to 0.01 is ~1 mb. Since beams of ~$5\times10^6 K_L^0$/burst in the few GeV/c energy range are attainable,[3] a 0.1 r.l. Pb target would provide ~$10 K_S^0$*/burst, or 10^7 in a reasonable experiment. The effective yield is about a factor of 3 less than this because the K_S^0* will decay into $\pi^0 K_S^0$ about 33% of the time.

Now in the approximation that $C=-1$ exchanges totally dominate forward K^{0*} production, one can produce a pure K_S^0 beam. Having detected both the π^0 and the K^0 decay and verifying that the resultant four-momentum was that of a forward K^*, one can be certain that the K^0 was indeed a K_S^0. Under the above assumptions a 10% detection efficiency would enable one to collect $3\times10^5\times b(K_S^0\to f)$ of K_S decays to a particular final state f.

Improvements in K_L^0 beams would increase this proportionately. An example of the utility of this technique is the decay $K_S^0\to\pi^+\pi^-\pi^0$ where the above sensitivity would allow one to probe $b(K_S^0\to\pi^+\pi^-\pi^0)$ to the 10^{-5} level, which corresponds to $|A(K_S\to\pi^+\pi^-\pi^0)|/|A(K_L\to\pi^+\pi^-\pi^0)|$ of 0.22. This would represent a considerable improvement upon the best previous limit[4] on this quantity (~0.6).

In a recent paper Kamal and Kane[5] have proposed an additional background process to the K^{0*} production mechanisms discussed above. In an attempt to explain the unexpectedly small experimental values[6] for $\Gamma(K^{*0}\to K^0\gamma)$ and $\Gamma(\rho\to\pi\gamma)$,[7] they have proposed that the contribution of A_2 $(I=1)$ exchange to the strong K^* production is about equal to that of the ω $(I=0)$ exchange in the case of heavy nuclei. This is asserted to confound the analysis of Refs. 2 and 7 in such a way as to reduce the apparent Primakoff contribution.

However, since $J^{PC}=2^{++}$ for the A_2, this mechanism can be expected to produce K_L^0* instead of K_S^0*. Therefore this phenomenon could readily be measured with the present technique. One would need to determine the ratio $(K^0\to\pi^+\pi^-\pi^0)/(K^0\to\pi^+\pi^-)$ from K^0's emanating from forward $K^{0*}\to\pi^0K^0$ produced off a heavy nucleus by K_L^0's. Correcting for the K_S and K_L lifetimes and for relative detection efficiency, this gives the $K_L^0{}^*/K_S^0{}^*$ ratio, which is in turn proportional to the relative strength of $C=+1$ exchange contribution. It should be relatively simple to verify whether this ratio is indeed ~1 as implied by the arguments of Ref. 5.

If a significant effect is in fact observed, one could use the measurement as input to an improved reanalysis of Refs. 2 and 7. One could also repeat the measurement of $\Gamma(K^{0*}\to K^0\gamma)$ detecting the $K^{0*}\to\pi^0K_S$ decay mode instead of $K^\pm\pi^\mp$ and thereby completely eliminate the $C=+1$ exchange contribution.

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[3]G. M. Bunce, BNL Report No. BNL 50874, 1978 (unpublished).

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