

PAG: Determination of the half-thickness of aluminium

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Y LINEAR REGRESSION of $\ln I/\text{Bq}$ (Figure 1) against x/mm , I determined the value of the half thickness of aluminium as $x_{1/2} = 0.000\,379\,6\text{ m}$, or about 0.38 mm. As an order of magnitude, this is consistent with common sense, as, very roughly speaking, the intensity halved when adding about 0.5 mm of aluminium.

A less precise calculation from the fitted exponential curve in Figure 2, and particularly the consideration of the points (0.515 mm, 18.00 Bq) and (0.894 mm, 9.01 Bq) suggests a half-thickness of about $(0.894 - 0.515)\text{mm} = 0.379\text{ mm}$, which is consistent with the actual analysis.

```
1 library(ggplot2)
2
3 dt = 10
4 C_bg = (3 + 0 + 2) / 3
5
6 ratio_U_C = 1.1
7 U_x = 0.5e-3 / 100
8
9 N = 500
10
11 beta_df <- read.table("data.csv", sep=",", header=TRUE)
12 beta_df$x <- beta_df$x * 1e-3
13 beta_df$I <- (rowMeans(beta_df[c("C1", "C2", "C3")]) - C_bg) / dt
14
15 show(beta_df)
16 show(log(beta_df$I))
17
18 model <- lm(log(I) ~ x, data=beta_df)
19 summary(model)
20 mu <- coef(summary(model))["x", "Estimate"]
21 x_half = log(2) / mu
22 print(paste("Half thickness: ", x_half))
23
24 qplot(x, log(I), data=beta_df,
25       main="Linearised intensity vs thickness of absorbent aluminium",
26       xlab="x/m", ylab="ln(I/Bq)") +
27   geom_errorbarh(data=beta_df,
28                 mapping=aes(xmin=x-U_x,
29                             xmax=x+U_x)) +
30   geom_errorbar(data=beta_df,
31                 mapping=aes(ymin=log(I / ratio_U_C),
32                             ymax=log(I * ratio_U_C))) +
```

```

33     theme(panel.grid.minor = element_line(colour="gray", size=0.4),
34           panel.grid.major = element_line(colour="gray", size=1),
35           panel.background = element_blank()) +
36     geom_smooth(method="lm")
37
38 prediction <- data.frame(
39   x = c(beta_df$x, seq(min(beta_df$x), max(beta_df$x), length.out=N)),
40   I = c(beta_df$I, rep(NA, N))
41 )
42 prediction$pred <- exp(predict(model, prediction))
43
44 #show(prediction)
45
46 qplot(x, I, data=beta_df,
47       main="Intensity vs thickness of absorbent aluminium",
48       xlab="x/m", ylab="I/Bq") +
49   geom_errorbarh(data=beta_df,
50                 mapping=aes(xmin=x-U_x,
51                             xmax=x+U_x)) +
52   geom_errorbar(data=beta_df,
53                 mapping=aes(ymin=(I / ratio_U_C),
54                             ymax=(I * ratio_U_C))) +
55   theme(panel.grid.minor = element_line(colour="gray", size=0.4),
56         panel.grid.major = element_line(colour="gray", size=1),
57         panel.background = element_blank()) +
58   geom_line(size=1, color="steelblue", data = prediction, aes(y = pred))

```

Listing 1: Source code of the program analyse.r.

```

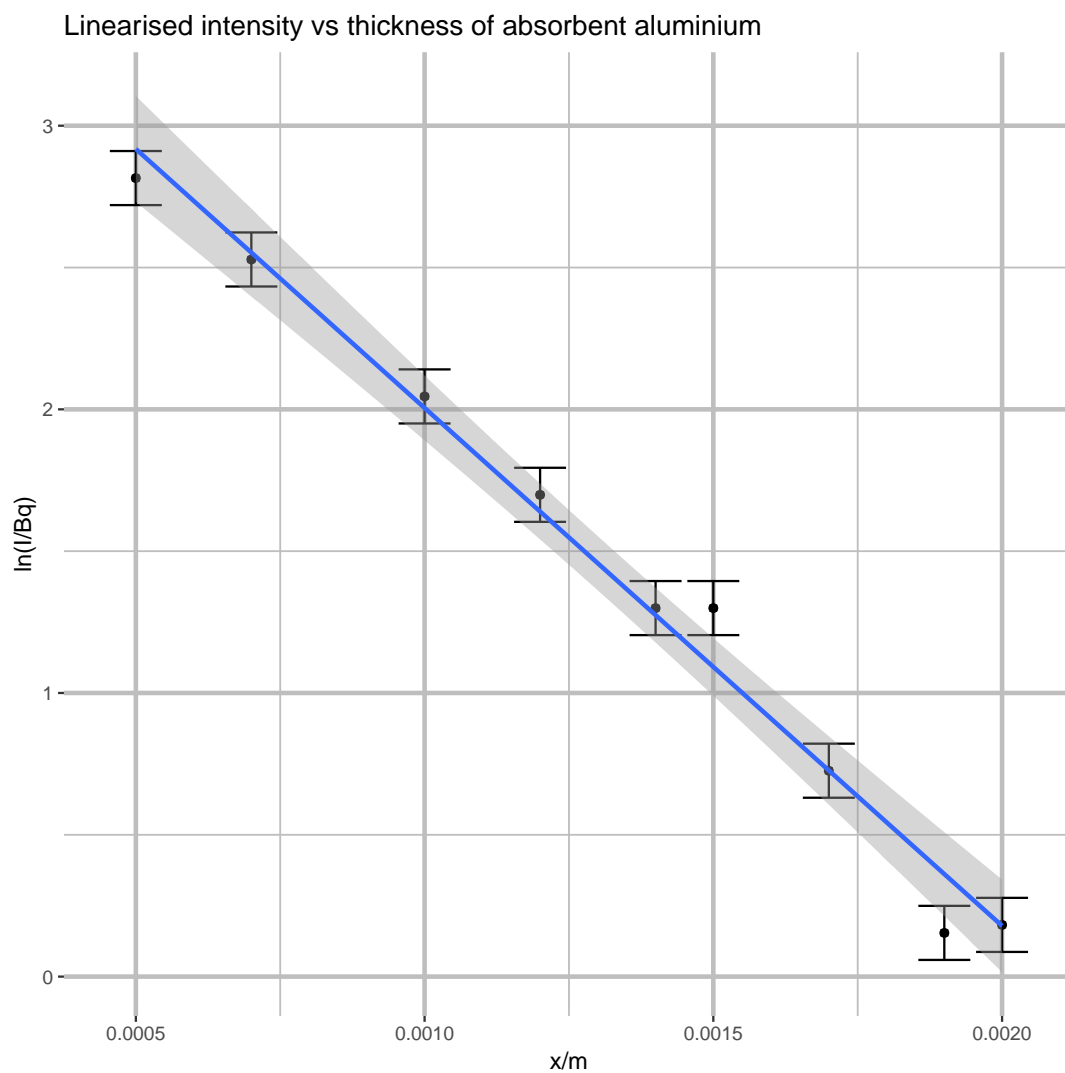
1      x  C1  C2  C3      I
2  1 0.0005 178 155 173 16.700000
3  2 0.0007 126 136 119 12.533333
4  3 0.0010  83  64  90  7.733333
5  4 0.0012  55  56  58  5.466667
6  5 0.0014  37  37  41  3.666667
7  6 0.0015  39  39  37  3.666667
8  7 0.0017  23  15  29  2.066667
9  8 0.0019  18  14   8  1.166667
10 9 0.0020  15  13  13  1.200000
11 [1] 2.8154087 2.5283918 2.0455400 1.6986690 1.2992830 1.2992830 0.7259370
12 [8] 0.1541507 0.1823216
13
14 Call:
15 lm(formula = log(I) ~ x, data = beta_df)
16
17 Residuals:
18      Min       1Q   Median       3Q      Max
19 -0.207413 -0.024306  0.003353  0.040626  0.207342
20
21 Coefficients:
22      Estimate Std. Error t value Pr(>|t|)

```

```

23 (Intercept)      3.8309      0.1164      32.91 6.19e-09 ***
24 x             -1825.9453     82.5616     -22.12 9.76e-08 ***
25 ---
26 Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
27
28 Residual standard error: 0.1212 on 7 degrees of freedom
29 Multiple R-squared:  0.9859,      Adjusted R-squared:  0.9839
30 F-statistic: 489.1 on 1 and 7 DF,  p-value: 9.764e-08
31
32 [1] "Half thickness: -0.000379610048983322"

```

Listing 2: Output of `analyse.r` (1) when run.Figure 1: Plot of $\ln I/Bq$ against x/mm

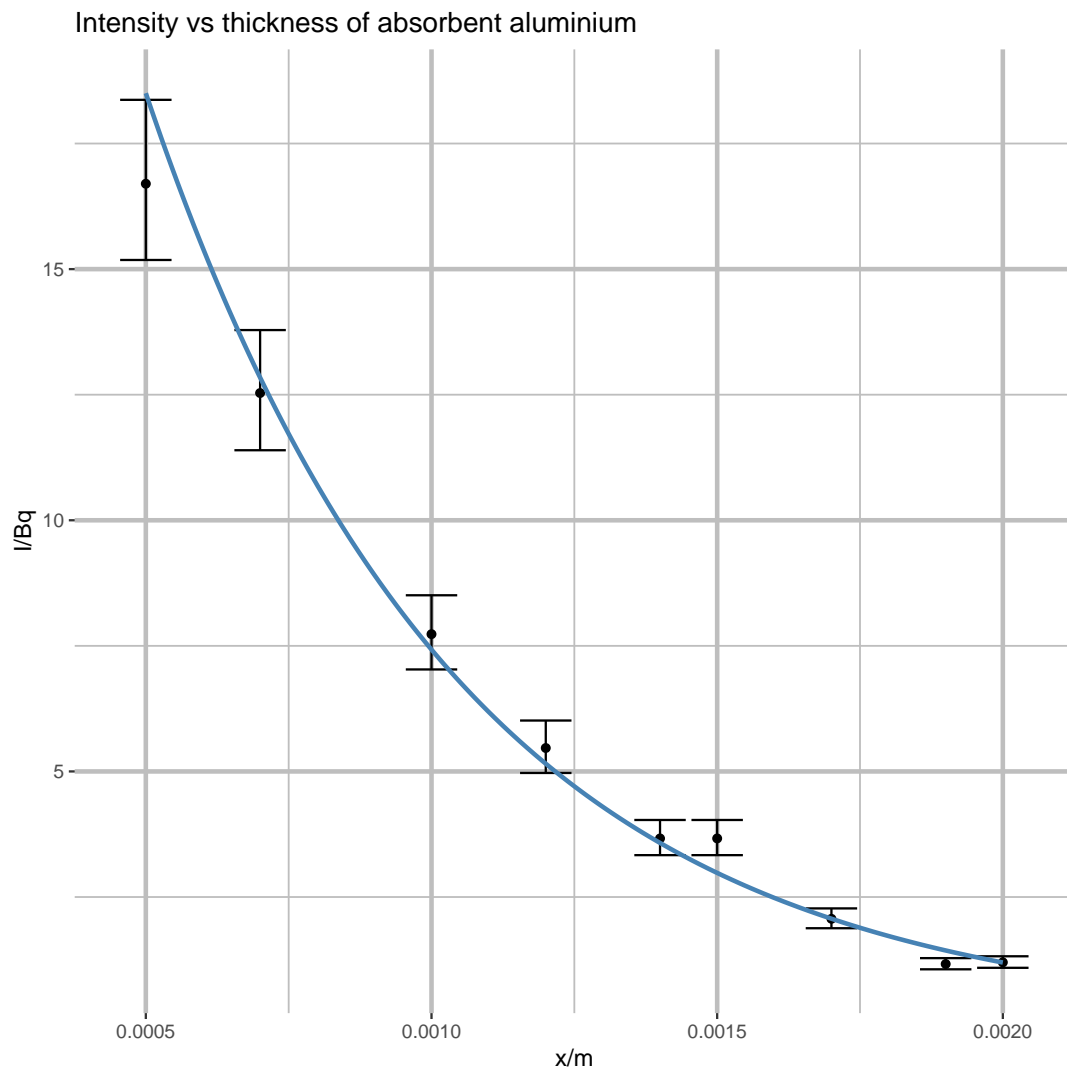


Figure 2: Plot of maximum displacements in experiment 2.