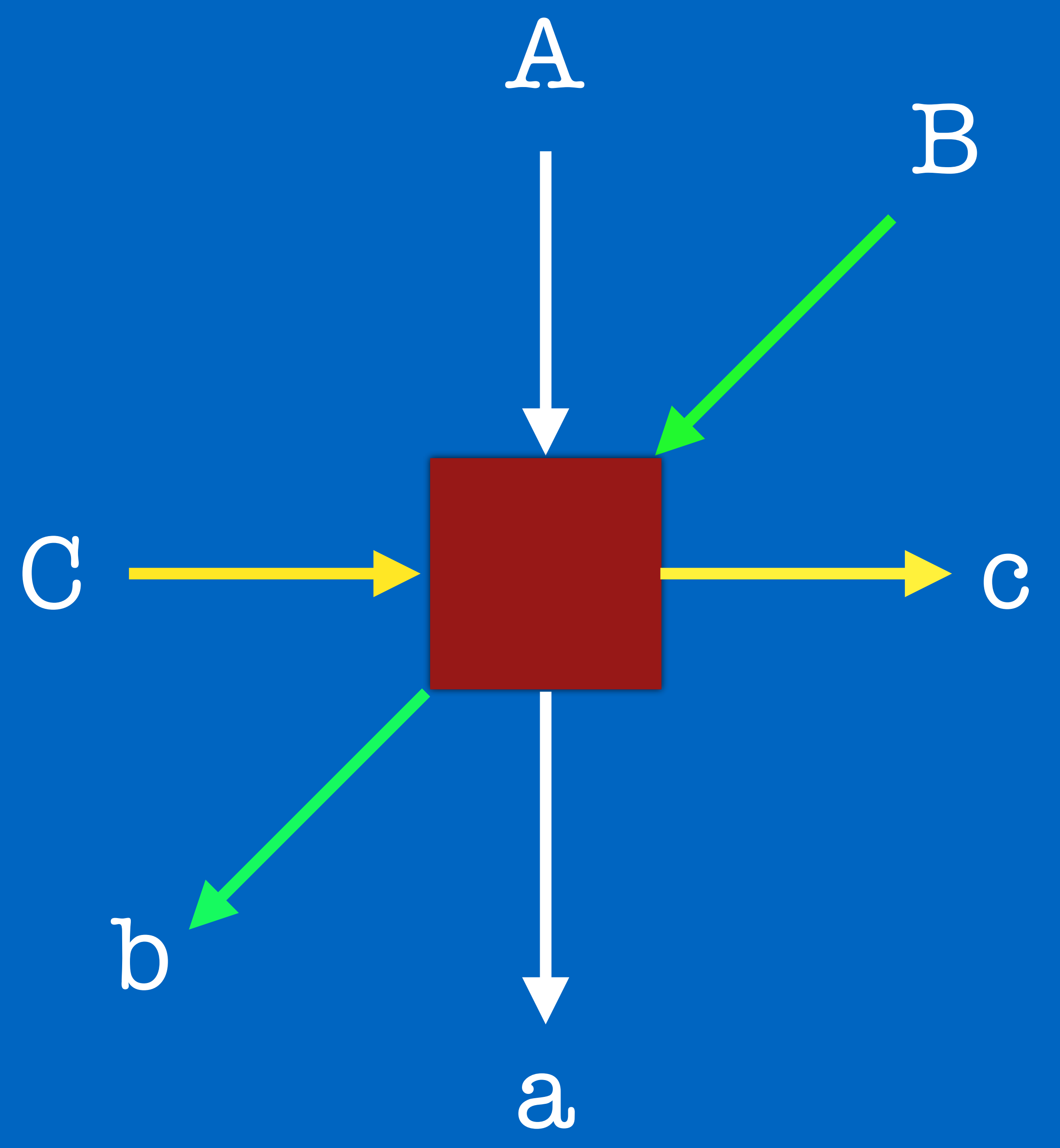
Testing the quantum-classical boundary with compression software

Outline

1. Standard approach to non-classicality

2. Triangle principle

3. Compression



given in experiment

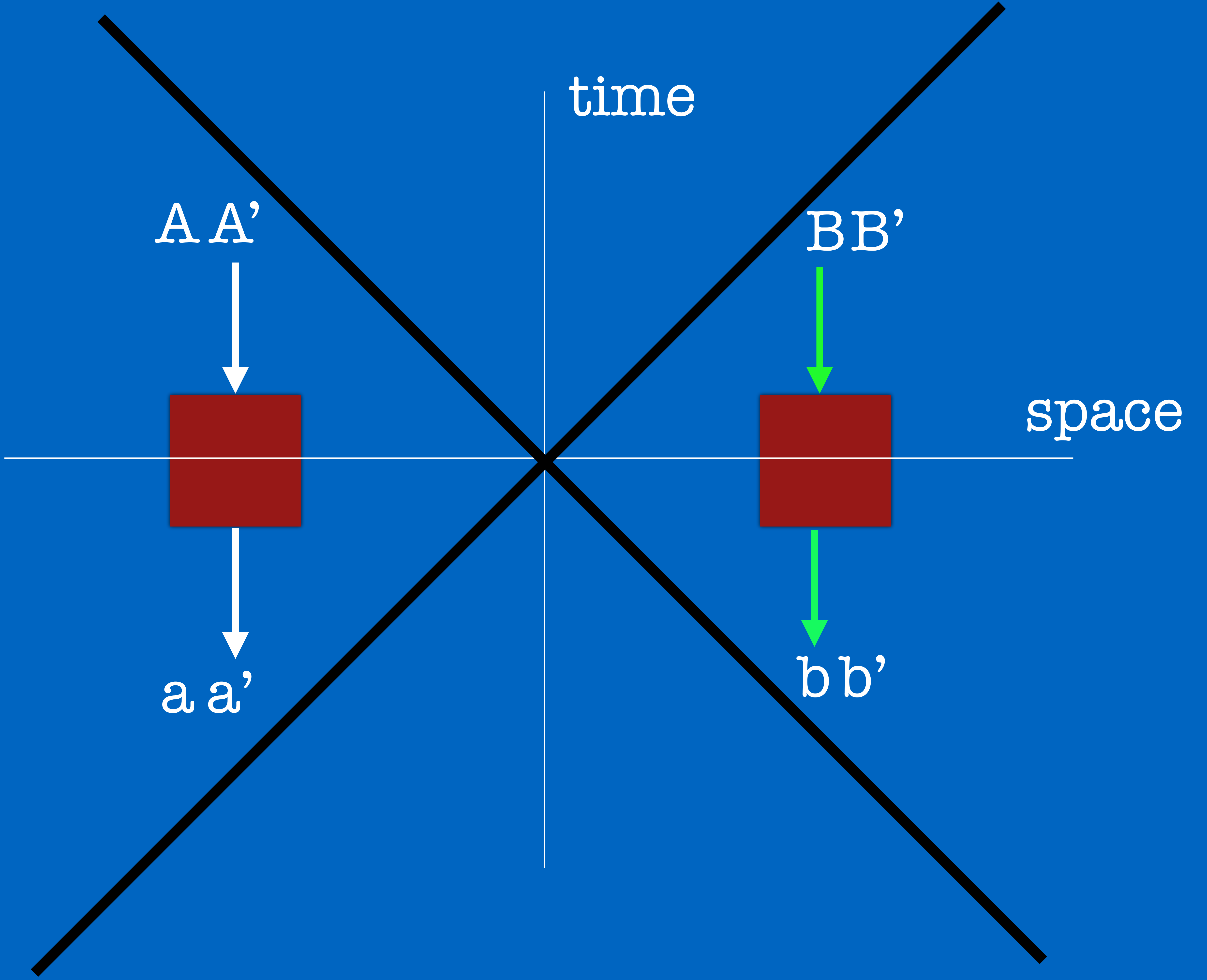
p(a,b)

p(b,c)

p(a,c)

classical theories

p(a,b,c)



given in experiment

p(a,b)

p(a,b')

p(a',b)

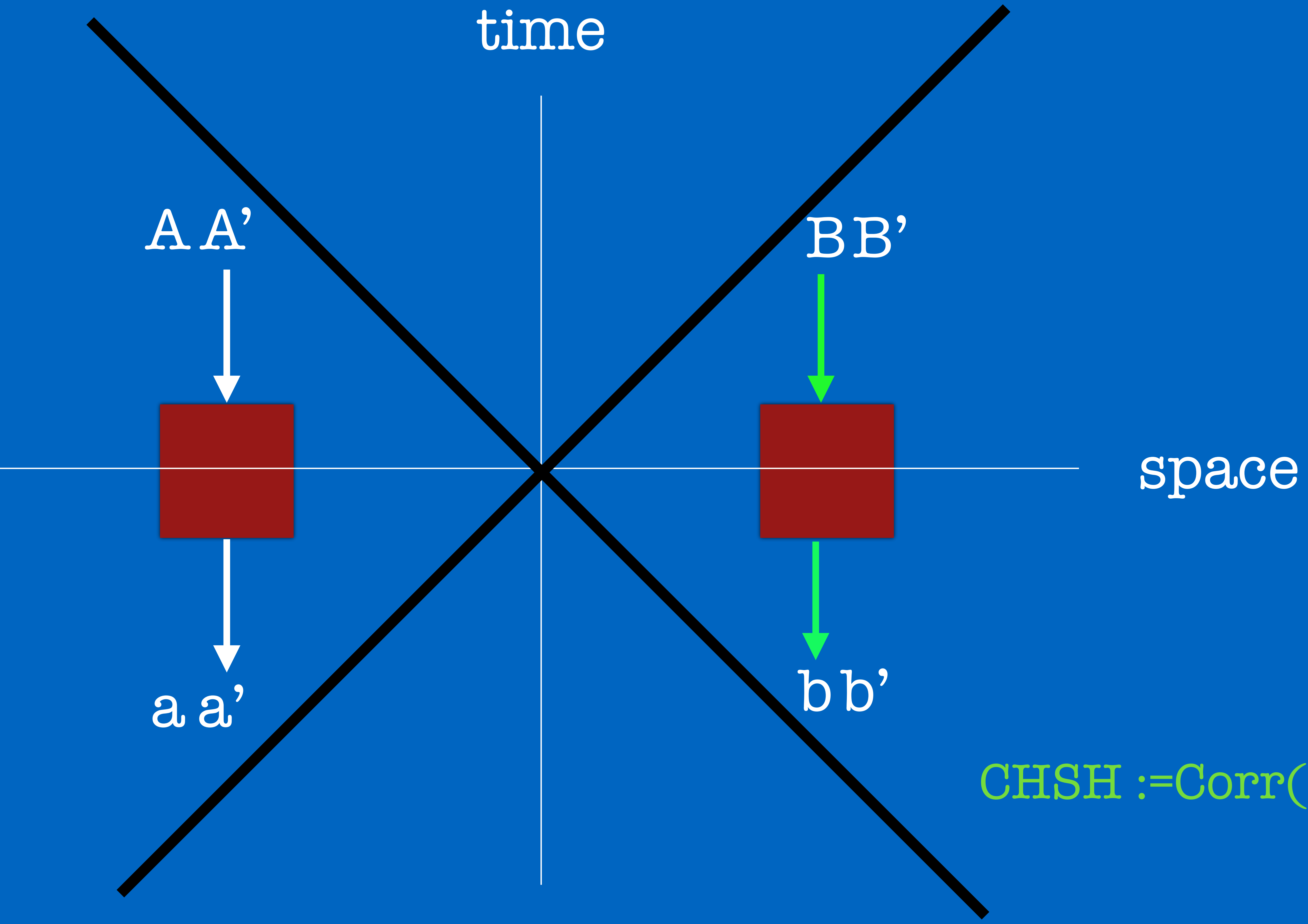
p(a',b')

classical theories

p(a,a';b,b')

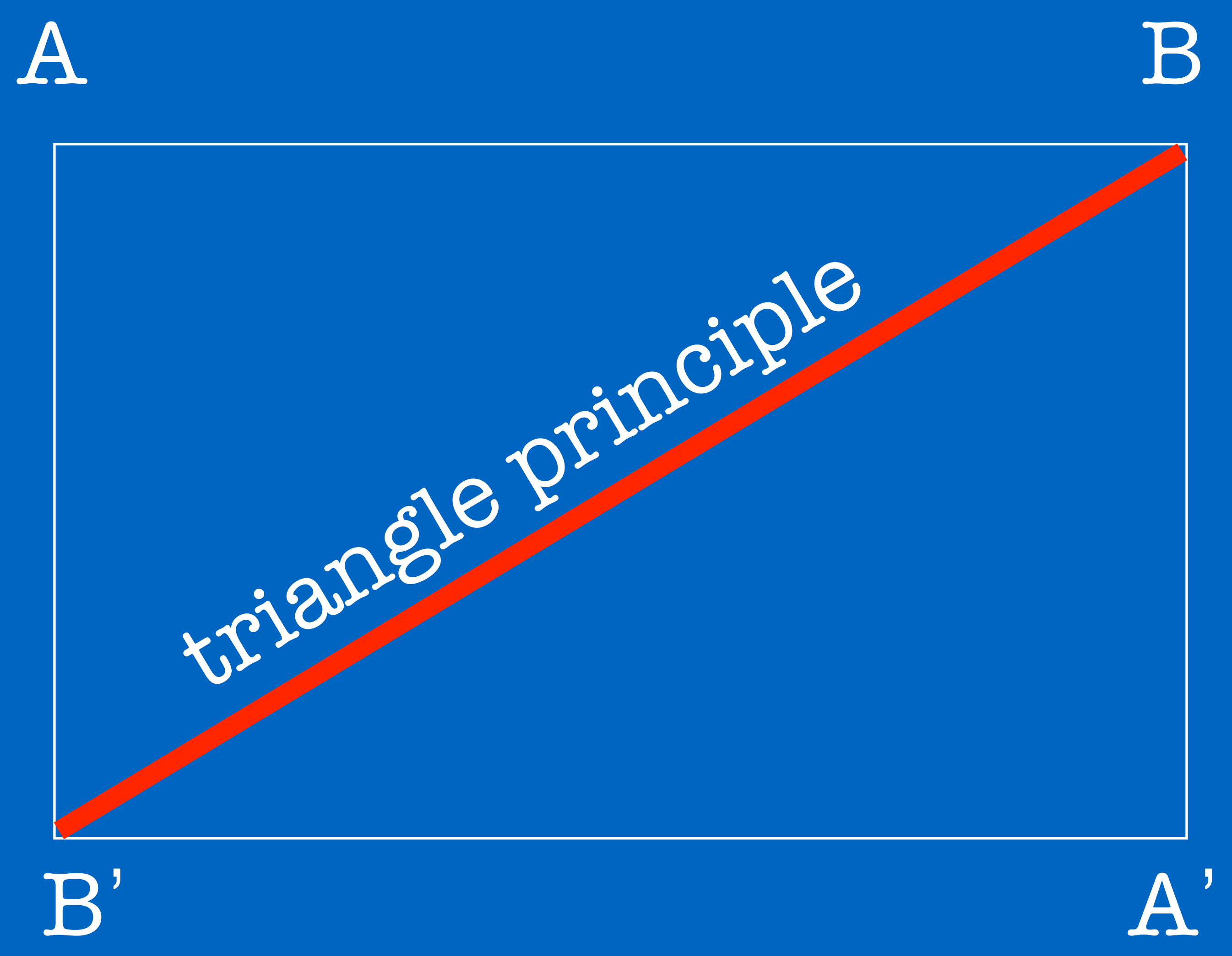
Classical $\longleftrightarrow$ joint probability distribution for all properties of system exists

Existence check $\longrightarrow$ some sort of inequality



$p(a,a';b,b')$

$\mathrm{CHSH} := \mathrm{Corr}(a,b)+\mathrm{Corr}(a,b')+\mathrm{Corr}(a',b)-\mathrm{Corr}(a',b') - 2 <= 0$

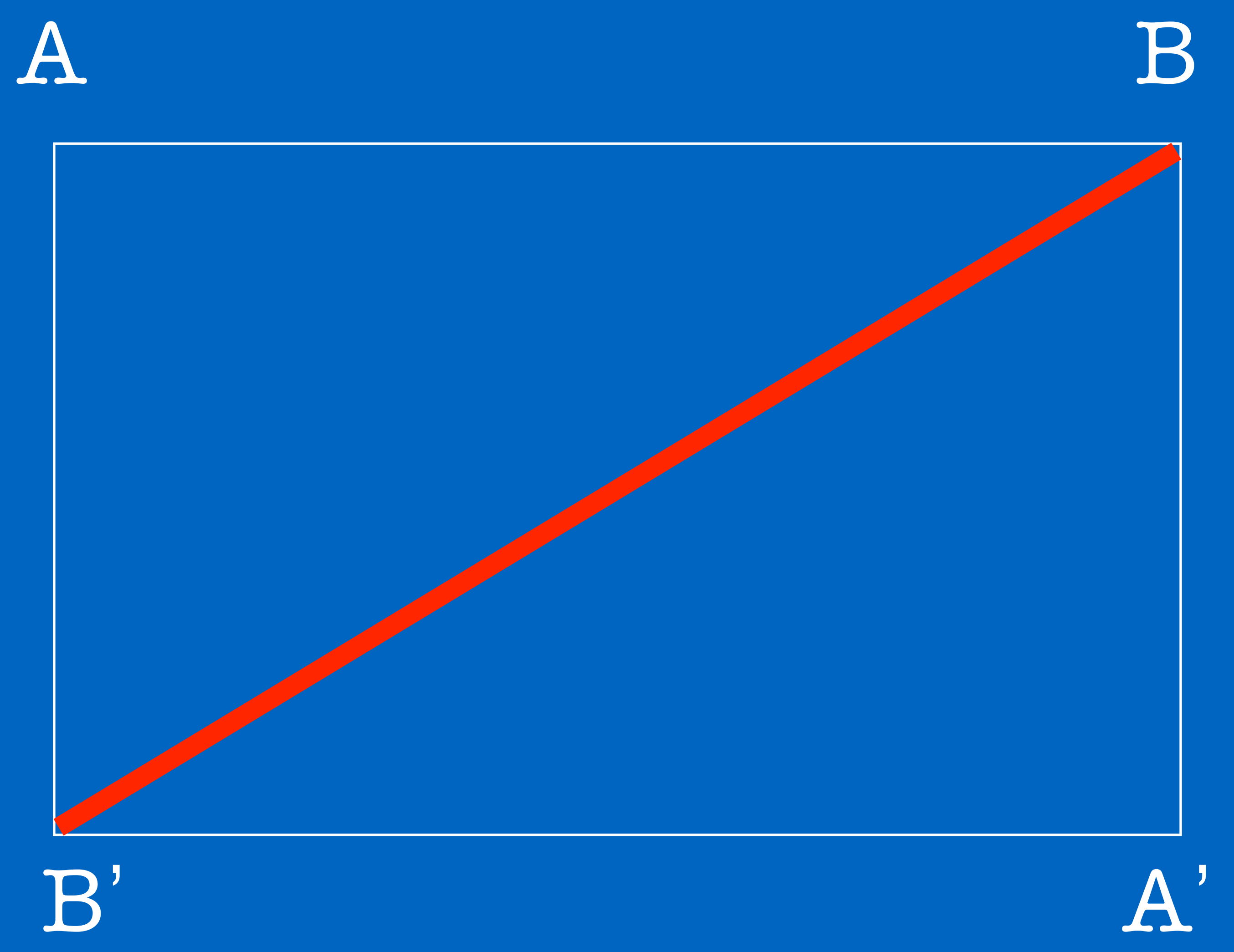


dist(A,B):= 1- Corr(A,B)

1. dist(A,A)= 0
2. dist(A,B)= dist(B,A)
3. dist(A,B)+ dist(B,C)=> dist(A,C)

d(A,B)+d(B,A')+d(A',B')-d(A,B') <= 0

CHSH <= 0

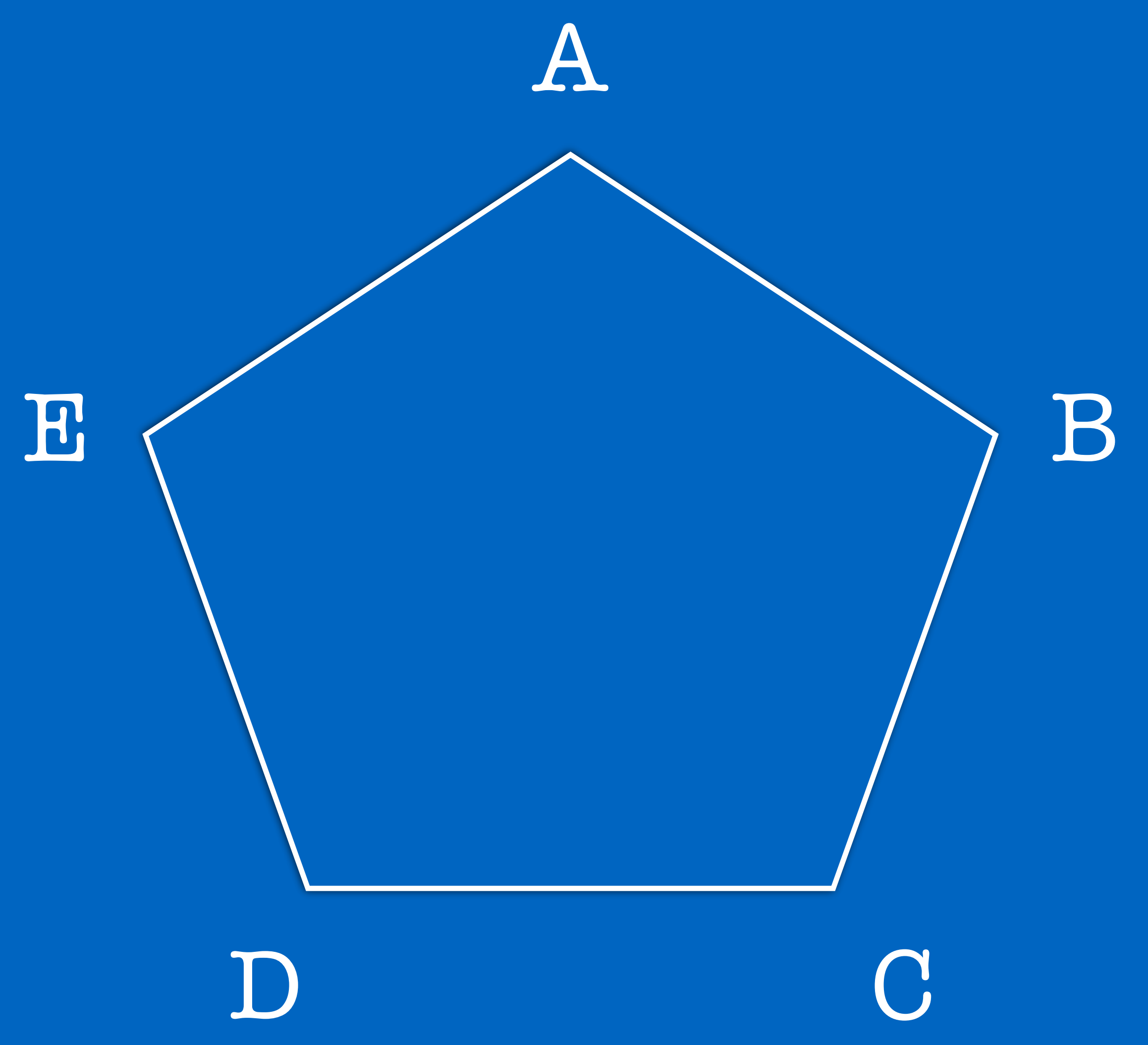


$$\mathrm{dist}(A,B) := H(A|B) + H(B|A)$$

$$\mathrm{dist}(A,B) := \max\{H(A),H(B)\} - I(A:B)$$

$$\downarrow$$

different 'Bell' inequalities



$$\mathrm{dist}(A,B) := H(A|B) + H(B|A)$$

$$\mathrm{dist}(A,B) := \max\{H(A), H(B)\} - I(A:B)$$

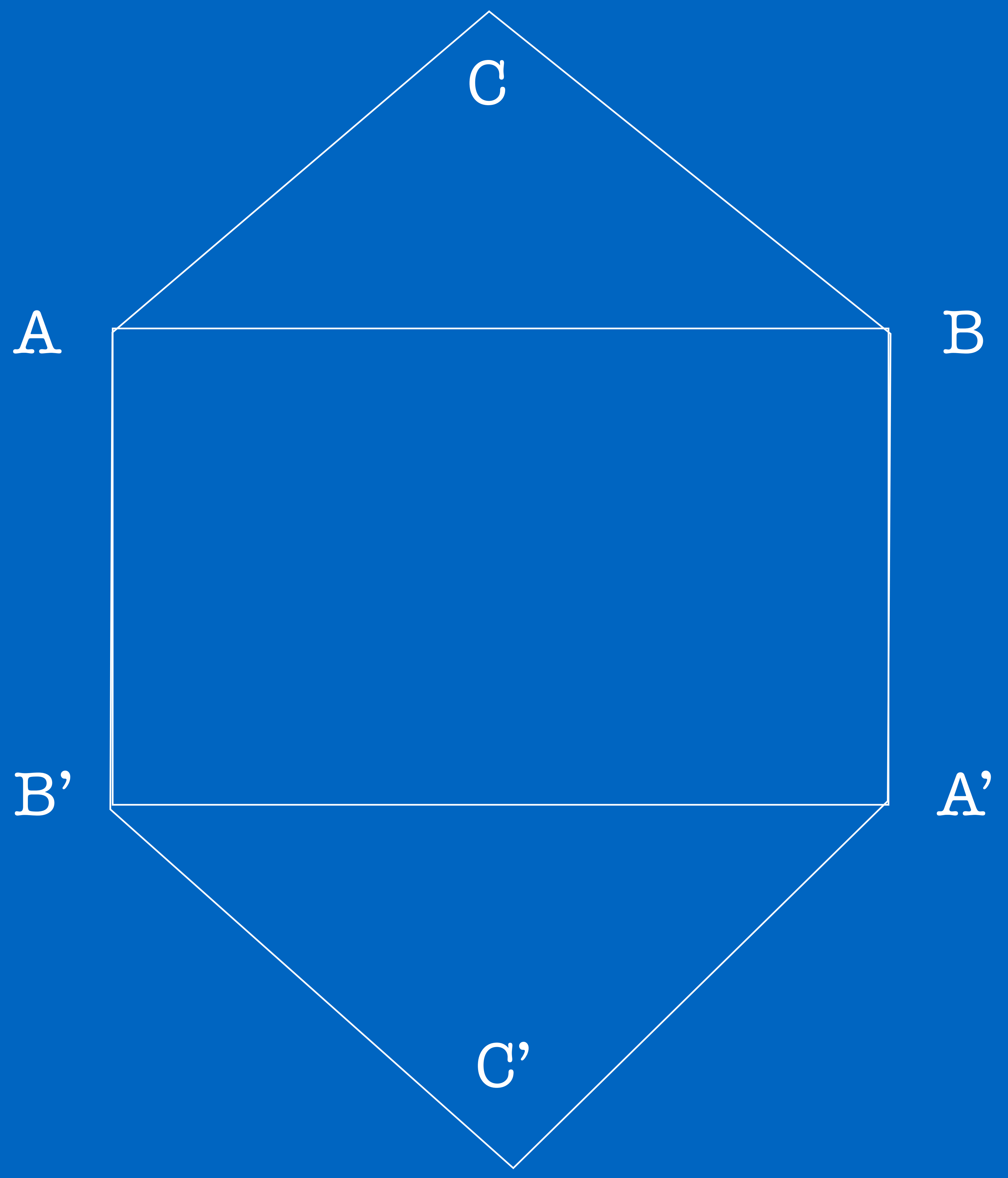
different non-contextual inequalities

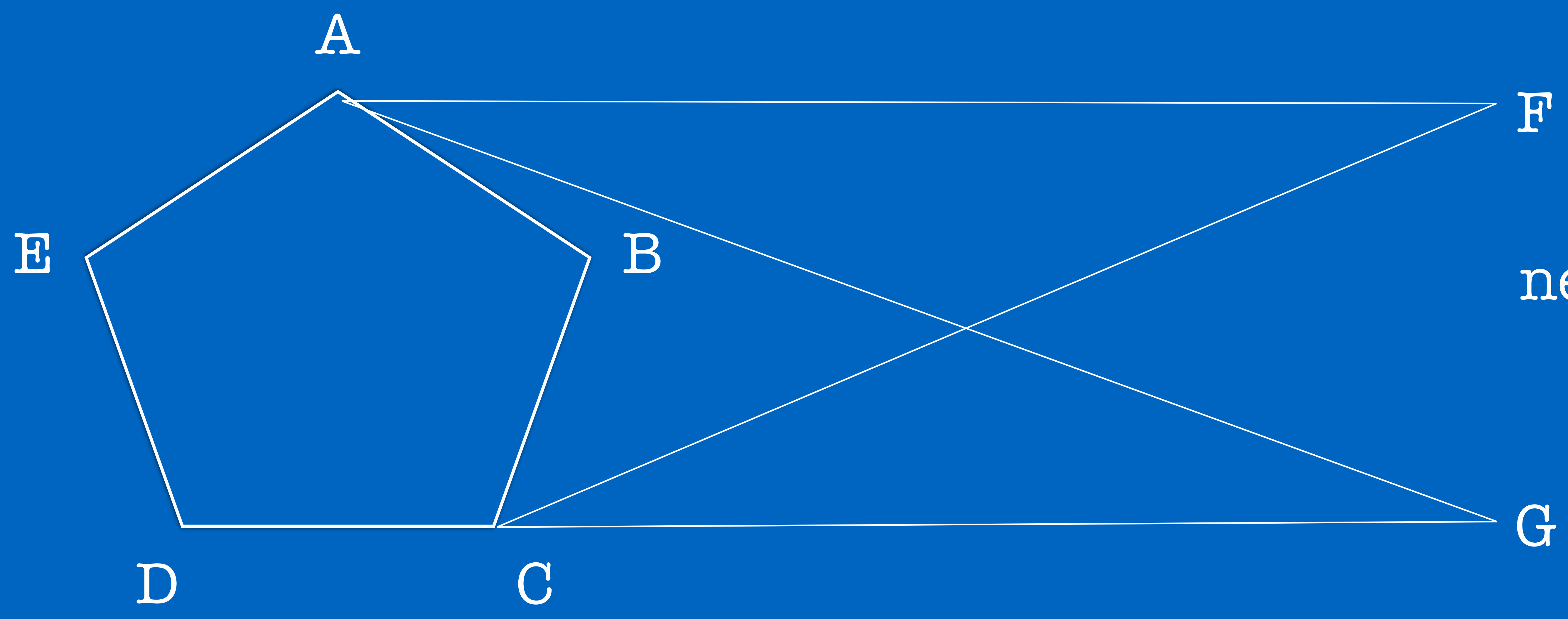
AC + CA'+ A'B' => AB'

AB + BA' + A'C' => AC'

add them

(AB+BA'+A'B'-AB')+(AC+CA'+A'C'-AC') => 0





new monogamy between contextuality
and non-locality

triangle principle is weaker

$p(A=1,B=0)=1$
$p(B=1,C=0)=1$
$p(C=1,A=0)=1$

multipartite scenario with
binary observables

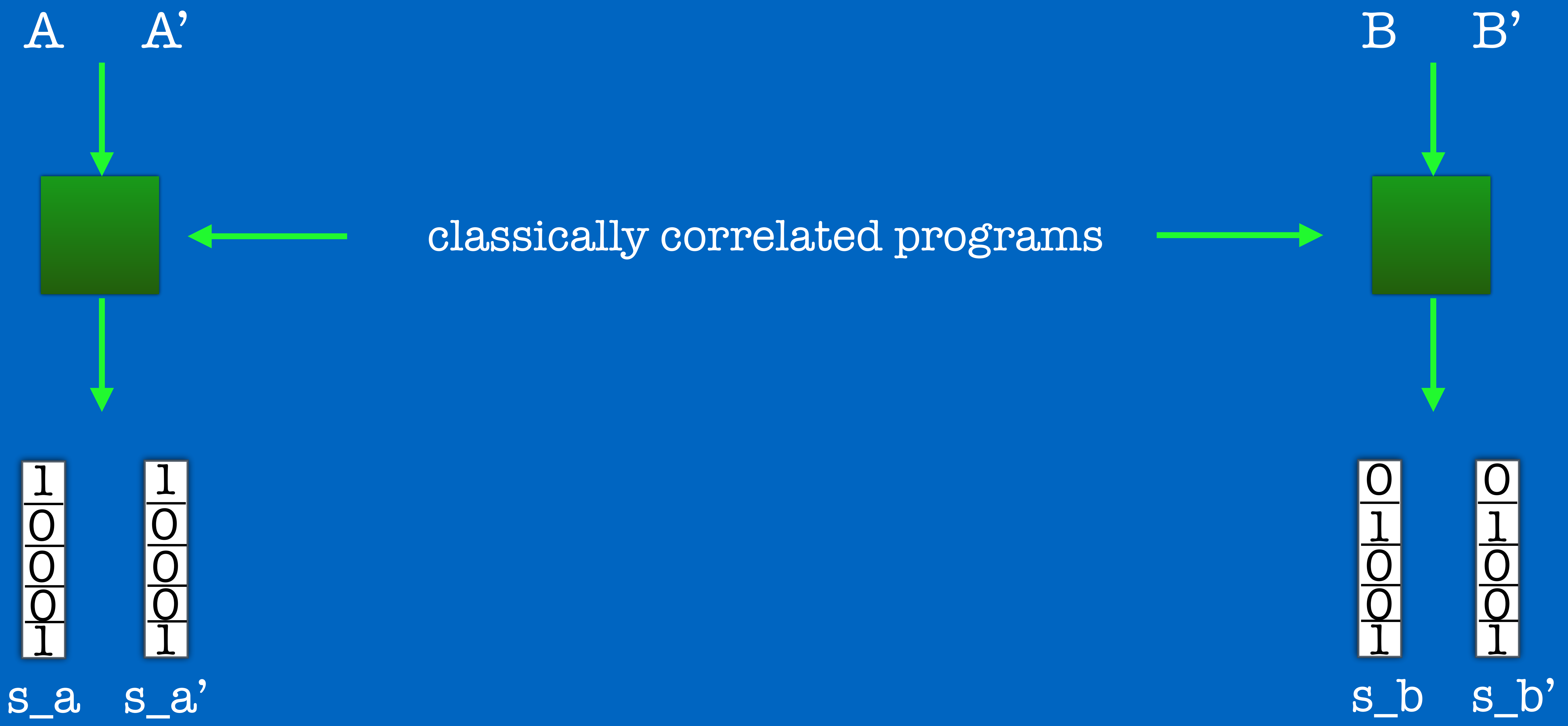
$$\mathrm{dist}(A,B) := H(AB)$$

$$\mathrm{dist}(A,B,C) := H(ABC)$$

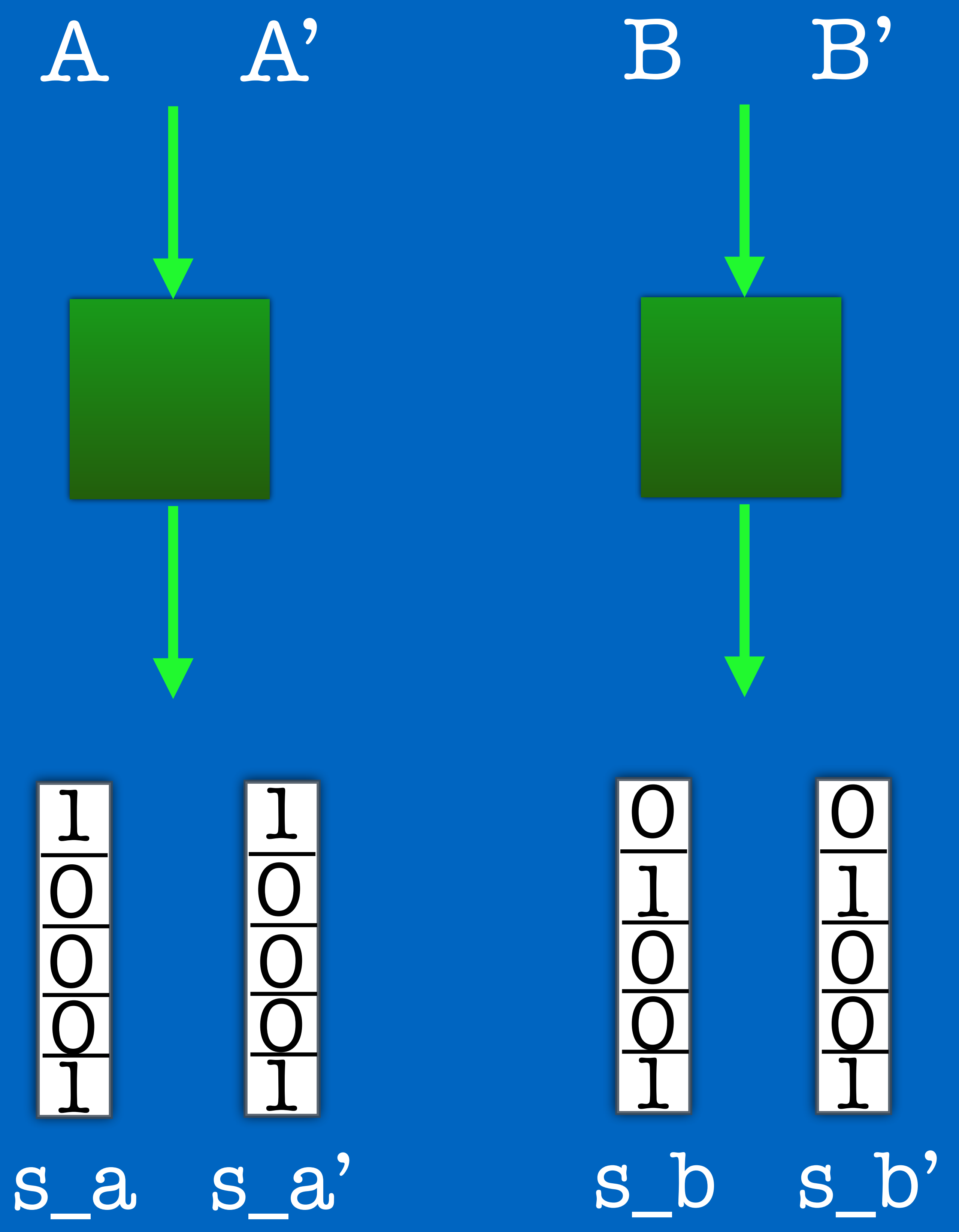
$$\mathrm{dist}(A,B) <= \mathrm{dist}(A,C)+\mathrm{dist}(CB)$$

$$\mathrm{dist}(A,B,C) <= \mathrm{dist}(A,B',C')+\mathrm{dist}(A',B',C)+\mathrm{dist}(A',B,C')$$

local classical Turing machines



local classical Turing machines



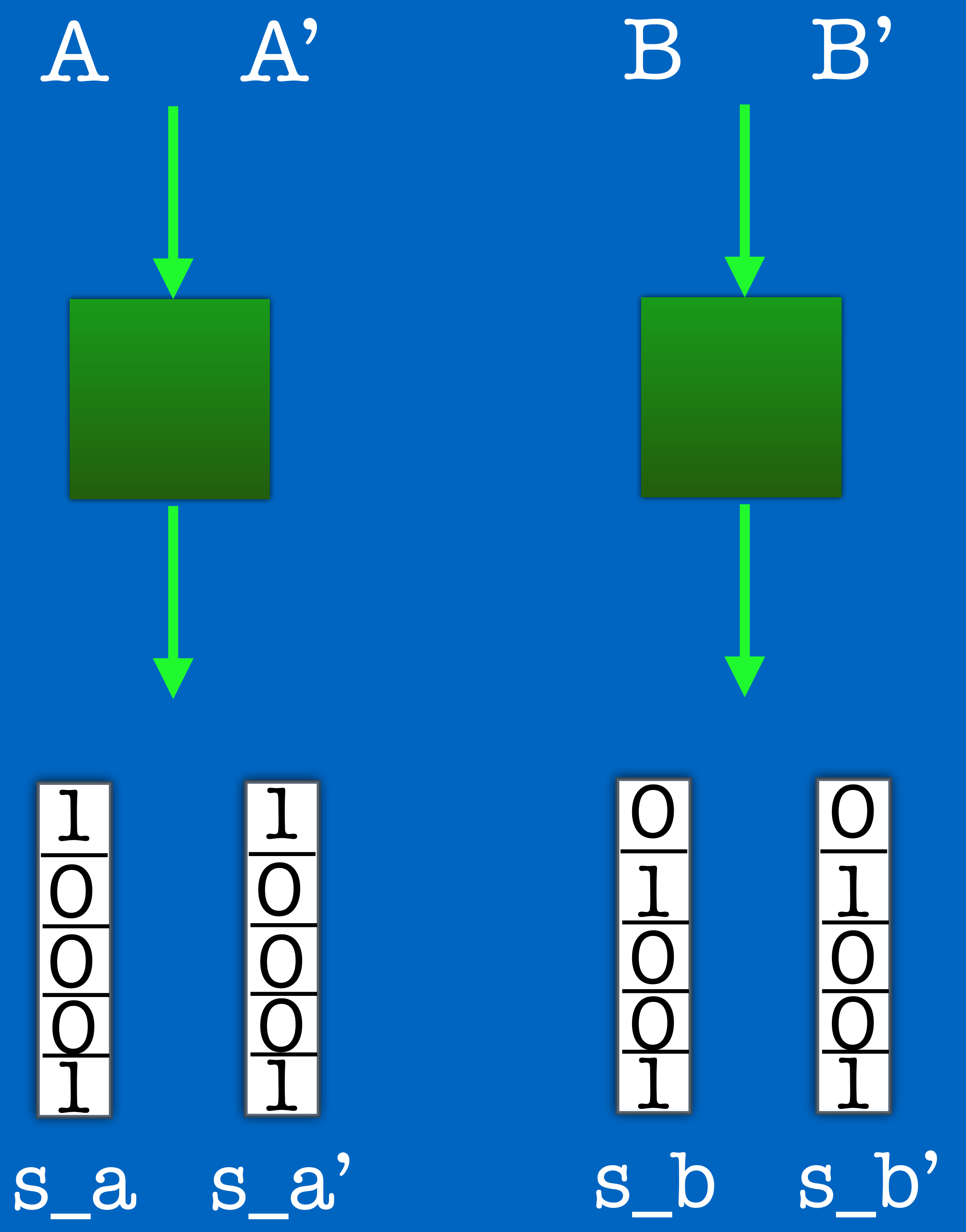
Kolmogorov(s_a) = K(s_a)

length of shortest program generating s_a

NID(s_a,s_b) :=

K(s_a,s_b)-min{K(s_a),K(s_b)}/max{K(s_a,s_b)}

local classical Turing machines

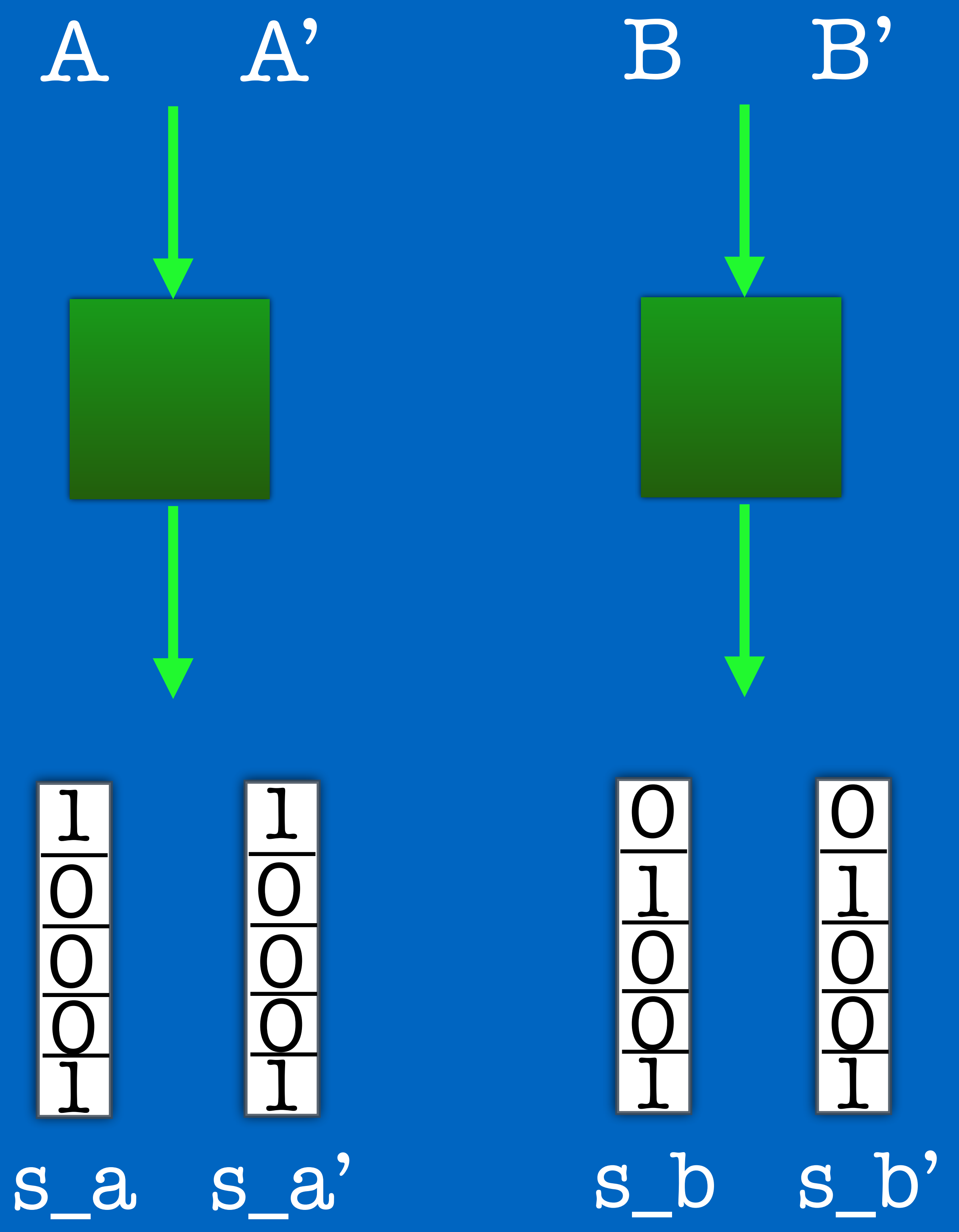


NID(s_a,s_b) is a proper distance

↓

NID(s_a,s_b) +NID(s_b,s_c) => NID(s_a,s_c)

local classical Turing machines

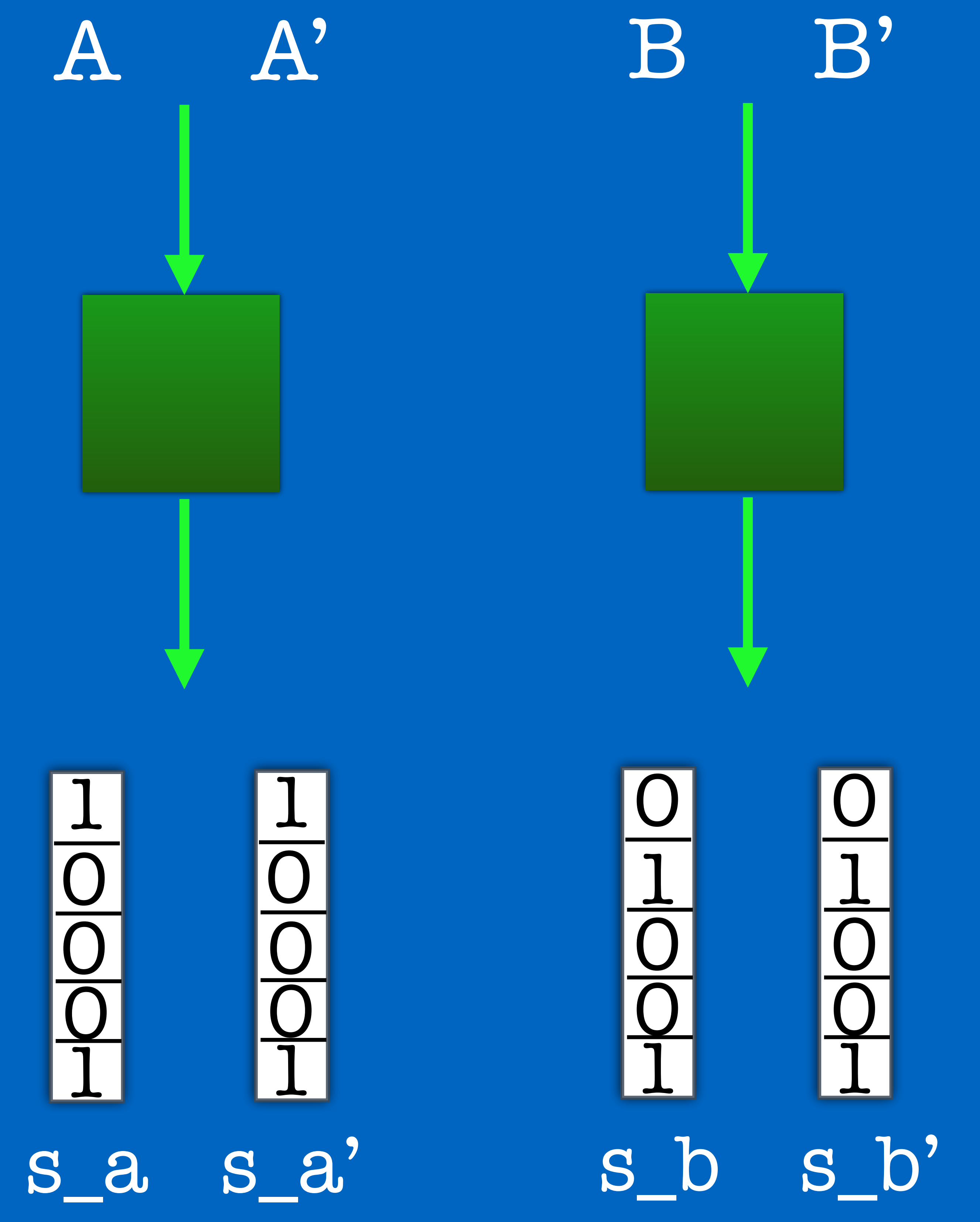


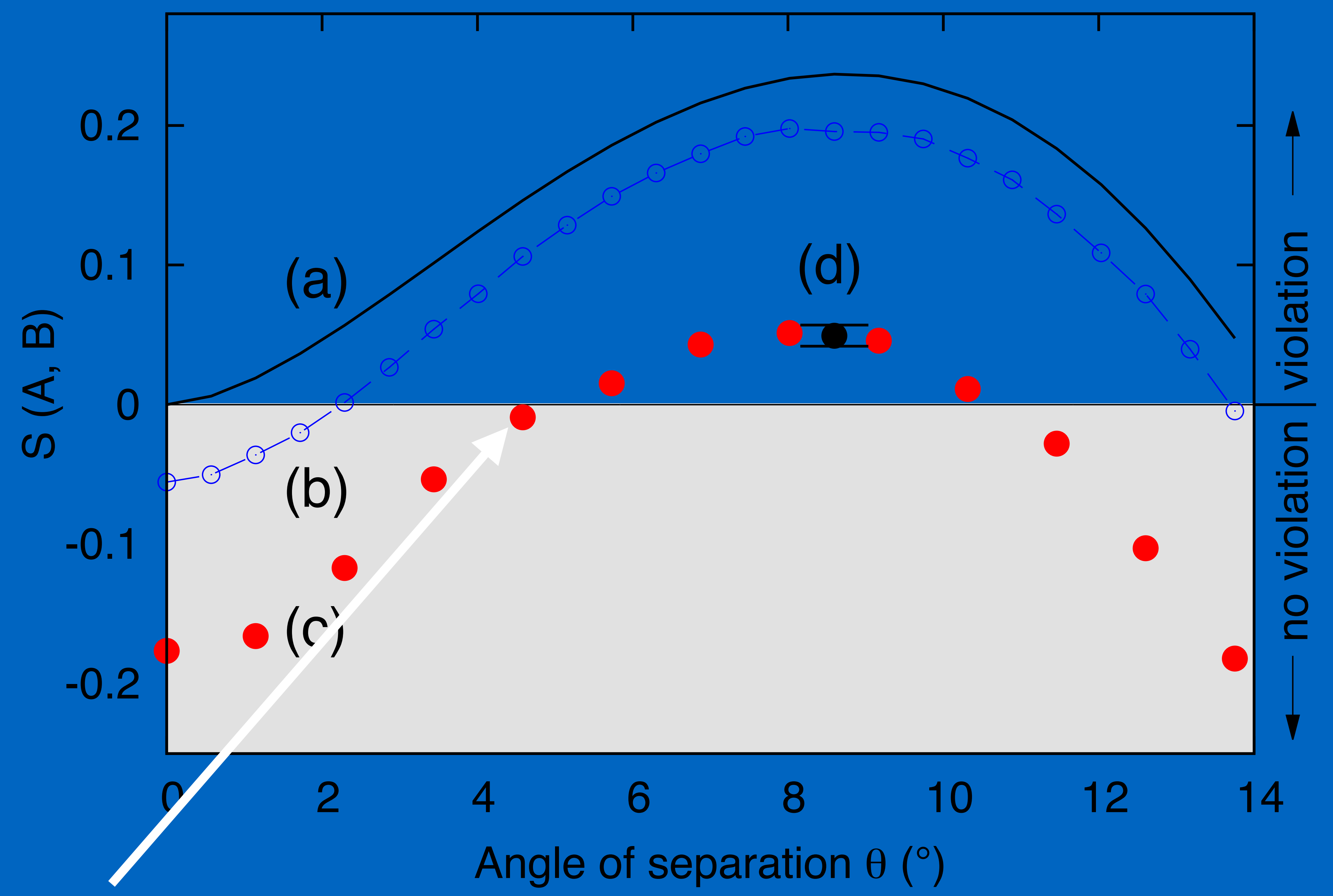
replace K(x) with C(x)

replace NID(s_a,s_b) with NCD(s_a,s_b)

NCD(s_a,s_b) + NCD(s_b,s_a’) + NCD(s_a’,s_b’)
- NCD(s_a’,s_b’) <= 0

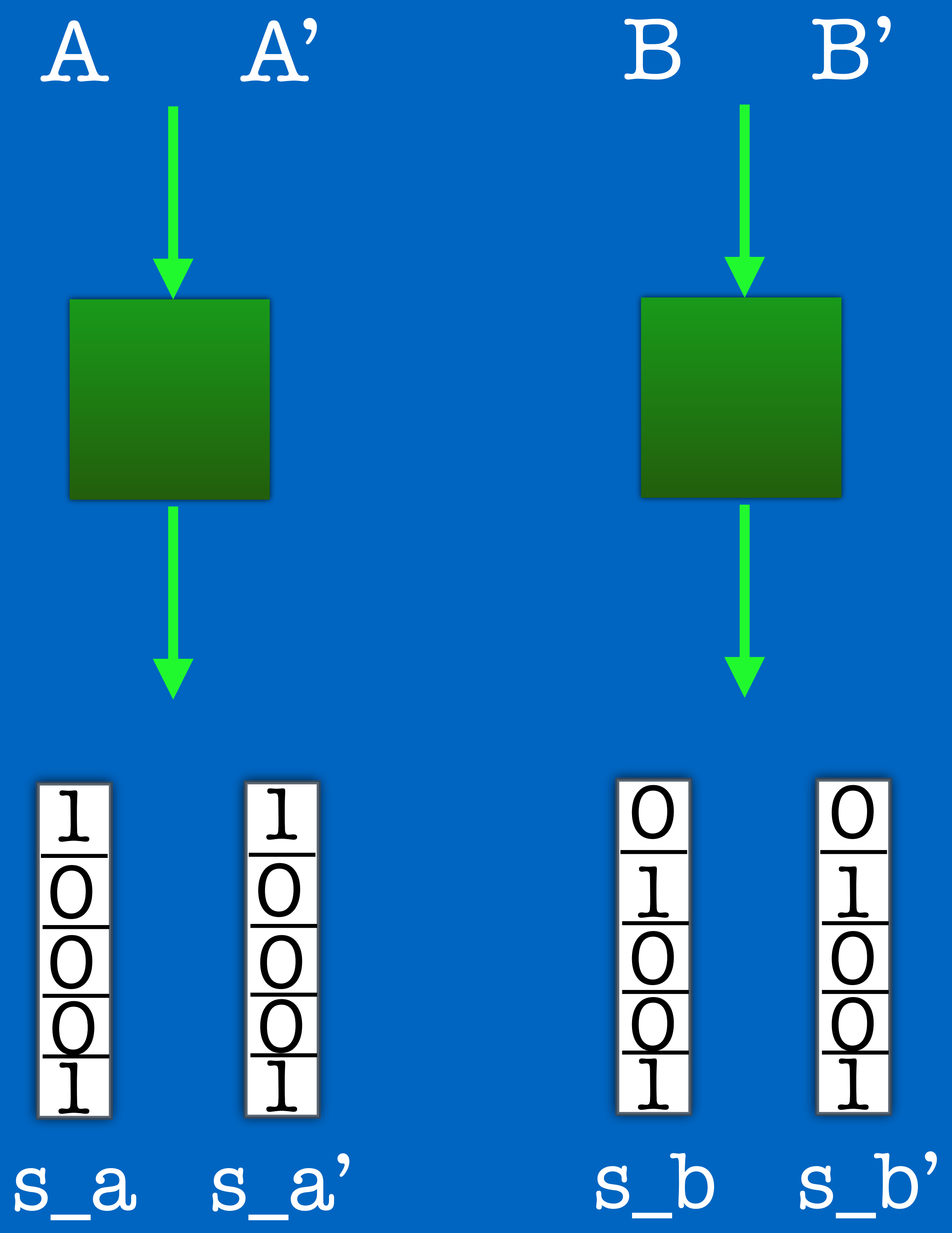
local classical Turing machines





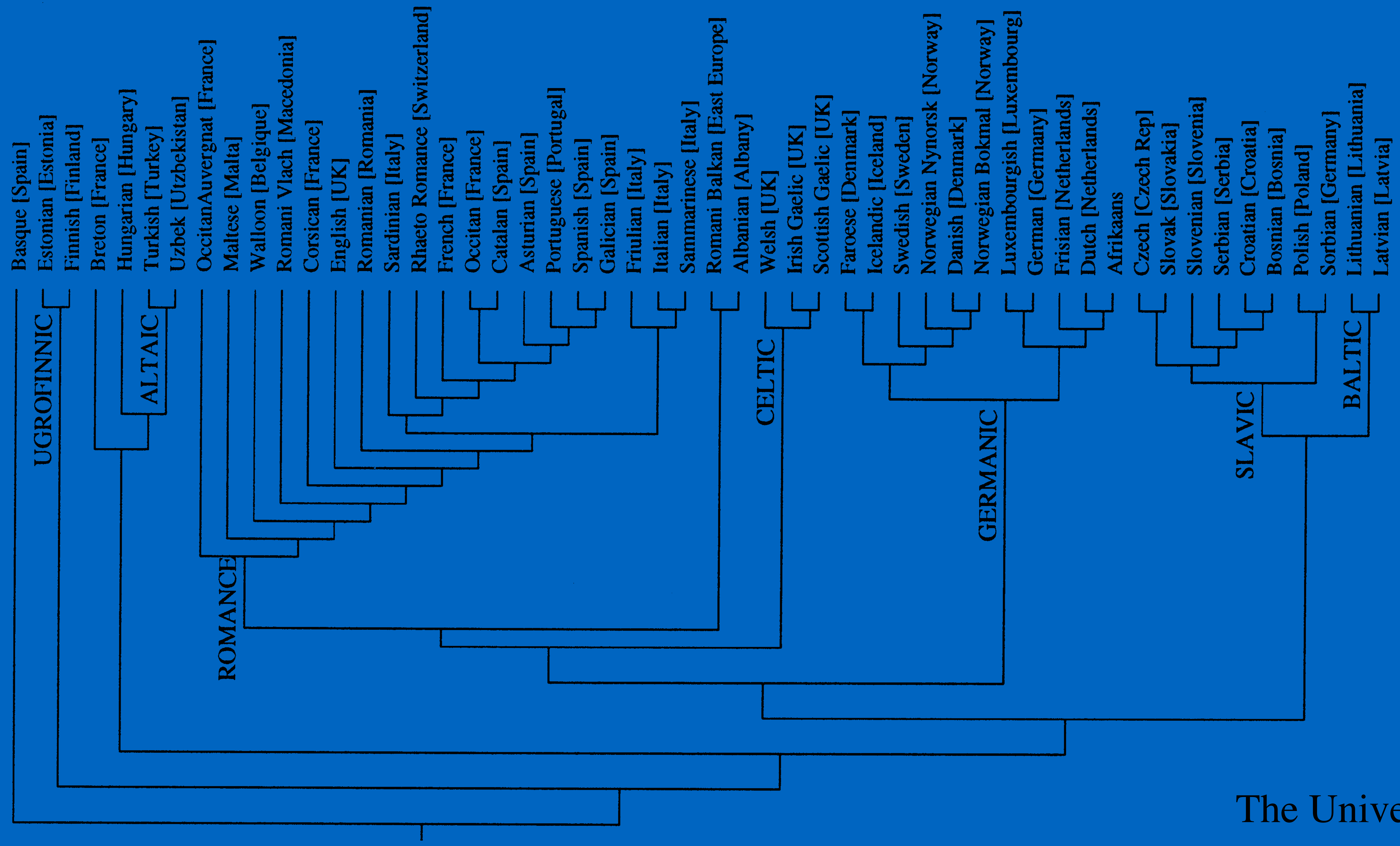
LZMA compressor

local classical Turing machines



why not use Shannon entropy?

1. no need to assume i.i.d. source
2. no need to statistically interpret QM
3. Kolmogorov entropy is ultimate



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