Untitled3

August 23, 2022

[1]:
```
pip install strawberryfields
```

```
Requirement already satisfied: strawberryfields in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages
(0.23.0)
Requirement already satisfied: python-dateutil>=2.8.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (2.8.2)
Requirement already satisfied: thewalrus>=0.18.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (0.19.0)
Requirement already satisfied: networkx>=2.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (2.8.4)
Requirement already satisfied: toml in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (0.10.2)
Requirement already satisfied: quantum-xir>=0.1.1 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (0.2.1)
Requirement already satisfied: xanadu-cloud-client>=0.2.1 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (0.2.1)
Requirement already satisfied: quantum-blackbird>=0.3.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (0.4.0)
Requirement already satisfied: numba in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (0.56.0)
Requirement already satisfied: requests>=2.22.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (2.28.1)
Requirement already satisfied: urllib3>=1.25.3 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (1.26.10)
Requirement already satisfied: sympy>=1.5 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (1.10.1)
```

```
Requirement already satisfied: scipy>=1.0.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (1.8.1)
Requirement already satisfied: numpy>=1.17.4 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
strawberryfields) (1.21.6)
Requirement already satisfied: six>=1.5 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
python-dateutil>=2.8.0->strawberryfields) (1.16.0)
Requirement already satisfied: antlr4-python3-runtime==4.8 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
quantum-blackbird>=0.3.0->strawberryfields) (4.8)
Requirement already satisfied: lark-parser>=0.11.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
quantum-xir>=0.1.1->strawberryfields) (0.12.0)
Requirement already satisfied: idna<4,>=2.5 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
requests>=2.22.0->strawberryfields) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
requests>=2.22.0->strawberryfields) (2021.5.30)
Requirement already satisfied: charset-normalizer<3,>=2 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
requests>=2.22.0->strawberryfields) (2.1.0)
Requirement already satisfied: mpmath>=0.19 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
sympy>=1.5->strawberryfields) (1.2.1)
Requirement already satisfied: dask[delayed] in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
thewalrus>=0.18.0->strawberryfields) (2022.8.1)
Requirement already satisfied: setuptools in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
numba->strawberryfields) (58.1.0)
Requirement already satisfied: llvmlite<0.40,>=0.39.0dev0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
numba->strawberryfields) (0.39.0)
Requirement already satisfied: fire in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
xanadu-cloud-client>=0.2.1->strawberryfields) (0.4.0)
Requirement already satisfied: appdirs in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
xanadu-cloud-client>=0.2.1->strawberryfields) (1.4.4)
Requirement already satisfied: pydantic[dotenv] in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
xanadu-cloud-client>=0.2.1->strawberryfields) (1.8.2)
Requirement already satisfied: pyyaml>=5.3.1 in /opt/conda/lib/python3.9/site-
packages (from dask[delayed]->thewalrus>=0.18.0->strawberryfields) (5.4.1)
Requirement already satisfied: toolz>=0.8.2 in
```

```
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
dask[delayed]->thewalrus>=0.18.0->strawberryfields) (0.12.0)
Requirement already satisfied: partd>=0.3.10 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
dask[delayed]->thewalrus>=0.18.0->strawberryfields) (1.3.0)
Requirement already satisfied: cloudpickle>=1.1.1 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
dask[delayed]->thewalrus>=0.18.0->strawberryfields) (2.1.0)
Requirement already satisfied: fsspec>=0.6.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
dask[delayed]->thewalrus>=0.18.0->strawberryfields) (2022.7.1)
Requirement already satisfied: packaging>=20.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
dask[delayed]->thewalrus>=0.18.0->strawberryfields) (21.3)
Requirement already satisfied: termcolor in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
fire->xanadu-cloud-client>=0.2.1->strawberryfields) (1.1.0)
Requirement already satisfied: typing-extensions>=3.7.4.3 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
pydantic[dotenv]->xanadu-cloud-client>=0.2.1->strawberryfields) (4.3.0)
Requirement already satisfied: python-dotenv>=0.10.4 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
pydantic[dotenv]->xanadu-cloud-client>=0.2.1->strawberryfields) (0.20.0)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
packaging>=20.0->dask[delayed]->thewalrus>=0.18.0->strawberryfields) (3.0.9)
Requirement already satisfied: locket in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.9/site-packages (from
partd>=0.3.10->dask[delayed]->thewalrus>=0.18.0->strawberryfields) (1.0.0)

[notice] A new release of pip
available: 22.1.2 -> 22.2.2
[notice] To update, run:
python -m pip install --upgrade pip
Note: you may need to restart the kernel to use updated packages.
```

[2]:
```
import numpy as np

# set the random seed
np.random.seed(42)

# import Strawberry Fields
import strawberryfields as sf
from strawberryfields.ops import *

# initialize a 4 mode program
boson_sampling = sf.Program(4)
```

```
with boson_sampling.context as q:
    # prepare the input fock states
    Fock(1) | q[0]
    Fock(1) | q[1]
    Vac     | q[2]
    Fock(1) | q[3]

    # rotation gates
    Rgate(0.5719)  | q[0]
    Rgate(-1.9782) | q[1]
    Rgate(2.0603)  | q[2]
    Rgate(0.0644)  | q[3]
    # rotation gates
    #Rgate(0.0644)  | q[0]
    #Rgate(0.5719) | q[1]
    #Rgate(2.0603)  | q[2]
    #Rgate(-1.9782)  | q[3]


    # beamsplitter array
    #BSgate(0.7804, 0.8578)  | (q[0], q[1])
    #BSgate(0.06406, 0.5165) | (q[2], q[3])
    #BSgate(0.473, 0.1176)   | (q[1], q[2])
    #BSgate(0.563, 0.1517)   | (q[0], q[1])
    #BSgate(0.1323, 0.9946)  | (q[2], q[3])
    #BSgate(0.311, 0.3231)   | (q[1], q[2])
    #BSgate(0.4348, 0.0798)  | (q[0], q[1])
    #BSgate(0.4368, 0.6157)  | (q[2], q[3])
    # beamsplitter array
    BSgate(0.7804, 0.8578)  | (q[0], q[1])
    BSgate(0.06406, 0.5165) | (q[2], q[3])
    BSgate(0.7804, 0.8578)   | (q[1], q[2])
    BSgate(0.06406, 0.5165)   | (q[0], q[1])
    BSgate(0.473, 0.1176)  | (q[2], q[3])
    BSgate(0.563, 0.1517)   | (q[1], q[2])
    BSgate(0.1323, 0.9946)  | (q[0], q[1])
    BSgate(0.311, 0.3231)  | (q[2], q[3])
```

```
2022-08-23 09:28:34.472696: W
tensorflow/stream_executor/platform/default/dso_loader.cc:64] Could not load
dynamic library 'libcudart.so.11.0'; dlerror: libcudart.so.11.0: cannot open
shared object file: No such file or directory
2022-08-23 09:28:34.472725: I tensorflow/stream_executor/cuda/cudart_stub.cc:29]
Ignore above cudart dlerror if you do not have a GPU set up on your machine.
```

[3]:
```
#MeasureFock() | q
```

[4]:
```
eng = sf.Engine(backend="fock", backend_options={"cutoff_dim": 7})
```

[ ]:
```

```

[5]:
```
results = eng.run(boson_sampling)
```

[6]:
```
print(results)
```

```
<Result: shots=0, num_modes=0, contains state=True>
```

[7]:
```
probs = results.state.all_fock_probs()
```

[8]:
```
print(probs[1, 1, 0, 1])
print(probs[2, 0, 0, 1])
```

```
0.027016565659807 43
0.2280016292105849
```

[9]:
```
import numpy as np
from numpy.linalg import multi_dot
from scipy.linalg import block_diag
```

[10]:
```
Uphase = np.diag([np.exp(0.5719*1j),np.exp(-1.9782*1j),np.exp(2.0603*1j),np.
↪exp(0.0644*1j)])
```

[11]:
```
BSargs = [
    (0.7804, 0.8578),
    (0.06406, 0.5165),
    (0.473, 0.1176),
    (0.563, 0.1517),
    (0.1323, 0.9946),
    (0.311, 0.3231),
    (0.4348, 0.0798),
    (0.4368, 0.6157)
]
```

[12]:
```
t_r_amplitudes = [(np.cos(q), np.exp(p*1j)*np.sin(q)) for q,p in BSargs]
```

[13]:
```
BSunitaries = [np.array([[t, -np.conj(r)], [r, t]]) for t,r in t_r_amplitudes]
```

[14]:
```
UBS1 = block_diag(*BSunitaries[0:2])
UBS2 = block_diag([[1]], BSunitaries[2], [[1]])
UBS3 = block_diag(*BSunitaries[3:5])
UBS4 = block_diag([[1]], BSunitaries[5], [[1]])
UBS5 = block_diag(*BSunitaries[6:8])
```

[15]:
```
U = multi_dot([UBS5, UBS4, UBS3, UBS2, UBS1, Uphase])
print(np.round(U, 4))
```

```
[[ 0.2195-0.2565j  0.6111+0.5242j -0.1027+0.4745j -0.0273+0.0373j]
 [ 0.4513+0.6026j  0.457 +0.0123j  0.1316-0.4504j  0.0353-0.0532j]
 [ 0.0387+0.4927j -0.0192-0.3218j -0.2408+0.5244j -0.4584+0.3296j]
 [-0.1566+0.2246j  0.11  -0.1638j -0.4212+0.1836j  0.8188+0.068j ]]
```

[16]:
```
prog_unitary = sf.Program(4)
prog_unitary.circuit = boson_sampling.circuit[4:]
prog_compiled = prog_unitary.compile(compiler="gaussian_unitary")
```

[ ]:

[ ]:

[ ]:

[17]:
```
prog_compiled.print()
```

```
GaussianTransform([[ 0.5291  0.7197  0.1376 -0.0075 -0.3596 -0.215  -0.0776
-0.0392]
 [ 0.2031 -0.1865 -0.1118  0.2626 -0.3405  0.0417  0.8458  0.0972]
 [-0.1945  0.0872 -0.2586 -0.6435 -0.4827  0.4838  0.0224 -0.0785]
 [-0.284   0.2046 -0.3207  0.7065 -0.2864  0.3402 -0.2775 -0.0254]
 [ 0.3596  0.215   0.0776  0.0392  0.5291  0.7197  0.1376 -0.0075]
 [ 0.3405 -0.0417 -0.8458 -0.0972  0.2031 -0.1865 -0.1118  0.2626]
 [ 0.4827 -0.4838 -0.0224  0.0785 -0.1945  0.0872 -0.2586 -0.6435]
 [ 0.2864 -0.3402  0.2775  0.0254 -0.284   0.2046 -0.3207  0.7065]]) | (q[0],
q[1], q[2], q[3])
```

[18]:
```
S = prog_compiled.circuit[0].op.p[0]
U = S[:4, :4] + 1j*S[4:, :4]
print(U)
```

```
[[ 0.5291+0.3596j  0.7197+0.215j   0.1376+0.0776j -0.0075+0.0392j]
 [ 0.2031+0.3405j -0.1865-0.0417j -0.1118-0.8458j  0.2626-0.0972j]
 [-0.1945+0.4827j  0.0872-0.4838j -0.2586-0.0224j -0.6435+0.0785j]
 [-0.284 +0.2864j  0.2046-0.3402j -0.3207+0.2775j  0.7065+0.0254j]]
```

[19]:
```
boson_sampling = sf.Program(4)

with boson_sampling.context as q:
    # prepare the input fock states
    Fock(1) | q[0]
    Fock(1) | q[1]
    Vac     | q[2]
```

```
    Fock(1) | q[3]

    Interferometer(U) | q
```

[20]:
```
boson_sampling.compile(compiler="fock").print()
```

```
Fock(1) | (q[0])
Fock(1) | (q[1])
Vac | (q[2])
Fock(1) | (q[3])
Rgate(-2.902) | (q[0])
BSgate(0.7932, 0) | (q[0], q[1])
Rgate(1.896) | (q[2])
BSgate(0.2473, 0) | (q[2], q[3])
Rgate(-1.869) | (q[1])
BSgate(1.123, 0) | (q[1], q[2])
Rgate(-1.438) | (q[0])
BSgate(0.1817, 0) | (q[0], q[1])
Rgate(4.9) | (q[0])
Rgate(2.465) | (q[1])
Rgate(3.982) | (q[2])
Rgate(0.09952) | (q[3])
BSgate(-0.6788, 0) | (q[2], q[3])
Rgate(2.82) | (q[2])
BSgate(-0.1073, 0) | (q[1], q[2])
Rgate(-2.951) | (q[1])
```

[21]:
```
print(probs[2,0,0,1])
```

```
0.2280016292105849
```

[22]:
```
from thewalrus import perm
```

[23]:
```
U[:,[0,1,3]]
```

[23]:
```
array([[ 0.5291+0.3596j,  0.7197+0.215j , -0.0075+0.0392j],
       [ 0.2031+0.3405j, -0.1865-0.0417j,  0.2626-0.0972j],
       [-0.1945+0.4827j,  0.0872-0.4838j, -0.6435+0.0785j],
       [-0.284 +0.2864j,  0.2046-0.3402j,  0.7065+0.0254j]])
```

[24]:
```
U[:,[0,1,3]][[0,0,3]]
```

[24]:
```
array([[ 0.5291+0.3596j,  0.7197+0.215j , -0.0075+0.0392j],
       [ 0.5291+0.3596j,  0.7197+0.215j , -0.0075+0.0392j],
       [-0.284 +0.2864j,  0.2046-0.3402j,  0.7065+0.0254j]])
```

[25]:
```
print(np.abs(perm(U[:, [0,1,3]][[0,0,3]]))**2 / 2)
```

```
0.2280016292105849
```

[26]:
```
BS = np.abs(perm(U[:, [0,1,3]][[0,0,3]]))**2 / 2
SF = probs[2,0,0,1]

print(100*np.abs(BS-SF)/BS)
```

```
0.0
```

[27]:
```
print(probs[3,0,0,0])
print(np.abs(perm(U[:, [0,1,3]][[0,0,0]]))**2 / 6)
```

```
0.002202343953200861
0.00220234395320086
```

[28]:
```
print(probs[1,1,0,1])
print(np.abs(perm(U[:, [0,1,3]][[0,1,3]]))**2 / 1)
```

```
0.02701656565980743
0.02701656565980743
```

[ ]:
```

```