TOPOLOGICAL CROSS SECTIONS IN THE MOMENTUM RANGE
50–920 MeV/c

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Abstract

The total and topological cross sections are presented for events seen in the
interaction of 50–920 MeV/c antiprotons with deuterium in the BNL 30 in. bubble
chamber.

EXPERIMENTAL DETAILS

In this paper we report on pd topological cross sections in the momentum range
50–920 MeV/c. The data were obtained from 10 runs at different beam momenta
using the BNL 30 in. bubble chamber. The beam details are given by Caro and

In the frames scanned in this study a total of 11 000 interactions were observed.
Events were sorted into momentum bins approximately 50 MeV/c wide by using a
template consisting of beam streamlines crossed by isomomentum lines that were
separated by equal track length intervals. The central momentum uncertainty in
each bin is estimated to be ±15 MeV/c. Two independent scans were made and
discrepancies were resolved by a third physicist scan. The overall scan efficiency is
estimated to be better than 99%.

RESULTS

Total pd cross sections σ have been calculated using the expression

$$\sigma = (m/p_x) \ln(I_0/I),$$

where ρ is the deuterium density, m the mass of the deuteron, x the distance between
the isomomentum lines defining a bin, I₀ the number of ¯p tracks entering a bin, and
I the number of beam tracks leaving the bin without interacting. Table 1 displays
the resulting topological cross sections and the calculated total pd cross section.
In calculating the latter an allowance must be made for a 4° scan cutoff in the
projected angle for scattering events. The correction for scattered tracks with large

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dip angles is estimated to be of order 25 mb from angular distributions obtained by measuring elastic scattering events. A further correction for lost forward scattering events is estimated by using the optical theorem to be of order 2 mb.

The total p\overline{d} cross section data reported here together with the trend of previous data at higher momenta (Galbraith et al. 1965; Abrams et al. 1967; Allaby et al. 1969) are plotted in Figure 1 against the reciprocal of the antiproton momentum in the pN c.m.s. system. The plot indicates that the total cross section is almost linear in this quantity in the range 0·35–50 GeV/c. For comparison we have plotted the \sigma_{0f}(\bar{p}p) data (Galbraith et al. 1965; Amaldi et al. 1966; Abrams et al. 1967; Allaby et al. 1969) on the same figure.

### Table 1

**OBSERVED TOPOLOGICAL AND TOTAL CROSS SECTIONS**

<table>
<thead>
<tr>
<th>Momentum (MeV/c)</th>
<th>(\sigma_{1+s})</th>
<th>(\sigma_1)</th>
<th>(\sigma_3+\sigma_{3s})</th>
<th>(\sigma_4)</th>
<th>(\sigma_5+\sigma_{5s})</th>
<th>(\sigma_8)</th>
<th>Other</th>
<th>Total</th>
<th>Scattering Correction</th>
<th>Corrected (\sigma_{t0}(\bar{p}d)) (mb)</th>
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<td>2</td>
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</table>

* The momenta associated with the two lowest momentum bins are extremely uncertain because of the rapid variation of cross section and range for very low momenta. The errors represent counting statistics only.

We do not attempt to display separate \(\bar{p}p\) and \(\bar{p}n\) elastic and inelastic cross sections since the extraction of these from \(\bar{p}d\) data is unreliable at low momentum.

Figure 2 displays the cross section difference \(\sigma_{\text{odd}} - \sigma_{\text{even}}\), where

\[
\sigma_{\text{odd}} = \sigma_1 + \sigma_{1s} + \sigma_3 + \sigma_{3s} + \sigma_5 + \sigma_{5s}
\]

and

\[
\sigma_{\text{even}} = \sigma_0 + \sigma_2 + \sigma_4 + \sigma_6.
\]  

If we assume that (1) \(\sigma_{\text{odd}}\) contains most of the \(\bar{p}n\) interactions and \(\sigma_{\text{even}}\) the \(\bar{p}p\) interactions and (2) the mesonic resonances reported by Cline et al. (1968; personal communication) at 1925 and 1945 MeV exist, then the deviations of our points in Figure 2 at 450 and 560 MeV/c from a smooth curve tend to indicate that the 1925 MeV resonance is \(I = 1\), and the 1945 MeV resonance is \(I = 0\).

Detailed measurements of the elastic scattering processes in deuterium and of the annihilation channels leading to three seen pions are in progress. A study is also
being made of the interaction $\bar{p}d \rightarrow \Lambda K(n\pi)$ for which some 50 examples have so far been obtained.

![Graph of total $\bar{p}d$ cross section versus reciprocal $pN$ c.m.s. momentum $P$. Also shown is the total $p\bar{p}$ cross section.](image)

Fig. 1.—Total $\bar{p}d$ cross section versus reciprocal $pN$ c.m.s. momentum $P$. Also shown is the total $p\bar{p}$ cross section. To facilitate comparison of the graphs the antiproton–nucleon centre of mass momentum has been employed. The $\bar{p}$ laboratory momentum is shown on the top abscissa.

![Graph of cross section difference $\sigma_{\text{odd}} - \sigma_{\text{even}}$ versus reciprocal $pN$ c.m.s. momentum $P$, where $\sigma_{\text{odd}}$ and $\sigma_{\text{even}}$ are defined by equations (1). Several momentum bins have been lumped to improve statistics. The arrows indicate the positions of the resonances reported by Cline et al. (1968).](image)

Fig. 2.—Cross section difference $\sigma_{\text{odd}} - \sigma_{\text{even}}$ versus reciprocal $pN$ c.m.s. momentum $P$, where $\sigma_{\text{odd}}$ and $\sigma_{\text{even}}$ are defined by equations (1). Several momentum bins have been lumped to improve statistics. The arrows indicate the positions of the resonances reported by Cline et al. (1968).

ACKNOWLEDGMENTS

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REFERENCES
