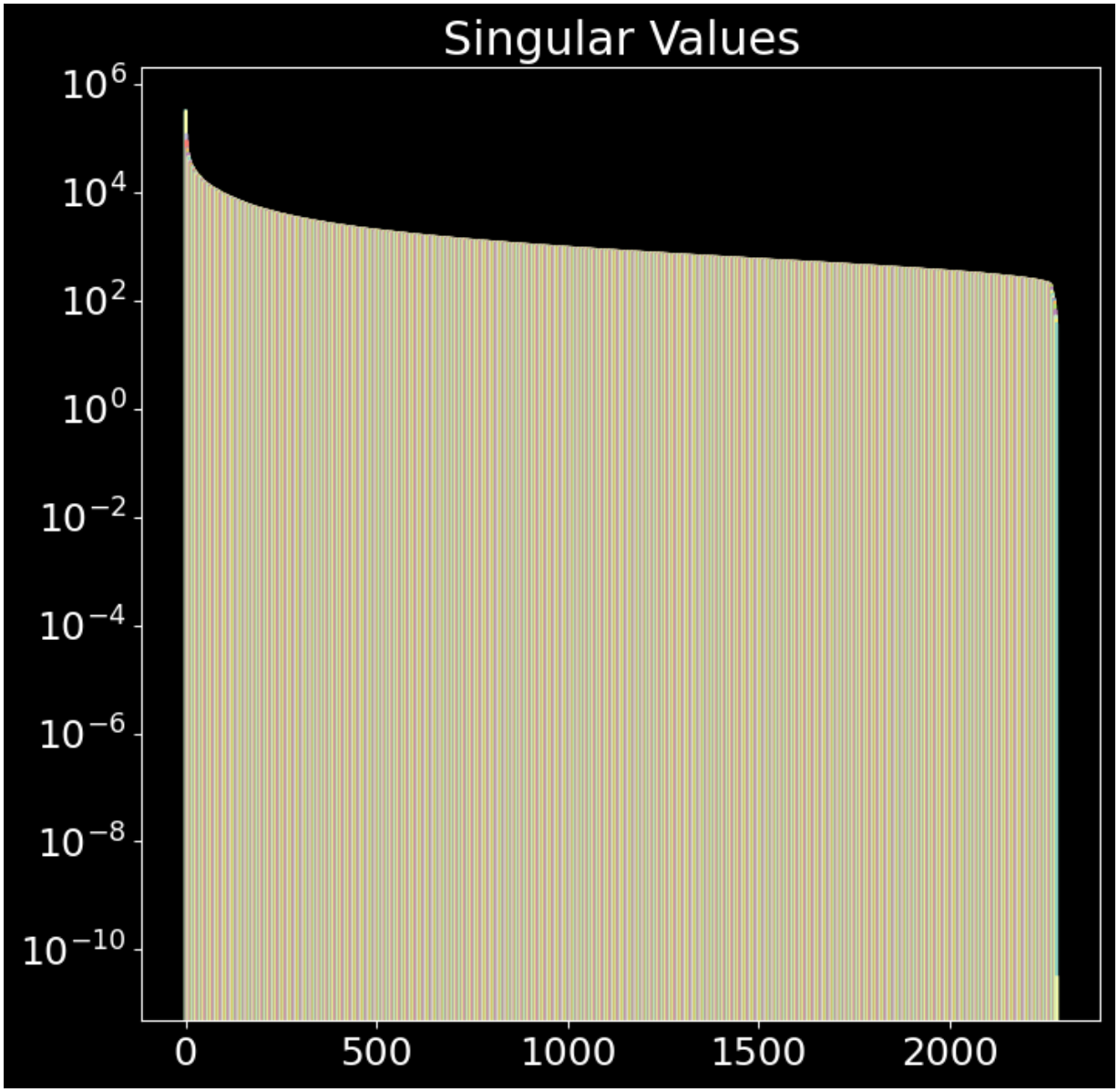
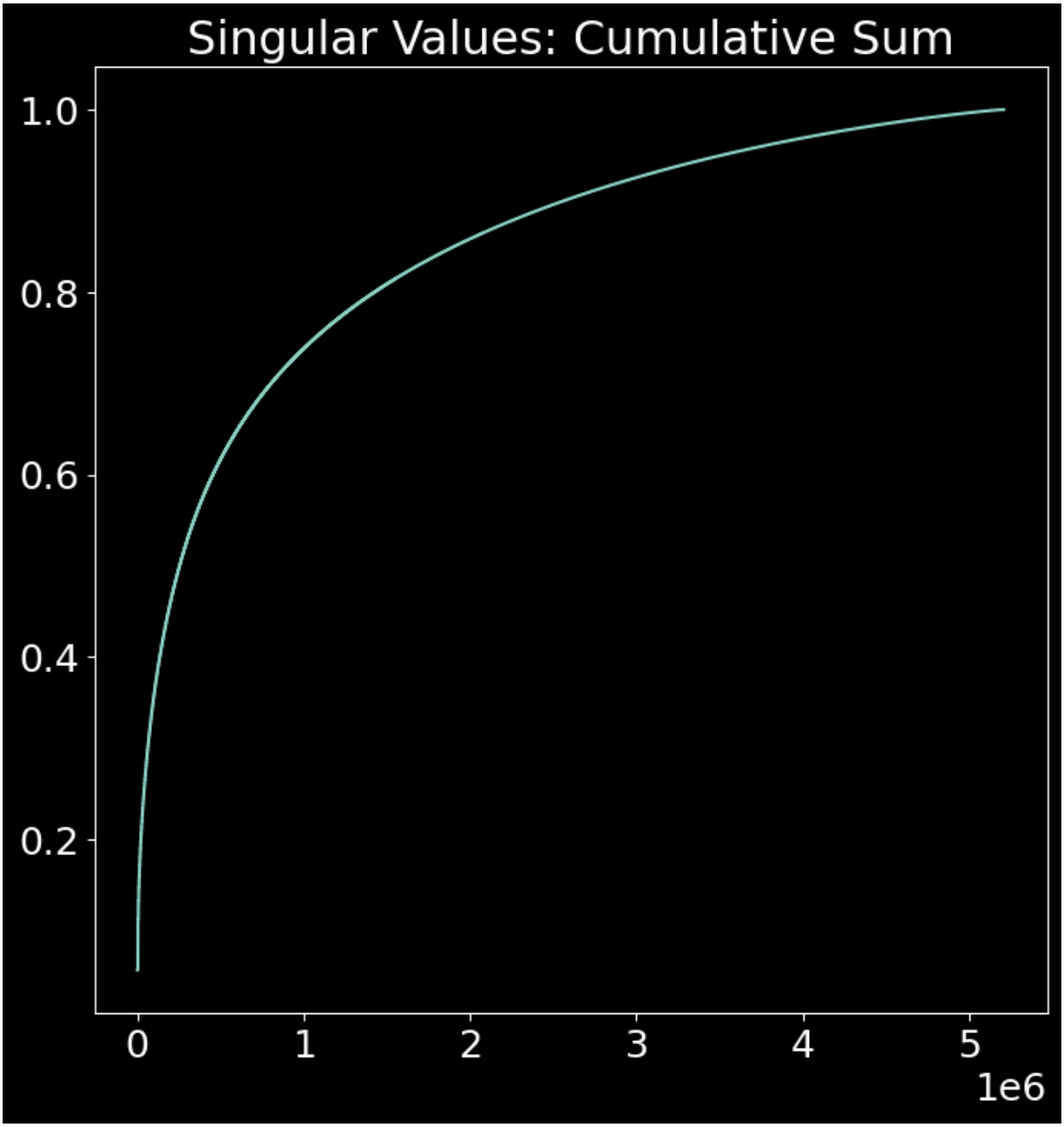
In [ ]:
```
%pip install scipy
```

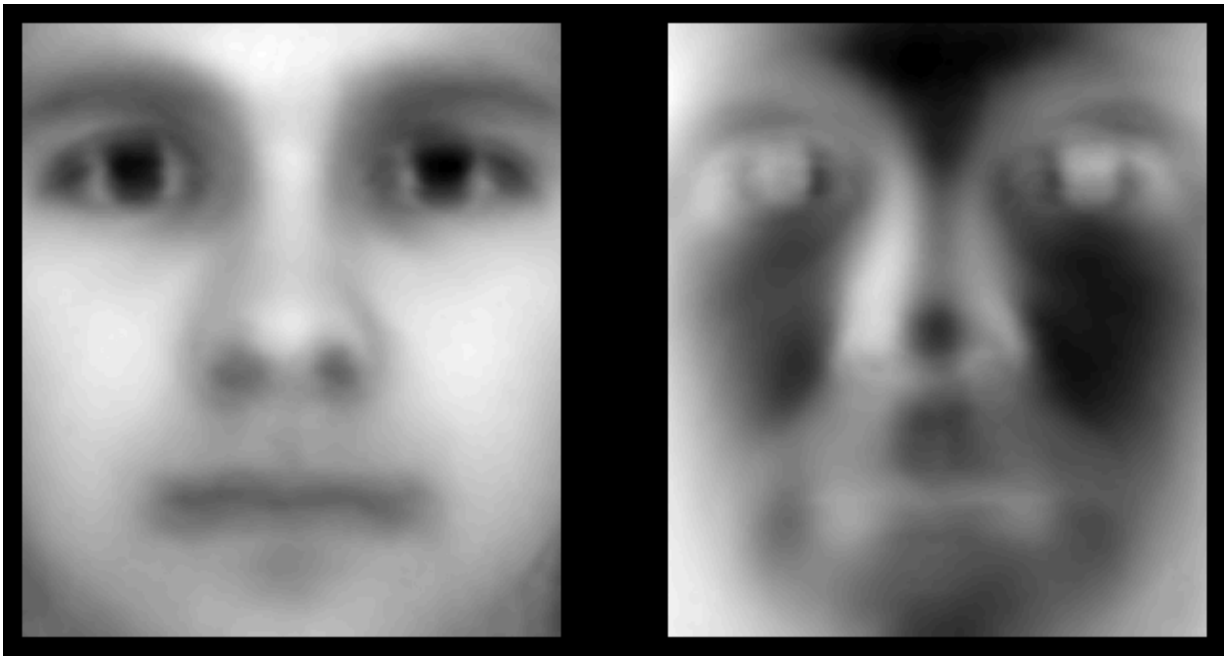
In [7]:
```
import matplotlib.pyplot as plt
import numpy as np
import scipy.io
plt.rcParams['figure.figsize'] = [8, 8]
plt.rcParams.update({'font.size': 18})

mat_contents = scipy.io.loadmat('./data/allFaces.mat')
faces = mat_contents['faces']
m = int(mat_contents['m'][0][0])
n = int(mat_contents['n'][0][0])
nfaces = np.ndarray.flatten(mat_contents['nfaces'])

trainingFaces = faces[:,:np.sum(nfaces[:36])]
avgFace = np.mean(trainingFaces,axis=1)

X = trainingFaces - np.tile(avgFace,(trainingFaces.shape[1],1)).T
U, S, VT = np.linalg.svd(X,full_matrices=0)
```

In [8]:
```
plt.figure(1)
plt.semilogy(np.diag(S))
plt.title('Singular Values')
plt.show()

plt.figure(2)
plt.plot(np.cumsum(np.diag(S))/np.sum(np.diag(S)))
plt.title('Singular Values: Cumulative Sum')
plt.show()
```


Singular Values
10^{6}
10^{4}
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
0
500
1000
1500
2000



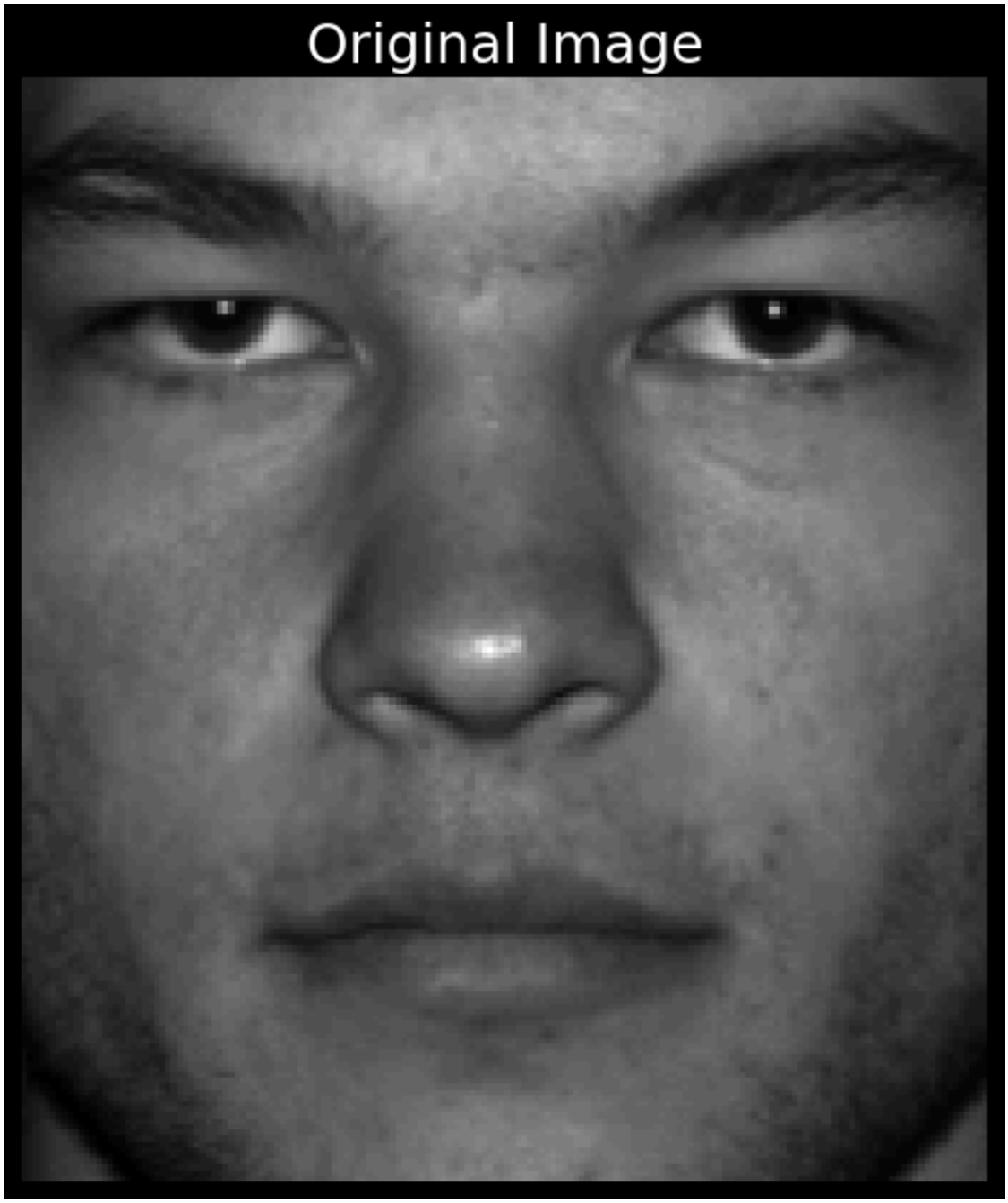
In [9]:
```
fig1 = plt.figure()
ax1 = fig1.add_subplot(121)
img_avg = ax1.imshow(np.reshape(avgFace,(m,n)).T)
img_avg.set_cmap('gray')
plt.axis('off')

ax2 = fig1.add_subplot(122)
img_u1 = ax2.imshow(np.reshape(U[:,0],(m,n)).T)
img_u1.set_cmap('gray')
plt.axis('off')

plt.show()
```



In [10]:
```
k = 0.95
energy = np.cumsum(S**2) / np.sum(S**2)     # udział energii kolejnych składowych
r_95 = int(np.searchsorted(energy, k) + 1)  # minimalne r, które przekracza 95%

print("Minimalne r dla 95% energii:", r_95)
print("Osiągnięta energia:", energy[r_95-1])
```

```
Minimalne r dla 95% energii: 61
Osiągnięta energia: 0.950390719381561
```

In [11]:
```
testFace = faces[:,np.sum(nfaces[:36])] # First face of person 37
plt.imshow(np.reshape(testFace,(m,n)).T)
plt.set_cmap('gray')
plt.title('Original Image')
plt.axis('off')
plt.show()

testFaceMS = testFace - avgFace
r_list = [25, 50, 100, 200, 400, 800, 1600, r_95]

for r in r_list:
    reconFace = avgFace + U[:,:r]  @ U[:,:r].T @ testFaceMS
    img = plt.imshow(np.reshape(reconFace,(m,n)).T)
    img.set_cmap('gray')
    plt.title('r = ' + str(r))
    plt.axis('off')
    plt.show()
```


Original Image


r = 25


r = 50


r = 100


r = 200


r = 400


r = 800


r = 1600

In [12]:
```
## Project person 2 and 7 onto PC5 and PC6

P1num = 2 # Person number 2
P2num = 7 # Person number 7

P1 = faces[:,np.sum(nfaces[:(P1num-1)]):np.sum(nfaces[:P1num])]
P2 = faces[:,np.sum(nfaces[:(P2num-1)]):np.sum(nfaces[:P2num])]

P1 = P1 - np.tile(avgFace,(P1.shape[1],1)).T
P2 = P2 - np.tile(avgFace,(P2.shape[1],1)).T

PCAmodes = [5, 6] # Project onto PCA modes 5 and 6
PCACoordsP1 = U[:,PCAmodes-np.ones_like(PCAmodes)].T @ P1
PCACoordsP2 = U[:,PCAmodes-np.ones_like(PCAmodes)].T @ P2

plt.plot(PCACoordsP1[0,:],PCACoordsP1[1,:],'d',color='k',label='Person 2')
```

```
plt.plot(PCACoordsP2[0,:],PCACoordsP2[1,:],'^',color='r',label='Person 7')

plt.legend()
plt.show()
```