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PROPOSAL FOR EXPERIMENTS TO BE PERFORMED WITH THE CERN HEAVY LIQUID BUBBLE CHAMBER IN A FAST ANTIPROTON BEAM.

The following is the proposed series of experiments to be performed with the CERN 500 litre heavy liquid bubble chamber in a fast antiproton beam. For the first series of photographs the momentum of the separated beam would be about 3 GeV/c, and it is hoped at a later date to take further photographs at a momentum of about 6 GeV/c.

1. Experimental Programme.

a) Hyperon - antihyperon pairs. Reasonable numbers (see Section 3) of hyperon - antihyperon pairs should be produced, enabling cross sections and angular distributions to be determined. Provided that the production cross section is not too low, $\Xi - \bar{\Xi}$ pairs will be produced, and in particular a heavy liquid will be suitable for detecting the decay of the Ξ^o, due to the high probability of materialization of the γ's from the π^o. The production process should not be too complex, as 3 GeV/c is fairly close to the threshold for $\bar{p} + p \longrightarrow \Xi + \bar{\Xi}$ of 2.63 GeV/c.

b) Interactions of strange particles. There is considerable interest in studying the nuclear interactions, scattering and charge exchange of strange particles.

c) Strange particle isobars. The abundance of strange particle isobars can be determined, and a search made for new isobars (such as a Ξ isobar).

d) Two-body annihilation. There is now considerable interest in two-body annihilation processes (Gribov and Pomeranchuk, Conference on Theoretical Aspects of High Energy Phenomena, CERN 1961, unpublished), and the

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ability of a heavy liquid chamber to detect π^0's should be an asset.

e) $\pi - \pi$ correlations. The distribution of angles between π's of like charge (I = 2) is strikingly different from that for π's of unlike charge (I = 0,1,2). The LIPS model must accordingly be modified, by introducing $\pi - \pi$ correlations, and experimental data at higher energies than heretofore is needed (cf. G. Goldhaber, W.B. Fowler, S. Goldhaber, T.F. Hoang, T.E. Kalogeropoulos, and W.M. Powell, Phys. Rev. Letters, 3, 181, 1959).

f) π multiplicities. There is interest in studying these at a higher $\bar{p}$ energy than has so far been available (comparison with the statistical model suggests a curiously large interaction volume). It will be possible to measure the number of π^0's produced, at present only deduced from the numbers of charged pions, and the percentage of K's (cf. S. Goldhaber, G. Goldhaber, W.M. Powell and R. Silberberg, Phys. Rev. 121, 1525, 1961).

g) Production cross sections for strange particles.

h) Charge-exchange production of antineutrons and their annihilation.

i) Antiproton elastic and inelastic cross sections.

2. Liquid mixture to be used.

It is desirable to have as many free protons as possible in the chamber, and for this reason a filling of pure propane (C_3H_8) is suitable. However, an admixture of freon (CF_3Br) reduces appreciably the radiation length, but increases the error in momentum measurement due to multiple scattering.

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		Pure C_3H_8	75 % C_3H_8 + 25 % CF_3Br by weight	Pure CF_3Br
Radiation length	Xo (cm)	110	34	11
Density of free hydrogen	Gm/cm^3	0.078	0.058	0
Error in momentum measurement for a fast particle ($\beta \sim 1$) due to multiple scattering, with a field of 18 kG.	50 cm track	4.3 %	7.7 %	13.6 %
	25 cm track	6 %	10.8 %	19.2 %

From the table it would seem that a mixture of about 75 % propane and 25 % freon would be a suitable compromise.

3. Estimate of number of events likely to be produced.

In estimating the number of events likely to be produced in the chamber the following assumptions are made :

a) The filling is 75 % C_3H_8 + 25 % CF_3Br by weight, or 90 % C_3H_8 + 10 % CF_3Br by volume.

b) Only the first 50 cm of the chamber are useful as target material, the rest being used as detector.

c) There are an average 3 antiprotons per picture, and the event rate is calculated per unit of 50 000 pictures.

d) Only the events produced on free protons are considered.

e) The cross sections for strange particle production do not vary strongly with energy, so that one can use the data from experiments at lower energies (in the range 1 to 2 GeV/c).

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Then the number of events produced in the chamber due to a cross section σ will be

$$N_E = 3 \times 5 \times 10^4 \times 1.76 \times 10^{24} \times 10^{-30} \times \sigma$$

$$= 0.26\,\sigma \quad (\sigma \text{ in } \mu b).$$

The cross section for $\bar{p} + p \longrightarrow \bar{\Lambda} + \Lambda$ is about 50 μb, so that about 10 - 15 such events should be produced.

No information on the cross section for $\bar{p} + p \longrightarrow \bar{\Xi}^0 + \Xi^0$ is available, but Alvarez, Eberhard, Good, Graziano, Ticho and Wojcicki (Phys. Rev. Letters 2, 215, 1959) estimate on the basis of one event that for K^- of 1.15 GeV/c,

$$\sigma\,(K^- + p \longrightarrow \Xi^0 + K^0) \simeq 50\ \mu b.$$

Though the cross section for $\Xi^0 - \bar{\Xi}^0$ production is not known, it will presumably be less than that for $\Lambda - \bar{\Lambda}$ production, as the latter has a lower threshold. If we assume a cross section (hopefully) of 20 μb, then about 5 cascade pairs would be produced in the chamber. Since the $\bar{p} - p$ annihilation cross section is about 50 mb, there will be of the order of 13 000 $\bar{p} - p$ annihilations in the chamber.

The actual numbers of strange particles produced in the chamber should be considerably in excess of the above numbers, mainly because of assumption d). Many strange particles will be produced in $\bar{p} - C$ interactions. Though these interactions are in general not suitable for studying production processes, they contribute greatly to the numbers of strange particles useful for points b), g), and possibly c) in the experimental programme. To estimate these numbers, one can extrapolate the results of Goldhaber et al (Phys. Rev. 121, 1525) from the Berkeley propane chamber, used with a beam of 1.05 GeV/c antiprotons. They observed Λ's, Σ^+'s, and Σ^-'s associated with annihilation stars in carbon, which they interpret as being most probably due to secondary interactions of K^- or $\bar{K}^0$ with a nucleon of the parent nucleus. We retain the first three

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of the above assumptions, and make the further one that the number of hyperons is proportional to the number of $\bar{p}$ - C annihilations. Then we find that the following numbers of hyperons will be produced.

Σ^+	400
Σ^-	300
Λ	800

4. Performance of the experiments.

It is proposed that the above experiments be carried out using the CERN heavy liquid bubble chamber. The beam will be initially the 3 GeV/c antiproton beam. At least one short run of 10 000 to 20 000 pictures will be required to ensure that all the experimental conditions are optimized. A reasonable total number of pictures is probably of the order of 200 000. These should be spread over several runs, to minimize the influence of possible PS and bubble chamber breakdowns, and to enable the total number of pictures taken to be determined by the results of the analysis of the first pictures.

It is proposed that this programme be started as early as possible in 1962, and that a 6 GeV/c exposure be made later in that year, when the high energy antiproton beam will be available. A detailed proposal for experiments to be done with the 6 GeV/c antiproton beam will be made at a later date, but it is clear that several of the experiments listed in Section 1 should be performed at more than one energy.

It is hoped that with the beam arrangement for 6 GeV/c antiprotons it will be possible to obtain a high energy K^- beam, perhaps $\sim$4 GeV/c. There would be considerable interest in using this beam with a heavy liquid chamber, particularly for producing Ξ's and Σ's, and a detailed proposal will be presented in due course. It is hoped that by this time initial experience will have been obtained with 4 GeV/c K^-'s (see NPA/Int. 61-13).

CERN Heavy Liquid Bubble
Chamber Group.

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