2D_Diff

June 25, 2023

[88]:
```
from math import*
import numpy as np
import matplotlib.pyplot as plt
import datetime as dt
from matplotlib.animation import FuncAnimation
import matplotlib.animation as animation

a=1
a2=a
k=1.0
m=2.1
p=2.1
p2=2.02

def grafik(k,m,p,p2,a,a2):
alfa=1.0/(1-p)
beta=-alfa*(p-k*m)/(m+1)
beta2=-alfa*(p2-k*m)/(m+1)
g1=1+1.0/m
g2=m/(m*k-1)
A=(fabs(fabs(beta)**(1.0/m)/(k*g1*g2)))**g2
A2=(fabs(fabs(beta2)**(1.0/m)/(k*g1*g2)))**g2
print(f"alf={alfa}\tbeta={beta}\tg1={g1}\tg2={g2}\tA={A}\tA2={A2}")
t_T=2
N=100
M=N
b1=-1.0
b2=1.0
T=1.0
hx=(b2-b1)*1.0/N
ht=T*1.0/M
print(f"hx={hx}\tht={ht}")

x=np.empty(shape=N,dtype=float)
for i in range(0,N):
    x[i]=b1+hx*i
    #print(f"x[{i}]={x[i]}\t")
```

```
t=np.empty(shape=N,dtype=float)
for j in range(0,M):
    t[j]=j*ht
    #print(f"t[{j}]={t[j]}\t")
xi=np.empty(shape=N,dtype=float)
for i in range(0,N):
    xi[i]=fabs(x[i])*((t_T+t[i])**(-beta))
    #print(f"xi[{i}]={xi[i]}\t")

f=np.empty(shape=N,dtype=float)
for i in range(0,N):
    f_f=a**g1-(xi[i]**g1)
    if(f_f<0):
        f[i]=0
    else:
        f[i]=A*(f_f**g2)
    #print(f"f[{i}]={f[i]}\t")

xi2=np.empty(shape=N,dtype=float)
for i in range(0,N):
    xi2[i]=fabs(x[i])*((t_T+t[i])**(-beta2))
    #print(f"xi2[{i}]={xi2[i]}\t")

f2=np.empty(shape=N,dtype=float)
for i in range(0,N):
    f_f=a2**g1-(xi2[i]**g1)
    if(f_f<0):
        f2[i]=0
    else:
        f2[i]=A2*(f_f**g2)
    #print(f"f2[{i}]={f2[i]}\t")

u=np.empty(shape=N,dtype=float)
for i in range(0,N):
    u[i]=((t_T+t[i])**alfa)*f[i]
    print(f"u[{i}]={u[i]}\t")

v=np.empty(shape=N,dtype=float)
for i in range(0,N):
    v[i]=((t_T+t[i])**alfa)*f2[i]
    print(f"v[{i}]={v[i]}\t")
```

```
alf=-0.9090909090909091 beta=-0.3695014662756599        g1=1.4761904761904763
g2=0.8898305084745762   A=0.33865241302437193   A2=0.34760198502162104
hx=0.02 ht=0.01
u[0]=0.0
u[1]=0.0
u[2]=0.0
```

```
u[3]=0.0
u[4]=0.0
u[5]=0.0
u[6]=0.0
u[7]=0.0
u[8]=0.0
u[9]=0.0
u[10]=0.0
u[11]=0.0
u[12]=0.0
u[13]=0.007863024520555652
u[14]=0.01541684051584884
u[15]=0.022393085315308807
u[16]=0.0289837375603966
u[17]=0.035272799687812016
u[18]=0.041307541631302215
u[19]=0.04711817872790095
u[20]=0.052725583327674824
u[21]=0.058144935466930434
u[22]=0.06338767506752938
u[23]=0.06846263931288173
u[24]=0.07337676864585368
u[25]=0.07813556658307869
u[26]=0.08274341035901414
u[27]=0.08720376655527116
u[28]=0.09151934350964279
u[29]=0.09569219992378507
u[30]=0.09972382187898898
u[31]=0.10361517606385895
u[32]=0.10736674418892596
u[33]=0.11097854163714872
u[34]=0.11445012198134975
u[35]=0.1177805678373102
u[36]=0.12096846742781137
u[37]=0.12401187503731474
u[38]=0.12690825203893147
u[39]=0.12965438308751218
u[40]=0.1322462589237118
u[41]=0.1346789121797178
u[42]=0.13694618399974878
u[43]=0.139040383872451
u[44]=0.1409517755048534
u[45]=0.1426677602063551
u[46]=0.14417148841783867
u[47]=0.14543925972629757
u[48]=0.14643488461285206
u[49]=0.14709387085426814
u[50]=0.14722803990321845
```

u[51]=0.14602505569333274
u[52]=0.14430410720235382
u[53]=0.1422561815131466
u[54]=0.1399477986244962
u[55]=0.13741680841236495
u[56]=0.13468833983654993
u[57]=0.13178050501671248
u[58]=0.12870703655808385
u[59]=0.12547869895048816
u[60]=0.12210411970944848
u[61]=0.11859031253516027
u[62]=0.11494302251918401
u[63]=0.11116696132677743
u[64]=0.10726597026685548
u[65]=0.10324313342318964
u[66]=0.09910085415979022
u[67]=0.09484090295742778
u[68]=0.09046444101525888
u[69]=0.08597202145178956
u[70]=0.08136356769487428
u[71]=0.0766383263170965
u[72]=0.07179478868153102
u[73]=0.06683057166016196
u[74]=0.061742241283220284
u[75]=0.05652505244809971
u[76]=0.05117255870064998
u[77]=0.04567600984654308
u[78]=0.04002338131694301
u[79]=0.03419771521913856
u[80]=0.02817404577676635
u[81]=0.02191300505786039
u[82]=0.015344951346959422
u[83]=0.008315857267460418
u[84]=0.0
u[85]=0.0
u[86]=0.0
u[87]=0.0
u[88]=0.0
u[89]=0.0
u[90]=0.0
u[91]=0.0
u[92]=0.0
u[93]=0.0
u[94]=0.0
u[95]=0.0
u[96]=0.0
u[97]=0.0
u[98]=0.0

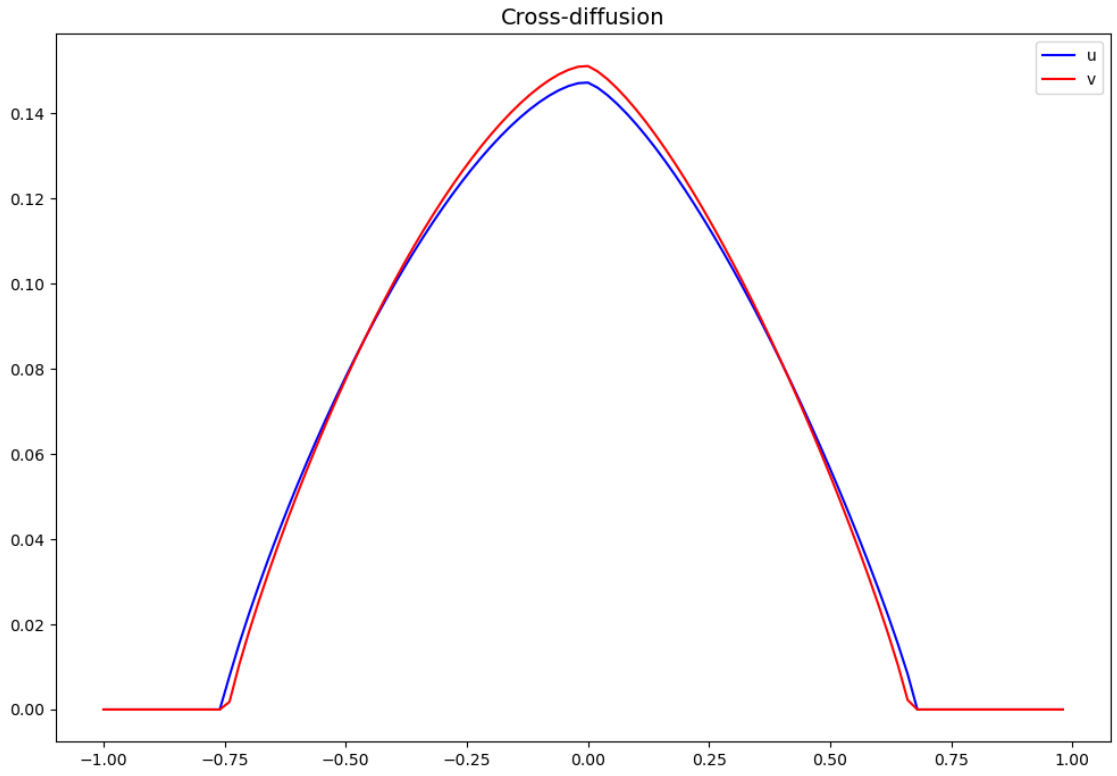
u[99]=0.0
v[0]=0.0
v[1]=0.0
v[2]=0.0
v[3]=0.0
v[4]=0.0
v[5]=0.0
v[6]=0.0
v[7]=0.0
v[8]=0.0
v[9]=0.0
v[10]=0.0
v[11]=0.0
v[12]=0.0
v[13]=0.0018031667584354199
v[14]=0.01051228606704262
v[15]=0.018146096643994015
v[16]=0.025260577723492657
v[17]=0.032006295851080876
v[18]=0.038455674987732745
v[19]=0.04465127243656005
v[20]=0.05062096629320666
v[21]=0.056384304670525597
v[22]=0.06195563422934808
v[23]=0.06734581967892675
v[24]=0.07256326559773392
v[25]=0.077614559999848
v[26]=0.08250489791138106
v[27]=0.08723836950963164
v[28]=0.09181816074966268
v[29]=0.09624669493691405
v[30]=0.10052573275393793
v[31]=0.10465644176701333
v[32]=0.10863944240392127
v[33]=0.11247483473819063
v[34]=0.11616220853592363
v[35]=0.11970063755219042
v[36]=0.12308865775169597
v[37]=0.12632422775967783
v[38]=0.12940466819245156
v[39]=0.13232657425647
v[40]=0.13508569263322326
v[41]=0.13767674828538196
v[42]=0.14009319770881806
v[43]=0.14232686879951073
v[44]=0.14436741615068213
v[45]=0.14620145554303246
v[46]=0.14781109210463342

v[47]=0.14917116413074552
v[48]=0.15024326641183597
v[49]=0.15095898918233794
v[50]=0.1511188373475966
v[51]=0.14986179603507432
v[52]=0.14805544087656936
v[53]=0.14590194751041094
v[54]=0.14347165414571925
v[55]=0.140804538282809
v[56]=0.13792710735940725
v[57]=0.13485843800574174
v[58]=0.13161296737085884
v[59]=0.1282019861349625
v[60]=0.12463451694131773
v[61]=0.1209178665117188
v[62]=0.11705798905154632
v[63]=0.1130597327637073
v[64]=0.10892700947321673
v[65]=0.10466291065084846
v[66]=0.10026978367118446
v[67]=0.09574927636366692
v[68]=0.09110235402517183
v[69]=0.08632929006309943
v[70]=0.08142962867099339
v[71]=0.07640211483354917
v[72]=0.07124458283221237
v[73]=0.06595378822792924
v[74]=0.06052515816120663
v[75]=0.054952417057358885
v[76]=0.049227011677479456
v[77]=0.04333719308878319
v[78]=0.037266468719801896
v[79]=0.030990788518323837
v[80]=0.024472856974448762
v[81]=0.017648642601627053
v[82]=0.01038528960480311
v[83]=0.002218454575891473
v[84]=0.0
v[85]=0.0
v[86]=0.0
v[87]=0.0
v[88]=0.0
v[89]=0.0
v[90]=0.0
v[91]=0.0
v[92]=0.0
v[93]=0.0
v[94]=0.0

```
v[95]=0.0
v[96]=0.0
v[97]=0.0
v[98]=0.0
v[99]=0.0
```

[119]:
```
xpoints = np.array(x)
upoints = np.array(u)
vpoints = np.array(v)
#print(xpoints)
#print(upoints)
#print(vpoints)

plt.rcParams["figure.figsize"] = [10, 7]
plt.rcParams["figure.autolayout"] = True

#plt.plot(xpoints, ypoints,color='blue')
#plt.show()
fig, ax = plt.subplots()

#timer = fig.canvas.new_timer(interval = 5000)
#timer.add_callback(plt.close)

# Set up plot to call animate() function periodically
'''
line, = ax.plot([], [], lw=3)

# initialization function
def init():
    line.set_data([], [])
    return line,

# animation function.
def animate(i):
    line.set_data(xpoints, upoints)
    return line,

anim = animation.FuncAnimation(fig, animate, init_func=init,
                               frames=220, interval=20, blit=True)

anim.save('Basic sine wave.mp4', writer = 'ffmpeg',fps=30)
'''
ax.plot(x, upoints, label='u', color='blue')
ax.plot(x, vpoints, label='v', color='red')
ax.set_title('Cross-diffusion', size=14)
#ax.set_xlim(-5, 5)
#ax.set_ylim(-5, 25)
```

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

#timer.start()

#ani = FuncAnimation(fig, upoints, interval=500)
#fig.tight_layout()
#plt.show()
```



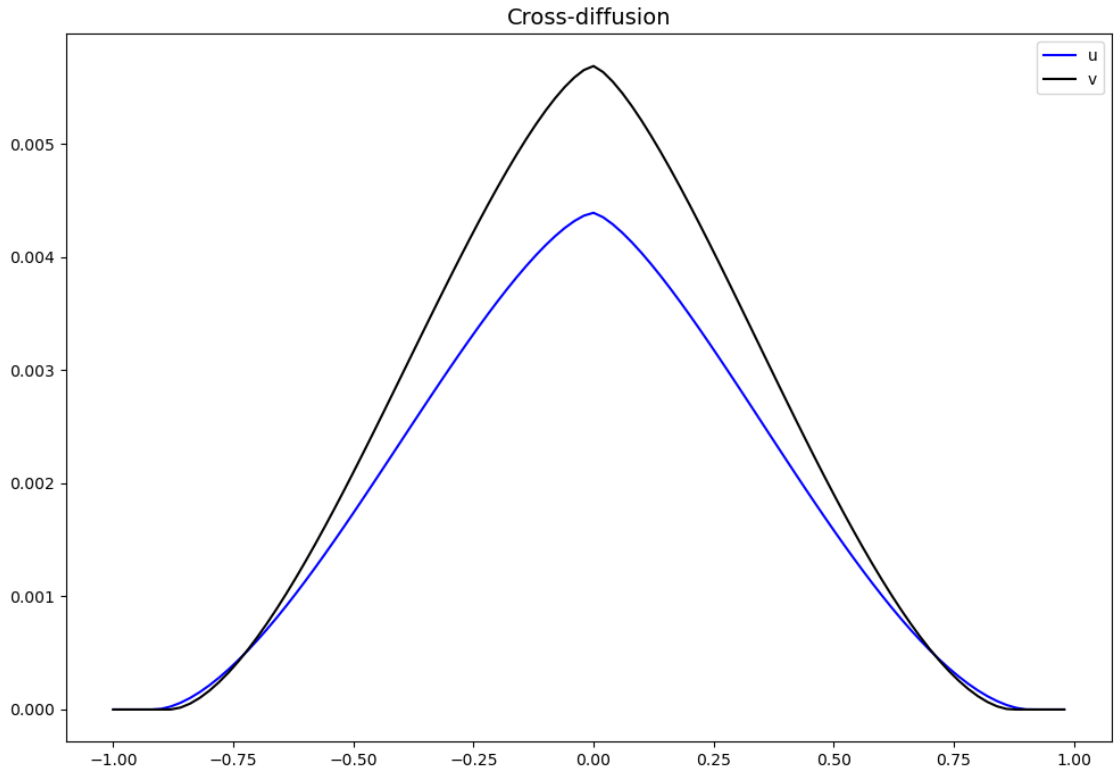
[173]:
```
from math import*
import numpy as np
import matplotlib.pyplot as plt
import datetime as dt
from matplotlib.animation import FuncAnimation
import matplotlib.animation as animation

a=1
a2=a
k=1.0
m=2.3
p=2.1
p2=2.02
```

```
def grafik(k,m,p,p2,a,a2):
    alfa=1.0/(1-p)
    beta=-alfa*(p-k*m)/(m+1)
    beta2=-alfa*(p2-k*m)/(m+1)
    g1=1+1.0/m
    g2=m/(m*k-1)
    A=(fabs(beta)**(1.0/m)/(k*g1*g2))**g2
    A2=(fabs(beta2)**(1.0/m)/(k*g1*g2))**g2
    print(f"alf={alfa}\tbeta={beta}\tg1={g1}\tg2={g2}\tA={A}\tA2={A2}")
    t_T=5
    N=100
    M=N
    b1=-1.0
    b2=1.0
    T=1.0
    hx=(b2-b1)*1.0/N
    ht=T*1.0/M
    print(f"hx={hx}\tht={ht}")

    x=np.empty(shape=N,dtype=float)
    for i in range(0,N):
        x[i]=b1+hx*i
        #print(f"x[{i}]={x[i]}\t")
    t=np.empty(shape=N,dtype=float)
    for j in range(0,M):
        t[j]=j*ht
        #print(f"t[{j}]={t[j]}\t")
    xi=np.empty(shape=N,dtype=float)
    for i in range(0,N):
        xi[i]=fabs(x[i])*((t_T+t[i])**(-beta))
        #print(f"xi[{i}]={xi[i]}\t")

    f=np.empty(shape=N,dtype=float)
    for i in range(0,N):
        f_f=a**g1-(xi[i]**g1)
        if(f_f<=0):
            f[i]=0
        else:
            f[i]=A*(f_f**g2)
        #print(f"f[{i}]={f[i]}\t")

    xi2=np.empty(shape=N,dtype=float)
    for i in range(0,N):
        xi2[i]=fabs(x[i])*((t_T+t[i])**(-beta2))
        #print(f"xi2[{i}]={xi2[i]}\t")
```

```
    f2=np.empty(shape=N,dtype=float)
    for i in range(0,N):
        f_f=a2**g1-(xi2[i]**g1)
        if(f_f<=0):
            f2[i]=0
        else:
            f2[i]=A2*(f_f**g2)
        #print(f"f2[{i}]={f2[i]}\t")

    u=np.empty(shape=N,dtype=float)
    for i in range(0,N):
        u[i]=((t_T+t[i])**alfa)*f[i]
        #print(f"u[{i}]={u[i]}\t")
    v=np.empty(shape=N,dtype=float)
    for i in range(0,N):
        v[i]=((t_T+t[i])**alfa)*f2[i]
        #print(f"v[{i}]={v[i]}\t")
    xpoints = np.array(x)
    upoints = np.array(u)
    vpoints = np.array(v)
    plt.rcParams["figure.figsize"] = [10, 7]
    plt.rcParams["figure.autolayout"] = True
    fig, ax = plt.subplots()
    ax.plot(x, upoints, label='u', color='blue')
    ax.plot(x, vpoints, label='v', color='black')
    ax.set_title('Cross-diffusion', size=14)
    plt.legend()
    plt.show()
```

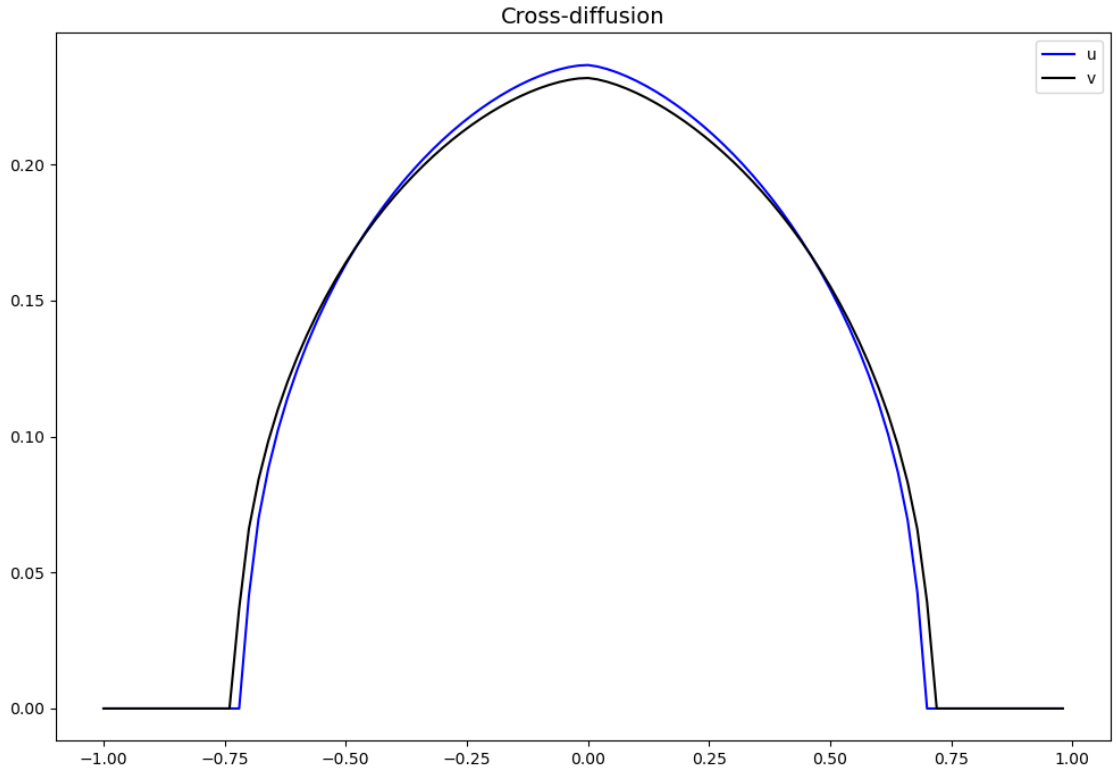
[174]:
```
grafik(k,m,p,p2,a,a2)
```

```
alf=-0.9090909090909091 beta=-0.0550964187327823        g1=1.4347826086956523
g2=1.7692307692307694   A=0.02069448533756767   A2=0.02680777757309592
hx=0.02 ht=0.01
```



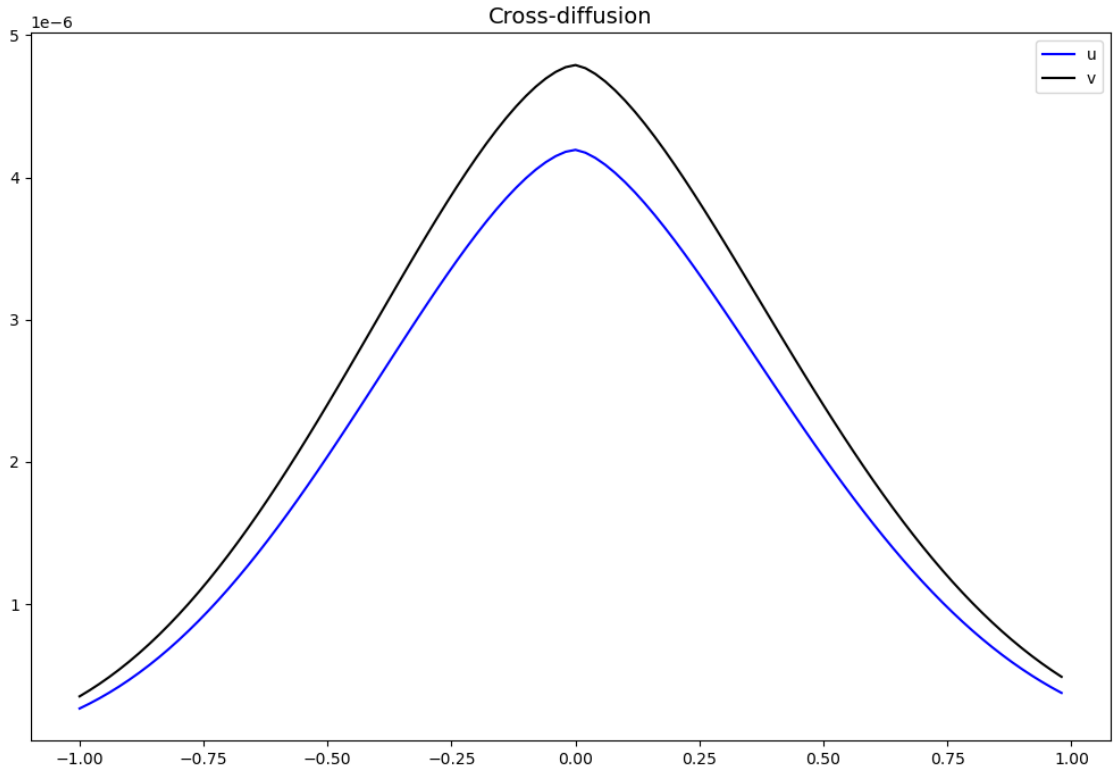
[175]:
```
grafik(2.8,1.7,3.4,3.5,1,1)
```

```
alf=-0.4166666666666667 beta=-0.20987654320987653       g1=1.5882352941176472
g2=0.4521276595744681   A=0.4814216106465467    A2=0.471741635426564
hx=0.02 ht=0.01
```



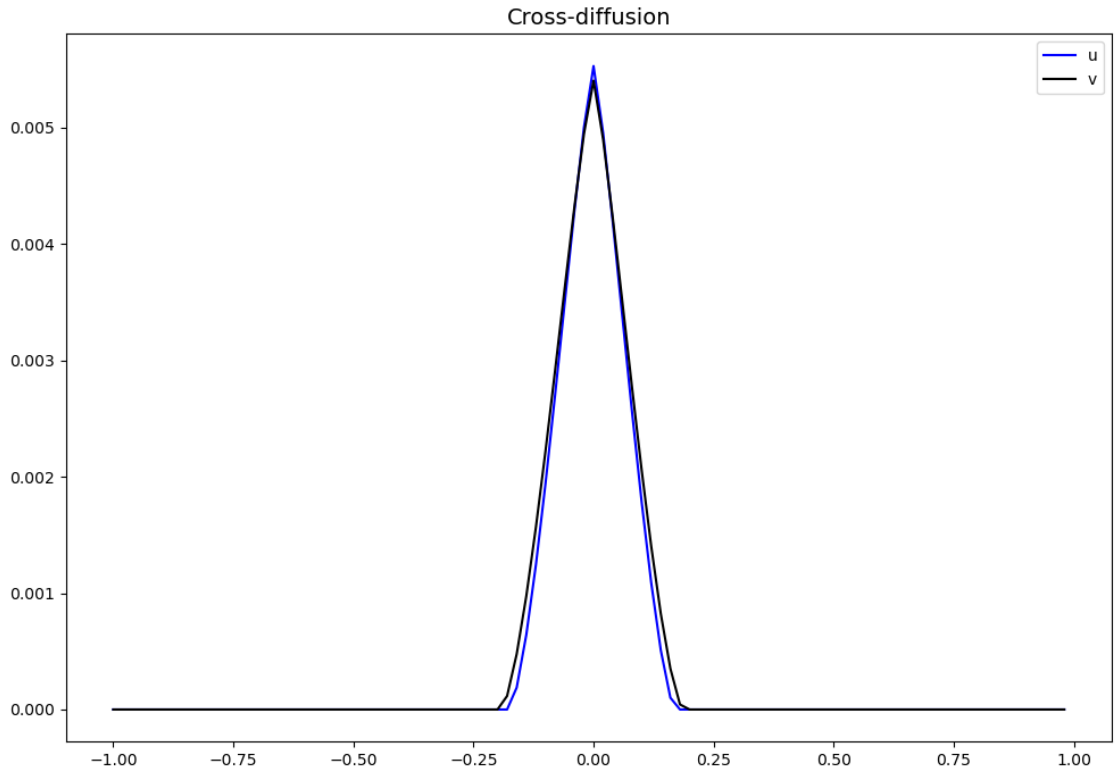
[176]:
```
grafik(0.8,1.7,3.4,3.5,1,1)
```

```
alf=-0.4166666666666667 beta=0.3148148148148148 g1=1.5882352941176472
g2=4.7222222222222205   A=8.533076817061444e-06 A2=9.746257781247255e-06
hx=0.02 ht=0.01
```



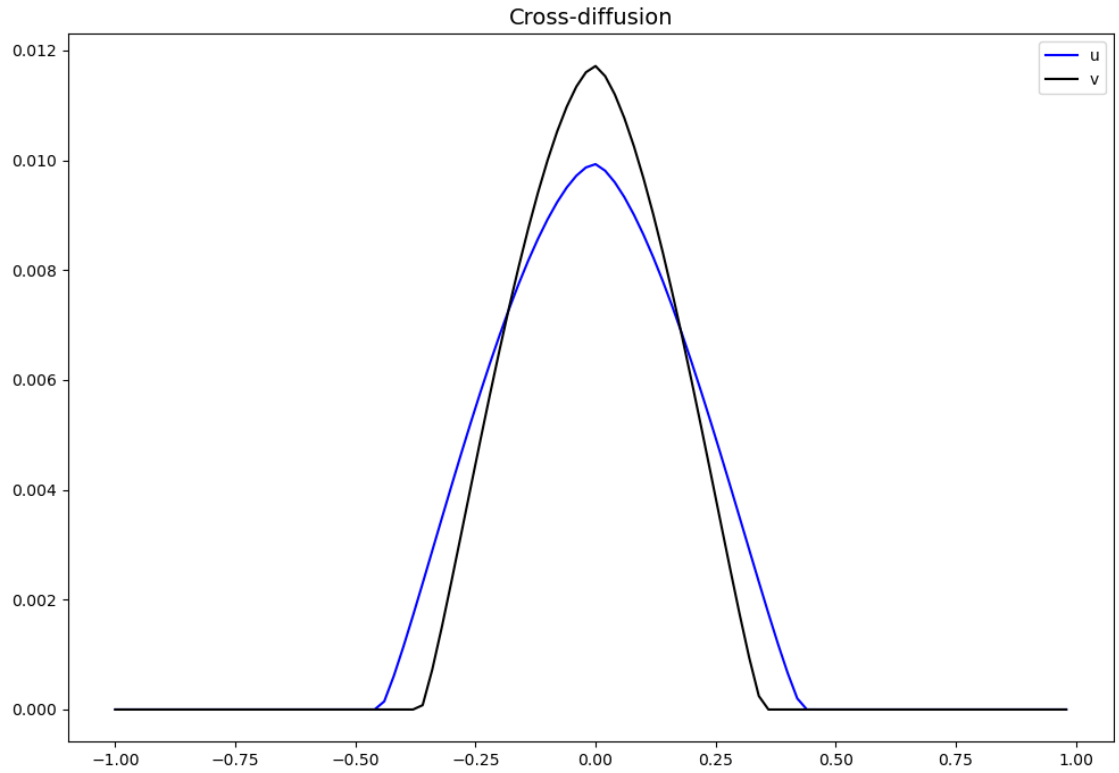
[177]:
```
grafik(0.9,3.7,1.4,1.5,1,1)
```

```
alf=-2.5000000000000004 beta=-1.0265957446808514        g1=1.2702702702702702
g2=1.5879828326180259   A=0.3923102157315954    A2=0.3834535695658947
hx=0.02 ht=0.01
```



[178]:
```
grafik(1.4,1.7,1.6,1.4,1,1)
```

```
alf=-1.6666666666666665 beta=-0.4814814814814813        g1=1.5882352941176472
g2=1.2318840579710146   A=0.1701755189094457    A2=0.20078510140506578
hx=0.02 ht=0.01
```


Cross-diffusion
u
v
0.012
0.010
0.008
0.006
0.004
0.002
0.000
−1.00
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00

[ ]:

[ ]:

[ ]: