

Are there Quantum Effects Coming from Outside Space-Time ?

Nonlocality, Free Will & no-many-worlds

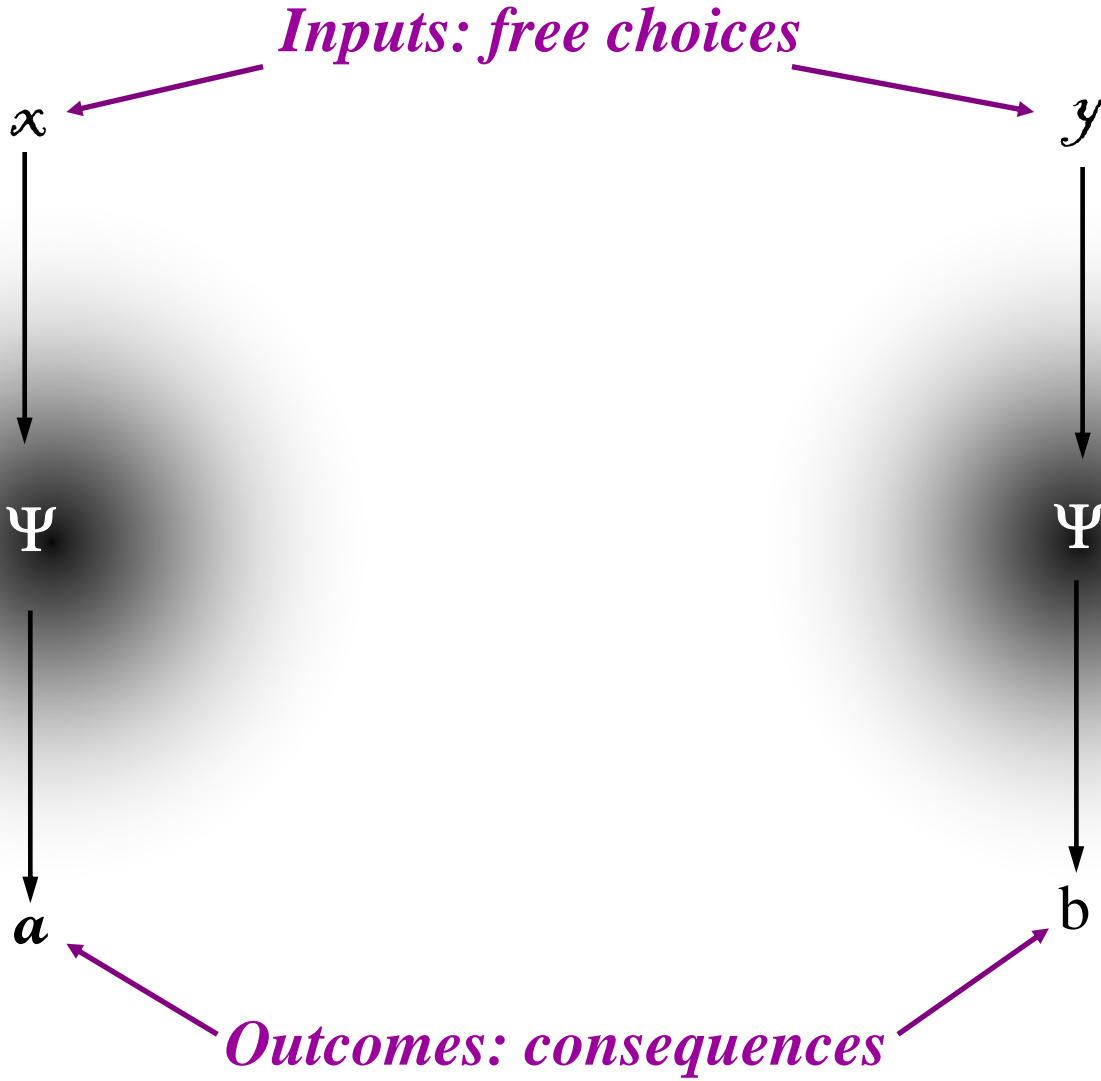
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Alice

Bob





Alice

 x  Ψ  a

$$P_{\Psi}(a,b|x,y) \neq P_{\Psi}(a|x) \cdot P_{\Psi}(b|y)$$

The events at Alice and Bob's sides are not independent!

It seems that somehow the two sides are coordinated or "interact" !?! (but without signalling)

 y  Ψ  b

Bob

Spatially separated systems are not logically separated.

\Rightarrow Quantum Physics is nonlocal



Alice

 x
↓
 λ
↓
 a

Don't think of λ as an old fashion
local hidden variable.

Think of λ
as the physical state of the
systems as described by any
possible future theory.

Bob

 y
↓
 λ
↓
 b



Assumptions:

Alice



1. locality:

$$P_{\lambda}(a,b|x,y) = P_{\lambda}(a|x) \cdot P_{\lambda}(b|y)$$

where λ =physical state of the systems according to any possible **future** theories.

2.a Alice can freely choose her input x and **read** the outcome a , similarly for **Bob**.

2.b x & y are independent of λ
 $I(x:\lambda)=I(y:\lambda)=0$



Bob

**Conclusion: Bell inequalities
Nonlocality**



Alice

 x  λ  a

Think of λ
as the physical state of the
systems as described by any
possible future theory.

Studying Bell's inequality tells
us something about any possible
future theory compatible with
today's experimental
observations.

 y  λ  b

Bob

**A violation of Bell's inequality today
implies that Nature herself is nonlocal.**

Violation of Bell inequality over 10 km, Geneva, 1997



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Alice
Bellevue

Source
Cornavin

Bob
Bernex

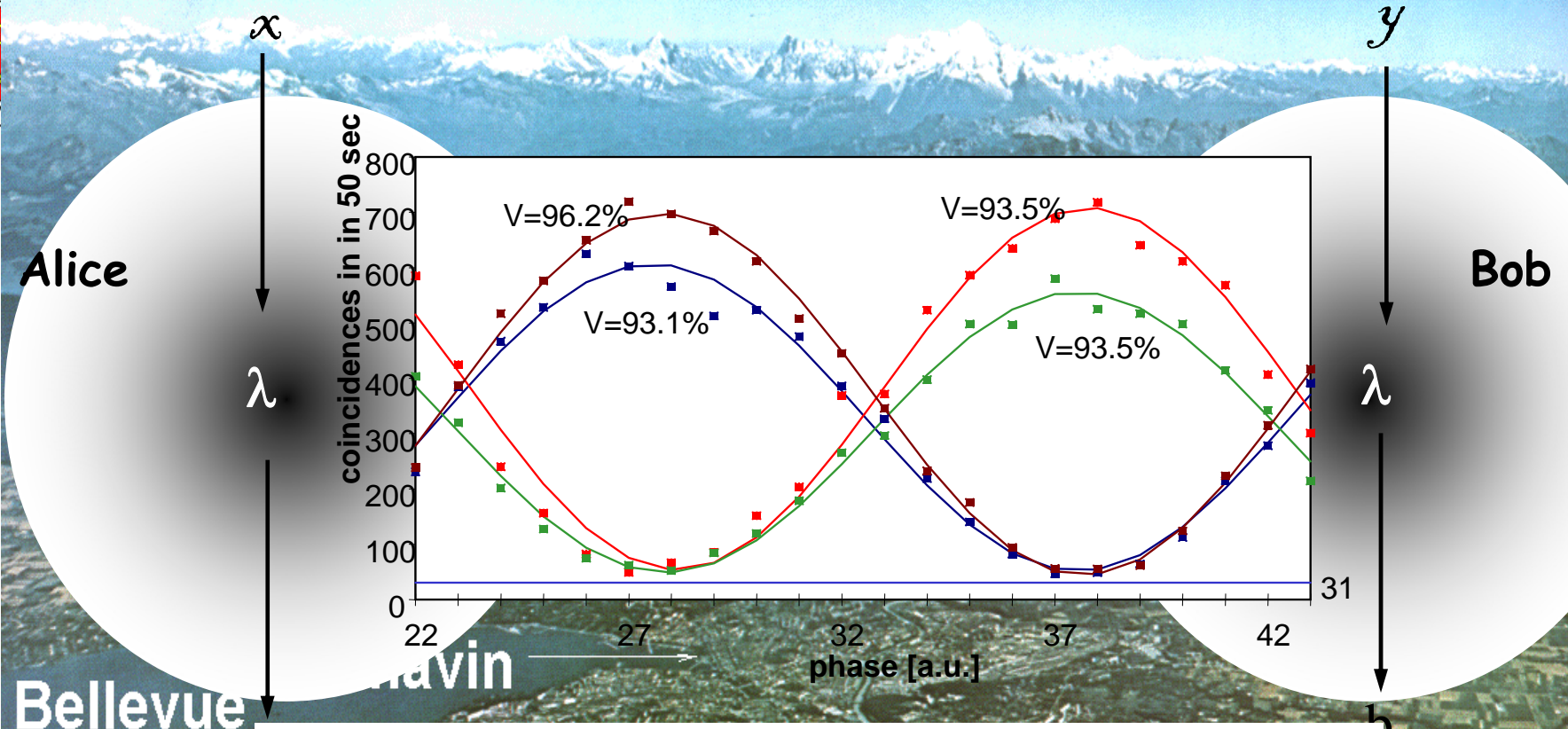


The "real-world" lab

experimental result



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Conclusion: Nature violates the Bell inequality
 \Rightarrow Nature is nonlocal

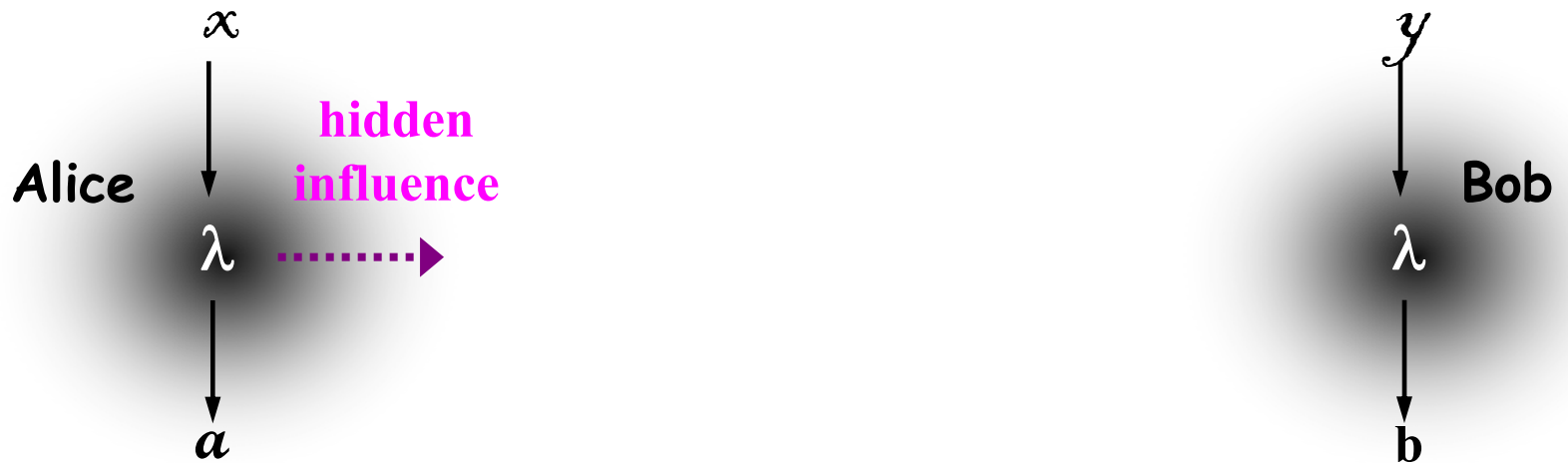
NG, Non-realism : deep thought or a soft option ? [quant-ph/0702021](https://arxiv.org/abs/quant-ph/0702021)



How does Nature perform the trick ?

- How can these two locations out there in space-time know about each other ?
- How does an event A know that it is nonlocally correlated to another event B ?
- Who keeps track of who is entangled with whom ?

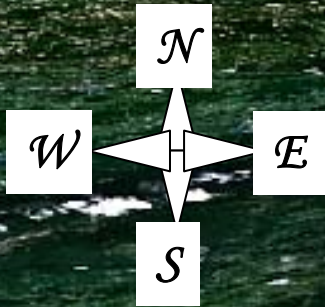
Assume a real influence propagating faster than light but with finite speed



Assume a real influence propagating faster than light but with finite speed



Satigny – Geneva – Jussy



Satigny

18.0 km

Jussy

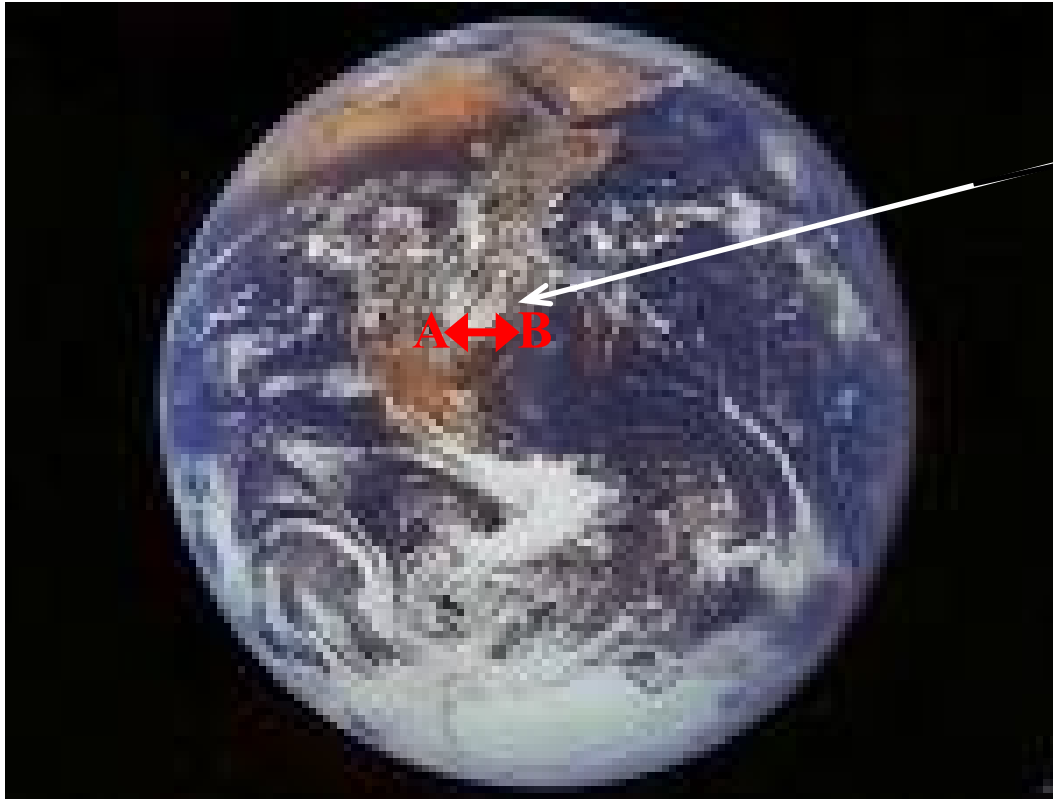
Geneva

In which frame should the events be simultaneous ?



Let's test this hypothetical preferred reference frame

reference frame

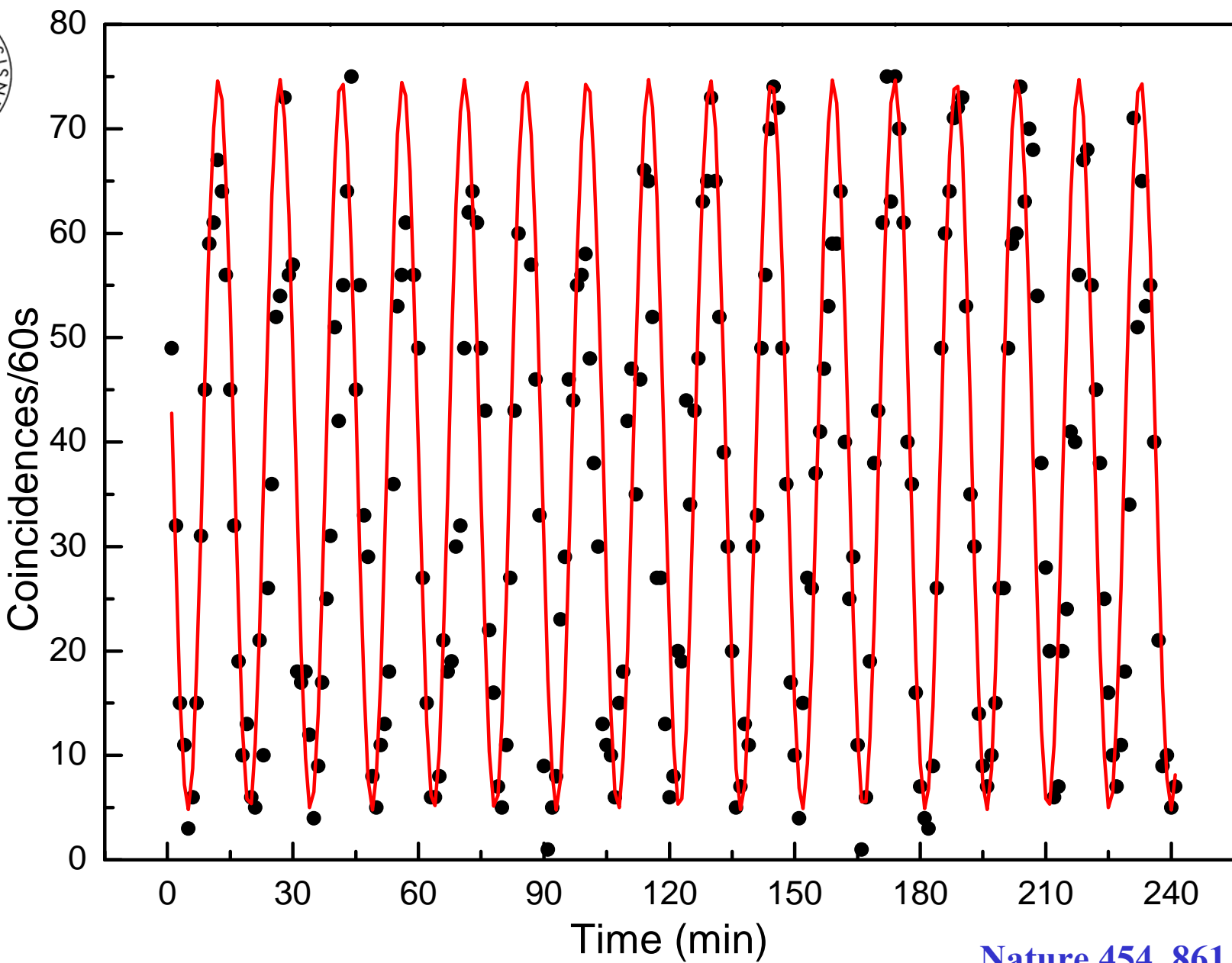


Alice and Bob,
east-west orientation,
perfect synchronization
with respect to earth
⇒ perfect synchronization
w.r.t any frame moving
perpendicular to the
A-B axis
⇒ in 12 hours all hypothet-
ical privileged frames
are scanned.

Ph. Eberhard, private communication



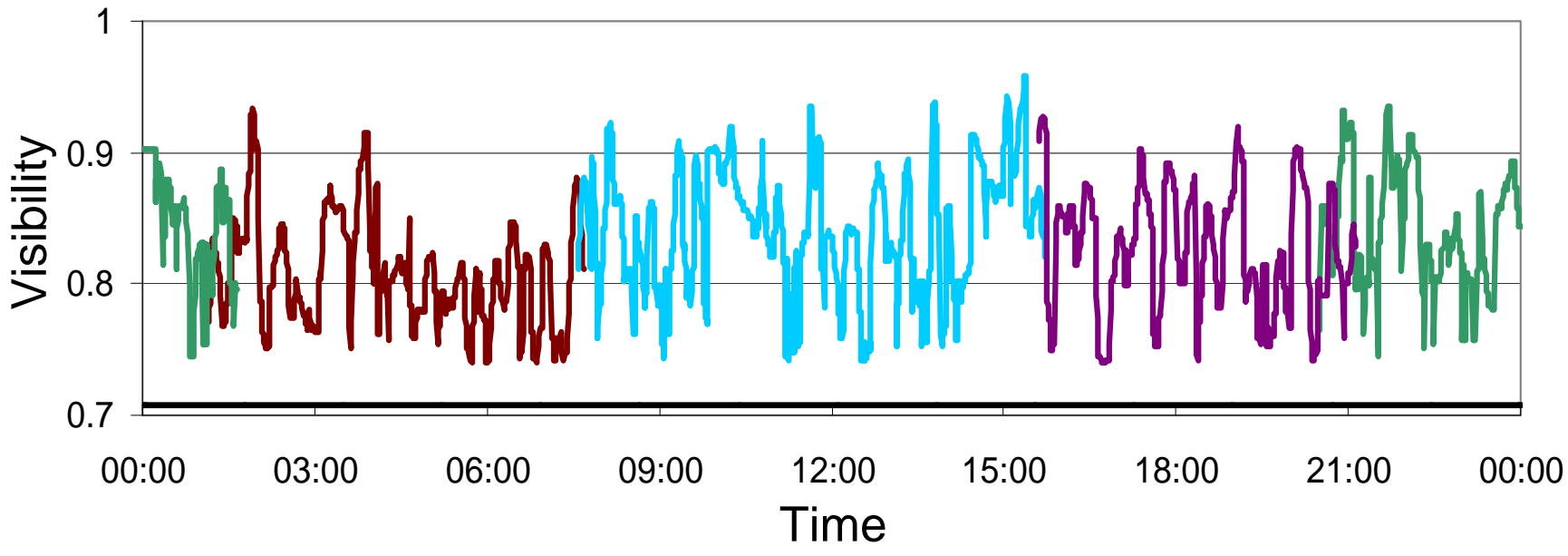
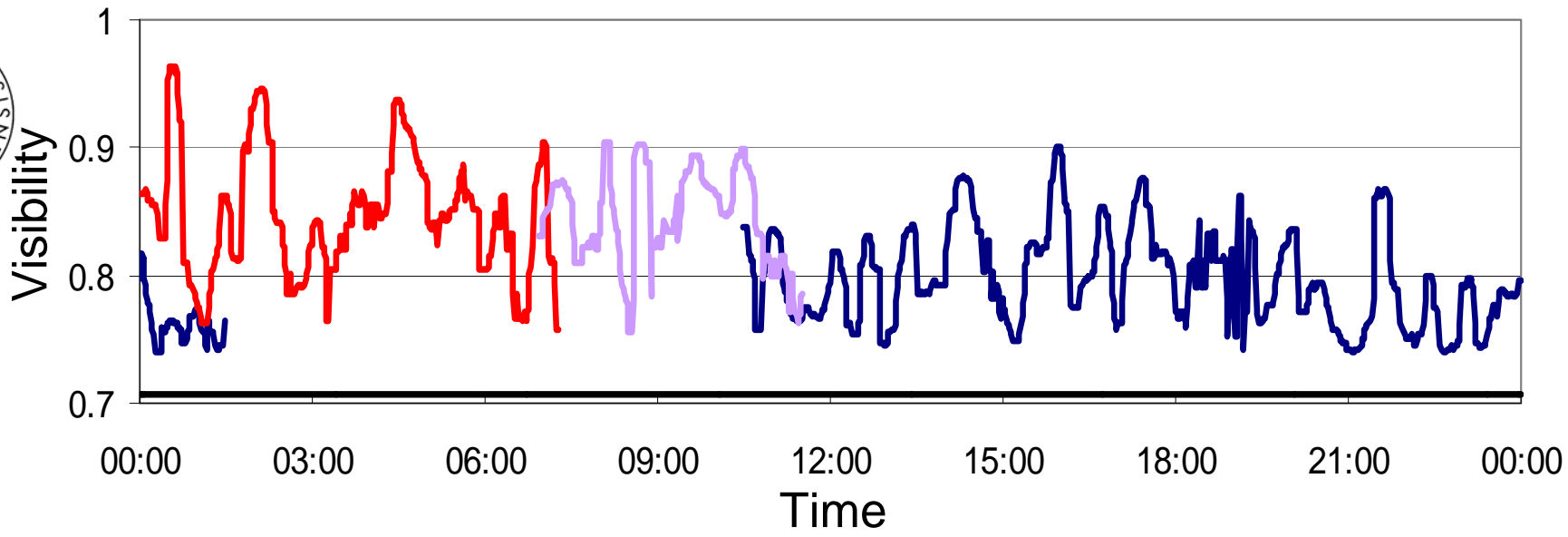
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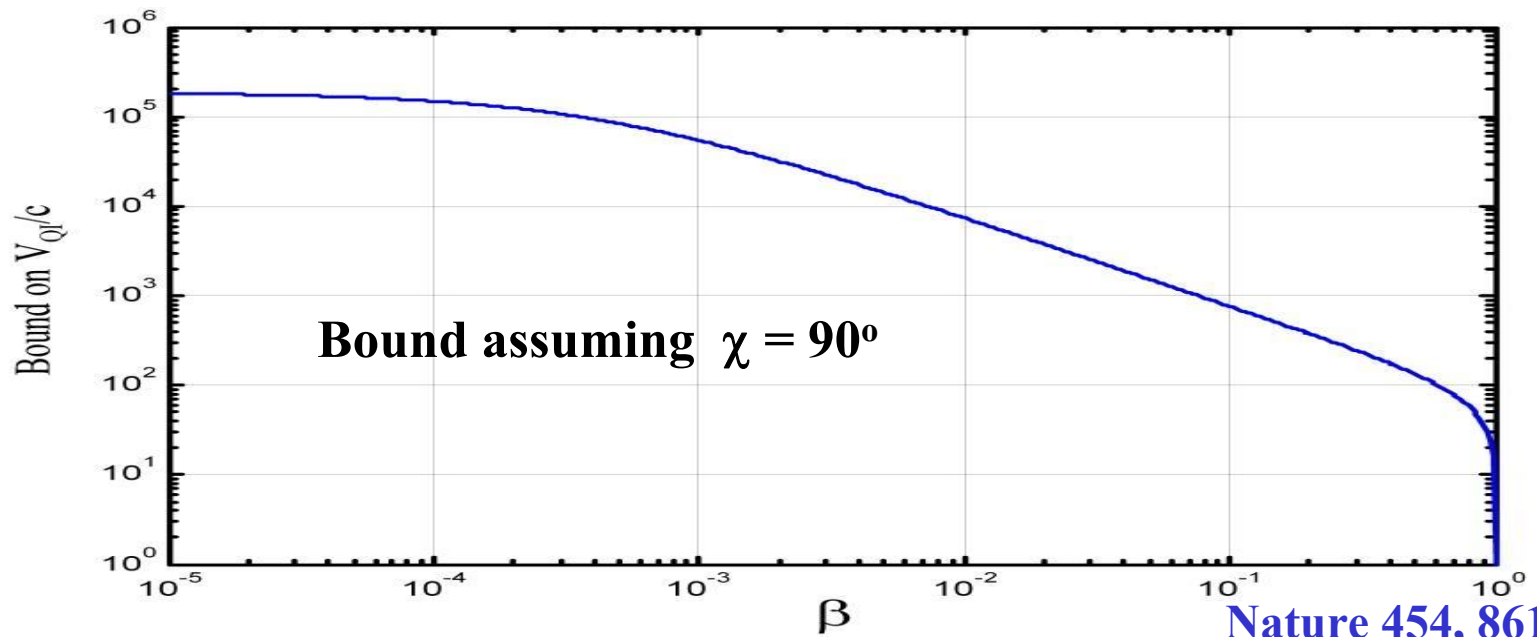
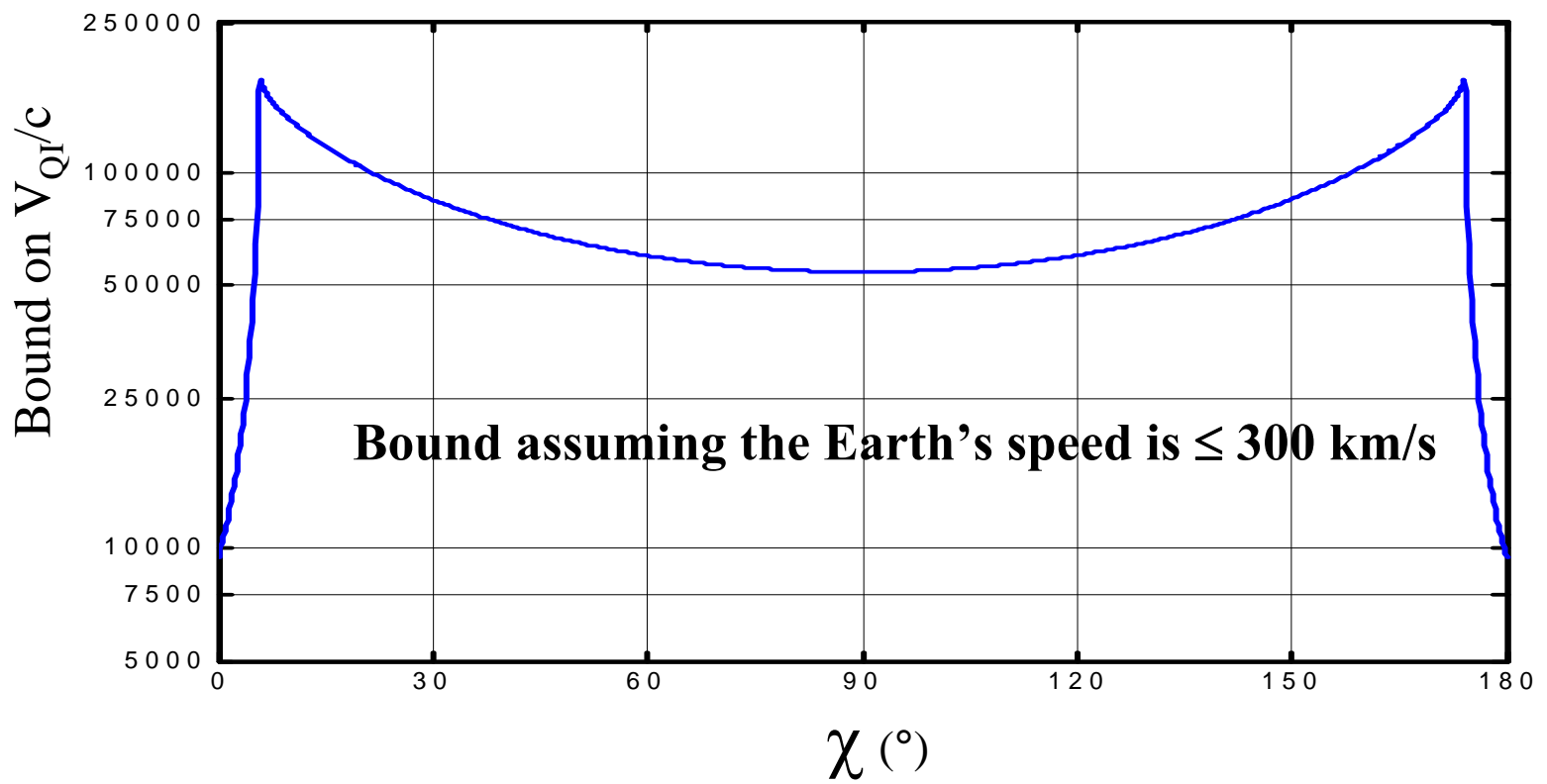
Nature 454, 861, 2008



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Nature 454, 861, 2008





Conclusion

- ⇒ There is no spooky action at a distance: there is not a first event that influences a second event.
 - ⇒ Quantum correlation just happen, without any time-ordering, somehow from outside space-time !
(there is no story in space-time that tells us how it happens)
- ... or ... the influences propagate at surprisingly large speeds

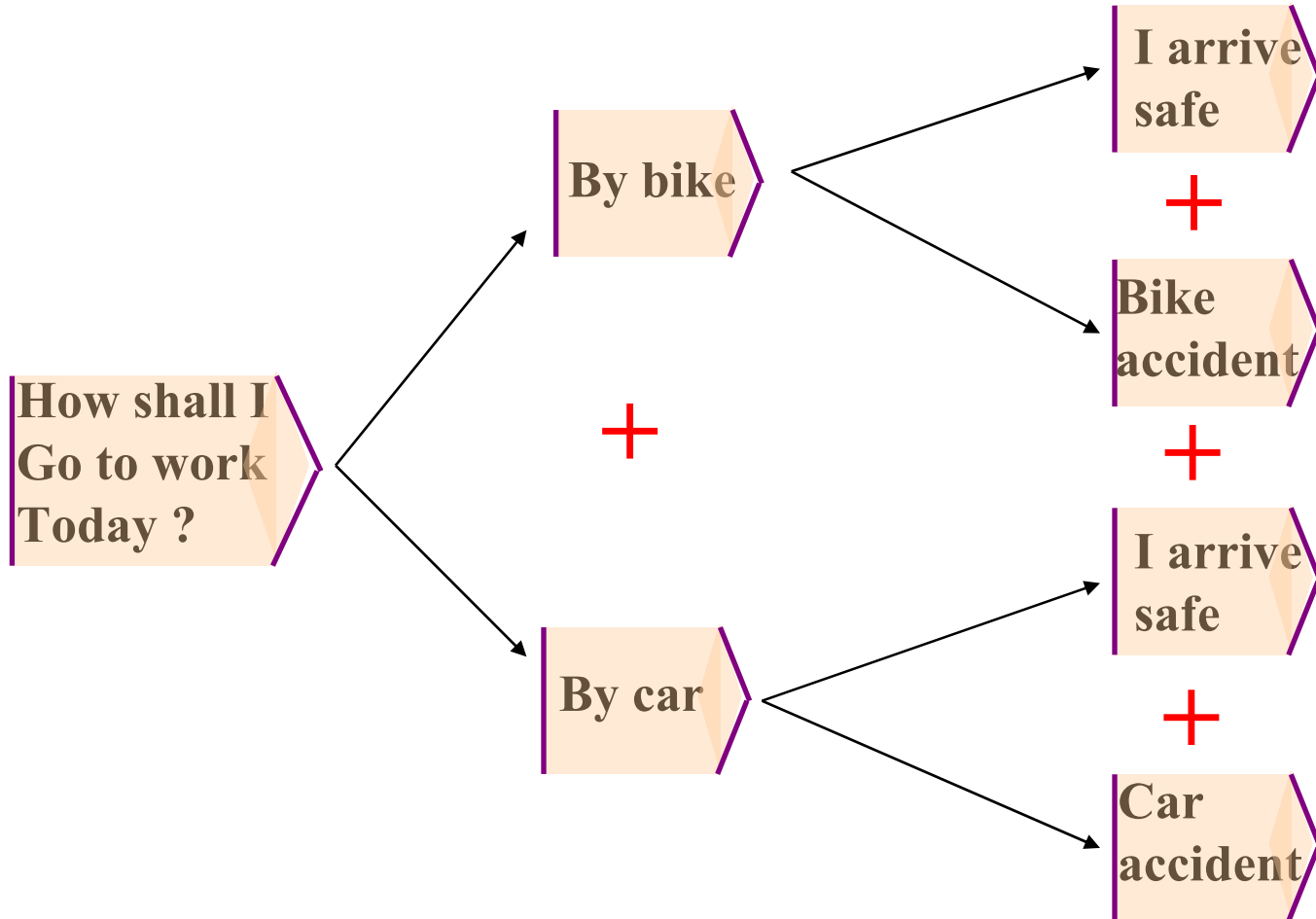


Many Worlds

Initial state

choice

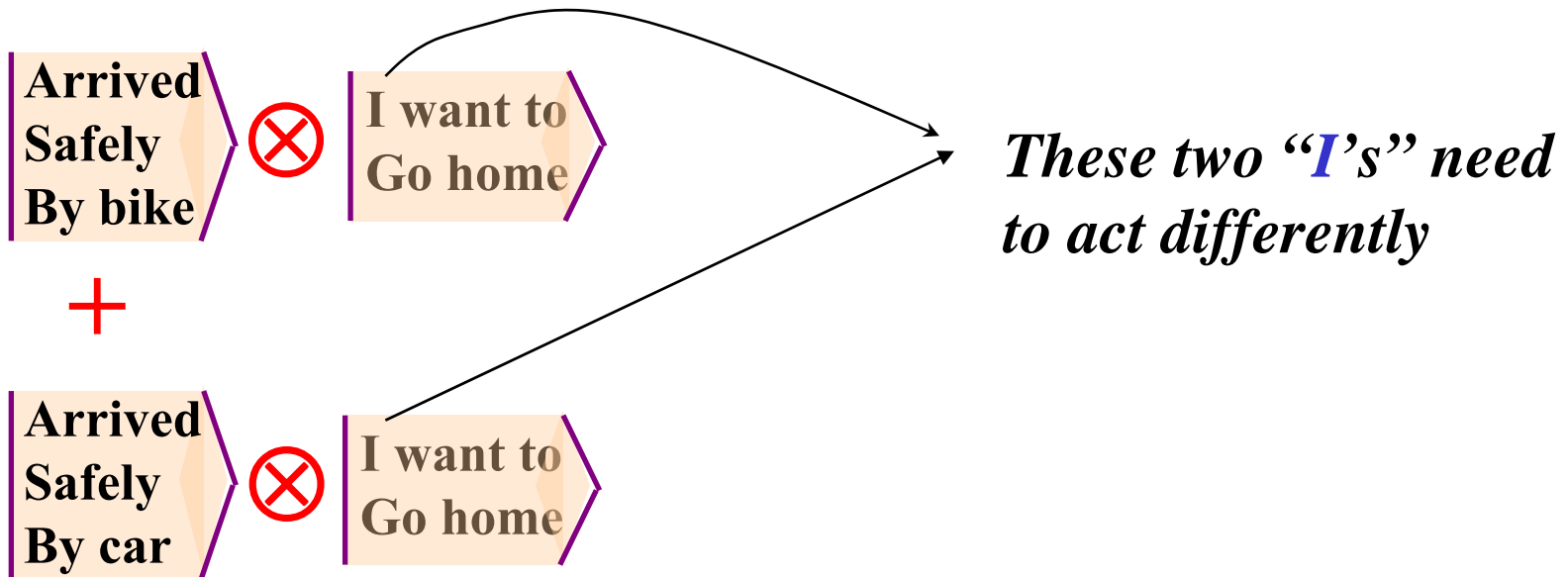
consequence





Many Worlds

Initial state and *I* want to go back home



\Rightarrow *There are several “myselfes”*



Against Many Worlds

According to many-worlds:

Arrived
Safely
By bike

⊗

I⁽¹⁾ want to
Go home

+

Arrived
Safely
By car

⊗

I⁽²⁾ want to
Go home

It is not merely the physical world that gets into a huge superposition of all possibilities, but “I” too !!!

But I know more than any thing else, in particular more than any equation, that I am making choices that have consequences.

Why am I so dismissive with this view while very open to all sort of assumptions like those presented before?

1. All the assumptions presented previously have an explanatory power. Moreover they could even be experimentally tested. On the contrary, I do not see any explanatory power in the many worlds: it seems to be made just to prevent one from asking questions.
2. Moreover, it has built in it the impossibility of any test. For me, it looks like a "cushion for laziness" (*un coussin de paresse* in French).
3. The many world view elevates the linearity of the Schrödinger equation to a religion belief.

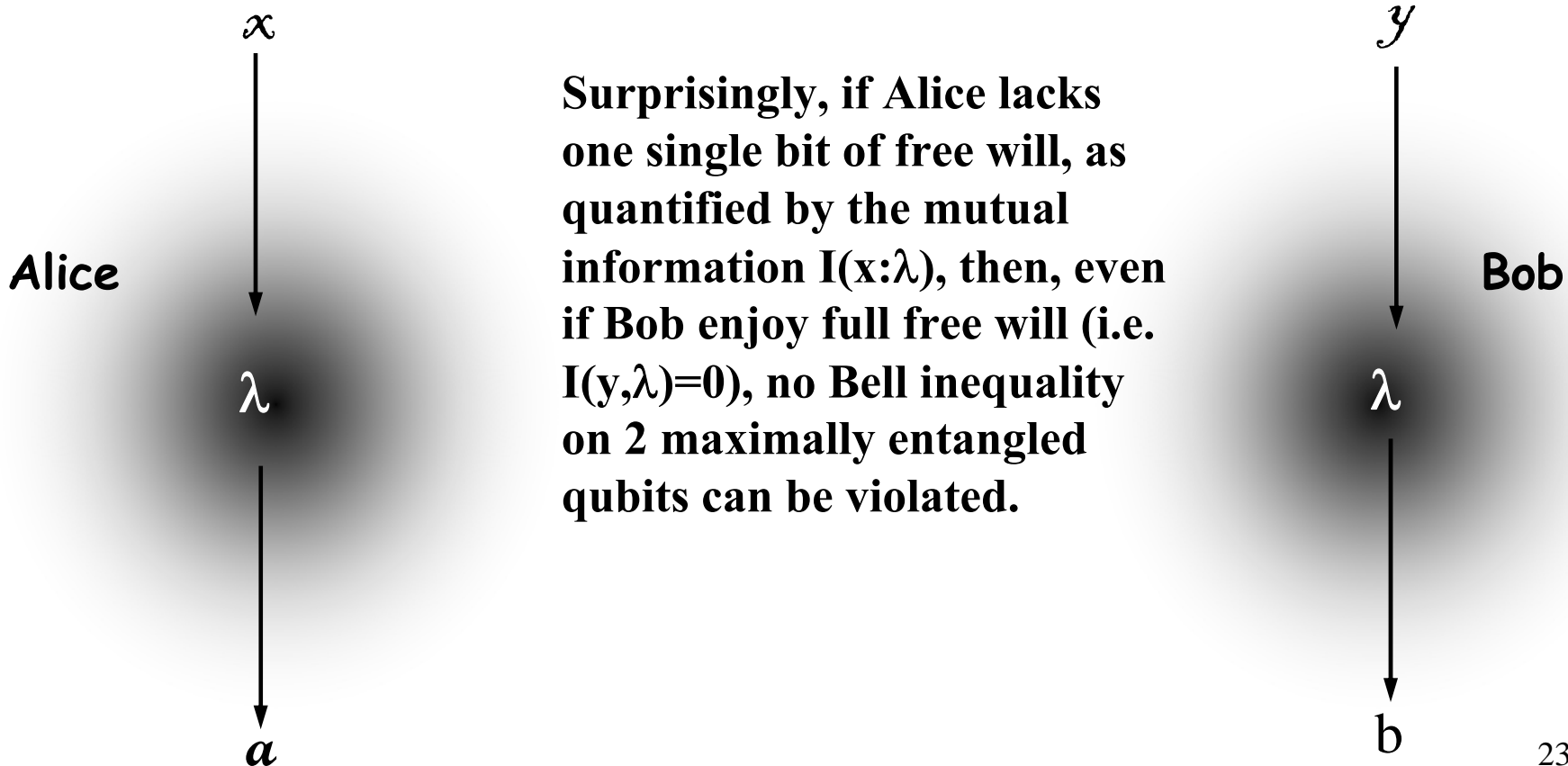




Can free will be quantified ?

The usual assumption is that the input can be freely chosen by Alice and Bob.

This is a usual assumption in all experimental sciences. What if Alice and Bob's free will is partly limited ?





Conclusions

- Any future theory consistent with today's experiments has to predict nonlocal correlations.
- Hence it is Nature herself that is nonlocal !
- There is nothing that we know more than that we are being enjoying free will. Hence, the many-world view is an illusion: it is a basic error in epistemology to claim that an equation of physics should convince one that we do not enjoy true free will.