Лабораторная работа №3

Сокрытие данных в пространственной области неподвижных изображений на основе прямого расширения спектра

по курсу: "Стеганография"

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In [1]:

```
%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt

from PIL import Image
from scipy.linalg import hadamard
from matplotlib.cbook import get_sample_data
```

In [2]:

```
img_tamplate = 'images/img{}.bmp'
steg_img_tamplate = 'images/stego{}.bmp'
text_file = 'text.txt'
eol = '$$'
```

In [3]:

```
def np_2_image(array):
    try:
        return Image.fromarray(array)
    except:
        return None
```

In [4]:

```
def image_2_np(image):
    try:
        return np.array(image)
    except:
        return None
```

In [5]:

```
def open_image_2_np(filename):
    return image_2_np(Image.open(filename))
```

In [6]:

```
def read_text(filename):
    with codecs.open(filename, encoding='ascii', mode='r') as f:
        return f.read().strip()
```

In [7]:

```
def str_2_bin(*args):
    return ''.join(bin(ord(x))[2:].zfill(8) for x in ''.join(args))
```

In [8]:

```
def bin_2_str(binary, length=8):
    bin_l = [binary[i:i+length] for i in range(0, len(binary), length)]
    return ''.join([chr(int(c, 2)) for c in bin_l])
```

In [9]:

```
def chunks(l, n, step=4):
    for i in range(0, len(l) - n + 1, step):
        yield l[i:i + n]
```

Задание №1 - Реализация алгоритмов формирования ансамблей ортогональных дискретных сигналов Уолша-Адамара и алгоритмов кодирования информационных бит данных сложными дискретными сигналами

In [10]:

```
def my_hadamard(k, hmat):
    if 2 ** (k-1) == 1:
        return hmat
    else:
        return np.kron(hmat, my_hadamard(k - 1, hmat))
```

In [11]:

```
def transform_message(bin_array):
    bin_array[bin_array != 1] = -1
    return bin_array
```

In [12]:

```
def inverse_transform_message(array):
    array[array != 1] = 0
    return array
```

In [13]:

```
def get_sum(height, message, matrix, k=4, g=3):
    res = []
    for i in range(height):
        a = sum([g*message[k*i+j]*matrix[j+1] for j in range(k) if k*i+j < len(mess
        if type(a) is int:
                break
        res.append(a)
    return res
```

In [14]:

```
%timeit my_hadamard(8, np.matrix([[1,1],[1,-1]]))
```

```
3.57 ms ± 305 µs per loop (mean ± std. dev. of 7 runs, 100 loops eac
h)
```

Задача №2 - Реализация алгоритмов сокрытия и извлечения данных в пространственной области изображений путем прямого расширения спектров с использованием ортогональных дискретных сигналов

In [15]:

```
def encode(image, message, matrixm, k=4, g=1):
    container = open_image_2_np(image)
    width, height, pix = container.shape
    result = np.copy(container)
    secret_message = str_2_bin(message, eol)
    l_sm = len(secret_message)
    if height < l_sm:
        raise ValueError('Message is to long for this image')

    secret_message = transform_message(np.array([int(i) for i in secret_message]))
    sums = get_sum(height,secret_message, matrix, k=k, g=g)

    for i in range(height):
        for j in range(width):
            if i < len(sums) and j < len(sums[i]):
                nr = result[i, j, 0] + sums[i][j]
                if nr > 255:
                    r = 255
                if nr < 0:
                     nr = 0
                result[i, j][0] = nr
    return np_2_image(result), sums
```

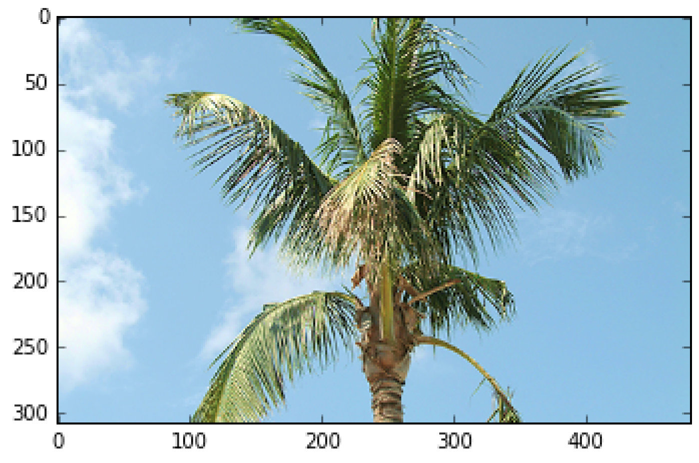
In [16]:

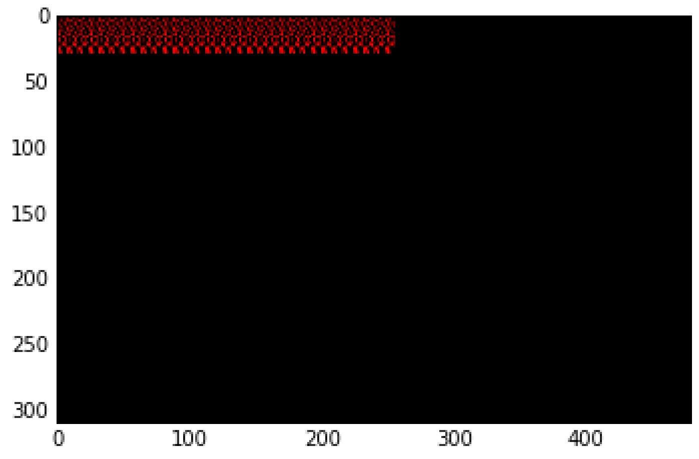
```
def decode(image, matrix, k=4, is_bin=False):
    container = open_image_2_np(image)
    width, height, pix = container.shape
    res = []

    for i in range(width):
        for j in range(k):
            a = np.array([p[0] for p in container[i]])[:256].dot(matrix[j+1])
            if a > 0:
                res.append(1)
            elif a <= 0:
                res.append(-1)
    res = np.array(res)

    if not is_bin:
        res = bin_2_str(''.join(str(int(i)) for i in inverse_transform_message(res)
        return res[:res.rfind(eol)]
    else:
        return ''.join(str(int(i)) for i in inverse_transform_message(res))
```

In [17]:

```
%time
matrix = hadamard(256)
stego_img, sums = encode(img_tamplate.format(2), 'Maxim Krivich', matrix)
stego_img.save(steg_img_tamplate.format(2))


f,ax = plt.subplots(2, figsize=(8, 8))
ax[0].imshow(stego_img)
ax[1].imshow(np_2_image(stego_img - open_image_2_np(img_tamplate.format(2))))
plt.show()
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 34.1 µs
```





In [18]:

```
%timeit encode(img_tamplate.format(2), 'Maxim Krivich', matrix)
```

```
486 ms ± 11.5 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

In [19]:

```
for i in range(5):
    print(sums[0].dot(matrix[i]))
```

```
0
-256
256
-256
-256
```

In [20]:

```
%timeit decode(steg_img_tamplate.format(2), matrix)
```

```
2.18 s ± 53.7 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

Задача №3 - Проведение экспериментальных исследований вероятностных свойств реализуемого метода, получение эмпирических зависимостей вероятности правильного извлечения данных и доли внесенных при этом погрешностей в контейнер-изображение

In [21]:

```
%time

Posh_kX = []
Posh_kY = []
W_kX = []
W_kY = []
msg = 'test' * 5

bmsg = str_2_bin(msg)

for i in range(9):
    stego_img, sums =  encode(img_tamplate.format(3), msg, matrix, k=2**i, g=1)
    stego_img.save(steg_img_tamplate.format(3))

    res = decode(steg_img_tamplate.format(3), matrix, is_bin=True)
    a = 0

    for j in range(len(bmsg)):
        if res[j] != bmsg[j]:
            a += 1
    Posh_kY.append(np.float64(a / len(bmsg)))
    Posh_kX.append(2**i)

    w = 0

    con1 = open_image_2_np(img_tamplate.format(3))
    con2 = open_image_2_np(steg_img_tamplate.format(3))

    for k in range(len(con2)):
        for j in range(len(con2)):
            w = w + abs(con1[k,j,0] - con2[k,j,0])
    W_kX.append((w * 100) / (len(con2) * len(con2[0]) * 256))
    W_kY.append(2**i)

W_kX.reverse()
print(W_kX)
print(W_kY)
```

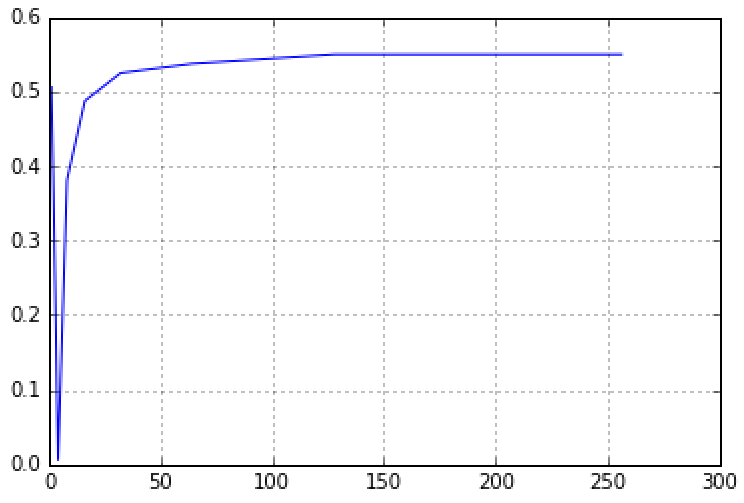
```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 36.5 µs
```

```
/usr/local/lib/python3.5/dist-packages/ipykernel_launcher.py:31: Runt
imeWarning: overflow encountered in ubyte_scalars
```

```
[0.046539306640625, 0.091552734375, 0.13580322265625, 0.25634765625,
 0.439453125, 0.8056640625, 1.318359375, 2.1484375, 8.59375]
[1, 2, 4, 8, 16, 32, 64, 128, 256]
```

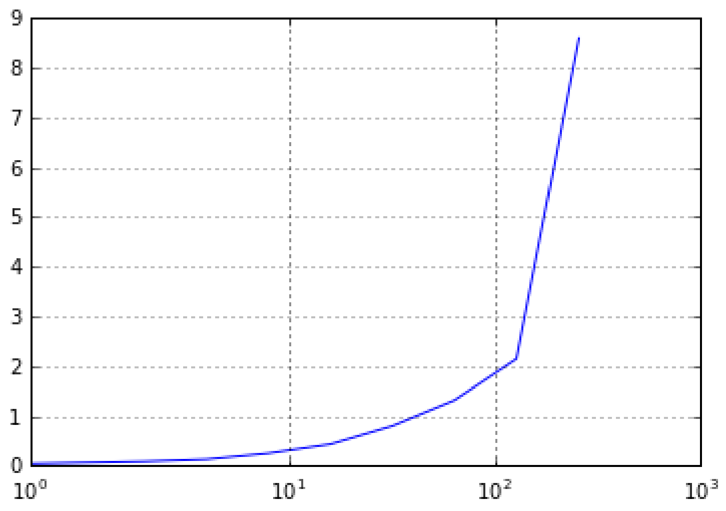
In [22]:

```
plt.plot(Posh_kX, Posh_kY)
plt.grid(True)
plt.gca().xaxis.grid(True, which='minor')
plt.show()
```



In [23]:

```
plt.plot(W_kY, W_kX)
plt.xscale('symlog')
plt.grid(True)
plt.gca().xaxis.grid(True, which='minor')
plt.show()
```



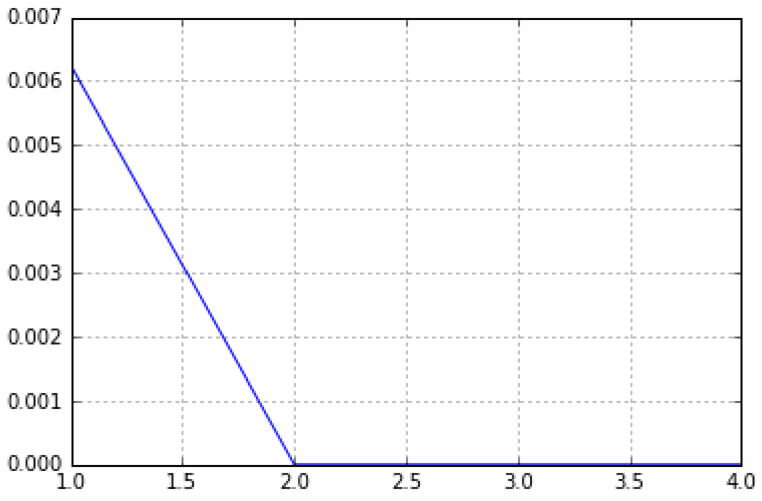
In [24]:

```
%time

Posh_gX = []
Posh_gY = []
W_gX = []
W_gY = []
msg = 'test' * 5

bmsg = str_2_bin(msg)

for i in range(1, 5):
    stego_img, sums =  encode(img_tamplate.format(3), msg, matrix, k=4, g=i)
    stego_img.save(steg_img_tamplate.format(3))

    res = decode(steg_img_tamplate.format(3), matrix, is_bin=True)
    a = 0

    for j in range(len(bmsg)):
        if res[j] != bmsg[j]:
            a += 1
    Posh_gY.append(np.float64(a / len(bmsg)))
    Posh_gX.append(i)

    w = 0

    con1 = open_image_2_np(img_tamplate.format(3))
    con2 = open_image_2_np(steg_img_tamplate.format(3))

    for k in range(len(con2)):
        for j in range(len(con2)):
            w = w + abs(con1[k,j,0] - con2[k,j,0])
    W_gX.append((w * 100) / (len(con2) * len(con2[0]) * 256))
    W_gY.append(i)

W_gX.reverse()
print(W_gX)
print(W_gY)
```

```
CPU times: user 0 ns, sys: 0 ns, total: 0 ns
Wall time: 35 µs

/usr/local/lib/python3.5/dist-packages/ipykernel_launcher.py:31: Runt
imeWarning: overflow encountered in ubyte_scalars

[1.318359375, 1.318359375, 1.318359375, 1.318359375]
[1, 2, 3, 4]
```

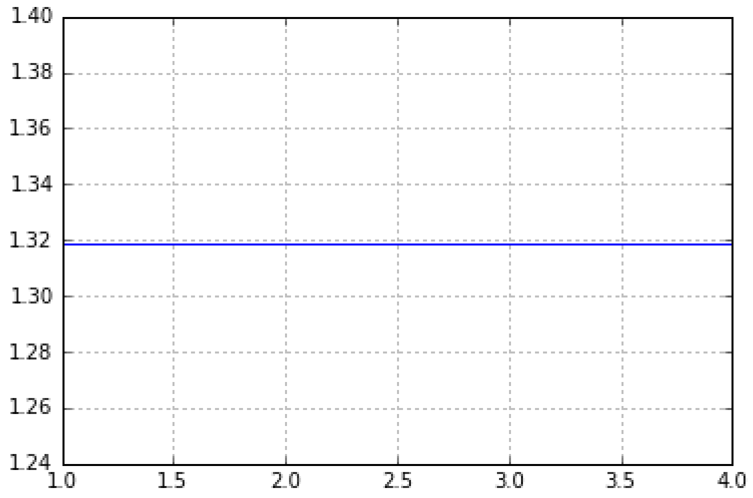
In [25]:

```
plt.plot(Posh_gX, Posh_gY)
plt.grid(True)
plt.gca().xaxis.grid(True, which='minor')
plt.show()
```



In [26]:

```
plt.plot(W_gY, W_gX)
plt.grid(True)
plt.show()
```



Задание №4 - Реализация алгоритмов формирования ансамблей квазиортогональных дискретных сигналов и алгоритмов сокрытия и извлечения данных в пространственной области изображений использованием квазиортогональных дискретных сигналов

In [27]:

```
def gen_ansable(size_a=1024, size_s=256):
    return np.array(transform_message(np.random.randint(2, size=size_a * size_s))).
```

In [28]:

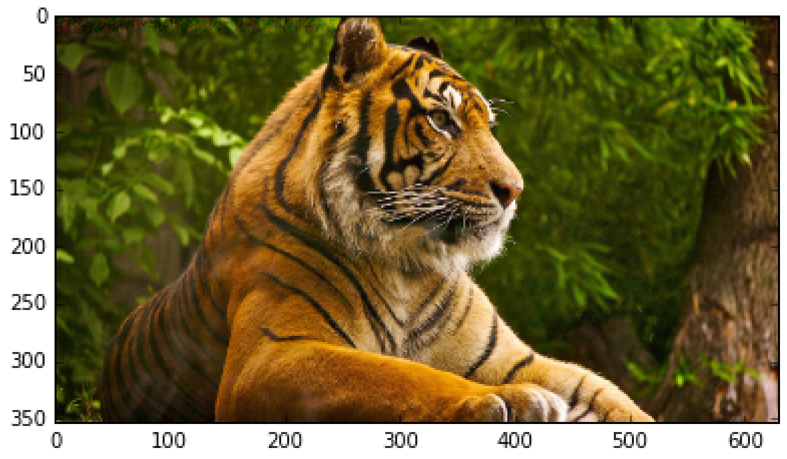
```
def ds_encode(image, message, matrix, g=40):
    container = open_image_2_np(image)
    width, height, pix = container.shape
    result = np.copy(container)
    secret_message = str_2_bin(message, eol)
    l_sm = len(secret_message)
    if height < l_sm:
        raise ValueError('Message is to long for this image')
    M_d = [int(s, 2) for s in chunks(secret_message, 8, 8)]
    sums = []
    for i in range(height):
        if i < len(M_d):
            sums.append(g * matrix[M_d[i]])
    for i in range(len(sums)):
        for j in range(len(sums[i])):
            nr = result[i, j, 0] + sums[i][j]
            if nr > 255:
                nr = 255
            if nr < 0:
                nr = 0
            result[i, j][0] = nr
    return np_2_image(result)
```

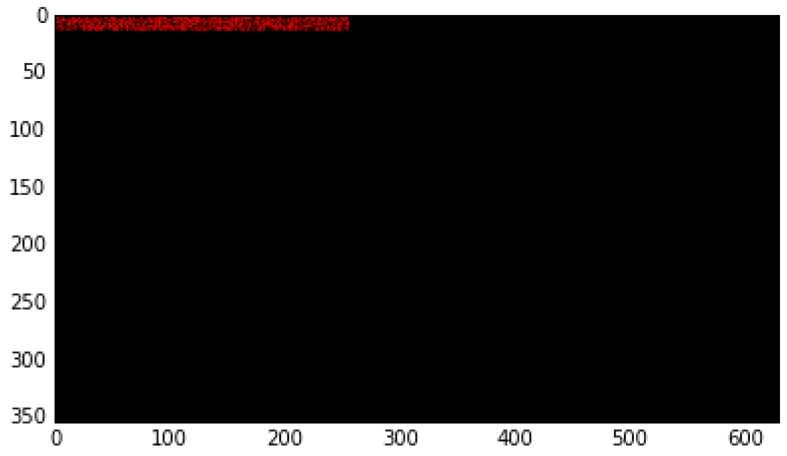
In [29]:

```
def ds_decode(image, matrix, is_bin=False):
    container = open_image_2_np(image)
    width, height, pix = container.shape
    res = {}

    for i in range(width):
        a = -0xFFFFFF
        r = np.array([p[0] for p in container[i]])[:256]
        for j in range(len(matrix)):
            cor = r.dot(matrix[j])
            if cor > a:
                a = cor
                res[i] = j
    msg = []
    for k in sorted(res):
        msg.append(bin(res[k])[2:].zfill(8))

    msg = ''.join(i for i in msg)

    if not is_bin:
        msg = bin_2_str(msg)
        return msg[:msg.rfind(eol)]
    else:
        return msg
```

In [30]:

```
arr = gen_ansable()
res_img = ds_encode(img_tamplate.format(4), 'Maxim Krivich', arr)
res_img.save(steg_img_tamplate.format(4))

f,ax = plt.subplots(2, figsize=(8, 8))
ax[0].imshow(res_img)
ax[1].imshow(np_2_image(res_img - open_image_2_np(img_tamplate.format(4))))
plt.show()
```





In [31]:

```
%timeit ds_decode(steg_img_tamplate.format(4), arr)
```

```
8.73 s ± 17.3 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

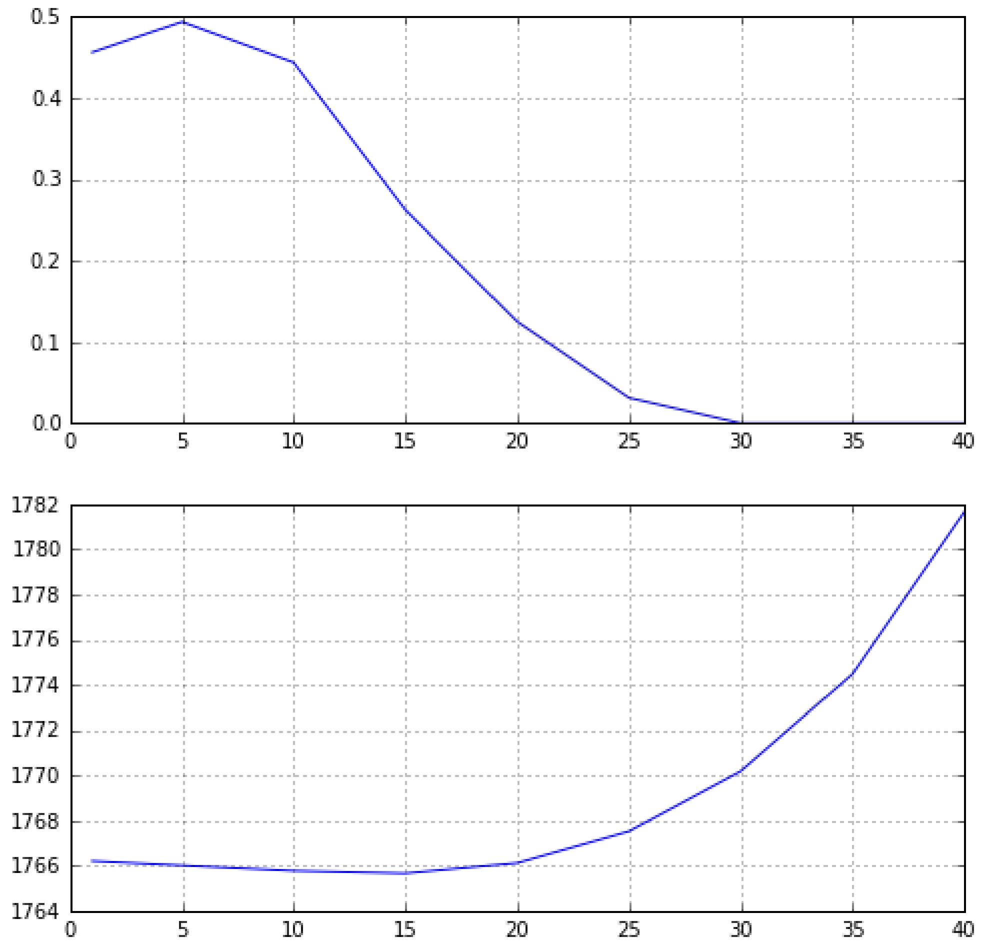
In [36]:

```
arr = gen_ansable()
msg = 'test' * 5
bmsg = str_2_bin(msg)
posh = []
w_g = []
Gg = []
for g in [1, ] + list(range(5, 45, 5)):

    a = 0
    steg_img = ds_encode(img_tamplate.format(4), msg, arr, g=g)
    steg_img.save(steg_img_tamplate.format(4))
    res = ds_decode(steg_img_tamplate.format(4), arr, is_bin=True)
    for i in range(len(bmsg)):
        if res[i] != bmsg[i]:
            a += 1
    posh.append(np.float64(a) / np.float64(len(bmsg)))

    w = 0
    con1 = open_image_2_np(img_tamplate.format(4))
    con2 = open_image_2_np(steg_img_tamplate.format(4))
    for i in range(len(con2)):
        for j in range(len(con2[i])):
            w = w + abs(con2[i,j,0] - con1[i,j,0])
    w_g.append((w * 100) / (len(bmsg) * 256))
    Gg.append(g)
```

```
/usr/local/lib/python3.5/dist-packages/ipykernel_launcher.py:23: Runt
imeWarning: overflow encountered in ubyte_scalars
```

In [37]:

```
f,ax = plt.subplots(2, figsize=(8,8))
ax[0].plot(Gg, posh)
ax[0].grid()
ax[1].plot(Gg, w_g)
ax[1].grid()
plt.show()
```


0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
30
35
40
1782
1780
1778
1776
1774
1772
1770
1768
1766
1764