

```
In[28]:= Id = {{1, 0}, {0, 1}}
```

```
Out[28]= {{1, 0}, {0, 1}}
```

```
In[11]:=
```

```
In[29]:= Z = PauliMatrix[3]
```

```
Out[29]= {{1, 0}, {0, -1}}
```

```
In[30]:= Z01 = KroneckerProduct[Z, Z, Id, Id]
```

```
Out[30]= {{1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1}}
```

```
In[31]:= Z23 = KroneckerProduct[Id, Id, Z, Z]
```

```
Out[31]= {{1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0},
          {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1}}
```

In[32]:=

Z13 = KroneckerProduct[Id, Z, Id, Z]

Out[32]= { {1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0} }

In[33]:= **Z03 = KroneckerProduct[Z, Id, Id, Z]**

Out[33]= { {1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0} }

In[100]:= **Z12 = KroneckerProduct[Id, Z, Z, Id]**

Out[100]= { {1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1} }

In[35]:= **Z1 = -I * A * (4 * IdentityMatrix[16] - Z23 - Z01 - Z13 - Z03) / 2**

Out[35]= { {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, -3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, -i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, -2 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, -2 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, -3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, -3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, -2 i A, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, -2 i A, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, -3 i A, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -3 i A, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -2 i A, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -2 i A, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -i A, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -3 i A, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}}

In[101]:= **Z2 = -I * A * (5 * IdentityMatrix[16] - Z23 - Z01 - Z13 - Z03 - Z12) / 2**

Out[101]= { {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, -3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, -2 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, -3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, -3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, -4 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, -3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, -2 i A, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, -2 i A, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, -3 i A, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -4 i A, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -3 i A, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -3 i A, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -2 i A, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -3 i A, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}}

In[103]:= **Z2T = -1 Z2**

Out[103]= { {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 2 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 4 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 3 i A, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 2 i A, 0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 2 i A, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 3 i A, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 4 i A, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 3 i A, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 3 i A, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2 i A, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 3 i A, 0},
 {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}}

```
In[37]:= U1 = MatrixExp[Z1]
```

```
Out[37]= { {1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, e^{-3 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, e^{-i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, e^{-2 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, e^{-2 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, e^{-3 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, e^{-3 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, e^{-2 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, e^{-2 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-3 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-3 i A}, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-2 i A}, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-2 i A}, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-i A}, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-3 i A}, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1} }
```

[illegible]

```
In[102]:= U2 = MatrixExp[Z2]
```

```
Out[102]= { {1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, e^{-3 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, e^{-2 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, e^{-3 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, e^{-3 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, e^{-4 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, e^{-3 i A}, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, e^{-2 i A}, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, e^{-2 i A}, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-3 i A}, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-4 i A}, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-3 i A}, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-3 i A}, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-2 i A}, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{-3 i A}},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1} }
```

In[104]:= **U2T = Transpose[MatrixExp[Z2T]]**

Out[104]= $\left\{ \begin{aligned} &\{1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, e^{3iA}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, e^{2iA}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, e^{3iA}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, e^{3iA}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, e^{4iA}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, e^{3iA}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, e^{2iA}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, 0, e^{2iA}, 0, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, 0, 0, e^{3iA}, 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{4iA}, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{3iA}, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{3iA}, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{2iA}, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{3iA}, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1\} \end{aligned} \right\}$

In[41]:= **Cos[30 Degree]**

Out[41]= $\frac{\sqrt{3}}{2}$

In[48]:= **Rx = MatrixExp[-I * B * PauliMatrix[1]]**

Out[48]= $\left\{ \left\{ \text{Cos}[B], -i \text{Sin}[B] \right\}, \left\{ -i \text{Sin}[B], \text{Cos}[B] \right\} \right\}$

In[55]:= **X11 = MatrixExp[-I * B (KroneckerProduct[PauliMatrix[1], Id, Id, Id])]**

Out[55]= $\left\{ \left\{ \begin{aligned} &\{\text{Cos}[B], 0, 0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, \text{Cos}[B], 0, 0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, \text{Cos}[B], 0, 0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, \text{Cos}[B], 0, 0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, \text{Cos}[B], 0, 0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, \text{Cos}[B], 0, 0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, \text{Cos}[B], 0, 0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, \text{Cos}[B], 0, 0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0\}, \\ &\{-i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0, \text{Cos}[B], 0, 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0, \text{Cos}[B], 0, 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0, \text{Cos}[B], 0, 0, 0, 0, 0, 0\}, \\ &\{0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0, 0, \text{Cos}[B], 0, 0, 0, 0\}, \\ &\{0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0, 0, \text{Cos}[B], 0, 0, 0\}, \\ &\{0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0, 0, \text{Cos}[B], 0, 0\}, \\ &\{0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{Cos}[B], 0\}, \\ &\{0, 0, 0, 0, 0, 0, 0, -i \text{Sin}[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, \text{Cos}[B]\} \end{aligned} \right\} \right\}$

```
In[56]:= X12 = MatrixExp[-I * B (KroneckerProduct[Id, Id, Id, PauliMatrix[1]])]
```

```
Out[56]= {{Cos[B], -I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{-I Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, Cos[B], -I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, -I Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, Cos[B], -I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, -I Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, Cos[B], -I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, -I Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, Cos[B], -I Sin[B], 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], Cos[B], 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], -I Sin[B], 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], Cos[B], 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], -I Sin[B], 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], Cos[B], 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], -I Sin[B]}}
```

```
In[107]:= X1 = KroneckerProduct[Id, Rx, Id, Id]
```

```
Out[107]= {{Cos[B], 0, 0, 0, -I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, Cos[B], 0, 0, 0, -I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, Cos[B], 0, 0, 0, -I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, Cos[B], 0, 0, 0, -I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0},
{-I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, -I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, -I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, -I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, Cos[B], 0, 0, 0, -I Sin[B], 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], 0, 0, 0, -I Sin[B], 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], 0, 0, 0, Cos[B], 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], 0, 0, -I Sin[B]},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], 0, 0, Cos[B]},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], -I Sin[B]},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], Cos[B]}}
```

```
In[108]:= X1T = Simplify[Inverse[X1]]
```

```
Out[108]= {{Cos[B], 0, 0, 0, I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, Cos[B], 0, 0, 0, I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, Cos[B], 0, 0, 0, I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, Cos[B], 0, 0, 0, I Sin[B], 0, 0, 0, 0, 0, 0, 0, 0},
{I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0, 0, 0, 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, Cos[B], 0, 0, 0, I Sin[B], 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], 0, 0, 0, Cos[B], 0, 0, 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], 0, 0, 0, -I Sin[B], 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], 0, 0, 0, Cos[B], 0},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], 0, 0, I Sin[B]},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, I Sin[B], 0, 0, Cos[B]},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], -I Sin[B]},
{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -I Sin[B], Cos[B]}}
```



```
In[70]:= XT12 = Transpose[{{Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], i Sin[B], 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, i Sin[B], Cos[B], 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], i Sin[B]},
  {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, i Sin[B], Cos[B]}}]
```

```
Out[70]= {{Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, Cos[B], i Sin[B], 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, i Sin[B], Cos[B], 0, 0, 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], i Sin[B], 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, i Sin[B], Cos[B], 0, 0, 0, 0},
  {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, Cos[B], i Sin[B]},
  {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, i Sin[B], Cos[B]}}
```

```
In[73]:= Mat = U1.X11.X12.Z03.XT12.XT11.U1T
```

```
Out[73]= {{Cos[B] (Cos[B]^3 - Cos[B] Sin[B]^2) + i Sin[B] (i Cos[B]^2 Sin[B] - i Sin[B]^3),
  e^(3 i A) (2 i Cos[B]^3 Sin[B] - 2 i Cos[B] Sin[B]^3), 0, 0, 0, 0, 0, 0,
  e^(2 i A) (i Sin[B] (Cos[B]^3 - Cos[B] Sin[B]^2) + Cos[B] (i Cos[B]^2 Sin[B] - i Sin[B]^3)),
  -4 e^(3 i A) Cos[B]^2 Sin[B]^2, 0, 0, 0, 0, 0, 0},
  {-2 i e^(-3 i A) Cos[B]^3 Sin[B] + 2 i e^(-3 i A) Cos[B] Sin[B]^3,
  e^(3 i A) (Cos[B] (-e^(-3 i A) Cos[B]^3 + e^(-3 i A) Cos[B] Sin[B]^2) +
  i Sin[B] (-i e^(-3 i A) Cos[B]^2 Sin[B] + i e^(-3 i A) Sin[B]^3)), 0, 0, 0, 0, 0, 0,
  4 e^(-i A) Cos[B]^2 Sin[B]^2, e^(3 i A) (i Sin[B] (-e^(-3 i A) Cos[B]^3 + e^(-3 i A) Cos[B] Sin[B]^2) +
  Cos[B] (-i e^(-3 i A) Cos[B]^2 Sin[B] + i e^(-3 i A) Sin[B]^3)), 0, 0, 0, 0, 0, 0},
  {0, 0, e^(i A) (Cos[B] (e^(-i A) Cos[B]^3 - e^(-i A) Cos[B] Sin[B]^2) +
  i Sin[B] (i e^(-i A) Cos[B]^2 Sin[B] - i e^(-i A) Sin[B]^3)),
  e^(2 i A) (2 i e^(-i A) Cos[B]^3 Sin[B] - 2 i e^(-i A) Cos[B] Sin[B]^3), 0, 0, 0, 0, 0, 0,
  e^(3 i A) (i Sin[B] (e^(-i A) Cos[B]^3 - e^(-i A) Cos[B] Sin[B]^2) +
  Cos[B] (i e^(-i A) Cos[B]^2 Sin[B] - i e^(-i A) Sin[B]^3)), -4 e^(i A) Cos[B]^2 Sin[B]^2, 0, 0, 0, 0, 0},
  {0, 0, e^(i A) (-2 i e^(-2 i A) Cos[B]^3 Sin[B] + 2 i e^(-2 i A) Cos[B] Sin[B]^3),
  e^(2 i A) (Cos[B] (-e^(-2 i A) Cos[B]^3 + e^(-2 i A) Cos[B] Sin[B]^2) +
  i Sin[B] (-i e^(-2 i A) Cos[B]^2 Sin[B] + i e^(-2 i A) Sin[B]^3)), 0, 0, 0, 0, 0, 0,
  4 e^(i A) Cos[B]^2 Sin[B]^2, e^(2 i A) (i Sin[B] (-e^(-2 i A) Cos[B]^3 + e^(-2 i A) Cos[B] Sin[B]^2) +
  Cos[B] (-i e^(-2 i A) Cos[B]^2 Sin[B] + i e^(-2 i A) Sin[B]^3)), 0, 0, 0, 0, 0},
```


$$\begin{aligned}
& \{0, 0, 0, 0, e^{2iA} (\cos[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), \\
& \quad e^{3iA} (2 i e^{-2iA} \cos[B]^3 \sin[B] - 2 i e^{-2iA} \cos[B] \sin[B]^3), 0, 0, 0, 0, 0, \\
& \quad 0, e^{2iA} (i \sin[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), -4 e^{-iA} \cos[B]^2 \sin[B]^2, 0, 0\}, \\
& \{0, 0, 0, 0, e^{2iA} (-2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3), \\
& \quad e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 0, 0, 0, 0, 0, 0, \\
& \quad 4 e^{-iA} \cos[B]^2 \sin[B]^2, e^{iA} (i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 0, 0\}, \\
& \{0, 0, 0, 0, 0, 0, e^{3iA} (\cos[B] (e^{-3iA} \cos[B]^3 - e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-3iA} \cos[B]^2 \sin[B] - i e^{-3iA} \sin[B]^3)), \\
& \quad e^{2iA} (2 i e^{-3iA} \cos[B]^3 \sin[B] - 2 i e^{-3iA} \cos[B] \sin[B]^3), 0, 0, 0, 0, 0, \\
& \quad 0, e^{3iA} (i \sin[B] (e^{-3iA} \cos[B]^3 - e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-3iA} \cos[B]^2 \sin[B] - i e^{-3iA} \sin[B]^3)), -4 e^{-3iA} \cos[B]^2 \sin[B]^2\}, \\
& \{0, 0, 0, 0, 0, 0, e^{3iA} (-2 i e^{-2iA} \cos[B]^3 \sin[B] + 2 i e^{-2iA} \cos[B] \sin[B]^3), \\
& \quad e^{2iA} (\cos[B] (-e^{-2iA} \cos[B]^3 + e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3)), 0, 0, 0, 0, 0, 0, \\
& \quad 0, 4 e^{iA} \cos[B]^2 \sin[B]^2, i \sin[B] (-e^{-2iA} \cos[B]^3 + e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3)\}, \\
& \{i \sin[B] (-e^{-2iA} \cos[B]^3 + e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3), 4 e^{iA} \cos[B]^2 \sin[B]^2, \\
& \quad 0, 0, 0, 0, 0, 0, e^{2iA} (\cos[B] (-e^{-2iA} \cos[B]^3 + e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3)), \\
& \quad e^{3iA} (-2 i e^{-2iA} \cos[B]^3 \sin[B] + 2 i e^{-2iA} \cos[B] \sin[B]^3), 0, 0, 0, 0, 0, 0\}, \\
& \{-4 e^{-3iA} \cos[B]^2 \sin[B]^2, e^{3iA} (i \sin[B] (e^{-3iA} \cos[B]^3 - e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-3iA} \cos[B]^2 \sin[B] - i e^{-3iA} \sin[B]^3)), 0, 0, \\
& \quad 0, 0, 0, 0, e^{2iA} (2 i e^{-3iA} \cos[B]^3 \sin[B] - 2 i e^{-3iA} \cos[B] \sin[B]^3), \\
& \quad e^{3iA} (\cos[B] (e^{-3iA} \cos[B]^3 - e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-3iA} \cos[B]^2 \sin[B] - i e^{-3iA} \sin[B]^3)), 0, 0, 0, 0, 0, 0\}, \\
& \{0, 0, e^{iA} (i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 4 e^{-iA} \cos[B]^2 \sin[B]^2, \\
& \quad 0, 0, 0, 0, 0, 0, e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), \\
& \quad e^{2iA} (-2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3), 0, 0, 0, 0\}, \\
& \{0, 0, -4 e^{-iA} \cos[B]^2 \sin[B]^2, e^{2iA} (i \sin[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), 0, 0, \\
& \quad 0, 0, 0, 0, e^{3iA} (2 i e^{-2iA} \cos[B]^3 \sin[B] - 2 i e^{-2iA} \cos[B] \sin[B]^3), \\
& \quad e^{2iA} (\cos[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), 0, 0, 0, 0\}, \\
& \{0, 0, 0, 0, e^{2iA} (i \sin[B] (-e^{-2iA} \cos[B]^3 + e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3)), 4 e^{iA} \cos[B]^2 \sin[B]^2, \\
& \quad 0, 0, 0, 0, 0, 0, e^{2iA} (\cos[B] (-e^{-2iA} \cos[B]^3 + e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3)), \\
& \quad e^{iA} (-2 i e^{-2iA} \cos[B]^3 \sin[B] + 2 i e^{-2iA} \cos[B] \sin[B]^3), 0, 0\}, \\
& \{0, 0, 0, 0, -4 e^{iA} \cos[B]^2 \sin[B]^2, e^{3iA} (i \sin[B] (e^{-iA} \cos[B]^3 - e^{-iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-iA} \cos[B]^2 \sin[B] - i e^{-iA} \sin[B]^3)), 0, \\
& \quad 0, 0, 0, 0, 0, 0, e^{2iA} (2 i e^{-iA} \cos[B]^3 \sin[B] - 2 i e^{-iA} \cos[B] \sin[B]^3), \\
& \quad e^{iA} (\cos[B] (e^{-iA} \cos[B]^3 - e^{-iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-iA} \cos[B]^2 \sin[B] - i e^{-iA} \sin[B]^3)), 0, 0\},
\end{aligned}$$

$$\begin{aligned}
& \{0, 0, 0, 0, 0, 0, e^{3iA} (i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 4 e^{-iA} \cos[B]^2 \sin[B]^2, \\
& 0, 0, 0, 0, 0, 0, e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), \\
& -2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3\}, \\
& \{0, 0, 0, 0, 0, 0, -4 e^{3iA} \cos[B]^2 \sin[B]^2, \\
& e^{2iA} (i \sin[B] (\cos[B]^3 - \cos[B] \sin[B]^2) + \cos[B] (i \cos[B]^2 \sin[B] - i \sin[B]^3)), \\
& 0, 0, 0, 0, 0, 0, e^{3iA} (2 i \cos[B]^3 \sin[B] - 2 i \cos[B] \sin[B]^3), \\
& \cos[B] (\cos[B]^3 - \cos[B] \sin[B]^2) + i \sin[B] (i \cos[B]^2 \sin[B] - i \sin[B]^3))\}
\end{aligned}$$

In[111]= Mat2 = U2.X1.X12.Z13.XT12.X1T.U2T

$$\begin{aligned}
\text{Out[111]} = & \{ \{ \cos[B] (\cos[B]^3 - \cos[B] \sin[B]^2) + i \sin[B] (i \cos[B]^2 \sin[B] - i \sin[B]^3), \\
& e^{3iA} (2 i \cos[B]^3 \sin[B] - 2 i \cos[B] \sin[B]^3), 0, 0, \\
& e^{3iA} (i \sin[B] (\cos[B]^3 - \cos[B] \sin[B]^2) + \cos[B] (i \cos[B]^2 \sin[B] - i \sin[B]^3)), \\
& -4 e^{4iA} \cos[B]^2 \sin[B]^2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 \}, \\
& \{ -2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3, \\
& e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 0, 0, \\
& 4 \cos[B]^2 \sin[B]^2, e^{4iA} (i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 0, 0, 0, 0, 0, 0, 0, 0, 0 \}, \\
& \{ 0, 0, e^{2iA} (\cos[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), \\
& e^{3iA} (2 i e^{-2iA} \cos[B]^3 \sin[B] - 2 i e^{-2iA} \cos[B] \sin[B]^3), 0, 0, \\
& e^{3iA} (i \sin[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), -4 \cos[B]^2 \sin[B]^2, 0, 0, 0, \\
& 0, 0, 0, 0, 0 \}, \{ 0, 0, e^{2iA} (-2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3), \\
& e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 0, 0, \\
& 4 \cos[B]^2 \sin[B]^2, e^{2iA} (i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 0, 0, 0, 0, 0, 0, 0, 0 \}, \\
& \{ i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3), 4 \cos[B]^2 \sin[B]^2, \\
& 0, 0, e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), \\
& e^{4iA} (-2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3), 0, 0, 0, 0, 0, 0, 0, 0, 0 \}, \\
& \{ -4 e^{4iA} \cos[B]^2 \sin[B]^2, e^{3iA} (i \sin[B] (e^{-4iA} \cos[B]^3 - e^{-4iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-4iA} \cos[B]^2 \sin[B] - i e^{-4iA} \sin[B]^3)), \\
& 0, 0, e^{3iA} (2 i e^{-4iA} \cos[B]^3 \sin[B] - 2 i e^{-4iA} \cos[B] \sin[B]^3), \\
& e^{4iA} (\cos[B] (e^{-4iA} \cos[B]^3 - e^{-4iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-4iA} \cos[B]^2 \sin[B] - i e^{-4iA} \sin[B]^3)), 0, 0, 0, 0, 0, 0, 0, 0, 0 \}, \\
& \{ 0, 0, e^{2iA} (i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), \\
& 4 \cos[B]^2 \sin[B]^2, 0, 0, e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), \\
& e^{2iA} (-2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3), 0, 0, 0, 0, 0, 0, 0, 0 \}, \\
& \{ 0, 0, -4 \cos[B]^2 \sin[B]^2, e^{3iA} (i \sin[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), \\
& 0, 0, e^{3iA} (2 i e^{-2iA} \cos[B]^3 \sin[B] - 2 i e^{-2iA} \cos[B] \sin[B]^3), \\
& e^{2iA} (\cos[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), 0, 0, 0, 0, 0, 0, 0, 0 \},
\end{aligned}$$

$$\begin{aligned}
& \{0, 0, 0, 0, 0, 0, 0, 0, 0, e^{2iA} (\cos[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), \\
& \quad e^{3iA} (2 i e^{-2iA} \cos[B]^3 \sin[B] - 2 i e^{-2iA} \cos[B] \sin[B]^3), 0, 0, \\
& \quad e^{3iA} (i \sin[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), -4 \cos[B]^2 \sin[B]^2, 0, 0\}, \\
& \{0, 0, 0, 0, 0, 0, 0, 0, 0, e^{2iA} (-2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3), \\
& \quad e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 0, 0, \\
& \quad 4 \cos[B]^2 \sin[B]^2, e^{2iA} (i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 0, 0\}, \\
& \{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{4iA} (\cos[B] (e^{-4iA} \cos[B]^3 - e^{-4iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-4iA} \cos[B]^2 \sin[B] - i e^{-4iA} \sin[B]^3)), \\
& \quad e^{3iA} (2 i e^{-4iA} \cos[B]^3 \sin[B] - 2 i e^{-4iA} \cos[B] \sin[B]^3), 0, 0, \\
& \quad e^{3iA} (i \sin[B] (e^{-4iA} \cos[B]^3 - e^{-4iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-4iA} \cos[B]^2 \sin[B] - i e^{-4iA} \sin[B]^3)), -4 e^{-4iA} \cos[B]^2 \sin[B]^2\}, \\
& \{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{4iA} (-2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3), \\
& \quad e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), 0, \\
& \quad 0, 4 \cos[B]^2 \sin[B]^2, i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)\}, \\
& \{0, 0, 0, 0, 0, 0, 0, 0, 0, e^{2iA} (i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), \\
& \quad 4 \cos[B]^2 \sin[B]^2, 0, 0, e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), \\
& \quad e^{2iA} (-2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3), 0, 0\}, \\
& \{0, 0, 0, 0, 0, 0, 0, 0, 0, -4 \cos[B]^2 \sin[B]^2, \\
& \quad e^{3iA} (i \sin[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), \\
& \quad 0, 0, e^{3iA} (2 i e^{-2iA} \cos[B]^3 \sin[B] - 2 i e^{-2iA} \cos[B] \sin[B]^3), \\
& \quad e^{2iA} (\cos[B] (e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3)), 0, 0\}, \\
& \{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, e^{4iA} (i \sin[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad \cos[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), \\
& \quad 4 \cos[B]^2 \sin[B]^2, 0, 0, e^{3iA} (\cos[B] (-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2) + \\
& \quad i \sin[B] (-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3)), \\
& \quad -2 i e^{-3iA} \cos[B]^3 \sin[B] + 2 i e^{-3iA} \cos[B] \sin[B]^3\}, \\
& \{0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -4 e^{4iA} \cos[B]^2 \sin[B]^2, \\
& \quad e^{3iA} (i \sin[B] (\cos[B]^3 - \cos[B] \sin[B]^2) + \cos[B] (i \cos[B]^2 \sin[B] - i \sin[B]^3)), \\
& \quad 0, 0, e^{3iA} (2 i \cos[B]^3 \sin[B] - 2 i \cos[B] \sin[B]^3), \\
& \quad \cos[B] (\cos[B]^3 - \cos[B] \sin[B]^2) + i \sin[B] (i \cos[B]^2 \sin[B] - i \sin[B]^3)\}\}
\end{aligned}$$

In[74]:= **H = HadamardMatrix[16]**

```
Out[74]= { { 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4 },
  { 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, 1/4, -1/4, -1/4, -1/4, -1/4, -1/4, -1/4, -1/4, -1/4 },
  { 1/4, 1/4, 1/4, 1/4, -1/4, -1/4, -1/4, -1/4, -1/4, -1/4, -1/4, -1/4, 1/4, 1/4, 1/4, 1/4 },
  { 1/4, 1/4, 1/4, 1/4, -1/4, -1/4, -1/4, -1/4, 1/4, 1/4, 1/4, 1/4, -1/4, -1/4, -1/4, -1/4 },
  { 1/4, 1/4, -1/4, -1/4, -1/4, -1/4, 1/4, 1/4, 1/4, 1/4, -1/4, -1/4, -1/4, -1/4, 1/4, 1/4 },
  { 1/4, 1/4, -1/4, -1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, 1/4, 1/4, -1/4, -1/4 },
  { 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4 },
  { 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4 },
  { 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4 },
  { 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4 },
  { 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4 },
  { 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4 },
  { 1/4, -1/4, 1/4, -1/4, -1/4, 1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4 },
  { 1/4, -1/4, 1/4, -1/4, -1/4, 1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4 },
  { 1/4, -1/4, 1/4, -1/4, -1/4, 1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4 },
  { 1/4, -1/4, 1/4, -1/4, -1/4, 1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4 },
  { 1/4, -1/4, 1/4, -1/4, -1/4, 1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4, 1/4, -1/4, -1/4, 1/4 } }
```

```
In[79]:= UP = {{1}, {0}}
```

```
Out[79]= {{1}, {0}}
```

```
In[81]:= KroneckerProduct[UP, UP, UP, UP]
```

```
Out[81]= {{1}, {0}, {0}, {0}, {0}, {0}, {0}, {0}, {0}, {0}, {0}, {0}, {0}, {0}, {0}, {0}, {0}}
```

```
In[88]:= PM = H.KroneckerProduct[UP, UP, UP, UP]
```

```
Out[88]= { { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 }, { 1/4 } }
```

```
In[90]:= Result = Transpose[PM].Mat.PM
```

```
Out[90]= { { 1/2 ( -e^{-3 i A} Cos[B]^2 Sin[B]^2 + 1/4 ( -2 i e^{-3 i A} Cos[B]^3 Sin[B] + 2 i e^{-3 i A} Cos[B] Sin[B]^3 ) +
  1/4 ( Cos[B] ( Cos[B]^3 - Cos[B] Sin[B]^2 ) + i Sin[B] ( i Cos[B]^2 Sin[B] - i Sin[B]^3 ) ) +
  1/4 ( i Sin[B] ( -e^{-2 i A} Cos[B]^3 + e^{-2 i A} Cos[B] Sin[B]^2 ) +
```

$$\begin{aligned}
& \cos[B] \left(-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3 \right) \Big) + \\
& \frac{1}{2} \left(-e^{iA} \cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{2iA} \left(-2i e^{-3iA} \cos[B]^3 \sin[B] + 2i e^{-3iA} \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} e^{2iA} \left(\cos[B] \left(e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad i \sin[B] \left(i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3 \right) \Big) + \\
& \quad \frac{1}{4} e^{2iA} \left(i \sin[B] \left(-e^{-2iA} \cos[B]^3 + e^{-2iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad \cos[B] \left(-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3 \right) \Big) \Big) + \\
& \frac{1}{2} \left(e^{-iA} \cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{2iA} \left(2i e^{-3iA} \cos[B]^3 \sin[B] - 2i e^{-3iA} \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} e^{2iA} \left(i \sin[B] \left(\cos[B]^3 - \cos[B] \sin[B]^2 \right) + \cos[B] \left(i \cos[B]^2 \sin[B] - i \sin[B]^3 \right) \right) \Big) + \\
& \quad \frac{1}{4} e^{2iA} \left(\cos[B] \left(-e^{-2iA} \cos[B]^3 + e^{-2iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad i \sin[B] \left(-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3 \right) \Big) \Big) + \\
& \frac{1}{2} \left(e^{-iA} \cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{2iA} \left(2i e^{-iA} \cos[B]^3 \sin[B] - 2i e^{-iA} \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} e^{2iA} \left(i \sin[B] \left(e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad \cos[B] \left(i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3 \right) \Big) + \\
& \quad \frac{1}{4} e^{2iA} \left(\cos[B] \left(-e^{-2iA} \cos[B]^3 + e^{-2iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad i \sin[B] \left(-i e^{-2iA} \cos[B]^2 \sin[B] + i e^{-2iA} \sin[B]^3 \right) \Big) \Big) + \\
& \frac{1}{2} \left(-e^{-iA} \cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{iA} \left(-2i e^{-2iA} \cos[B]^3 \sin[B] + 2i e^{-2iA} \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} e^{iA} \left(\cos[B] \left(e^{-iA} \cos[B]^3 - e^{-iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad i \sin[B] \left(i e^{-iA} \cos[B]^2 \sin[B] - i e^{-iA} \sin[B]^3 \right) \Big) + \\
& \quad \frac{1}{4} e^{iA} \left(i \sin[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad \cos[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \Big) \Big) + \\
& \frac{1}{2} \left(-e^{3iA} \cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{3iA} \left(-2i e^{-2iA} \cos[B]^3 \sin[B] + 2i e^{-2iA} \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} e^{3iA} \left(\cos[B] \left(e^{-3iA} \cos[B]^3 - e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad i \sin[B] \left(i e^{-3iA} \cos[B]^2 \sin[B] - i e^{-3iA} \sin[B]^3 \right) \Big) + \\
& \quad \frac{1}{4} e^{3iA} \left(i \sin[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad \cos[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \Big) \Big) + \\
& \frac{1}{2} \left(e^{iA} \cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{3iA} \left(2i e^{-2iA} \cos[B]^3 \sin[B] - 2i e^{-2iA} \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} e^{3iA} \left(i \sin[B] \left(e^{-iA} \cos[B]^3 - e^{-iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \quad \cos[B] \left(i e^{-iA} \cos[B]^2 \sin[B] - i e^{-iA} \sin[B]^3 \right) \Big) +
\end{aligned}$$

$$\begin{aligned} & \frac{1}{4} e^{3iA} \left(\cos[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\ & \quad \left. i \sin[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \right) + \\ & \frac{1}{2} \left(e^{iA} \cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{3iA} \left(2i \cos[B]^3 \sin[B] - 2i \cos[B] \sin[B]^3 \right) + \right. \\ & \quad \frac{1}{4} e^{3iA} \left(i \sin[B] \left(e^{-3iA} \cos[B]^3 - e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\ & \quad \left. \cos[B] \left(i e^{-3iA} \cos[B]^2 \sin[B] - i e^{-3iA} \sin[B]^3 \right) \right) + \\ & \quad \left. \frac{1}{4} e^{3iA} \left(\cos[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \right. \\ & \quad \left. \left. i \sin[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \right) \right) \} \} \end{aligned}$$

In[91]:= **Simplify[Result]**

$$\text{Out[91]} = \left\{ \left\{ \frac{1}{8} i e^{-3iA} \left(1 + e^{iA} \right)^2 \left(-1 + e^{iA} - e^{2iA} + e^{3iA} \right) \right. \right. \\ \left. \left. \sin[2B] \left(\left(1 + e^{iA} \right) \cos[2B] + i \left(-1 + e^{iA} \right) \sin[2B] \right) \right\} \right\}$$

$$\begin{aligned} \text{In[94]} := \text{Expec} &= \frac{1}{8} i \left(\cos[3A] - i \sin[3A] \right) \left(1 + \cos[A] + i \sin[A] \right)^2 \\ & \left(-1 + \cos[A] + i \sin[A] - \cos[2A] - i \sin[2A] + \cos[3A] + i \sin[3A] \right) \sin[2B] \\ & \left(\left(1 + \left(\cos[A] + i \sin[A] \right) \right) \cos[2B] + i \left(-1 + \left(\cos[A] + i \sin[A] \right) \right) \sin[2B] \right) \end{aligned}$$

$$\begin{aligned} \text{Out[94]} = & \frac{1}{8} i \left(1 + \cos[A] + i \sin[A] \right)^2 \left(\cos[3A] - i \sin[3A] \right) \\ & \left(-1 + \cos[A] - \cos[2A] + \cos[3A] + i \sin[A] - i \sin[2A] + i \sin[3A] \right) \sin[2B] \\ & \left(\cos[2B] \left(1 + \cos[A] + i \sin[A] \right) + i \left(-1 + \cos[A] + i \sin[A] \right) \sin[2B] \right) \end{aligned}$$

In[99]:= **Fa = 1/2 (1 - Simplify[Expec])**

$$\text{Out[99]} = \frac{1}{2} \left(1 - 2 \cos\left[\frac{A}{2}\right]^2 \cos\left[\frac{1}{2}(A + 4B)\right] \left(\sin\left[\frac{A}{2}\right] - \sin\left[\frac{3A}{2}\right] \right) \sin[2B] \right)$$

In[112]:= **Result2 = Transpose[PM].Mat2.PM**

$$\begin{aligned}
\text{Out}[112] = \left\{ \right. & \frac{1}{4} e^{3iA} \left(2i e^{-2iA} \cos[B]^3 \sin[B] - 2i e^{-2iA} \cos[B] \sin[B]^3 \right) + \\
& \frac{1}{4} e^{2iA} \left(-2i e^{-3iA} \cos[B]^3 \sin[B] + 2i e^{-3iA} \cos[B] \sin[B]^3 \right) + \\
& \frac{1}{4} e^{3iA} \left(i \sin[B] \left(e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. \cos[B] \left(i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3 \right) \right) + \\
& \frac{1}{4} e^{2iA} \left(\cos[B] \left(e^{-2iA} \cos[B]^3 - e^{-2iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. i \sin[B] \left(i e^{-2iA} \cos[B]^2 \sin[B] - i e^{-2iA} \sin[B]^3 \right) \right) + \\
& \frac{1}{4} e^{2iA} \left(i \sin[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. \cos[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \right) + \\
& \frac{1}{4} e^{3iA} \left(\cos[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. i \sin[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \right) + \\
& \frac{1}{2} \left(-e^{-4iA} \cos[B]^2 \sin[B]^2 + \frac{1}{4} \left(-2i e^{-3iA} \cos[B]^3 \sin[B] + 2i e^{-3iA} \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} \left(\cos[B] \left(\cos[B]^3 - \cos[B] \sin[B]^2 \right) + i \sin[B] \left(i \cos[B]^2 \sin[B] - i \sin[B]^3 \right) \right) + \\
& \quad \frac{1}{4} \left(i \sin[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. \left. \cos[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \right) \right) + \\
& \frac{1}{2} \left(\cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{3iA} \left(2i e^{-4iA} \cos[B]^3 \sin[B] - 2i e^{-4iA} \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} e^{3iA} \left(i \sin[B] \left(\cos[B]^3 - \cos[B] \sin[B]^2 \right) + \cos[B] \left(i \cos[B]^2 \sin[B] - i \sin[B]^3 \right) \right) + \\
& \quad \frac{1}{4} e^{3iA} \left(\cos[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. \left. i \sin[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \right) \right) + \\
& \frac{1}{2} \left(\cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{3iA} \left(2i \cos[B]^3 \sin[B] - 2i \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} e^{3iA} \left(\cos[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. i \sin[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \right) + \\
& \quad \frac{1}{4} e^{3iA} \left(i \sin[B] \left(e^{-4iA} \cos[B]^3 - e^{-4iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. \left. \cos[B] \left(i e^{-4iA} \cos[B]^2 \sin[B] - i e^{-4iA} \sin[B]^3 \right) \right) \right) + \\
& \frac{1}{2} \left(-e^{-4iA} \cos[B]^2 \sin[B]^2 + \frac{1}{4} e^{4iA} \left(-2i e^{-3iA} \cos[B]^3 \sin[B] + 2i e^{-3iA} \cos[B] \sin[B]^3 \right) + \right. \\
& \quad \frac{1}{4} e^{4iA} \left(i \sin[B] \left(-e^{-3iA} \cos[B]^3 + e^{-3iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. \cos[B] \left(-i e^{-3iA} \cos[B]^2 \sin[B] + i e^{-3iA} \sin[B]^3 \right) \right) + \\
& \quad \frac{1}{4} e^{4iA} \left(\cos[B] \left(e^{-4iA} \cos[B]^3 - e^{-4iA} \cos[B] \sin[B]^2 \right) + \right. \\
& \quad \left. \left. i \sin[B] \left(i e^{-4iA} \cos[B]^2 \sin[B] - i e^{-4iA} \sin[B]^3 \right) \right) \right) \left. \right\}
\end{aligned}$$

In[113]:= **Simplify[Result2]**

$$\text{Out[113]} = \left\{ \left\{ -\frac{1}{8} e^{-4 i A} \left(-1 + e^{2 i A} \right) \left(1 + e^{2 i A} \right)^2 \sin[2 B] \left(-2 i e^{i A} \cos[2 B] + \left(-1 + e^{2 i A} \right) \sin[2 B] \right) \right\} \right\}$$

In[114]:= **Expect2 =**

$$\begin{aligned} & -\frac{1}{8} \left(\cos[4 A] - i \sin[4 A] \right) \left(-1 + \left(\cos[2 A] + i \sin[2 A] \right) \right) \left(1 + \left(\cos[2 A] + i \sin[2 A] \right) \right)^2 \\ & \sin[2 B] \left(-2 i \left(\cos[A] + i \sin[A] \right) \cos[2 B] + \left(-1 + \left(\cos[2 A] + i \sin[2 A] \right) \right) \sin[2 B] \right) \\ \text{Out[114]} = & -\frac{1}{8} \left(-1 + \cos[2 A] + i \sin[2 A] \right) \left(1 + \cos[2 A] + i \sin[2 A] \right)^2 \left(\cos[4 A] - i \sin[4 A] \right) \\ & \sin[2 B] \left(-2 i \cos[2 B] \left(\cos[A] + i \sin[A] \right) + \left(-1 + \cos[2 A] + i \sin[2 A] \right) \sin[2 B] \right) \end{aligned}$$

In[116]:= **Fb = 1/2 (1 - Simplify[Expect2])**

$$\text{Out[116]} = \frac{1}{2} \left(1 + 4 \cos[A]^2 \cos[B] \sin[A] \sin[B] \left(\cos[B]^2 - 2 \cos[B] \sin[A] \sin[B] - \sin[B]^2 \right) \right)$$

In[120]:= **Fb + 4 Fa**

$$\begin{aligned} \text{Out[120]} = & \frac{1}{2} \left(1 + 4 \cos[A]^2 \cos[B] \sin[A] \sin[B] \left(\cos[B]^2 - 2 \cos[B] \sin[A] \sin[B] - \sin[B]^2 \right) \right) + \\ & 2 \left(1 - 2 \cos\left[\frac{A}{2}\right]^2 \cos\left[\frac{1}{2} (A + 4 B)\right] \left(\sin\left[\frac{A}{2}\right] - \sin\left[\frac{3 A}{2}\right] \right) \sin[2 B] \right) \end{aligned}$$

In[121]:= **Cost = Simplify[Fb + 4 Fa]**

$$\begin{aligned} \text{Out[121]} = & \frac{1}{2} \left(5 + 8 \cos\left[\frac{A}{2}\right]^2 \cos\left[\frac{1}{2} (A + 4 B)\right] \left(-\sin\left[\frac{A}{2}\right] + \sin\left[\frac{3 A}{2}\right] \right) \sin[2 B] - \right. \\ & \left. \frac{1}{2} \sin[2 A]^2 \sin[2 B]^2 + \cos[A]^2 \sin[A] \sin[4 B] \right) \end{aligned}$$