

弗兰克-赫兹实验

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1 汞管与氩管测量结果

1.1 汞管

参数设置：反向电压 $U_3 = 1.99\text{ V}$ ， $U_1 = 1.00\text{ V}$ ，汞蒸汽温度 $\theta = 175^\circ\text{C}$

| i | 1 | 2 | 3 | 4 | 5 | 6 |
|----------------|-----|------|------|------|------|------|
| U_2/V | 5.5 | 10.5 | 15.3 | 20.3 | 25.4 | 30.6 |

表 1: 粗测峰位置

表 2: 汞管实验数据表

| U_2/V | U_{out}/mV | U_2/V | U_{out}/mV | U_2/V | U_{out}/mV | U_2/V | U_{out}/mV |
|----------------|---------------------|----------------|---------------------|----------------|---------------------|----------------|---------------------|
| 0.0 | 9.8 | 9.2 | 44.5 | 16.5 | 34.2 | 25.1 | 356.2 |
| 0.4 | 9.9 | 9.4 | 52.5 | 16.7 | 25.3 | 25.3 | 339.0 |
| 0.8 | 9.7 | 9.6 | 64.3 | 17.0 | 17.1 | 25.4 | 331.9 |
| 1.3 | 10.1 | 9.8 | 85.6 | 17.3 | 17.6 | 25.5 | 313.3 |
| 1.5 | 10.1 | 9.9 | 91.9 | 17.7 | 25.6 | 25.8 | 249.7 |
| 1.8 | 9.9 | 10.1 | 106.6 | 17.9 | 33.6 | 26.0 | 200.4 |
| 2.1 | 9.8 | 10.4 | 120.0 | 18.3 | 58.3 | 26.3 | 135.7 |
| 2.4 | 10.4 | 10.6 | 108.3 | 18.6 | 90.0 | 26.6 | 84.0 |
| 2.6 | 10.1 | 10.7 | 86.6 | 18.8 | 115.7 | 27.0 | 64.4 |
| 3.0 | 10.3 | 10.8 | 73.1 | 19.0 | 123.0 | 27.3 | 64.6 |
| 3.3 | 10.3 | 11.0 | 51.5 | 19.5 | 203.6 | 27.6 | 56.9 |
| 3.6 | 11.3 | 11.2 | 34.3 | 19.6 | 224.6 | 27.8 | 62.7 |
| 3.8 | 12.6 | 11.6 | 18.4 | 19.7 | 225.5 | 28.1 | 82.0 |
| 4.1 | 12.2 | 12.1 | 12.8 | 19.9 | 258.9 | 28.3 | 106.7 |
| 4.3 | 13.3 | 12.4 | 12.2 | 20.1 | 272.6 | 28.5 | 133.0 |
| 4.6 | 16.4 | 12.8 | 18.9 | 20.3 | 261.9 | 28.7 | 165.2 |
| 4.8 | 19.6 | 13.3 | 36.2 | 20.5 | 217.0 | 28.9 | 190.6 |
| 4.9 | 21.6 | 13.7 | 62.3 | 20.7 | 187.3 | 29.2 | 263.7 |

表 2 (续)

| U_2/V | U_{out}/mV | U_2/V | U_{out}/mV | U_2/V | U_{out}/mV | U_2/V | U_{out}/mV |
|----------------|---------------------|----------------|---------------------|----------------|---------------------|----------------|---------------------|
| 5.1 | 25.6 | 13.9 | 82.6 | 20.8 | 173.7 | 29.4 | 306.1 |
| 5.3 | 27.4 | 14.1 | 94.4 | 21.3 | 91.5 | 29.6 | 342.5 |
| 5.6 | 33.3 | 14.2 | 96.9 | 21.6 | 50.6 | 29.9 | 375.0 |
| 5.7 | 35.4 | 14.4 | 115.9 | 22.0 | 31.1 | 30.0 | 382.2 |
| 5.8 | 34.4 | 14.6 | 150.6 | 22.3 | 29.3 | 30.1 | 385.6 |
| 5.9 | 29.3 | 14.7 | 161.5 | 22.6 | 34.5 | 30.2 | 387.1 |
| 6.0 | 29.1 | 14.8 | 167.9 | 23.0 | 58.4 | 30.3 | 376.4 |
| 6.2 | 22.6 | 15.0 | 192.4 | 23.3 | 84.6 | 30.5 | 356.0 |
| 6.5 | 14.1 | 15.1 | 206.6 | 23.6 | 122.4 | 30.8 | 312.3 |
| 6.8 | 12.3 | 15.2 | 204.1 | 23.8 | 151.6 | 30.9 | 285.7 |
| 7.0 | 10.9 | 15.3 | 195.4 | 24.0 | 197.1 | 31.0 | 257.7 |
| 7.4 | 11.0 | 15.5 | 172.6 | 24.3 | 255.1 | 31.2 | 231.4 |
| 7.8 | 12.2 | 15.6 | 144.2 | 24.4 | 276.2 | 31.3 | 209.7 |
| 8.3 | 17.0 | 15.9 | 96.6 | 24.6 | 319.0 | 31.5 | 171.8 |
| 8.7 | 24.2 | 16.0 | 82.7 | 24.7 | 321.0 | 31.7 | 148.7 |
| 9.0 | 35.4 | 16.3 | 46.3 | 25.0 | 355.3 | | |

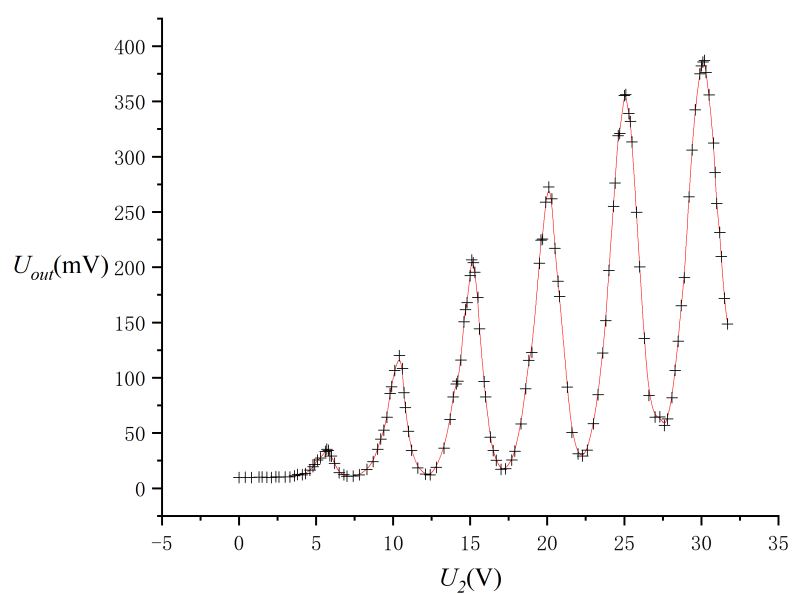


图 1: 汞管第一激发态弗兰克-赫兹曲线

| i | 1 | 2 | 3 | 4 | 5 | 6 |
|----------------|-----|------|------|------|------|------|
| U_2/V | 5.7 | 10.4 | 15.1 | 20.1 | 25.1 | 30.2 |

表 3: U_{out} 达到极大值时对应 U_2 的值

对表 3 中的数据点进行线性拟合, $U_2 = a + ib$

$$a = 0.61 \pm 0.17\text{V} \quad (1)$$

$$b = 4.90 \pm 0.05\text{V} \quad (2)$$

$$r = 0.99985 \quad (3)$$

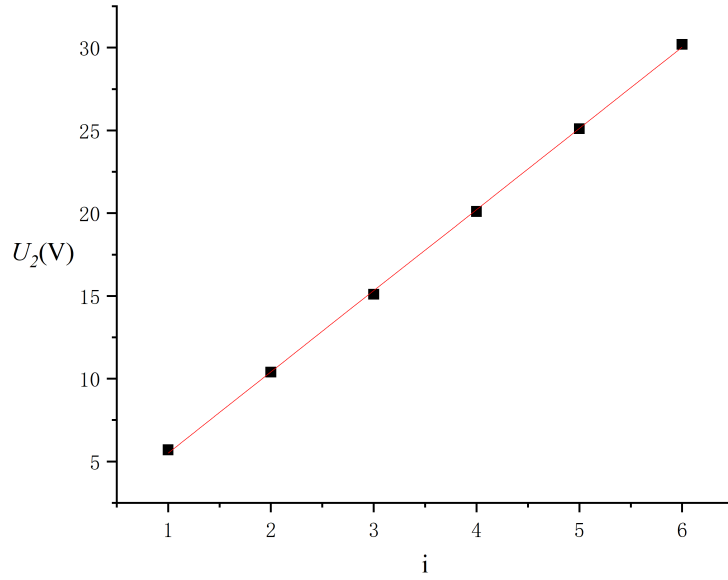


图 2: 峰序拟合曲线

拟合所得到的 b 即为汞的第一激发电位

$$U = 4.90 \pm 0.05\text{V} \quad (4)$$

1.2 氙管

参数设置: $V_{HH} = 2.7\text{V}$, $V_{AG_2} = 6.5\text{V}$, $V_{G_1K} = 2.0\text{V}$

| i | 1 | 2 | 3 | 4 | 5 | 6 |
|----------------|------|------|------|------|------|------|
| V_2/V | 17.3 | 30.0 | 40.0 | 52.5 | 65.3 | 78.2 |

表 4: 粗测峰位置

表 5: 氩管实验数据表

| U_{G_2K}/V | $I/10^{-9}A$ | U_{G_2K}/V | $I/10^{-9}A$ | U_{G_2K}/V | $I/10^{-9}A$ | U_{G_2K}/V | $I/10^{-9}A$ |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 0.0 | -0.5 | 26.4 | 57.7 | 44.7 | 17.6 | 65.6 | 111.0 |
| 1.8 | -0.5 | 27.1 | 62.1 | 45.2 | 13.0 | 65.9 | 108.0 |
| 2.3 | -0.6 | 27.4 | 62.8 | 45.7 | 15.9 | 66.3 | 103.5 |
| 3.0 | -0.6 | 27.7 | 63.7 | 46.3 | 28.1 | 67.0 | 94.2 |
| 3.8 | -0.5 | 28.2 | 64.3 | 46.9 | 40.0 | 67.4 | 85.6 |
| 4.7 | -0.5 | 28.5 | 63.9 | 47.3 | 49.8 | 67.8 | 79.0 |
| 5.3 | -0.5 | 28.8 | 63.4 | 47.7 | 59.2 | 68.2 | 69.9 |
| 6.1 | -0.6 | 29.1 | 62.3 | 48.4 | 73.3 | 68.6 | 64.5 |
| 7.1 | -0.5 | 29.4 | 60.6 | 49.2 | 84.3 | 69.1 | 59.8 |
| 7.7 | -0.5 | 30.2 | 53.4 | 50.1 | 95.1 | 69.6 | 58.9 |
| 8.4 | -0.4 | 30.7 | 46.8 | 50.6 | 98.0 | 70.1 | 61.1 |
| 9.3 | 1.6 | 31.5 | 34.1 | 51.0 | 99.4 | 70.8 | 67.3 |
| 10.1 | 9.0 | 32.1 | 22.6 | 51.4 | 100.5 | 71.6 | 78.6 |
| 11.1 | 23.4 | 32.9 | 13.2 | 52.1 | 100.2 | 72.3 | 88.3 |
| 11.5 | 25.7 | 33.6 | 8.7 | 52.3 | 99.4 | 72.9 | 96.8 |
| 12.0 | 29.6 | 34.3 | 13.1 | 52.5 | 98.8 | 73.9 | 110.0 |
| 12.4 | 31.4 | 34.9 | 26.7 | 52.7 | 97.4 | 74.5 | 117.6 |
| 12.9 | 34.1 | 35.5 | 43.2 | 53.1 | 94.7 | 74.8 | 119.6 |
| 13.6 | 36.8 | 36.1 | 53.0 | 53.7 | 88.3 | 75.1 | 122.5 |
| 14.4 | 39.2 | 36.7 | 64.0 | 54.2 | 81.2 | 75.3 | 124.0 |
| 15.1 | 41.1 | 37.1 | 69.6 | 54.6 | 73.7 | 75.6 | 126.4 |
| 15.6 | 41.2 | 37.3 | 70.2 | 55.1 | 64.2 | 75.8 | 128.1 |
| 16.0 | 41.1 | 37.5 | 72.8 | 55.4 | 57.4 | 76.2 | 129.8 |
| 16.4 | 40.7 | 37.8 | 75.6 | 55.7 | 50.3 | 76.6 | 131.6 |
| 16.7 | 40.6 | 38.1 | 77.7 | 56.5 | 35.1 | 77.1 | 132.6 |
| 17.1 | 40.5 | 38.6 | 80.6 | 57.0 | 30.6 | 77.6 | 132.5 |
| 17.7 | 40.1 | 38.8 | 82.0 | 57.4 | 31.4 | 78.0 | 131.6 |
| 18.2 | 38.7 | 39.0 | 82.5 | 58.1 | 40.0 | 78.3 | 130.4 |
| 18.6 | 36.9 | 39.3 | 83.5 | 58.6 | 49.2 | 78.7 | 126.9 |
| 19.3 | 33.3 | 39.6 | 83.9 | 59.2 | 60.1 | 79.2 | 122.2 |
| 19.8 | 29.4 | 39.9 | 84.0 | 59.8 | 71.1 | 80.2 | 109.4 |
| 20.5 | 24.5 | 40.1 | 83.6 | 60.5 | 83.4 | 80.8 | 101.7 |
| 21.1 | 19.5 | 40.3 | 82.8 | 61.8 | 103.6 | 81.1 | 98.1 |
| 21.7 | 15.2 | 40.8 | 80.6 | 62.4 | 108.1 | 81.8 | 93.2 |
| 22.3 | 12.8 | 41.1 | 77.9 | 62.8 | 111.5 | 82.4 | 91.6 |
| 22.9 | 13.3 | 41.6 | 72.9 | 63.4 | 115.1 | 83.1 | 93.2 |

表 5 (续)

| U_{G_2K}/V | $I/10^{-9}A$ | U_{G_2K}/V | $I/10^{-9}A$ | U_{G_2K}/V | $I/10^{-9}A$ | U_{G_2K}/V | $I/10^{-9}A$ |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 23.7 | 22.0 | 42.1 | 66.6 | 63.8 | 116.3 | 83.9 | 98.4 |
| 24.1 | 29.4 | 42.7 | 54.9 | 64.4 | 116.7 | 84.4 | 107.3 |
| 25.0 | 44.1 | 43.4 | 41.1 | 64.8 | 115.8 | 85.7 | 117.0 |
| 25.9 | 53.4 | 43.9 | 30.5 | 65.1 | 114.5 | | |

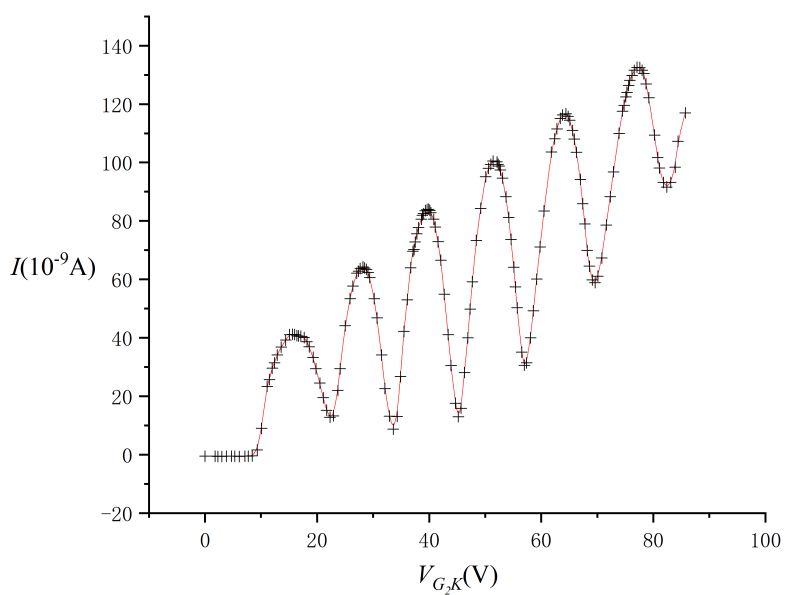


图 3: 氖管第一激发态弗兰克-赫兹曲线

| i | 1 | 2 | 3 | 4 | 5 | 6 |
|--------------|------|------|------|------|------|------|
| V_{G_2K}/V | 15.1 | 27.7 | 39.3 | 51.4 | 63.8 | 77.1 |

表 6: I 达到极大值时对应 V_{G_2K} 的值

对表 6 中的数据点进行线性拟合, $V_{G_2K} = a + ib$

$$a = 2.7 \pm 0.5V \quad (5)$$

$$b = 12.30 \pm 0.12V \quad (6)$$

$$r = 0.99981 \quad (7)$$

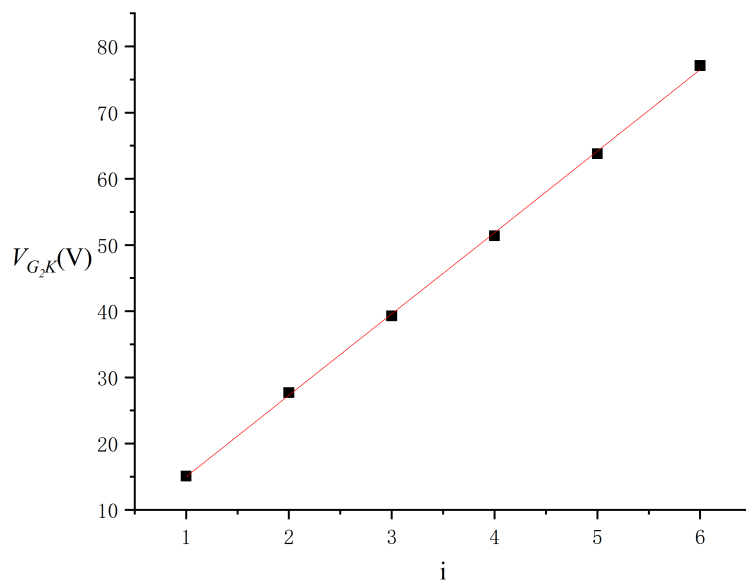


图 4: 峰序拟合曲线

拟合所得到的 b 即为氙的第一激发电位

$$U = 12.30 \pm 0.12V \quad (8)$$

2 改变反向电压

使用汞管，在其他条件一定的情况下 ($U_1 = 1.00 V$ ，汞蒸汽温度 $\theta = 175^\circ C$)，改变反向电压 U_3 ，分别取 $U_3 = 0.95 V, 1.99 V, 3.04 V$ ，考虑最后两组峰的差别。

表 7: 汞管实验数据表

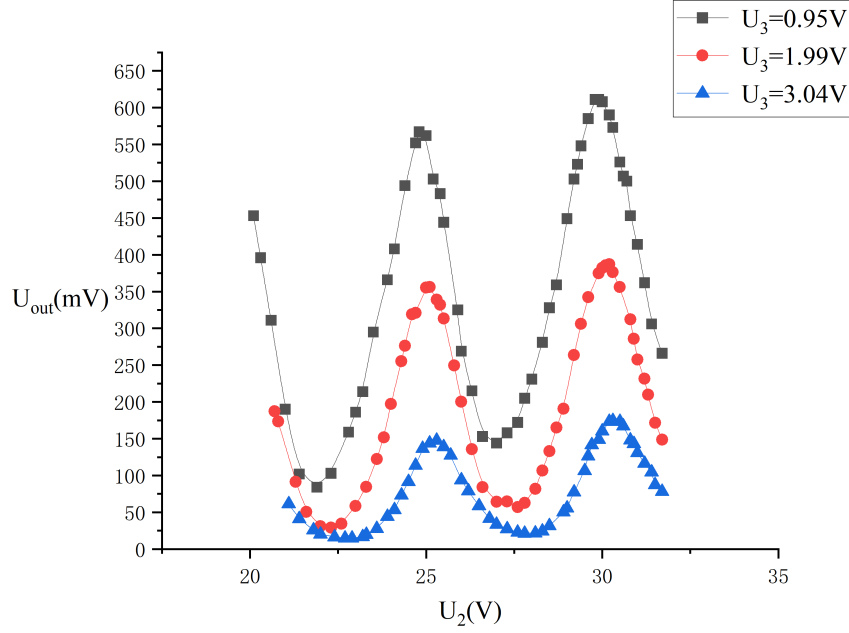
| $U_3 = 0.95 V$ | | $U_3 = 1.99 V$ | | $U_3 = 3.04 V$ | |
|----------------|--------------|----------------|--------------|----------------|--------------|
| U_2/V | U_{out}/mV | U_2/V | U_{out}/mV | U_2/V | U_{out}/mV |
| 20.1 | 453 | 20.7 | 187.3 | 21.1 | 61.3 |
| 20.3 | 396 | 20.8 | 173.7 | 21.4 | 41.0 |
| 20.6 | 311 | 21.3 | 91.5 | 21.8 | 25.8 |
| 21.0 | 190 | 21.6 | 50.6 | 22.0 | 20.2 |
| 21.4 | 102 | 22.0 | 31.1 | 22.4 | 16.3 |
| 21.9 | 84 | 22.3 | 29.3 | 22.7 | 14.8 |
| 22.3 | 103 | 22.6 | 34.5 | 22.9 | 14.7 |
| 22.8 | 159 | 23.0 | 58.4 | 23.2 | 16.8 |
| 23.0 | 186 | 23.3 | 84.6 | 23.3 | 19.8 |

表 7 (续)

| U_2/V | U_{out}/mV | U_2/V | U_{out}/mV | U_2/V | U_{out}/mV |
|----------------|---------------------|----------------|---------------------|----------------|---------------------|
| 23.2 | 214 | 23.6 | 122.4 | 23.6 | 27.8 |
| 23.5 | 295 | 23.8 | 151.6 | 23.9 | 44.2 |
| 23.9 | 366 | 24.0 | 197.1 | 24.1 | 53.3 |
| 24.1 | 408 | 24.3 | 255.1 | 24.3 | 73.2 |
| 24.4 | 494 | 24.4 | 276.2 | 24.5 | 91.4 |
| 24.7 | 552 | 24.6 | 319.0 | 24.7 | 113.7 |
| 24.8 | 567 | 24.7 | 321.0 | 24.9 | 136.5 |
| 25.0 | 562 | 25.0 | 355.3 | 25.1 | 144.0 |
| 25.2 | 503 | 25.1 | 356.2 | 25.3 | 147.9 |
| 25.4 | 483 | 25.3 | 339.0 | 25.5 | 138.9 |
| 25.5 | 444 | 25.4 | 331.9 | 25.7 | 127.6 |
| 25.9 | 325 | 25.5 | 313.3 | 26.0 | 93.7 |
| 26.0 | 269 | 25.8 | 249.7 | 26.2 | 78.9 |
| 26.3 | 215 | 26.0 | 200.4 | 26.5 | 58.6 |
| 26.6 | 153 | 26.3 | 135.7 | 26.8 | 41.5 |
| 27.0 | 144 | 26.6 | 84.0 | 27.0 | 33.5 |
| 27.3 | 158 | 27.0 | 64.4 | 27.3 | 27.5 |
| 27.6 | 172 | 27.3 | 64.6 | 27.6 | 22.8 |
| 27.8 | 205 | 27.6 | 56.9 | 27.8 | 21.4 |
| 28.0 | 231 | 27.8 | 62.7 | 28.1 | 21.7 |
| 28.3 | 281 | 28.1 | 82.0 | 28.3 | 24.4 |
| 28.5 | 328 | 28.3 | 106.7 | 28.5 | 31.5 |
| 28.7 | 359 | 28.5 | 133.0 | 28.9 | 50.3 |
| 29.0 | 449 | 28.7 | 165.2 | 29.0 | 55.8 |
| 29.2 | 503 | 28.9 | 190.6 | 29.2 | 77.5 |
| 29.3 | 523 | 29.2 | 263.7 | 29.5 | 106.5 |
| 29.4 | 548 | 29.4 | 306.1 | 29.6 | 126.4 |
| 29.6 | 585 | 29.6 | 342.5 | 29.7 | 141.5 |
| 29.8 | 611 | 29.9 | 375.0 | 29.9 | 148.7 |
| 29.9 | 611 | 30.0 | 382.2 | 30.0 | 160.4 |
| 30.0 | 608 | 30.1 | 385.6 | 30.2 | 173.2 |
| 30.2 | 590 | 30.2 | 387.1 | 30.3 | 174.3 |
| 30.3 | 573 | 30.3 | 376.4 | 30.5 | 173.5 |
| 30.5 | 526 | 30.5 | 356.0 | 30.6 | 167.3 |
| 30.6 | 507 | 30.8 | 312.3 | 30.8 | 148.3 |
| 30.7 | 500 | 30.9 | 285.7 | 30.9 | 143.3 |
| 30.8 | 453 | 31.0 | 257.7 | 31.0 | 130.8 |

表 7 (续)

| U_2/V | U_{out}/mV | U_2/V | U_{out}/mV | U_2/V | U_{out}/mV |
|----------------|---------------------|----------------|---------------------|----------------|---------------------|
| 31.0 | 414 | 31.2 | 231.4 | 31.2 | 116.5 |
| 31.2 | 362 | 31.3 | 209.7 | 31.4 | 104.7 |
| 31.4 | 306 | 31.5 | 171.8 | 31.5 | 87.5 |
| 31.7 | 266 | 31.7 | 148.7 | 31.7 | 78.1 |

图 5: 改变反向电压得到的 $U_{out} - U_2$ 图

| 峰序 | $U_3 = 0.95 \text{ V}$ | $U_3 = 1.99 \text{ V}$ | $U_3 = 3.04 \text{ V}$ |
|----|------------------------|------------------------|------------------------|
| 5 | 24.8 | 25.1 | 25.3 |
| 6 | 29.8 | 30.2 | 30.3 |

表 8: 三组反向电压对应峰值电压加速电压 U_2/V

通过图 5 可以很明显的看出反向电压越大, 输出 U_{out} 越小, 这是显然的。因为反向电压越大, 能够克服反向电压到达极板的电子就越少。

在表 8 我们发现, 反向电压越大, 达到峰值所对应的加速电压 U_2 就越大。

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|-------------------------------|------|-------------------------|-----------------------|--------------------------------------|------|------|----------|
| Hg 管 | | | | | | | |
| $\theta = 17.5^\circ\text{C}$ | | $U_1 = 1.00\text{V}$ | | $U_3 = 1.99\text{V}$ ^{2.00} | | | |
| 粗略峰位置 | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| V_2/V | 5.5 | 10.5 | 15.3 | 20.3 | 25.4 | 30.6 | |
| $U_1 = 1.00\text{V}$ | | | | | | | |
| Ar 管 | | | | | | | |
| $V_{HH} = 2.7\text{V}$ | | | | | | | |
| $V_{AG2} = 6.5\text{V}$ | | | | | | | |
| $V_{G1K} = 2.0\text{V}$ | | | | | | | |
| 粗略峰位置 | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| V_2/V | 17.3 | 40.0 30.0 | 52.3 40 | 52.5 | 65.3 | 77.2 | |

图 6: 课上实验记录