Generate Quantum Expressions for Papers, Books and Other Publications

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Introduction

This is a tutorial on the use of Quantum`Computing` *Mathematica* add-on to generate Quantum expressions that can be copy-pasted to other editors.

Load the Package

First load the Quantum`Computing` package. Write:
Needs["Quantum`Computing`"];
then press at the same time the keys SHIFT-ENTER to evaluate. *Mathematica* will load the package. The semicolon prevents *Mathematica* from printing the welcome message:

```
Needs["Quantum`Computing`"]
```

In order to use the keyboard to enter quantum objects write:
SetComputingAliases[ ];
then press at the same time the keys SHIFT-ENTER to evaluate. The semicolon prevents *Mathematica* from printing the help message. Remember that SetComputingAliases[ ] must be evaluated again in each new notebook:

```
SetComputingAliases[];
```

Copy-Paste or Export to TEX editors

This is an expression in Dirac notation, with the conventions of this *Mathematica* add-on

```
QuantumEvaluate[ℋ1̂ ⊗ ℋ2̂]
```

$$\frac{1}{2}\,|0_{\hat{1}},0_{\hat{2}}\rangle\cdot\langle 0_{\hat{1}},0_{\hat{2}}|+\frac{1}{2}\,|0_{\hat{1}},1_{\hat{2}}\rangle\cdot\langle 0_{\hat{1}},0_{\hat{2}}|+$$
$$\frac{1}{2}\,|1_{\hat{1}},0_{\hat{2}}\rangle\cdot\langle 0_{\hat{1}},0_{\hat{2}}|+\frac{1}{2}\,|1_{\hat{1}},1_{\hat{2}}\rangle\cdot\langle 0_{\hat{1}},0_{\hat{2}}|+$$
$$\frac{1}{2}\,|0_{\hat{1}},0_{\hat{2}}\rangle\cdot\langle 0_{\hat{1}},1_{\hat{2}}|-\frac{1}{2}\,|0_{\hat{1}},1_{\hat{2}}\rangle\cdot\langle 0_{\hat{1}},1_{\hat{2}}|+\frac{1}{2}\,|1_{\hat{1}},0_{\hat{2}}\rangle\cdot\langle 0_{\hat{1}},1_{\hat{2}}|-$$
$$\frac{1}{2}\,|1_{\hat{1}},1_{\hat{2}}\rangle\cdot\langle 0_{\hat{1}},1_{\hat{2}}|+\frac{1}{2}\,|0_{\hat{1}},0_{\hat{2}}\rangle\cdot\langle 1_{\hat{1}},0_{\hat{2}}|+\frac{1}{2}\,|0_{\hat{1}},1_{\hat{2}}\rangle\cdot\langle 1_{\hat{1}},0_{\hat{2}}|-$$
$$\frac{1}{2}\,|1_{\hat{1}},0_{\hat{2}}\rangle\cdot\langle 1_{\hat{1}},0_{\hat{2}}|-\frac{1}{2}\,|1_{\hat{1}},1_{\hat{2}}\rangle\cdot\langle 1_{\hat{1}},0_{\hat{2}}|+\frac{1}{2}\,|0_{\hat{1}},0_{\hat{2}}\rangle\cdot\langle 1_{\hat{1}},1_{\hat{2}}|-$$
$$\frac{1}{2}\,|0_{\hat{1}},1_{\hat{2}}\rangle\cdot\langle 1_{\hat{1}},1_{\hat{2}}|-\frac{1}{2}\,|1_{\hat{1}},0_{\hat{2}}\rangle\cdot\langle 1_{\hat{1}},1_{\hat{2}}|+\frac{1}{2}\,|1_{\hat{1}},1_{\hat{2}}\rangle\cdot\langle 1_{\hat{1}},1_{\hat{2}}|$$

TraditionalForm gives an expression closer to the Dirac notation as used in books and papers

```
TraditionalForm[QuantumEvaluate[ℋ1̂ ⊗ ℋ2̂]]
```

$$\frac{1}{2}\,|00\rangle\langle 00|+\frac{1}{2}\,|01\rangle\langle 00|+\frac{1}{2}\,|10\rangle\langle 00|+\frac{1}{2}\,|11\rangle\langle 00|+\frac{1}{2}\,|00\rangle\langle 01|-\frac{1}{2}\,|01\rangle\langle 01|+\frac{1}{2}\,|10\rangle\langle 01|-\frac{1}{2}\,|11\rangle\langle 01|+$$
$$\frac{1}{2}\,|00\rangle\langle 10|+\frac{1}{2}\,|01\rangle\langle 10|-\frac{1}{2}\,|10\rangle\langle 10|-\frac{1}{2}\,|11\rangle\langle 10|+\frac{1}{2}\,|00\rangle\langle 11|-\frac{1}{2}\,|01\rangle\langle 11|-\frac{1}{2}\,|10\rangle\langle 11|+\frac{1}{2}\,|11\rangle\langle 11|$$

TeXForm can be used to generate an expression that can be copy-pasted to a TEX editor:

```
TeXForm[TraditionalForm[QuantumEvaluate[ℋ1̂ ⊗ ℋ2̂]]]
```

```
\frac{1}{2} |00\rangle \langle 00|+\frac{1}{2}
   |01\rangle \langle 00|+\frac{1}{2} |10\rangle \langle
   00|+\frac{1}{2} |11\rangle \langle 00|+\frac{1}{2}
   |00\rangle \langle 01|-\frac{1}{2} |01\rangle \langle
   01|+\frac{1}{2} |10\rangle \langle 01|-\frac{1}{2}
   |11\rangle \langle 01|+\frac{1}{2} |00\rangle \langle
   10|+\frac{1}{2} |01\rangle \langle 10|-\frac{1}{2}
   |10\rangle \langle 10|-\frac{1}{2} |11\rangle \langle
   10|+\frac{1}{2} |00\rangle \langle 11|-\frac{1}{2}
   |01\rangle \langle 11|-\frac{1}{2} |10\rangle \langle
   11|+\frac{1}{2} |11\rangle \langle 11|
```

The standard *Mathematica* command Export can be used to generate a file in TEX format:

```
Export["mytest.tex", TraditionalForm[QuantumEvaluate[ℋ1̂ ⊗ ℋ2̂]]]
```

```
mytest.tex
```

This is the content of the file that was created above:

```
ReadList["mytest.tex", String]
```

```
{%% AMS-LaTeX Created by Wolfram Mathematica 7.0 : www.wolfram.com,
 \documentclass{article}, \usepackage{amsmath, amssymb, graphics},
 \newcommand{\mathsym}[1]{{}}, \newcommand{\unicode}[1]{{}},
 \begin{document}, \[\frac{1}{2} |00\rangle \langle
   00|+\frac{1}{2} |01\rangle \langle 00|+\frac{1}{2} |10\rangle
   \langle 00|+\frac{1}{2} |11\rangle \langle 00|+\frac{1}{2},
 |00\rangle \langle 01|-\frac{1}{2} |01\rangle \langle 01|+\frac{1}{2} |10\rangle
   \langle 01|-\frac{1}{2} |11\rangle \langle 01|+\frac{1}{2} |00\rangle,
 \langle 10|+\frac{1}{2} |01\rangle \langle 10|-\frac{1}{2} |10\rangle
   \langle 10|-\frac{1}{2} |11\rangle \langle 10|+\frac{1}{2} |00\rangle \langle,
 11|-\frac{1}{2} |01\rangle \langle 11|-\frac{1}{2} |10\rangle \langle
   11|+\frac{1}{2} |11\rangle \langle 11|\], \end{document}}
```

Copy-paste Dirac Expressions as Images to Microsoft Word and Other Processors

Here we generate the Truth-Table for an operator. The resulta has the notation of this *Mathematica* package, which is **not** the same as the usual notation for Quantum Computing papers. Furthermore, **this table cannot be sucessfully copy-pasted (some elements and formating is lost) to a Microsoft Word document yet**, please continue reading, below in this document it will be shown how to generate expressions that can be copy-pasted (as images) to Microsoft Word.

```
QuantumTableForm[ℋ1̂ ⊗ ℋ2̂]
```

	Input	Output
0	$\vert 0_{\hat{1}}, 0_{\hat{2}}\rangle$	$\frac{1}{2} \vert 0_{\hat{1}}, 0_{\hat{2}}\rangle + \frac{1}{2} \vert 0_{\hat{1}}, 1_{\hat{2}}\rangle + \frac{1}{2} \vert 1_{\hat{1}}, 0_{\hat{2}}\rangle + \frac{1}{2} \vert 1_{\hat{1}}, 1_{\hat{2}}\rangle$
1	$\vert 0_{\hat{1}}, 1_{\hat{2}}\rangle$	$\frac{1}{2} \vert 0_{\hat{1}}, 0_{\hat{2}}\rangle - \frac{1}{2} \vert 0_{\hat{1}}, 1_{\hat{2}}\rangle + \frac{1}{2} \vert 1_{\hat{1}}, 0_{\hat{2}}\rangle - \frac{1}{2} \vert 1_{\hat{1}}, 1_{\hat{2}}\rangle$
2	$\vert 1_{\hat{1}}, 0_{\hat{2}}\rangle$	$\frac{1}{2} \vert 0_{\hat{1}}, 0_{\hat{2}}\rangle + \frac{1}{2} \vert 0_{\hat{1}}, 1_{\hat{2}}\rangle - \frac{1}{2} \vert 1_{\hat{1}}, 0_{\hat{2}}\rangle - \frac{1}{2} \vert 1_{\hat{1}}, 1_{\hat{2}}\rangle$
3	$\vert 1_{\hat{1}}, 1_{\hat{2}}\rangle$	$\frac{1}{2} \vert 0_{\hat{1}}, 0_{\hat{2}}\rangle - \frac{1}{2} \vert 0_{\hat{1}}, 1_{\hat{2}}\rangle - \frac{1}{2} \vert 1_{\hat{1}}, 0_{\hat{2}}\rangle + \frac{1}{2} \vert 1_{\hat{1}}, 1_{\hat{2}}\rangle$

Next expression is better; TraditionalForm[] generates an expression in the notation that is usually used in papers and books. However, **this table cannot be sucessfully copy-pasted (some elements and formating is lost) to a Microsoft Word document yet**, please continue reading, below in this document it will be shown how to generate expressions that can be copy-pasted to Microsoft Word.

```
TraditionalForm[QuantumTableForm[ℋ1̂ ⊗ ℋ2̂]]
```

	Input	Output
0	$\vert 00\rangle$	$\frac{1}{2} \vert 00\rangle + \frac{1}{2} \vert 01\rangle + \frac{1}{2} \vert 10\rangle + \frac{1}{2} \vert 11\rangle$
1	$\vert 01\rangle$	$\frac{1}{2} \vert 00\rangle - \frac{1}{2} \vert 01\rangle + \frac{1}{2} \vert 10\rangle - \frac{1}{2} \vert 11\rangle$
2	$\vert 10\rangle$	$\frac{1}{2} \vert 00\rangle + \frac{1}{2} \vert 01\rangle - \frac{1}{2} \vert 10\rangle - \frac{1}{2} \vert 11\rangle$
3	$\vert 11\rangle$	$\frac{1}{2} \vert 00\rangle - \frac{1}{2} \vert 01\rangle - \frac{1}{2} \vert 10\rangle + \frac{1}{2} \vert 11\rangle$

Finally an expression that **can** be succesfully copy-pasted to Microsoft Word and it looks identical to what you see in *Mathematica*. However it is ugly. Please continue reading below.

```
QuantumToGraphics[TraditionalForm[QuantumTableForm[ℋ1̂ ⊗ ℋ2̂]]]
```

	" Input"	" Output"
0	$\|00\rangle$	$\frac{1}{2}\|00\rangle+\frac{1}{2}\|01\rangle+\frac{1}{2}\|10\rangle+\frac{1}{2}\|11\rangle$
1	$\|01\rangle$	$\frac{1}{2}\|00\rangle-\frac{1}{2}\|01\rangle+\frac{1}{2}\|10\rangle-\frac{1}{2}\|11\rangle$
2	$\|10\rangle$	$\frac{1}{2}\|00\rangle+\frac{1}{2}\|01\rangle-\frac{1}{2}\|10\rangle-\frac{1}{2}\|11\rangle$
3	$\|11\rangle$	$\frac{1}{2}\|00\rangle-\frac{1}{2}\|01\rangle-\frac{1}{2}\|10\rangle+\frac{1}{2}\|11\rangle$

Using Grid[] and QuantumTable[] instead of QuantumTableForm[] a more beatiful table can be generated. This table **can** be copy-pasted to Microsoft Word because of the command QuantumToGraphics[]

```
QuantumToGraphics[TraditionalForm[Grid[QuantumTable[ℋ1̂ ⊗ ℋ2̂],
   Background → {None, {{LightCyan, LightMagenta}}}, Frame → All]]]
```

$\|00\rangle$	$\frac{1}{2}\|00\rangle+\frac{1}{2}\|01\rangle+\frac{1}{2}\|10\rangle+\frac{1}{2}\|11\rangle$
$\|01\rangle$	$\frac{1}{2}\|00\rangle-\frac{1}{2}\|01\rangle+\frac{1}{2}\|10\rangle-\frac{1}{2}\|11\rangle$
$\|10\rangle$	$\frac{1}{2}\|00\rangle+\frac{1}{2}\|01\rangle-\frac{1}{2}\|10\rangle-\frac{1}{2}\|11\rangle$
$\|11\rangle$	$\frac{1}{2}\|00\rangle-\frac{1}{2}\|01\rangle-\frac{1}{2}\|10\rangle+\frac{1}{2}\|11\rangle$

Table headings can be added using Join[] and Style[] with the option ShowStringCharacters->False. This table **can** be copy-pasted to Microsoft Word because of the command QuantumToGraphics[]

```
QuantumToGraphics[
 TraditionalForm[Style[Grid[Join[{{"Input", "Output"}}, QuantumTable[ℋ1̂ ⊗ ℋ2̂]],
    Background → {None, {{LightCyan, LightMagenta}}},
    Frame → All], ShowStringCharacters → False]]]
```

Input	Output
$\|00\rangle$	$\frac{1}{2}\|00\rangle+\frac{1}{2}\|01\rangle+\frac{1}{2}\|10\rangle+\frac{1}{2}\|11\rangle$
$\|01\rangle$	$\frac{1}{2}\|00\rangle-\frac{1}{2}\|01\rangle+\frac{1}{2}\|10\rangle-\frac{1}{2}\|11\rangle$
$\|10\rangle$	$\frac{1}{2}\|00\rangle+\frac{1}{2}\|01\rangle-\frac{1}{2}\|10\rangle-\frac{1}{2}\|11\rangle$
$\|11\rangle$	$\frac{1}{2}\|00\rangle-\frac{1}{2}\|01\rangle-\frac{1}{2}\|10\rangle+\frac{1}{2}\|11\rangle$

Same example, with differente color for the headings:

```
QuantumToGraphics[TraditionalForm[
  Style[Grid[Join[{{"Input", "Output"}}, QuantumTable[ℋ_1̂ ⊗ ℋ_2̂]], Background →
     {None, {{LightYellow, LightCyan, LightMagenta, LightCyan, LightMagenta}}},
    Frame → All], ShowStringCharacters → False]]]
```

Input	Output
$\|00\rangle$	$\frac{1}{2}\|00\rangle + \frac{1}{2}\|01\rangle + \frac{1}{2}\|10\rangle + \frac{1}{2}\|11\rangle$
$\|01\rangle$	$\frac{1}{2}\|00\rangle - \frac{1}{2}\|01\rangle + \frac{1}{2}\|10\rangle - \frac{1}{2}\|11\rangle$
$\|10\rangle$	$\frac{1}{2}\|00\rangle + \frac{1}{2}\|01\rangle - \frac{1}{2}\|10\rangle - \frac{1}{2}\|11\rangle$
$\|11\rangle$	$\frac{1}{2}\|00\rangle - \frac{1}{2}\|01\rangle - \frac{1}{2}\|10\rangle + \frac{1}{2}\|11\rangle$

Another option is to Export[] as a figure. Here we export to a PDF graphic that can be read with Acrobat reader:

```
Export["myfig01.PDF", TraditionalForm[
  Style[Grid[Join[{{"Input", "Output"}}, QuantumTable[ℋ_1̂ ⊗ ℋ_2̂]], Background →
     {None, {{LightYellow, LightCyan, LightMagenta, LightCyan, LightMagenta}}},
    Frame → All], ShowStringCharacters → False]]]
```

```
myfig01.PDF
```

Here we can see the file that was exported.

```
FileNames["myfig01.*"]
```

```
{myfig01.PDF}
```

Here we export to a GIF graphic that can be inserted in Microsoft Word documents and in HTML web pages:

```
Export["myfig02.GIF", TraditionalForm[
  Style[Grid[Join[{{"Input", "Output"}}, QuantumTable[ℋ_1̂ ⊗ ℋ_2̂]], Background →
     {None, {{LightYellow, LightCyan, LightMagenta, LightCyan, LightMagenta}}},
    Frame → All], ShowStringCharacters → False]]]
```

```
myfig02.GIF
```

Here we can see the files that were exported.

```
FileNames["myf*.*"]
```

```
{myfig01.PDF, myfig02.GIF}
```

Style[] can be used to generate an expression in the desired format. This expression **can** be copy-pasted to Microsoft Word because of the command QuantumToGraphics[]

```
QuantumToGraphics[TraditionalForm[
  Style[QuantumEvaluate[ℋ1̂ ⊗ ℋ2̂], Darker[Red], FontFamily → "Verdana"]]]
```

$$\frac{1}{2}\,|00\rangle\langle 00| + \frac{1}{2}\,|01\rangle\langle 00| + \frac{1}{2}\,|10\rangle\langle 00| + \frac{1}{2}\,|11\rangle\langle 00| +$$
$$\frac{1}{2}\,|00\rangle\langle 01| - \frac{1}{2}\,|01\rangle\langle 01| + \frac{1}{2}\,|10\rangle\langle 01| - \frac{1}{2}\,|11\rangle\langle 01| +$$
$$\frac{1}{2}\,|00\rangle\langle 10| + \frac{1}{2}\,|01\rangle\langle 10| - \frac{1}{2}\,|10\rangle\langle 10| - \frac{1}{2}\,|11\rangle\langle 10| +$$
$$\frac{1}{2}\,|00\rangle\langle 11| - \frac{1}{2}\,|01\rangle\langle 11| - \frac{1}{2}\,|10\rangle\langle 11| + \frac{1}{2}\,|11\rangle\langle 11|$$

Notice the use of the option ItemSize in the QuantumToGraphics command. This expression **can** be copy-pasted to Microsoft Word because of the command QuantumToGraphics[]

```
QuantumToGraphics[TraditionalForm[Style[QuantumEvaluate[ℋ1̂ ⊗ ℋ2̂],
   Darker[Red], FontFamily → "Verdana"]], ItemSize → 18]
```

$$\frac{1}{2}\,|00\rangle\langle 00| + \frac{1}{2}\,|01\rangle\langle 00| +$$
$$\frac{1}{2}\,|10\rangle\langle 00| + \frac{1}{2}\,|11\rangle\langle 00| +$$
$$\frac{1}{2}\,|00\rangle\langle 01| - \frac{1}{2}\,|01\rangle\langle 01| +$$
$$\frac{1}{2}\,|10\rangle\langle 01| - \frac{1}{2}\,|11\rangle\langle 01| +$$
$$\frac{1}{2}\,|00\rangle\langle 10| + \frac{1}{2}\,|01\rangle\langle 10| -$$
$$\frac{1}{2}\,|10\rangle\langle 10| - \frac{1}{2}\,|11\rangle\langle 10| +$$
$$\frac{1}{2}\,|00\rangle\langle 11| - \frac{1}{2}\,|01\rangle\langle 11| -$$
$$\frac{1}{2}\,|10\rangle\langle 11| + \frac{1}{2}\,|11\rangle\langle 11|$$

Notice the use of the option ItemSize in the QuantumToGraphics command. This expression **can** be copy-pasted to Microsoft Word because of the command QuantumToGraphics[]

```
QuantumToGraphics[TraditionalForm[Style[QuantumEvaluate[ℋ1̂ ⊗ ℋ2̂],
   Darker[Red], FontFamily → "Courier", FontWeight → "Bold"]], ItemSize → 36]
```

$$\begin{aligned}
&\tfrac{1}{2}\ |00\rangle\langle 00| + \tfrac{1}{2}\ |01\rangle\langle 00| + \tfrac{1}{2}\ |10\rangle\langle 00| + \tfrac{1}{2}\ |11\rangle\langle 00| + \\
&\tfrac{1}{2}\ |00\rangle\langle 01| - \tfrac{1}{2}\ |01\rangle\langle 01| + \tfrac{1}{2}\ |10\rangle\langle 01| - \tfrac{1}{2}\ |11\rangle\langle 01| + \\
&\tfrac{1}{2}\ |00\rangle\langle 10| + \tfrac{1}{2}\ |01\rangle\langle 10| - \tfrac{1}{2}\ |10\rangle\langle 10| - \tfrac{1}{2}\ |11\rangle\langle 10| + \\
&\tfrac{1}{2}\ |00\rangle\langle 11| - \tfrac{1}{2}\ |01\rangle\langle 11| - \tfrac{1}{2}\ |10\rangle\langle 11| + \tfrac{1}{2}\ |11\rangle\langle 11|
\end{aligned}$$

---

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