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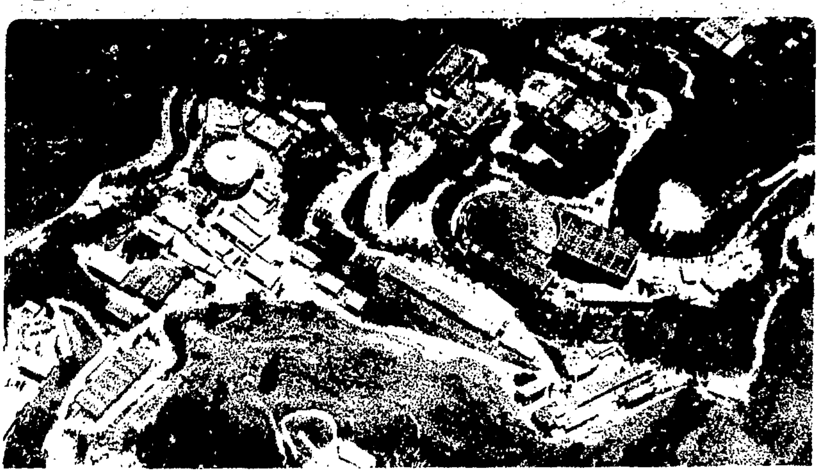

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PROBLEMS AND PROSPECTS IN STRANGE BARYON SPECTROSCOPY

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The study of Y^* resonances by means of formation experiments has long suffered from deficiences of available K^- beams, both in intensity and purity. For example a typical single-stage separated K^- beam of 750 MeV/c has at BNL[1] or CERN an intensity of about 10^5 K^-/pulse with a ratio of K^- to contaminating π^-, μ^-, and e^- of 1:10. At a kaon factory the K^- yield is expected to be several orders of magnitude higher. Then, trading intensity for purity by employing two stages of separation and/or improved beam optics,[2] one could reasonably expect to obtain an intensity of 10^6 K^-/sec, unencumbered by the high contamination that would otherwise torture the apparatus. Such luxurious beams have long been available with pions for use in studying nucleon resonances and are the major reason for the more satisfactory experimental status of the N^* resonances.

In fact most of our knowledge of Y^*'s derives not from high flux experiments but from systematic but low statistics K^- bubble chamber experiments. The usual bubble chamber experiment at one momentum contains a K^- path length[3] equivalent to less than a one-second exposure to a high intensity (10^6) K^- beam! Such experiments laboriously scanned the Y^* region during the 1960's, carefully measuring and cataloging the various K^- reactions ($K^-p \rightarrow K^-p$, $\bar{K}^0n$, $\Lambda\pi$, $\Sigma^{\pm,0}\pi^{\mp,0}$, $\Lambda\pi$ $\Sigma^0\eta$, $\Xi^{0,-}K^{0,+}$, 3 body reactions), thereby determining channel cross sections, angular distributions, and hyperon polarizations as a function of beam momentum. These data, sometimes augmented by K^-n or K_Lp studies, were subjected to energy-dependent partial wave analyses; coupled channel at low momenta,[4,5] but essentially channel-by-channel at higher momenta[6,7,8] where 3-body reactions vitiate the constraints of unitarity. From partial wave analyses emerged the presently known Y^* spectrum.[9]

The 1970's brought a series of specific K^- electronic experiments chosen to remedy some of the more obvious weaknesses of the earlier bubble chamber and counter experiments. Total K^-p and K^-d cross sections were remeasured with higher precision to yield the isospin decomposed I=0 and I=1 cross sections.[10] These measurements revealed six new narrow resonances between 500 and 900 MeV/c K^- momenta. These structures have never been adequately accommodated in subsequent partial wave analyses,[7,8] nor have they been confirmed by counter experiments designed to measure other things such as $K^-p \rightarrow \bar{K}^0n$[11] and $K^-p \rightarrow K^-p$ backward elastic scattering.[12] In fact, even apart from the new structures, these total cross sections have generally been difficult to handle in any partial wave analysis, requiring considerable enlargement of the quoted errors to avoid an inordinately large contribution to the overall χ^2 for the fit.[8] It would be highly desirable to remeasure the total cross sections using wire chambers rather than counters so as to greatly diminish the large empty-target background arising from K^- decays after the target. Such an experiment could be readily done with present beam intensities.

Polarized target experiments[13] have contributed measurements of K^-p elastic polarization. Although they did not disclose any new physics, it was very reassuring to see that previous partial wave analyses had good predictive power and so presumably represented a reasonable approximation of reality. With better K^- beams from a kaon factory polarization experiments could be greatly improved and extended to other channels such as charge exchange and perhaps $\Sigma\pi$ and $\Lambda\pi$.

Here it is appropriate to point out a philosophical difference between πN and $\bar{K}N$ partial wave analyses. The practitioners of the former,[14] because of the greater ease of obtaining pion data and the dominantly single channel nature of the πN system have been able to enjoy the luxury of performing energy-independent partial wave analyses.[15] Efforts of this nature for $\bar{K}N$ led nowhere[16] so from the beginning [4,5] one had to "cheat" by imposing dynamical prejudices. For the S waves at low momentum a constant K matrix or its equivalent was assumed and, as resonances appeared at higher momenta, a Breit-Wigner resonant form was introduced into the appropriate partial wave. Background amplitudes were parametrized with various degrees of sophistication. When there are large prominent resonances, experience has shown that this is an extremely powerful way to extract essentially unique amplitudes. There are none of the ambiguities that plague energy-independent analyses. However when resonances are weak, things become much less certain. For the $\bar{K}N$ system both conditions prevail, depending on momentum. At 400 MeV/c, $\Lambda(1520)$ is prominent (σ_{res} = 37 mb.) and uniquely constrains and stabilizes the analysis.[5] Near 1 GeV/c the behavior is dominated by $\Lambda(1820)$ and $\Sigma(1775)$ and again fits are good[6,7,8] and predictive powers are excellent. However between 450 and 850 MeV/c where there are a number of resonances weakly coupled to the $\bar{K}N$ system the situation is much murkier. Fits become poor and there are anomalies[12] that defy current parametrizations, suggesting that there is more going on than is presently understood.[17] Unfortunately, and not coincidentally, it is precisely here that the systematic bubble chamber data are statistically the weakest, being based solely on one exploratory experiment.[18] Above 1 GeV/c bubble chamber data are more abundant, but the appearance of many partial waves complicates the analysis so that better experiments would be welcome.

What kind of experiments would most effectively contribute to clarification of the Y^* spectrum? Recall that there are 10 two-body channels to investigate as well as many important quasi-two-body channels such as $\Sigma(1385)\pi$, $\Lambda(1520)\pi$ and $\Lambda\omega$. For these a bubble chamber is nearly the ideal instrument and a hundred-fold increase in data would probably suffice to clarify all important issues. But modern man would scarcely abide such a stone age approach. What is needed is an electronic bubble chamber with particle identification and probably photon identification as well. Namely, a TPC. One is already in successful use in a high rate (10^6 μ^-/sec) environment at TRIUMF.[(19)] There, however, fewer demands are placed upon its performance than would be required to sort out the various K^- reactions with high precision without the visual advantages of a bubble chamber for vertex resolution. The software and data analysis problems should be a formidable challenge, to say the least. These data would provide the backbone for a new partial wave analysis. Presumably they could be complemented by specific electronic experiments designed to overcome some of the deficiencies inherent in such a universal detector.

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