

Oltre Turing

La Computazione Quantistica

Ugo Dal Lago

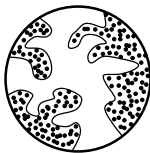


ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Inria
informatiques mathématiques

ScienzaGiovane, 27 Ottobre 2012

Un Semplice Gioco



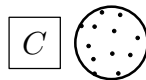
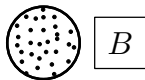
A

B

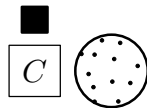
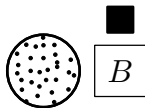
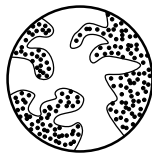
C



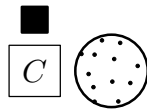
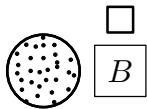
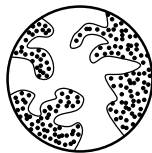
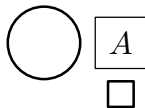
Un Semplice Gioco



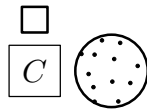
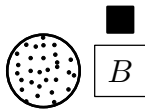
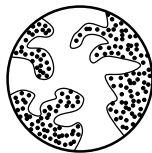
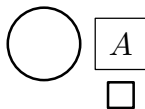
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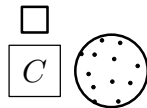
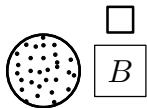
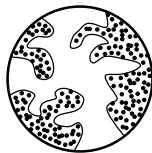
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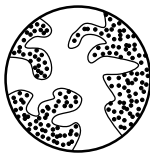
Un Semplice Gioco



Un Semplice Gioco



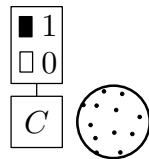
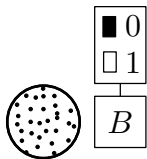
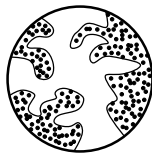
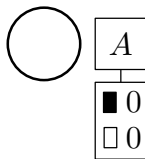
Un Semplice Gioco



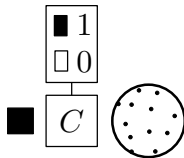
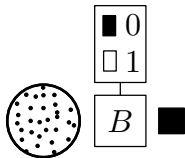
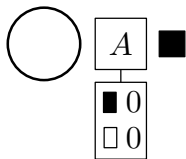
<i>A</i>	<i>B</i>	<i>C</i>
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<input type="checkbox"/> 0	<input type="checkbox"/> 1	<input type="checkbox"/> 0



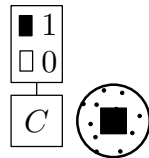
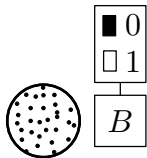
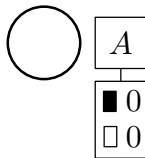
Un Semplice Gioco



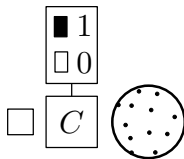
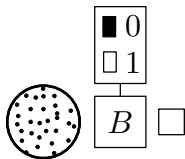
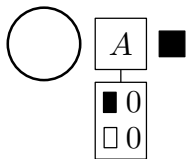
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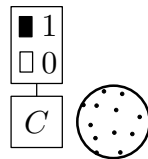
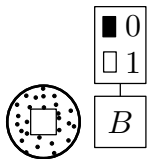
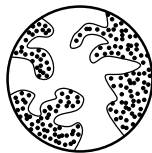
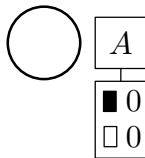
Un Semplice Gioco



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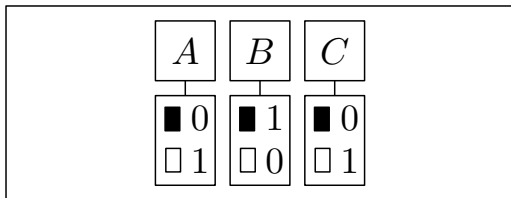
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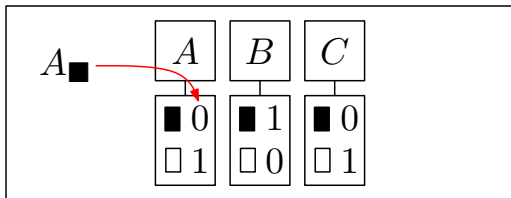
Quando A , B e C Vincono?

A	B	C	
■	■	■	Dispari
■	□	□	} Pari
□	■	□	
□	□	■	

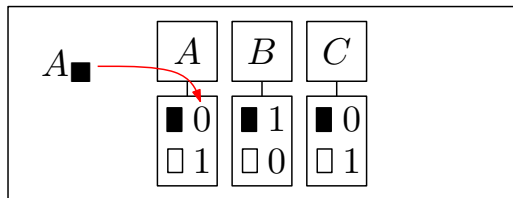
Quando A , B e C Vincono?



Quando A , B e C Vincono?



Quando A , B e C Vincono?



$$A_{\blacksquare} + B_{\blacksquare} + C_{\blacksquare} = \text{Dispari}$$

$$A_{\blacksquare} + B_{\square} + C_{\square} = \text{Pari}$$

$$A_{\square} + B_{\blacksquare} + C_{\square} = \text{Pari}$$

$$A_{\square} + B_{\square} + C_{\blacksquare} = \text{Pari}$$

A, B e C Non Possono Vincere!

$$2A_{\blacksquare} + 2A_{\square} + 2B_{\blacksquare} + 2B_{\square} + 2C_{\blacksquare} + 2C_{\square} = \text{Dispari}$$

A, *B* e *C* Non Possono Vincere!

$$2A_{\blacksquare} + 2A_{\square} + 2B_{\blacksquare} + 2B_{\square} + 2C_{\blacksquare} + 2C_{\square} = \text{Dispari}$$


Turing

$|000\rangle$

Oltre Turing

$$0,5 \cdot |001\rangle + 0,7 \cdot |100\rangle + 0,01 \cdot |010\rangle + 0,5 \cdot |111\rangle$$

Turing

$$|000\rangle$$

Oltre Turing

$$0,5 \cdot |001\rangle + 0,7 \cdot |100\rangle + 0,01 \cdot |010\rangle + 0,5 \cdot |111\rangle$$

Strategie Quantistiche

	A
\square	$a 1yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle + \sqrt{\frac{1}{2}}a 0yz\rangle$
	$a 0yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle - \sqrt{\frac{1}{2}}a 0yz\rangle$

\blacksquare	$a 1yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle + \sqrt{\frac{1}{2}}a 0yz\rangle$
	$a 0yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle - \sqrt{\frac{1}{2}}a 0yz\rangle$

Se arriva $\blacksquare \dots$

$$\sqrt{\frac{1}{2}}|111\rangle + \sqrt{\frac{1}{2}}|000\rangle \rightarrow \frac{1}{2}|111\rangle + \frac{1}{2}|011\rangle + \frac{1}{2}|100\rangle - \frac{1}{2}|000\rangle$$

Strategie Quantistiche

	A
\square	$a 1yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle + \sqrt{\frac{1}{2}}a 0yz\rangle$
	$a 0yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle - \sqrt{-\frac{1}{2}}a 0yz\rangle$

\blacksquare	$a 1yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle + \sqrt{\frac{1}{2}}a 0yz\rangle$
	$a 0yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle - \sqrt{\frac{1}{2}}a 0yz\rangle$

Se arriva $\blacksquare \dots$

$$\sqrt{\frac{1}{2}}|111\rangle + \sqrt{\frac{1}{2}}|000\rangle \rightarrow \frac{1}{2}|111\rangle + \frac{1}{2}|011\rangle + \frac{1}{2}|100\rangle - \frac{1}{2}|000\rangle$$

Strategie Quantistiche

	A
□	$a 1yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle + \sqrt{\frac{1}{2}}a 0yz\rangle$
	$a 0yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle - \sqrt{\frac{1}{2}}a 0yz\rangle$

■	$a 1yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle + \sqrt{\frac{1}{2}}a 0yz\rangle$
	$a 0yz\rangle \rightarrow \sqrt{\frac{1}{2}}a 1yz\rangle - \sqrt{\frac{1}{2}}a 0yz\rangle$

Se arriva ■...

$$\sqrt{\frac{1}{2}}|111\rangle + \sqrt{\frac{1}{2}}|000\rangle \rightarrow \frac{1}{2}|111\rangle + \frac{1}{2}|011\rangle + \frac{1}{2}|100\rangle - \frac{1}{2}|000\rangle$$

Supponiamo che A , B , C Ricevano ■ ...

$$\begin{aligned}\sqrt{\frac{1}{2}}|111\rangle + \sqrt{\frac{1}{2}}|000\rangle &\rightarrow \frac{1}{4}|111\rangle + \frac{1}{4}|110\rangle + \frac{1}{4}|111\rangle - \frac{1}{4}|110\rangle \\ &+ \frac{1}{4}|101\rangle + \frac{1}{4}|100\rangle - \frac{1}{4}|101\rangle + \frac{1}{4}|100\rangle \\ &+ \frac{1}{4}|011\rangle + \frac{1}{4}|010\rangle - \frac{1}{4}|011\rangle + \frac{1}{4}|010\rangle \\ &+ \frac{1}{4}|001\rangle + \frac{1}{4}|000\rangle + \frac{1}{4}|001\rangle - \frac{1}{4}|000\rangle \\ &= \frac{1}{2}|111\rangle + \frac{1}{2}|100\rangle + \frac{1}{2}|010\rangle - \frac{1}{2}|001\rangle\end{aligned}$$

Supponiamo che A , B , C Ricevano ■ ...

$$\begin{aligned}\sqrt{\frac{1}{2}}|111\rangle + \sqrt{\frac{1}{2}}|000\rangle &\rightarrow \frac{1}{4}|111\rangle + \frac{1}{4}|110\rangle + \frac{1}{4}|111\rangle - \frac{1}{4}|110\rangle \\ &+ \frac{1}{4}|101\rangle + \frac{1}{4}|100\rangle - \frac{1}{4}|101\rangle + \frac{1}{4}|100\rangle \\ &+ \frac{1}{4}|011\rangle + \frac{1}{4}|010\rangle - \frac{1}{4}|011\rangle + \frac{1}{4}|010\rangle \\ &+ \frac{1}{4}|001\rangle + \frac{1}{4}|000\rangle + \frac{1}{4}|001\rangle - \frac{1}{4}|000\rangle \\ &= \frac{1}{2}|111\rangle + \frac{1}{2}|100\rangle + \frac{1}{2}|010\rangle - \frac{1}{2}|001\rangle\end{aligned}$$

Supponiamo che A , B , C Ricevano ■ ...

$$\begin{aligned}\sqrt{\frac{1}{2}}|111\rangle + \sqrt{\frac{1}{2}}|000\rangle &\rightarrow \frac{1}{4}|111\rangle + \frac{1}{4}|110\rangle + \frac{1}{4}|111\rangle - \frac{1}{4}|110\rangle \\ &+ \frac{1}{4}|101\rangle + \frac{1}{4}|100\rangle - \frac{1}{4}|101\rangle + \frac{1}{4}|100\rangle \\ &+ \frac{1}{4}|011\rangle + \frac{1}{4}|010\rangle - \frac{1}{4}|011\rangle + \frac{1}{4}|010\rangle \\ &+ \frac{1}{4}|001\rangle + \frac{1}{4}|000\rangle + \frac{1}{4}|001\rangle - \frac{1}{4}|000\rangle \\ &= \frac{1}{2}|111\rangle + \frac{1}{2}|100\rangle + \frac{1}{2}|010\rangle - \frac{1}{2}|001\rangle\end{aligned}$$

Grazie!

Domande?