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AN INVESTIGATION INTO SPURIOUS SCATTERING IN PHOTOGRAPHIC EMULSIONS.

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SUMMARY:

From multiple scattering measurements made on 17 Gev/c π^- beam tracks in G_5 emulsions, it is found that the correlation coefficient ρ_s for spurious scattering between second and third difference , has a value of the order of unity, in the pellicles investigated. This is attributed to the distortion component of spurious scattering . The effect of randomization on higher differences has been investigated. Variation of $\bar{D}_s$ with cell length has also been investigated , and various methods for the elimination of spurious scattering have been examined from the point of view of their relative merit.

1. EXPERIMENTAL PROCEDURE:

Multiple scattering measurements were made in two pellicles by the co-ordinate method[1)] on 3.8 metres of 17.2 Gev/c π^- beam tracks. Basic cell length of 1 mm was used and independent cells of 2, 4, 6, 8, and 10 mm were constructed. The stage noise for Leitz Ortholux microscope is constant at 0.10μ between 1 mm and 1 cm. Since the beam tracks were flat, a potential track length of 10 cms was invariably available. The tracks were carefully aligned in order to avoid biases which may arise if large angle scatters are missed.

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TABLE I

Cell Length	$\overline{D}_o$	$\overline{D}_c$	$\overline{T}_o$	ρ_{32} (observed)	D_s	T_s	ρ_s
1 mm	0.202 ± 0.013	0.090	0.323 ± 0.013	1.599 ± 0.019	0.09 ± 0.005	0.10 ± 0.005	1.111 ± 0.051
2 mm	0.369 ± 0.018	0.261	0.514 ± 0.019	1.393 ± 0.027	0.21 ± 0.013	0.26 ± 0.019	1.238 ± 0.050
4 mm	0.921 ± 0.026	0.713	1.154 ± 0.027	1.253 ± 0.040	0.56 ± 0.044	0.62 ± 0.066	1.107 ± 0.057
6 mm	1.580 ± 0.033	1.325	1.972 ± 0.033	1.248 ± 0.050	0.84 ± 0.114	0.91 ± 0.170	1.083 ± 0.098
8 mm	2.464 ± 0.038	2.020	2.952 ± 0.042	1.198 ± 0.059	1.39 ± 0.194	1.30 ± 0.337	0.935 ± 0.087
10 mm	3.287 ± 0.045	2.930	4.047 ± 0.049	1.231 ± 0.067	1.48 ± 0.395	1.30 ± 0.780	0.878 ± 0.155

This may be explained by asserting that the distribution for spurious scattering alone is non-Gaussian. In badly distorted pellicles the observed distribution would be non-Gaussian . But when the level of spurious scattering is low , the observed distribution which is largely due to coulomb and noise , and is therefore expected to be Gaussian , would be practically unmodified.

2.2. D_2 (s) in various pellicles:

Spurious scattering is thus present in all pellicles investigated , but the level could be different from pellicle to pellicle . In L_4 pellicle it is low ($D_s \backsim 0.2\mu$). In G_5 pellicles (TS 2, 3, 4 & 7) it is moderately large ($\bar{D}_s = 0.4\mu \div 0.8\mu$ at 2 mm cell). In the K_5 pellicle $\bar{D}_s$ is small for the most part , but in the central region it is abnormally high(Mean value 2μ and Max: value 5μ). This suggests that in this pellicle it is unlikely that spurious scattering would have come about due to processing regime. Since measurements in most of the pellicles suggest that $\bar{D}_s$ is constant in a pellicle within a factor of 2. In the K_5 pellicle spurious scattering might therefore exist due to reasons other than that of proessing . It may very well arise from gelatin giving way due to defects in pouring.

2.3. D_2 (s) & D_3 (s) Variation with cell length:

In Fig. 2(a) and (b) are shown the variation of D_2(s) and D_3(s) with cell lengths between 2mm and 12mm . To a good approximation both D_2(s) & D_3(s) may be represented by a straight line. The straight line fit was previously pointed out by Yashpal & Ray [8]. The slopes appear to be different in various pellicles.

2.4. Variation of D_2 (s) with depth:

Biswas et al[9] had shown that in one stack there was significant variation of $\bar{D}_2$(s) with respect to the depth, being more near the surface and less near the glass, while another stack had similar variation but to a smaller extent. Table II shows that in L_4 pellicle $\bar{D}_2$(s) is practically constant; while in G_5 pellicles it appears to increase from glass to surface . In Ortholux microscope, it is found that grain noise varies with grain density because of the limited length of filar. This factor has been taken into account . It is possible that mechanical stresses such as those which are caused in mounting the pellicle on the glass by a light roller, can distort the emulsion more on the surface.

2.5. Variation of $\bar{D}_2$ (s) with dip:

Neighbouring beam tracks of different dip angles were compared. Fig 3 shows the variation of $\bar{D}_s$ with cell length for two sets of dip angles in G_5 pellicles. In general the level of spurious scattering rises with the dip of the track. This result is in agreement with that of Biswas et al[6] and Jones & Kalbach [10].

2.6. Variation of D_s in z - direction:

Aditya at al [11] have found that the z-component of $\bar{D}_s$ is larger than the corresponding y-component (which is usually measured) by a factor of 4. Similar observations are given the absolute mean values of Φ_n for all the tracks, in various differences at 2 mm cell length. Φ_n becomes fairly small from third difference onwards. No attempt was made to employ the method of algebraic mean[1] in order to correct for C-shaped distortion , since the wavy nature of tracks tends to render this method questionable. To summarise then, ρ_s is by no means unique. Thus Lohrmann and Teucher[5] obtain $\rho_s = 1.45 \pm 0.034$; Chasnikov[7] obtains 1.75 ± 0.02 and 1.81 ± 0.09; while Yash Pal and Ray[8] have shown $\rho_s = 1.61 \pm 0.03$; and our own observations suggest $\rho_s \sim 1$.

Table II also shows the effect of randomization on differences of higher order. This is understood by representing the contours of the tracks by a polynomial of degree n plus a random component. The latter embodies Coulomb, noise and a part of spurious scattering. The second column shows μ_2 the second moment about zero. In the third column are given a set of numbers appropriate for various order of difference n, well known in the theory of randomization[9,10]. It is seen from the fourth column that the value μ_2/x becomes almost constant from the fourth difference onwards. This procedure is similar to the one used by Lavakare and Sudershan[10] .

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TABLE II

n	$\mu_{\sim}$	x	$\mu_{\sim}/x$	$p_{r\sim}$
2	0.279	6	0.0465	0.186
3	0.584	20	0.0292	0.088
4	1.766	70	0.0252	0.033
5	5.819	252	0.0231	0.028
6	21.064	924	0.0228	0.025
7	75.750	3432	0.0221	0.028
8	281.434	12870	0.0219	0.027
9	1015.421	48620	0.0209	0.026
10	3583.711	184756	0.0194	0.026

Fig 1 shows the variation of D_s with cell length. To a good approximation it may be fitted up by a straight line in the range 2 mm to 10 mm; with a slope of 1.6/cm. Marzari - Chiesa and Wataghin[11)] have obtained a linear variation $D_s = 2t$, upto 4 cms. Lohrmann and Teucher[5)] also point out a linear dependence expressed by $D_s = 4.2\ t$. Yash Pal and Ray [8)] obtain a linearity between 200 μ and 8 mm , which may be expressed by $D_s = 1.2\ t$ in one of their pellicles.

In our observations , however, if the curve is to pass through 1 mm point and the origin as well , a power law of the type $D_s = at^x$ appears to be a better choice. A least square fit gives $a = 0.098 \pm 0.003$ and $x = 1.26 \pm 0.045$.

In table III are given the results of other authors for the power law fit. The straight line fit is shown by $x = 1$.

Various methods for the elimination of spurious scattering have been examined in order to investigate their relative merits. The first one uses the information on the average D_s obtained from equation (1) for the entire data. This value of D_s (t= 2mm)

TABLE III

Authors	Lohrmann & Teucher[5]	Chasnikov[7]	Pal & Ray[8]	Marzari-Chiesa & Wataghin[11]	Biswas et al[12]
x	~ 1	0.5	1	1	1.57 ÷ 1.11

Authors	Fay[13]	Brisbout et al[14]	Apostolakis et al[15]	Bozoki et al[16]	Present Experiment
x	~ 1	1; 0.7	~ 1	1.22 ± 0.17	1.26 ± 0.045

together with $\bar{D}_N$ was subtracted quadratically , in individual tracks; and the resulting $\bar{D}_c$ values were used to evaluate the scattering constant K_{co}.

In the second method , which is a variation of the previous one, $\bar{T}_s$ was used in order to evaluate T_c for individual tracks, using equation (2). This was converted into D_c, through $\rho_c = T_c/D_c = 1.3$.

In the third method , the variation of D_s with cell length is assumed to be linear[8]. The observed values $D_o(2)$ and $D_o(4)$ at 2 mm and 4mm for individual tracks were used and D_c at 2mm was evaluated from D_c .

The method used by Chasnikov[7] and Iursonov et al[17] based on the information on both ρ_s and ρ_c , is rendered impracticible since ρ_s is of the order of ρ_c in the pellicles investigated.

Fig. 2 , shows the distribution of K_{co} values obtained from the first three methods. The Standard Deviation for these distributions is also indicated.

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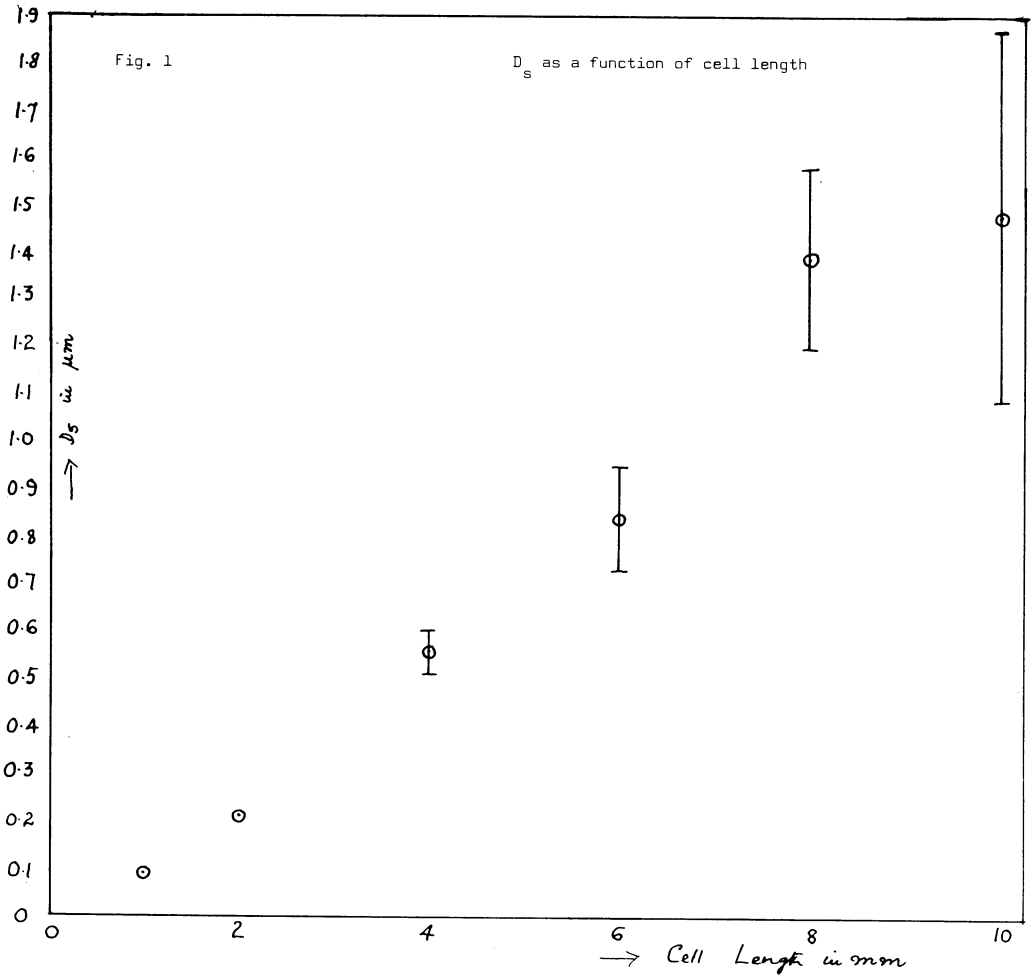

Fig. 1
D_s as a function of cell length
→ D_s in μm
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
1·7
1·8
1·9
0
2
4
6
8
10
→ Cell Length in mm

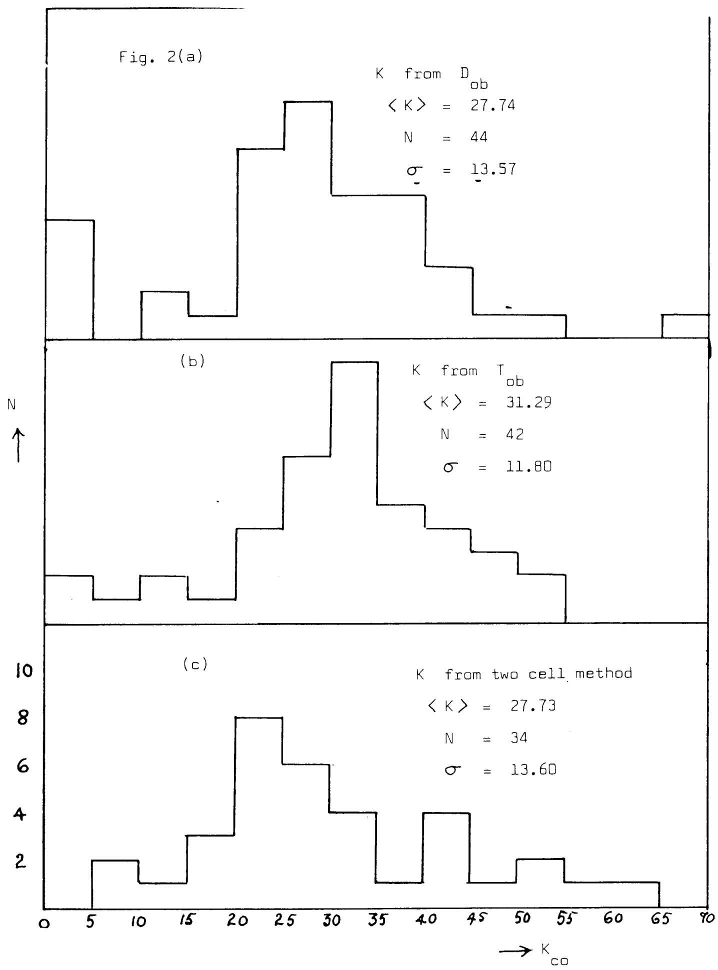

Fig. 2(a)
K from D_{ob}
$\langle K \rangle$ = 27.74
N = 44
σ = 13.57
(b)
K from T_{ob}
$\langle K \rangle$ = 31.29
N = 42
σ = 11.80
N ↑
(c)
K from two cell method
$\langle K \rangle$ = 27.73
N = 34
σ = 13.60
10
8
6
4
2
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
→ K_{co}