Определение скорости звука разными методами

Дифракционная картина

In [9]:
```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
```

In [10]:
```
#Деления винта (для перевода Y)
vint_del = 400 #мкм
```

In [11]:
```
#Частоты
nu_1 = 1.09 #mHz
nu_2 = 1.2 #mHz
nu_3 = 1.4 #mHz
```

Данные для первого эксперимент в формате (m, Y)

In [12]:
```
data1 =[[-3, 8.16],[-2, 8.44], [-1, 8.79], [0, 9.15], [1, 9.45], [2
, 9.79], [3, 10]]
```

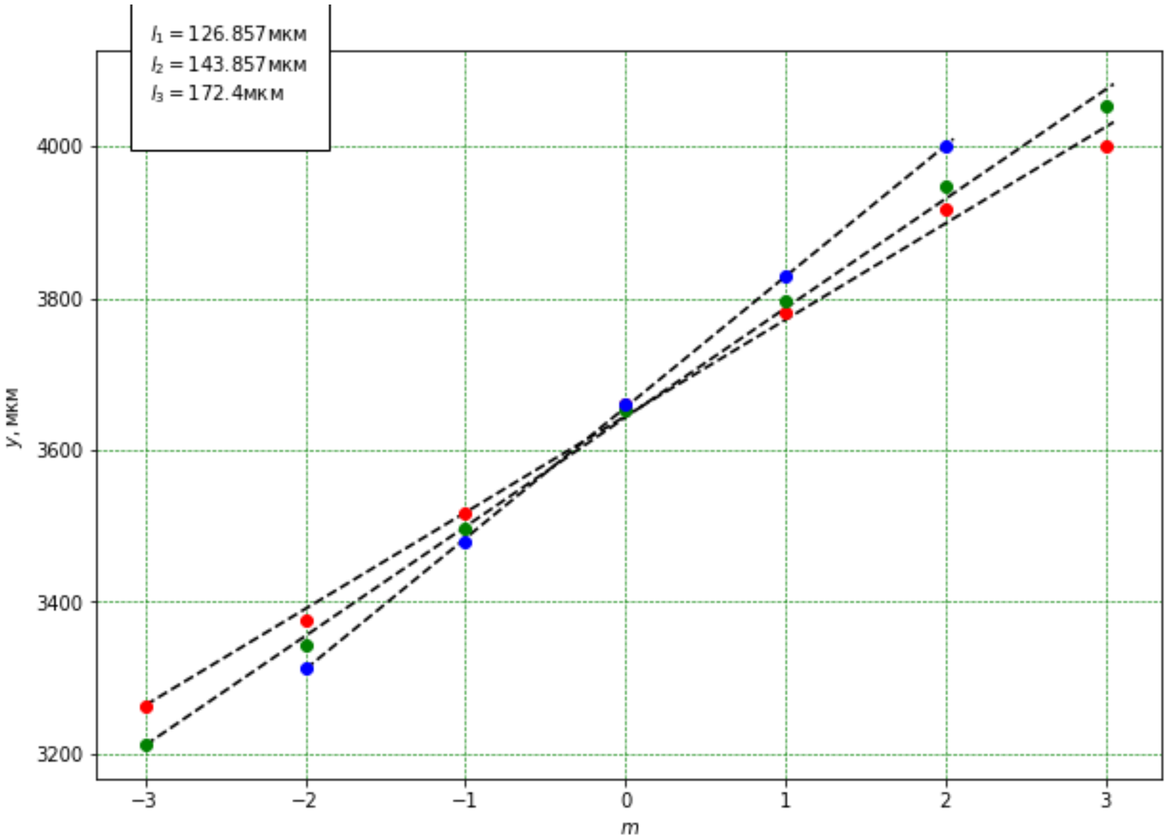
In [13]:
```
data2 = [[-3, 8.03], [-2, 8.36], [-1,8.74], [0, 9.13], [1, 9.49], [
2, 9.87], [3, 10.13]]
```

In [14]:
```
data3 = [[-2, 8.28], [-1, 8.7], [0, 9.15], [1, 9.57], [2, 10]]
```

In [15]:
```
d1 = pd.DataFrame(data=data1, columns=['m', 'Y'])
d2 = pd.DataFrame(data=data2, columns=['m', 'Y'])
d3 = pd.DataFrame(data=data3, columns=['m', 'Y'])
```

In [30]:

```
plt.rcParams["figure.figsize"] = (10,7)
fig, ax = plt.subplots()
ax.grid(color='g', linestyle='--', linewidth=0.6)
ax.grid(color='g', linestyle='--', linewidth=0.1, which = 'minor' )
plt.xlabel(r'$m$')
plt.ylabel(r'$y,$' + u'мкм')

k1, x_01   = np.polyfit(d1['m'], vint_del*d1['Y'], 1)
k2, x_02   = np.polyfit(d2['m'], vint_del*d2['Y'], 1)
k3, x_03   = np.polyfit(d3['m'], vint_del*d3['Y'], 1)
label = r'$l_1 = {}$'.format(round(k1,3)) + u'мкм' + '\n' + r'$l_2 = {}$'.format(round(k2,3)) + u'мкм' + '\n' + r'$l_3 = {}$'.format(round(k3,3)) + u'мкм' + '\n'
ax.text(0.05, 0.9, label, transform=ax.transAxes, bbox={'facecolor':'white', 'edgecolor':'black', 'pad':10})



plt.errorbar(d1['m'], vint_del*d1['Y'],xerr=None, yerr=0.01, fmt='o', color='red')

plt.plot(np.arange(-3, 3.1,0.05),  k1*np.arange(-3,3.1, 0.05) + x_01, 'k--')

plt.errorbar(d2['m'], vint_del*d2['Y'],xerr=None, yerr=0.01, fmt='o', color='green')

plt.plot(np.arange(-3, 3.1,0.05),  k2*np.arange(-3,3.1, 0.05) + x_02, 'k--')

plt.errorbar(d3['m'], vint_del*d3['Y'],xerr=None, yerr=0.01, fmt='o', color='blue')

plt.plot(np.arange(-2, 2.1,0.05),  k3*np.arange(-2,2.1, 0.05) + x_03, 'k--')
plt.savefig('speed_by_difr.png')
plt.show()
```



$$l_m = mf\frac{\lambda}{\Lambda}$$

In [17]:
```
f = 280000 #мкм - фокусное расстония O2
lambda_red = 0.64 #мкм ± 0.02
```

In [18]:
```
L1 = f*lambda_red / k1
L2 = f*lambda_red / k2
L3 = f*lambda_red / k3
```

In [19]:
```
L1err = L1 * (200/6400. + 0.01/d1['Y'].mean())
L2err = L2 * (200/6400. + 0.01/d2['Y'].mean())
L3err = L3 * (200/6400. + 0.01/d3['Y'].mean())
```

In [20]:
```
#длина ультразвуковой волны
print round(L1), r'$\pm$', round(L1err), u'мкм'
print round(L2), r'$\pm$', round(L2err), 'мкм'
print round(L3), r'$\pm$', round(L3err), u'мкм'
```

```
1413.0 $\pm$ 46.0 мкм
1246.0 $\pm$ 40.0 мкм
1039.0 $\pm$ 34.0 мкм
```

In [21]:
```
# скорость звука и средняя скорость
print round(L1*nu_1), L2*nu_2, L3*nu_3
print np.array([L1*nu_1, L2*nu_2, L3*nu_3]).mean().round(3), 'м/с'
```

```
1540.0 1494.8162859980132 1455.2204176334096
1496.595 м/с
```

Метод темного поля

In [22]:
```
scale = 4/1.64
```

Данные для второго эксперимента в формате (ν, l, r, m)

In [23]:
```
data = [[1, 1.38, 3.22, 6], [1.08, 1.08, 3.08, 7], [1.17, 0.94, 3.04, 8], [1.24, 0.94, 3.42, 10], [1.35, 0.9, 3.42, 11] , [1.45, 1.06, 3, 9]]
```

In [24]:
```
d = pd.DataFrame(data = data, columns=['freq', 'l', 'r', 'm'])
```

In [25]:
```
d['len'] = d.apply(lambda row: 2*(row['r'] - row['l'])*scale/row['m'] , axis = 1)
```

In [26]:
```
d['lenerr'] = d.apply(lambda row: row['len'] * (0.01/row['r'] + 0.01/row['l']), axis = 1)
d['freqerr'] = d.apply(lambda row: 0.005, axis = 1)
```

In [31]:
```
d
```

Out[31]:

	freq	l	r	m	len	lenerr	freqerr
0	1.00	1.38	3.22	6	1.495935	0.015486	0.005
1	1.08	1.08	3.08	7	1.393728	0.017430	0.005
2	1.17	0.94	3.04	8	1.280488	0.017834	0.005
3	1.24	0.94	3.42	10	1.209756	0.016407	0.005
4	1.35	0.90	3.42	11	1.117517	0.015684	0.005
5	1.45	1.06	3.00	9	1.051491	0.013425	0.005

In [32]:

```
import numpy as np

plt.rcParams["figure.figsize"] = (10,7)
fig, ax = plt.subplots()
ax.grid(color='g', linestyle='--', linewidth=0.6)
ax.grid(color='g', linestyle='--', linewidth=0.1, which = 'minor' )
plt.xlabel(r'$\nu,\ \frac{1}{MHz}$')
plt.ylabel(r'$\lambda,$' + u'мм')

k, x_0 = np.polyfit(1./d['freq'], d['len'], 1)


xerr = d['freqerr']/(d['freq']**2)
plt.errorbar(1./d['freq'], d['len'], xerr=xerr, yerr=d['lenerr'], f
mt='o', ecolor='red')
er = (xerr.mean()*d['freqerr'].mean() + d['lenerr'].mean()/d['len']
.mean())*k

label = r'$c = {} \pm {}$ '.format(round(k,3), round(er,2)) + u'км/
c'
ax.text(0.05, 0.9, label, transform=ax.transAxes, bbox={'facecolor'
:'white', 'edgecolor':'black', 'pad':10})
plt.plot(np.arange(0.65, 1.06,0.05),  k*np.arange(0.65,1.06, 0.05)
+ x_0, 'k--')
plt.savefig('speed_by_dark_field.png')
plt.show()
```