https://www.youtube.com/watch?v=ALGKIcfXxcM
Anton Zeilinger and the Dalai Lama

# Buddhism, Mind, Quantum Mechanics (Is there a connection?)

Richard Gill

Intercity Seminar Mind, Brain, Mindfulness
https://mindbrainmindfulness.wordpress.com/
30 January 2015

Mathematical content & references: http://arxiv.org/abs/1207.5103
Spoken talk: http://www.math.leidenuniv.nl/~gill/MBM_talk.m4a
(English language, except for first 3 mins)

# Abstract

New age thinking (if one may call it such) has taken on board the idea that quantum physics has proven that classical Western dualistic thinking about the physical world is inadequate. It is a fact that a number of the founding fathers (sorry, as far as I know, no founding mothers (*)) of quantum physics — Erwin Schrödinger, Niels Bohr, Wolfgang Pauli — were fascinated by Eastern thinking and associated their insights into fundamental physics with what they saw as Eastern philosophical insights into the nature of the world in general (cf. Marin, 2009, 'Mysticism' in quantum mechanics: the forgotten controversy).

However, even the founding fathers were disturbed by the EPR paradox, and if they would have lived long enough, would have been even more disturbed by the Bell theorem (named after John Bell, 1964), which is generally supposed to prove the existence of spooky action at a distance ("quantum nonlocality", "passion at a distance"). Moreover, the shocking predictions of this theorem are supposed now to have been experimentally confirmed, over and over again. Is this the end of reductionism? Everything is connected … subject and object cannot be distinguished.

The entangling of subject and object is dramatically brought home by interpretations of quantum mechanics which connect the collapse of the wave-function to an interaction with a conscious observer (subject). The observer is now an essential part of the physics (the moon is *not* there when nobody looks). There are interpretations of quantum mechanics in which Schrödinger's cat is both alive and dead. There are theories of mind which claim that consciousness itself can only be explained through quantum mechanics. The 100 year old problem of how to interpret quantum mechanics is further from resolution than ever.

I would like to explain to you Bell's theorem (don't worry: without mathematical formulae, without physics even!) and discuss my own picture of a quantum-driven universe which I think does actually fit well to Buddha's picture of mind, with one exception: it introduces irreducible randomness, which I suspect would have been as unpalatable to Buddha as it is to us today. I will argue that we cannot "understand" quantum physics because it contradicts what our embodied cognition allows us to understand. It violates our built-in "systems of core knowledge", according to which irreducible randomness does not exist.

(*) Erwin Schrödinger allegedly obtained his deepest insights in physics at the moment of sexual union with his mistress at the very same sanatorium in the Alps which was the inspiration for Thomas Mann's "Zauberberg".

# Contents

- Part 1: Bell's Theorem
    - Corollary: realism or locality has to go
- Part 2: Exploring what happens if we abandon "realism"
    - "Realism" is a misnomer: it is an idealistic position
    - Belavkin's "eventum mechanics" (the Heisenberg cut is for real)
- Part 3: Conclusion: irreducible randomness and an arrow of time; only the present exists
    - Wave-particle duality? The past is particles, the future is a wave!
    - Goodbye to Einstein picture of  a frozen, deterministic space-time
    - Speculations on why we can't understand quantum mechanics
    - Did this have anything to do with Buddhism? With theories of Mind?

# Part 1: Bell's theorem

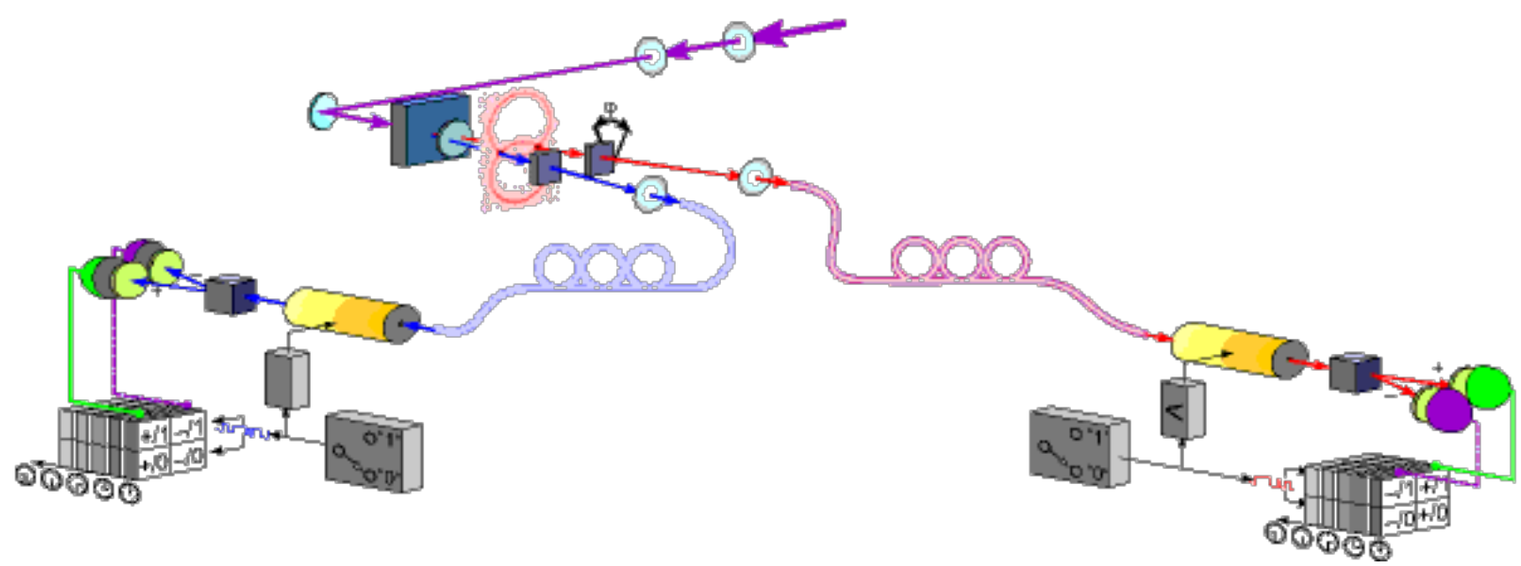
- J.S. Bell (1964) "On the Einstein Podolsky Rosen paradox" (One of the most cited papers of modern physics) http://www.drchinese.com/David/Bell_Compact.pdf (the paper)

- https://www.youtube.com/watch?v=V8CCfOD1iu8
  John Bell explains: "I cannot say that action at a distance is required in physics. But I cannot say that you can get away with no action at a distance. You cannot separate off what happens in one place with what happens at another"

- https://www.youtube.com/watch?v=ZuvK-od647c (Veritasium video)

- No **action at a distance**, but what some call **passion at a distance**

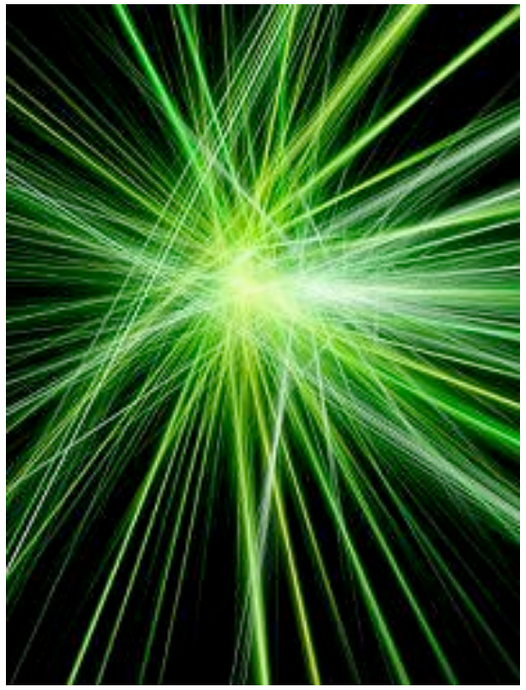
# Weihs et al. (1998)

Coming soon: Delft; Delft + Leiden

# Ursin et al. (2006)

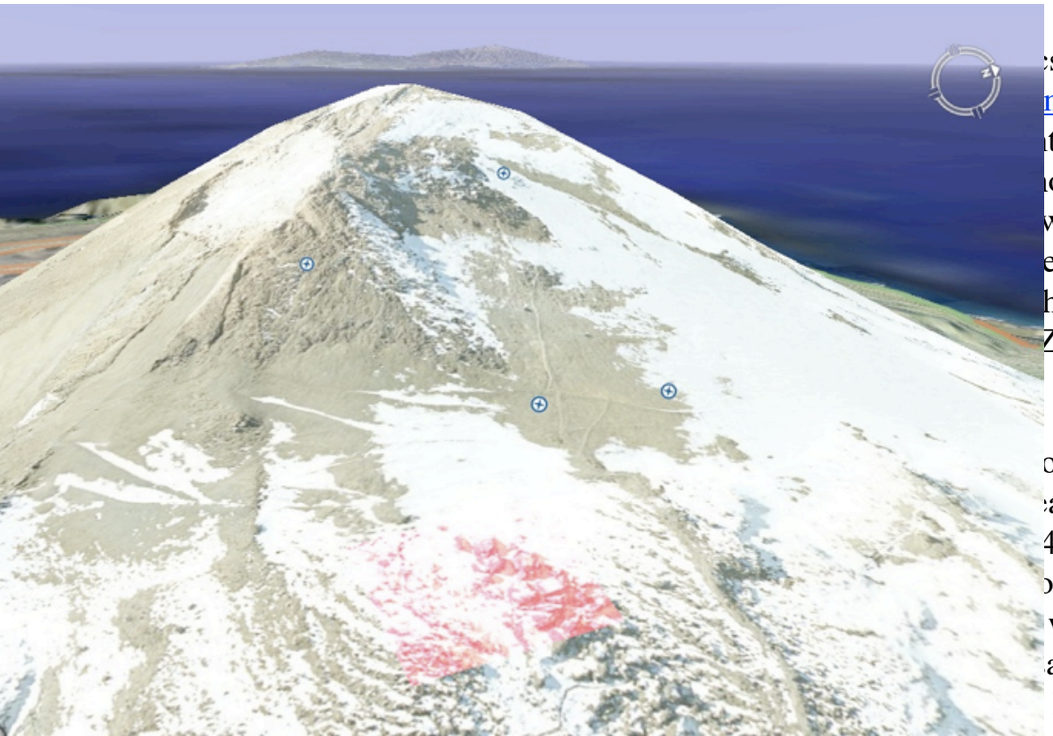
News in Science
abc.net.au/science/news



## Distance no worries for spooky particles

Stephen Pincock
ABC Science Online
Friday, 8 December 2006

A message sent using entangled, or spooky, particles of light has been beamed across the ocean *(Image: iStockphoto)*



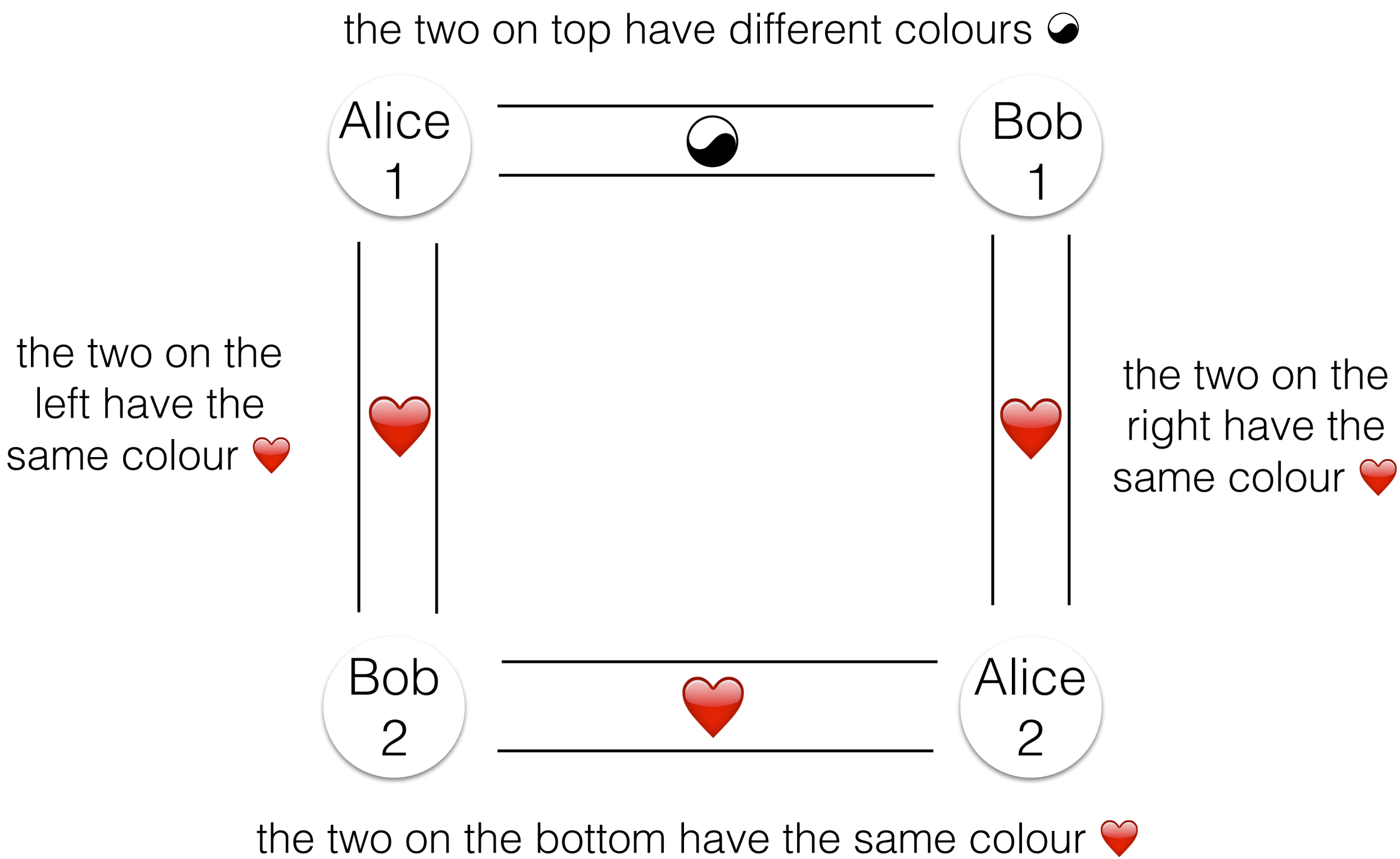
s to zap an encrypted message more than 140 kilometres between two Spanish islands. Professor Anton nna and an international team of scientists used 'spooky' pulses of light to send the message. They say this is ternational communications more secure. Zeilinger described the study this week at the Australian Institute of otons they sent were linked together through a process known as quantum entanglement. This means that wined or entangled, even when separated by large distances, a property Einstein called spooky. The group's erging field of quantum cryptography, which aims to use properties such as entanglement to send encrypted he world are working in this field. But until now they have only been able to send messages relatively short Zeilinger's team wants to be able to beam the messages to satellites in space, so they could theoretically be

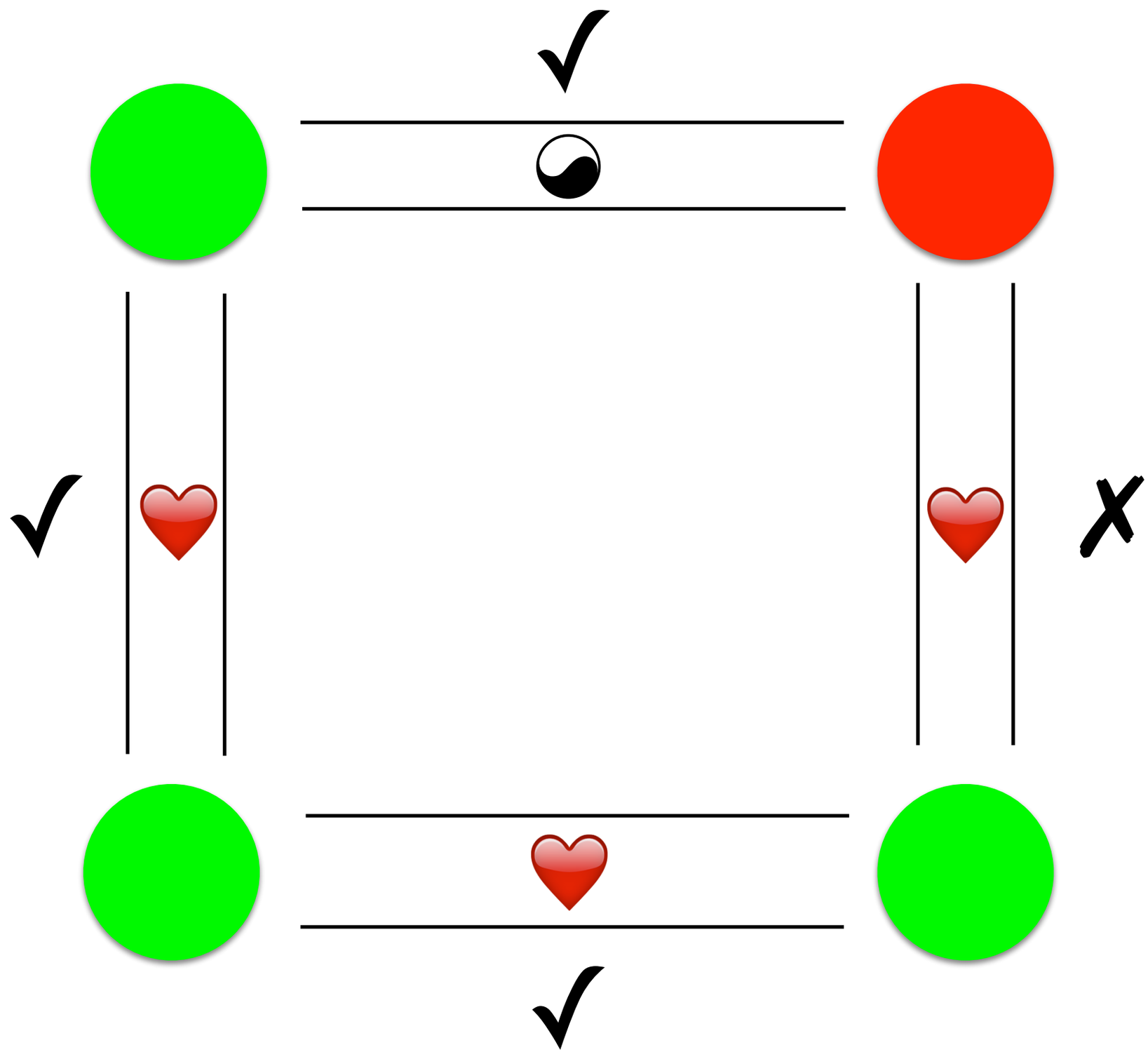
o Tenerife in the Canary Islands, where the European Space Agency operates a telescope specifically designed ad of pointing the telescope at the stars, Zeilinger says, the scientists turned it to the horizontal and aimed it 4 kilometres away on the neighbouring island of La Palma. "Very broadly speaking, we were able to establish on," he says. "We worried a lot about whether atmospheric turbulence would destroy the quantum states. But it we feared." The results suggest it should be possible to send encrypted photons to a satellite orbiting 300 or ays. "This is our hope. We believe that such a system is feasible." The next step is to try the system out with likely to involve the European Space Agency and others. "This is about developing quantum communications

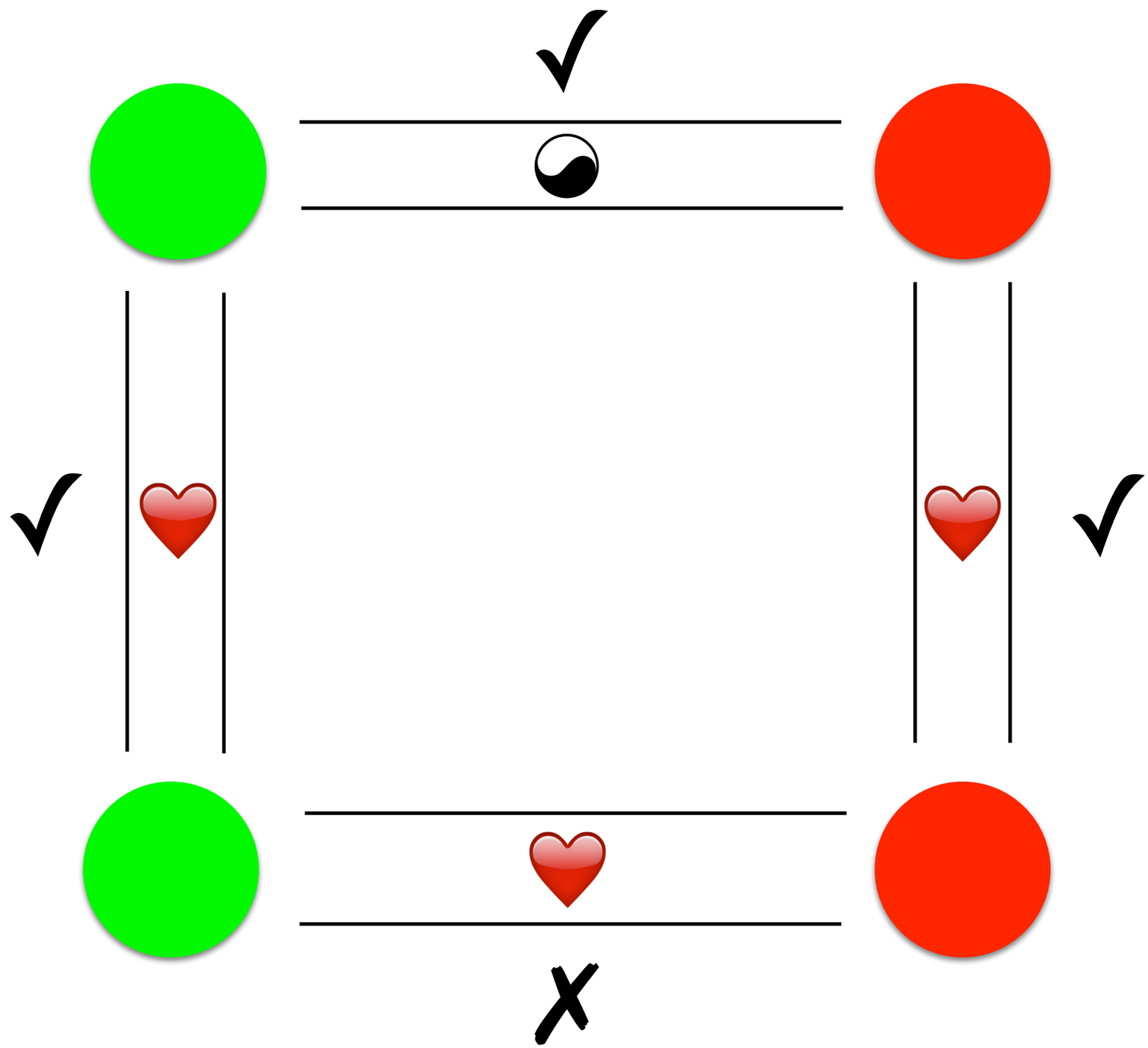
# The Bell game

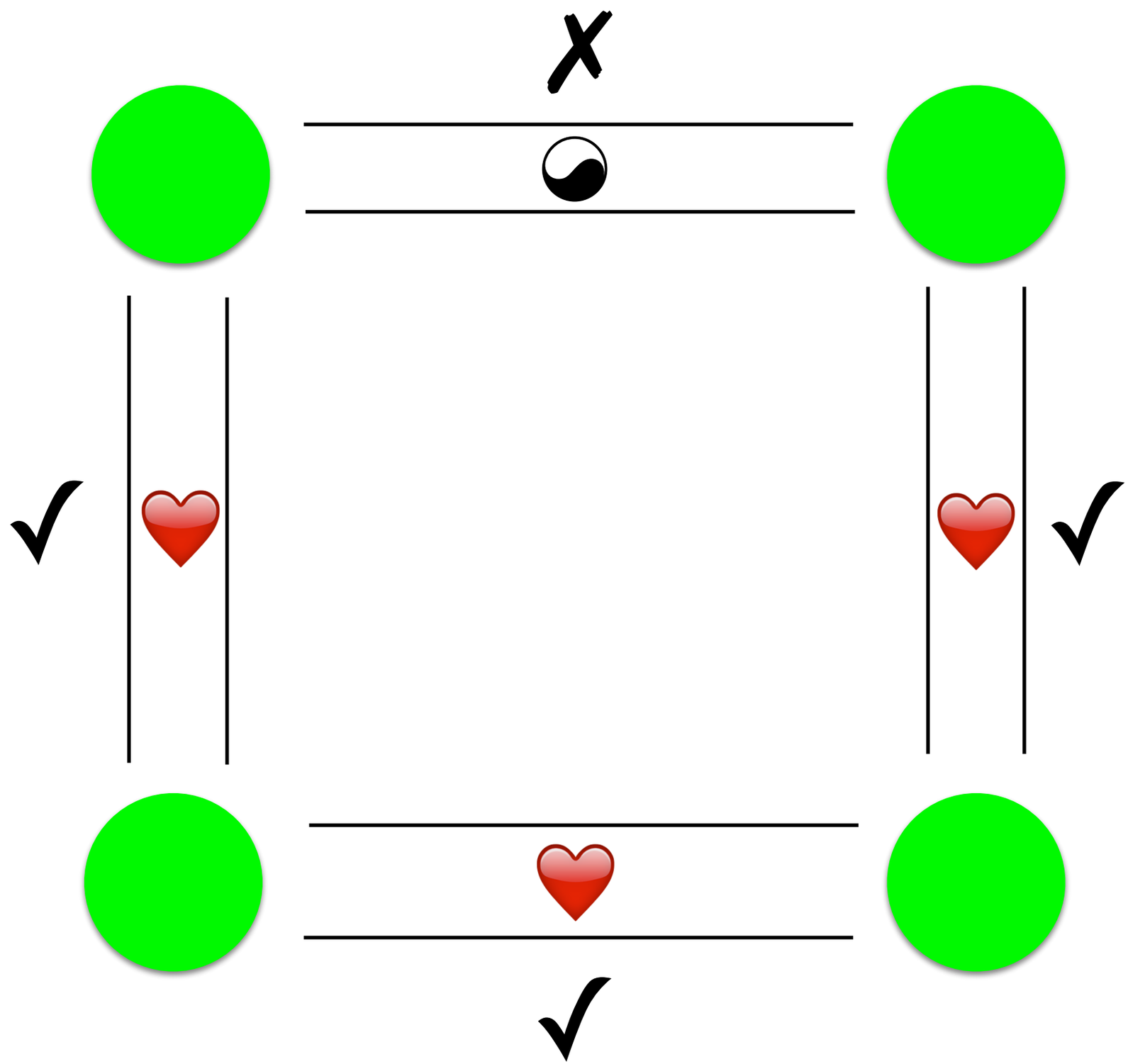
- Version 1: leave space/time out of it
- Version 2: add them in

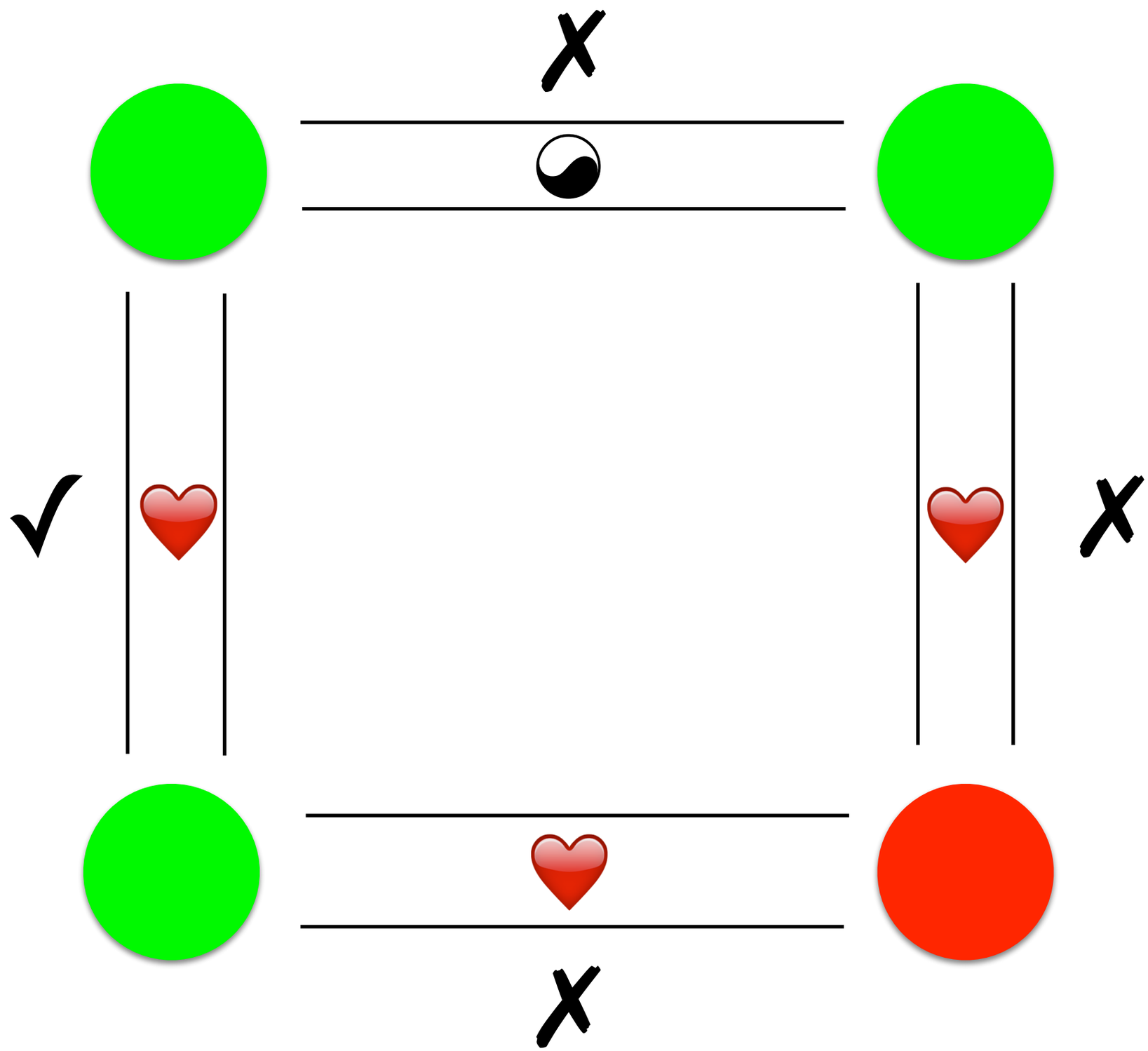
**Question**: can you colour the four balls **green** and **red**, so that

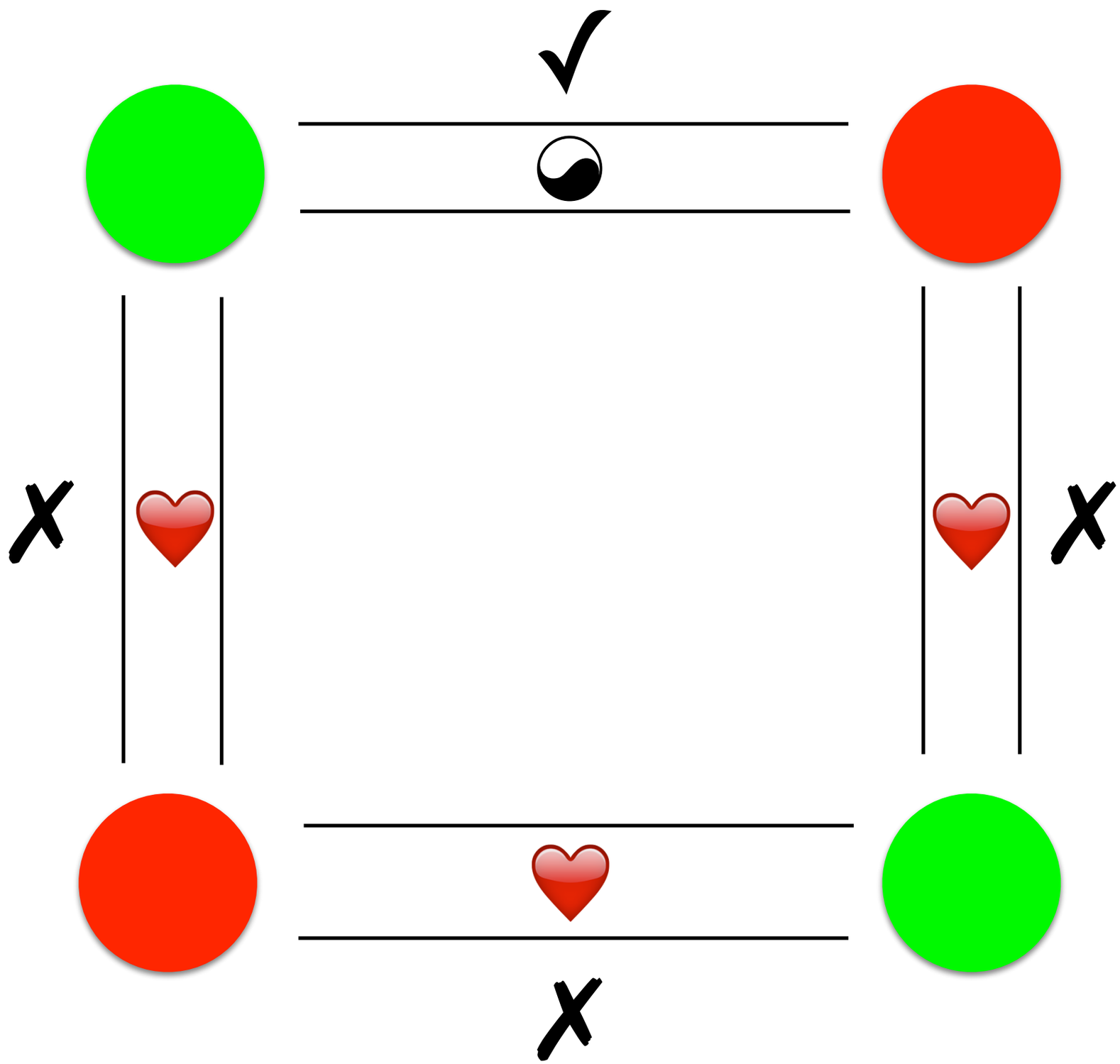


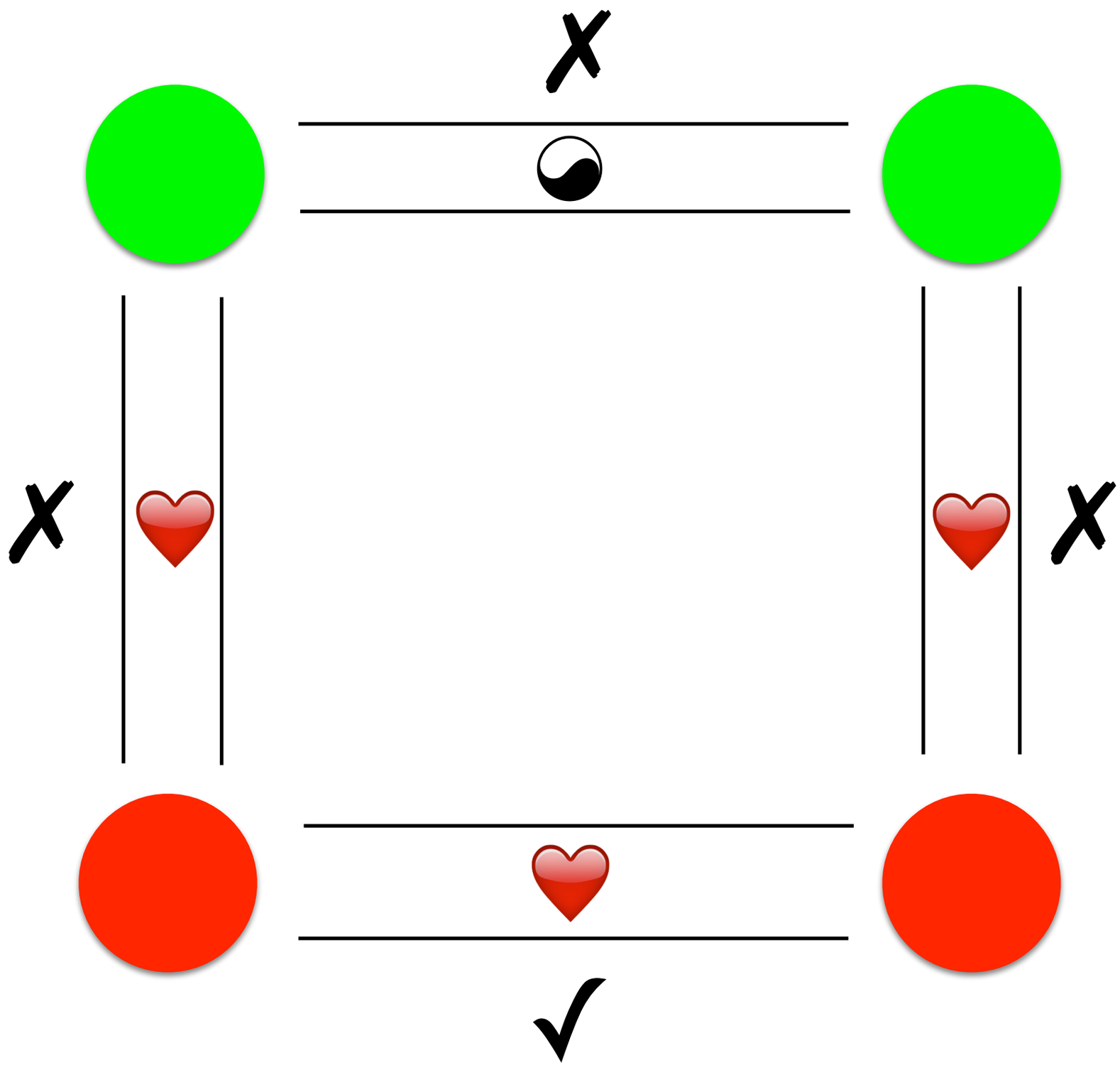












**Question**: can you colour the four balls **green** and **red**, so that

the two on top have different colours

the two on the left have the same colour

**Answer**:
No you can't.
Either one
or three
failures

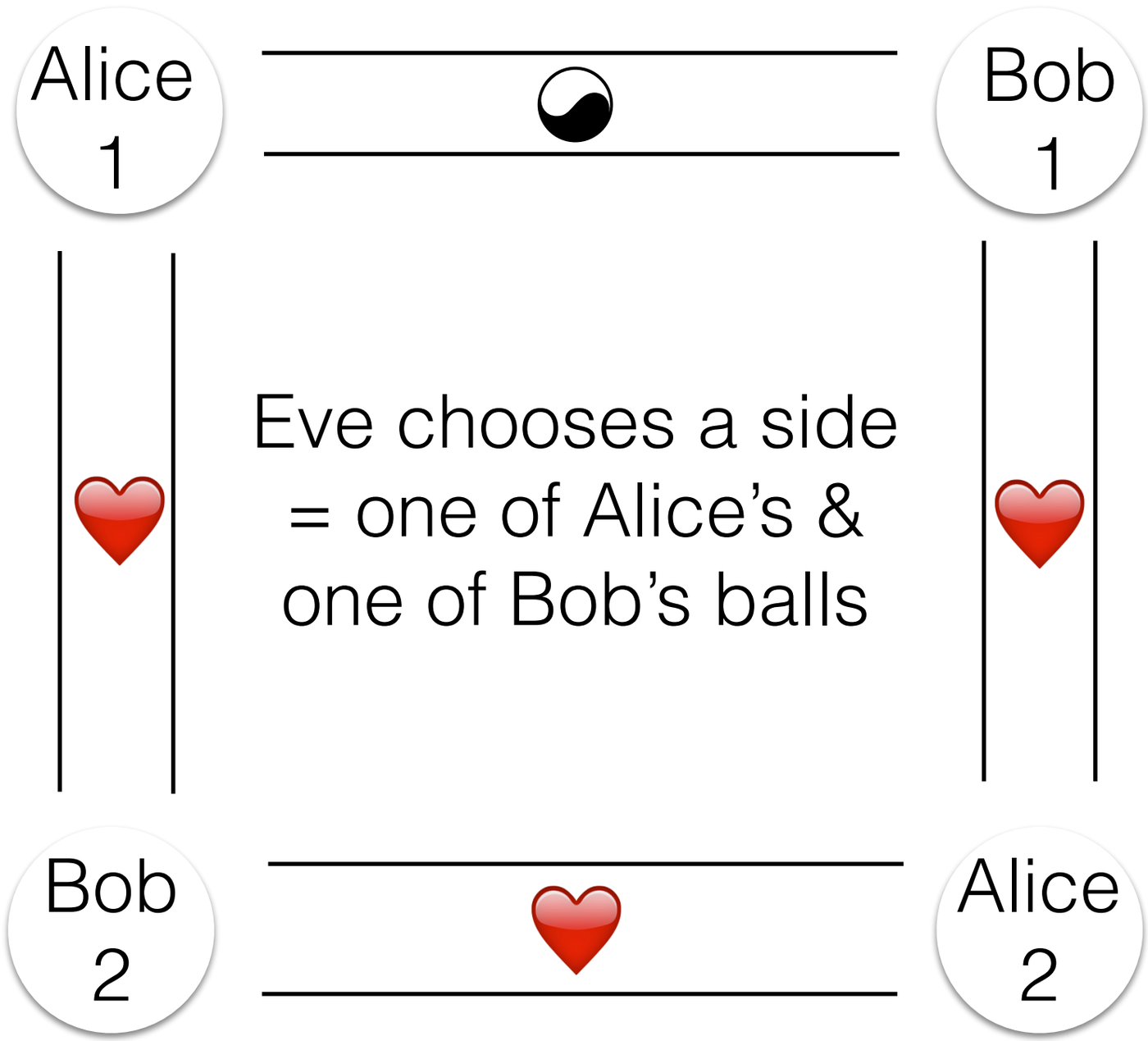
the two on the right have the same colour

the two on the bottom have the same colour

# Bell game: version 1

- Alice and Bob collaborate against Eve
- Alice and Bob get to colour the balls (two each, opposite corners)
- Eve gets to choose a side of the square = one of Alice's and one of Bob's balls
- Alice and Bob want their colours to comply with the requirement on Eve's chosen side (other sides don't matter)

J. S. Bell (1964) "On the Einstein Podolski Rosen paradox"


Alice
1
Bob
1
Eve chooses a side
= one of Alice's &
one of Bob's balls
Bob
2
Alice
2

# Bell game

- Alice chooses colours top left and right bottom ball
- Bob chooses colours top right and left bottom ball
- Eve chooses one of the four sides = chooses one of Alice's two balls and one of Bob's two balls
- Alice and Bob win if their chosen colours comply with the demand for Eve's chosen side
- Optimal strategy for Alice and Bob: choose colouring with mismatch on one side; side of mismatch completely random
- Optimal strategy for Eve: choose one of the four sides completely at random
- Alice and Bob will win three times out of four (i.e., with probability 75%)

# Bell game

- What if Eve has to choose first, Alice and Bob colour afterwards? (or vice versa)
- Boring game!
- We'll make it more interesting by separating Alice and Bob and only telling them which ball of theirs will be checked, afterwards

# Bell game: version 2: distributed variant

- Alice and Bob confer (in secret)
- Alice and Bob are separated (no more communication; but they can take notebooks, computers, etc etc with them)
- Eve tells Alice which of her two balls will be inspected
- Eve tells Bob which of his two balls will be inspected
- Alice and Bob choose colours of designated balls

# Bell game: distributed variant

- Optimal (classical) solution: Alice and Bob choose in advance, at random, one of the “solutions” of the original game

- Why? Because they may as well perform in advance (in secret) any randomisations (tosses of coins, dice throws…) which might be needed; and they might just as well decide in advance how each of their own two balls will be coloured if it happens to get chosen

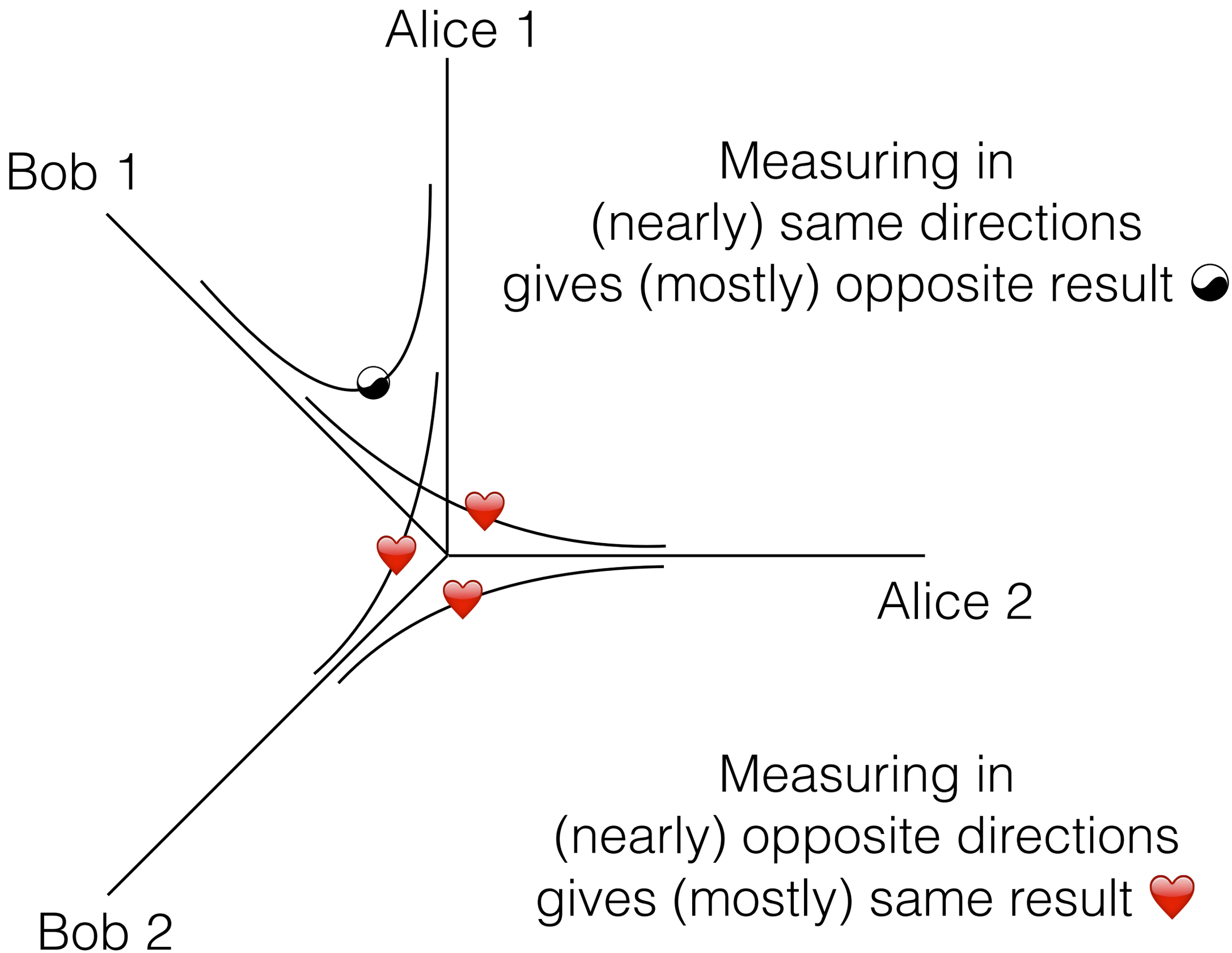
# Bell game: distributed variant

- Optimal (quantum) solution: Alice and Bob each take one part of a pair of maximally entangled qubits with them (qubit = quantum two-level system, e.g., polarisation of a photon, spin of an electron, …)

- When told which ball they should colour, they measure their qubit according to one of two pre-chosen settings, and colour according to measurement outcome

- Alice and Bob can win with probability 85% $= 100 * (1 / 2 + \sqrt{2} / 4)$ %

# Singlet state, two spin half particles



# Remarks

- There is no Bell telephone: Alice can't send messages to Bob at superluminal speed
- They can't even speed up information transfer (*) Tsirelson bound: 85%
- Bell <u>forces</u> randomness
- Quantum physics enlarges possibilities in some directions, reduces them in others

(*) Pawlowski et al (2009), Nature

# Part 2
# Some quantum speculations

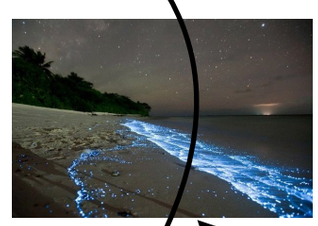
- At “ground level” there exists irreducible randomness in nature
- There is an arrow of time
- Time and space are not as exchangeable as Einstein would have us believe
- Slogan: “the past is particles, the future is a wave”

**Past**

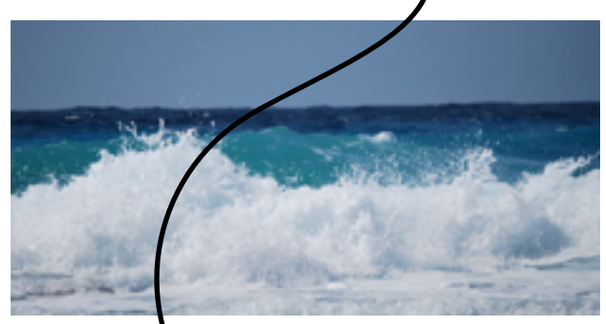
**Now**

**Future**

Einstein's
space-time



awareness
(consciousness)



Collapse of the wave function

# Part 3
# And what about Mind?

- https://en.wikipedia.org/wiki/Quantum_mind

  The quantum mind or quantum consciousness hypothesis proposes that classical mechanics cannot explain consciousness, while quantum mechanical phenomena, such as quantum entanglement and superposition, may play an important part in the brain's function, and could form the basis of an explanation of consciousness.

- (IMHO: mainly garbage)

# Why can no-one understand QM?

- Embodied cognition
- Neuro-linguistics: “systems of core knowledge”

Developmental Science 10:1 (2007), pp 89–96 DOI: 10.1111/j.1467-7687.2007.00569.x

## Core knowledge

**Elizabeth S. Spelke and Katherine D. Kinzler**

*Department of Psychology, Harvard University, USA*

### Abstract

*Human cognition is founded, in part, on four systems for representing objects, actions, number, and space. It may be based, as well, on a fifth system for representing social partners. Each system has deep roots in human phylogeny and ontogeny, and it guides and shapes the mental lives of adults. Converging research on human infants, non-human primates, children and adults in diverse cultures can aid both understanding of these systems and attempts to overcome their limits.*

### Introduction

Cognitive science has been dominated by two views of human nature. On one view, the human mind is a flexible and adaptable mechanism for discovering regularities in experience: a single learning system that copes with all the diversity of life. On the competing view, the human predispositions. Instead, we believe that humans are endowed with a small number of separable systems of core knowledge. New, flexible skills and belief systems build on these core foundations.

Studies of human infants and non-human animals, focused on the ontogenetic and phylogenetic origins of knowledge, provide evidence for four core knowledge

# Conclusion

- Buddhists can appreciate Bell's *I cannot say that action at a distance is required in physics. But I cannot say that you can get away with no action at a distance. You cannot separate off what happens in one place with what happens at another*

- The concept of irreducible randomness is intolerable, but it seems we have to put up with it

- Buddhists can appreciate the idea that the now exists, the past and the future are both imaginary, only awareness exists