

Simulation Based on Michel Fodje's epr-simple simulation translated from Python to Mathematica by John Reed 13 Nov 2013
Modified by Fred Diether for CHSH Analysis July 2021
Some parts by Bill Nelson

Setting Run Time Parameters and Initializing Arrays and Tables

```
In[391]:= m = 20000;
s = ConstantArray[0, m];
λ = ConstantArray[0, m];
outA4 = Table[{0, 0, 0, 0, 0}, m];
outB4 = Table[{0, 0, 0, 0, 0}, m];
outA1 = Table[{0, 0, 0, 0, 0}, m];
outB1 = Table[{0, 0, 0, 0, 0}, m];
outA2 = Table[{0, 0, 0, 0, 0}, m];
outB2 = Table[{0, 0, 0, 0, 0}, m];
a2 = ConstantArray[0, m];
b2 = ConstantArray[0, m];
A = ConstantArray[0, m];
B = ConstantArray[0, m];
β = 0.3;
φ = 3; ξ = -15;
```

Generating Particle Data with Three Independent Do-Loops

```
In[405]:= Do[e = RandomReal[{0, 360}]; (*Singlet vector angle*)
s[[i]] = e; (*Hidden Variable*)
λ[[i]] = β Cos[ $\frac{e}{\phi}$  ^ 2],
{i, m}]
```

```
In[406]:= Do[a = RandomChoice[{0, 90}]; (*Detector vector angle*)
If[Abs[Cos[(a - s[[i]]) Degree]]] < λ[[i]], C1 = f1, C1 = g1];
If[Abs[Cos[(a - s[[i]]) Degree]]] > λ[[i]],
Aa = -Sign[Cos[(a - s[[i]]) Degree]], Aa = -Sign[Sin[(a - s[[i]] + ξ) Degree]]];
A5 = -Sign[Sin[(a - s[[i]] + ξ) Degree]];
outA4[[i]] = {a, Aa, i, C1, A5}, {i, m}
outA1 = Select[outA4, MemberQ[#, g1] &];
outA2 = Select[outA4, MemberQ[#, f1] &];
```

```
In[409]:= Do[b = RandomChoice[{45, 135}]; (*Detector vector angle*)
If[Abs[Cos[(b - s[[i]]) Degree]]] < λ[[i]], C2 = f2, C2 = g2];
If[Abs[Cos[(b - s[[i]]) Degree]]] > λ[[i]],
Bb = Sign[Cos[(b - s[[i]]) Degree]], Bb = Sign[(Sin[(b - s[[i]] + ξ) Degree])]];
B5 = Sign[(Sin[(b - s[[i]] + ξ) Degree])]];
outB4[[i]] = {b, Bb, i, C2, B5}, {i, m}
outB1 = Select[outB4, MemberQ[#, g2] &];
outB2 = Select[outB4, MemberQ[#, f2] &];
```

Matching Events Observed by Alice and Bob by Trial Numbers

```
In[412]:= list13 = outA1[[All, 3]]; (*Two lists of trial numbers used for matching events.*)
list23 = outB1[[All, 3]];
```

Local Detection Analysis of the Events Observed by Alice

```
In[414]:= listA4 = Select[outA1, Intersection[#[[3]], list23] == {#[[3]]} &];
listad2 = outA1[[All, 3]];
listad3 = listA4[[All, 3]];
listA3 = Select[outA1, Intersection[#[[3]], listad3] != {#[[3]]} &];
listAa4 = Select[listA4, Intersection[#[[3]], listad2] != {#[[3]]} &];
M = Length[listA3];
listA6 = Table[{0, 0, 0, 0, 0}, M];
a2 = ConstantArray[0, M];
A2 = ConstantArray[0, M];
ind2 = ConstantArray[0, M];
A3 = ConstantArray[0, M];
A7 = ConstantArray[0, M];
A4 = ConstantArray[0, M];
A6 = ConstantArray[0, M];
a2 = listA3[[All, 1]];
A2 = listA3[[All, 2]];
ind2 = listA3[[All, 3]];
A7 = listA3[[All, 5]];
Do[A4 = A2[[i]]; A6 = A7[[i]];
  If[A4 == A6, A2 = A2, A2 = A7];
  listA6[[i]] = {a2[[i]], A2[[i]], ind2[[i]], f1, A7[[i]], {i, M}}
outA = Sort[Catenate[{listA4, outA2, listA6}], #1[[3]] < #2[[3]] &];
a2 = outA[[All, 1]];
A = outA[[All, 2]];
```

Local Detection Analysis of the Events Observed by Alice

```

In[436]:= listB4 = Select[outB1, Intersection[#{#[[3]]}, list13] == {#[[3]]} &];
listbd2 = outB1[[All, 3]];
listbd3 = listB4[[All, 3]];
listB3 = Select[outB1, Intersection[#{#[[3]]}, listbd3] != {#[[3]]} &];
listBb4 = Select[listB4, Intersection[#{#[[3]]}, listbd2] != {#[[3]]} &];
M2 = Length[listB3];
listB6 = Table[{0, 0, 0, 0, 0}, M2];
b2 = ConstantArray[0, M2];
B2 = ConstantArray[0, M2];
ind3 = ConstantArray[0, M2];
B3 = ConstantArray[0, M2];
B7 = ConstantArray[0, M2];
B4 = ConstantArray[0, M2];
B6 = ConstantArray[0, M2];
b2 = listB3[[All, 1]];
B2 = listB3[[All, 2]];
ind3 = listB3[[All, 3]];
B7 = listB3[[All, 5]];
Do[B4 = B2[[i]]; B6 = B7[[i]];
  If[B4 == B6, B2 = B2, B2 = B7];
  listB6[[i]] = {b2[[i]], B2[[i]], ind3[[i]], f1, B7[[i]]}, {i, M2}];
outB = Sort[Catenate[{listB4, outB2, listB6}], #1[[3]] < #2[[3]] &];
b2 = outB[[All, 1]];
B = outB[[All, 2]];

```

CHSH Analysis of the Particle Data Received from Alice and Bob

```

In[458]:= nP1 = 0; nN1 = 0; nP2 = 0; nN2 = 0; nP3 = 0; nN3 = 0; nP4 = 0; nN4 = 0;
Do[a1 = a2[[j]]; b1 = b2[[j]];
  aliceD = A[[j]]; bobD = B[[j]];
  If[(b1 == 45) && (a1 - b1 == -45) && aliceD * bobD == 1, nP1++];
  If[(b1 == 45) && (a1 - b1 == -45) && aliceD * bobD == -1, nN1++];
  If[(a1 - b1) == -135 && aliceD * bobD == 1, nP2++];
  If[(a1 - b1) == -135 && aliceD * bobD == -1, nN2++];
  If[(a1 - b1) == 45 && aliceD * bobD == 1, nP3++];
  If[(a1 - b1) == 45 && aliceD * bobD == -1, nN3++];
  If[a1 == 90 && (a1 - b1) == -45 && aliceD * bobD == 1, nP4++];
  If[a1 == 90 && (a1 - b1) == -45 && aliceD * bobD == -1, nN4++], {j, m}];
E1 = N[(nP1 - nN1) / (nP1 + nN1)];
E2 = N[(nP2 - nN2) / (nP2 + nN2)];
E3 = N[(nP3 - nN3) / (nP3 + nN3)];
E4 = N[(nP4 - nN4) / (nP4 + nN4)];
CHSH = Abs[E1 - E2 + E3 + E4];
Print["CHSH = ", CHSH]

CHSH = 2.78

```