Introducing the film

Caveat: This is an informal and incomplete discussion only. See Conway and Kochen's paper for a proper analysis.

The film we will see is a lecture by John Conway, who will discuss philosophical implications of a recent result, in fact it is a mathematical theorem!, that he and Simon Kochen about free will! C & K are well known mathematicians at Princeton.

Free will is not usually the subject of theorems in mathematics, to say the least. What C&K do is to take three physical observations about atoms and other elementary particles, observed in experiments repeatedly and without fail: SPIN, TWIN and FIN.

These physical observations are also consequences of the theories of relativity and quantum mechanics. But we will not need any relativity or quantum mechanics here, just a knowledge of what these observed phenomena are. But be warned, they are counter intuitive, despite being undeniably the way the physical universe does indeed operate.

C&K concerned with human free will. Whatever else free will is, all C&K use is that experimenters can freely choose which button to press from a panel of buttons. By this they mean that the button selected is not a function of, i.e. cannot be predicted from, i.e. is not determined by, i.e. ANY button could possibly be chosen, given the total prior history of universe at the time and place the choice is made.

Free will means much more than this, but this small amount of free will is all that is needed for te proof of the following theorem. And it is similar to what is assereted in the conclusion of the theorem

So that they can make a completely rigorous mathematical proof, relying only on the rules of logic, C&K use these 3 physical observations as axioms. They prove that if experimenters have a certain small amount of free will, then the atomic particles they are measuring have a similar amount of free will.

I would like to emphasise that the assumptions (axioms) have have been observed frequently and without fail.

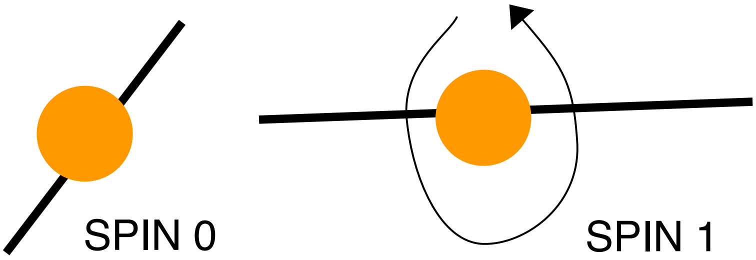
The theorem is not a proof of free will. It is a proof that if we have a small amount of free will, then so do elementary particles.

This film is the last of 6! The previous 5 discus the underlying physics and mathematics and the physical consequences. So I need to summarise this in the next 20 minutes or so, in a way that will put Conway's discussion in context.

For this, I will worked with a model problem concerning "tripedes". This is analogous to the proof by Conway and Kochen, but simpler. However, it is only an analogue — tripede behaviour as presented here cannot be realised in standard quantum mechanical formalism!

FREE WILL THEOREM
& SPIN ONE PARTICLES

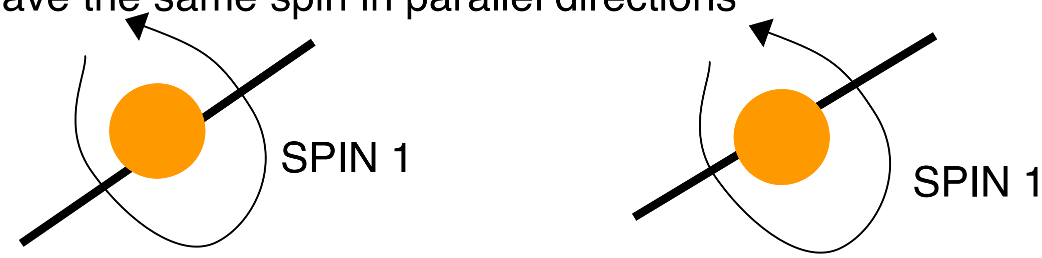
Spin one particles are those whose (total) Spin is always one or zero



THREE PROPERTIES, AXIOMS

SPIN: The spin in any 3 orthogonal directions is always 101 in some order

TWIN: Twinned particles, even thousands of kilometres apart, have the same spin in parallel directions



FIN: Information cannot travel faster than the speed of light

FREE WILL includes the ability to choose *any one* of a finite number of alternatives --- the choice is not determined by, not a consequence of, not forced by, not a function of, anything in the entire prior history of the universe.

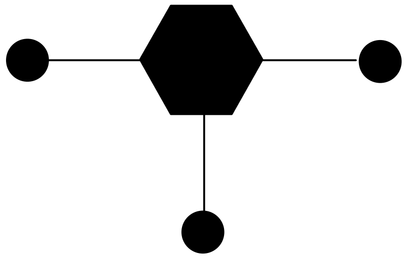
THEOREM [Conway, Kochen]: SPIN + TWIN + FIN imply the following. If experimenters have the free will to choose any one of a finite number of directions to measure spin, then the particle measured has a similar amount of free will to decide its spin.

TRIPEDES

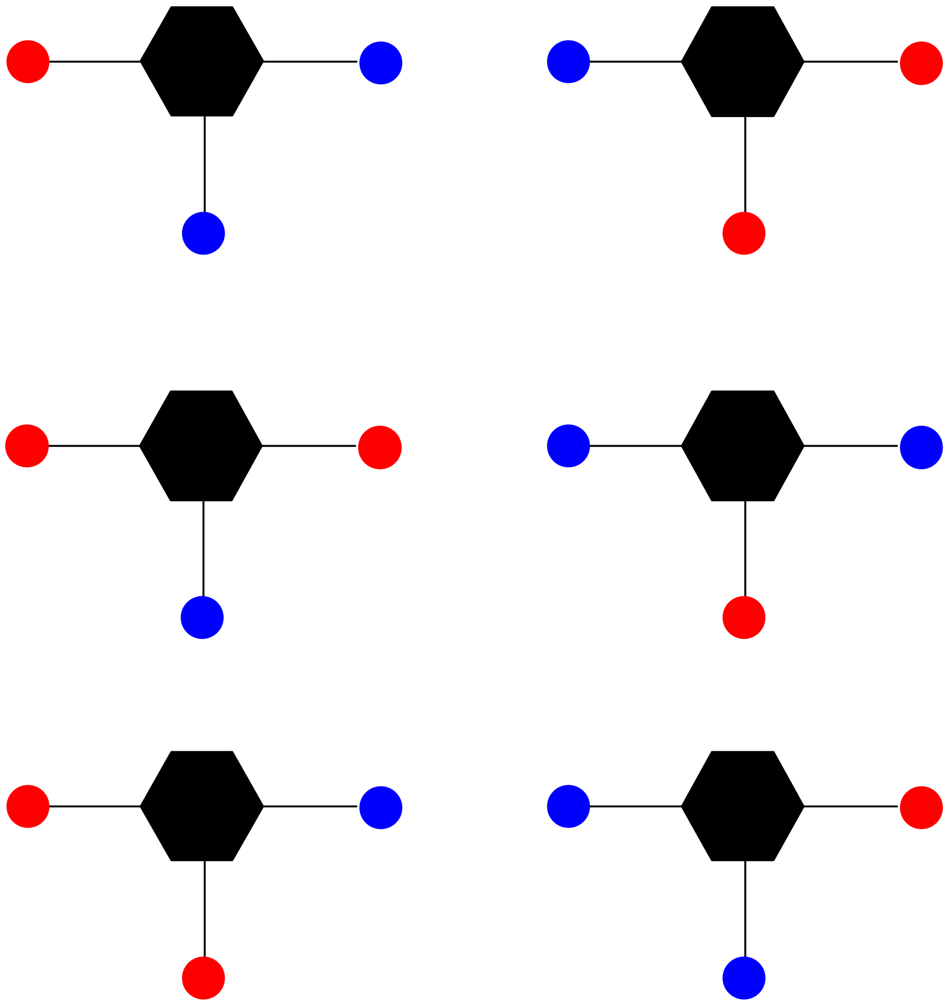
MYSTERIOUS NEW OBJECTS, RECENTLY DISCOVERED

(Just a thought experiment to explain the ideas involved in the proof of the previous theorem !)

Tripedes adhere to the wall with their three pads, L(eft), B(ottom) and R(ight)



Six observed possibilities after turning over their pads; some arrangement of either two blue and one red, or one red and two blue.

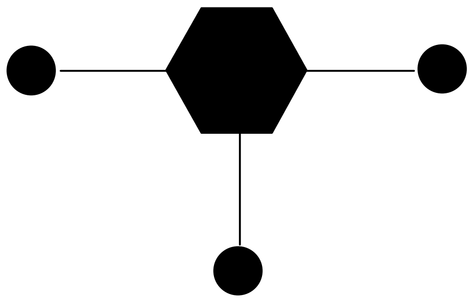


SPIN AXIOM

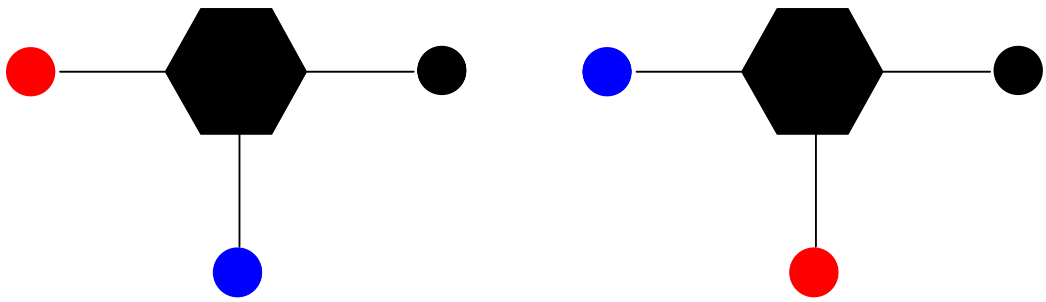
TURN OVER ("SPIN") TWO PADS OF A **SINGLE** TRIPEDE.
THE COLOURS ARE ALWAYS DIFFERENT:
ONE **RED** AND ONE **BLUE**.

EXAMPLE: TURN (SPIN) THE LEFT AND BOTTOM PADS:

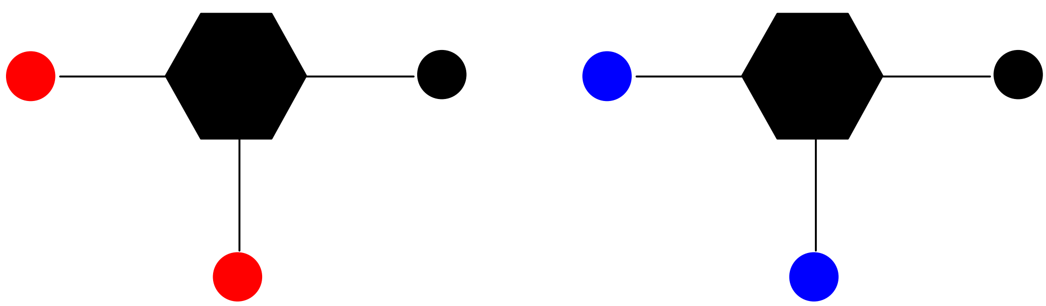
TRIPEDE BEFORE TURNING PADS



ONLY TWO POSSIBILITIES AFTER TURNING PADS

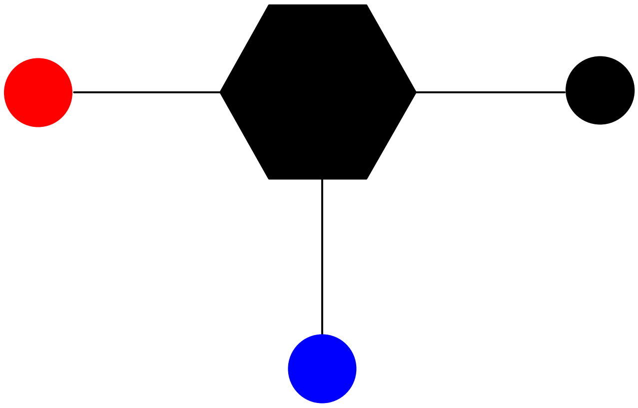


NOT POSSIBLE



(NO CONSTRAINT ON WHAT COLOUR THE THIRD PAD WILL BE)

COLOURING "PARADOX"



DEFINITION: A **red*****blue** colouring of the pads is a colouring such that every pair of pads has exactly one red and one blue pad.

THEOREM: *There is no possible **red*****blue** colouring of the pads of a tripede.*

PROOF: Just examine the possible cases.

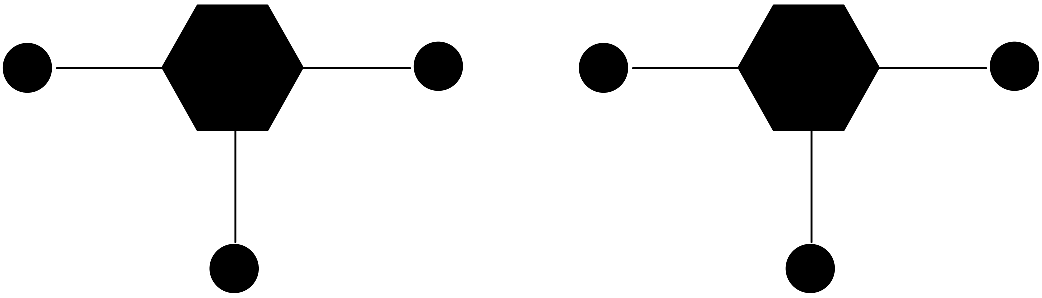
- This theorem does not contradict the SPIN axiom.
- This theorem, together with SPIN, implies that the pad colour is not determined ahead of turning the pads. The colours depend on, amongst possibly other things, the actual turning of the pads.
- This theorem, together with SPIN, does not imply free will for tripedes. Why?

ANSWER: *Some mechanical or electrical feedback mechanism could be at work*

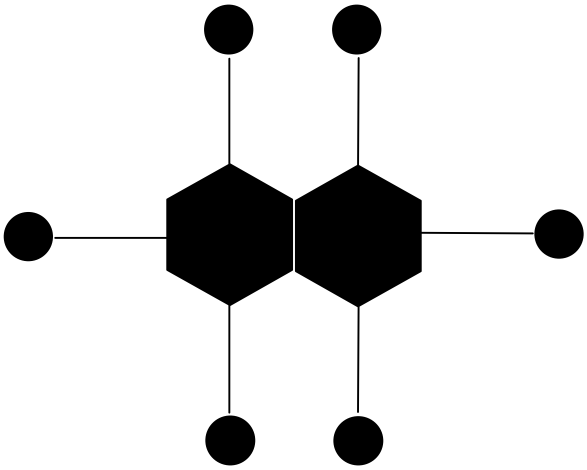
TWIN AXIOM

TWO TRIPEDES ARE "TWINNED"

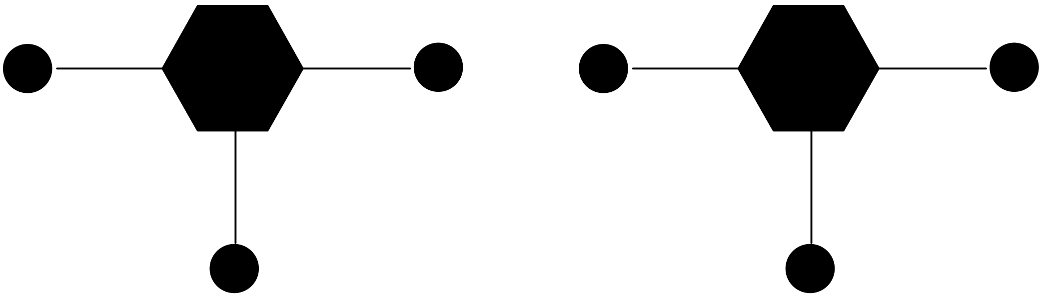
Before Twinning



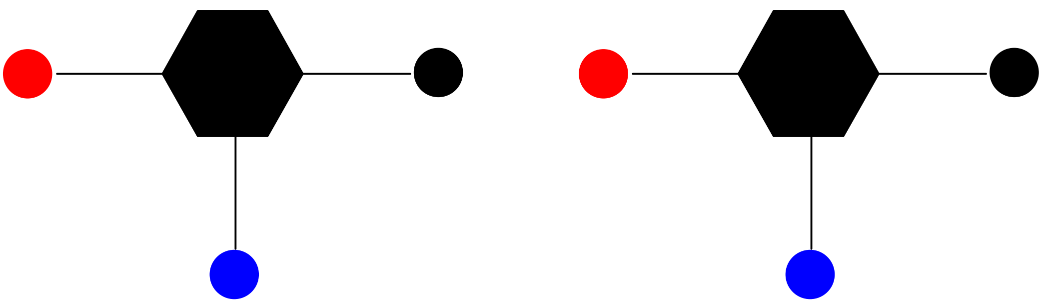
Twinning



After Twinning

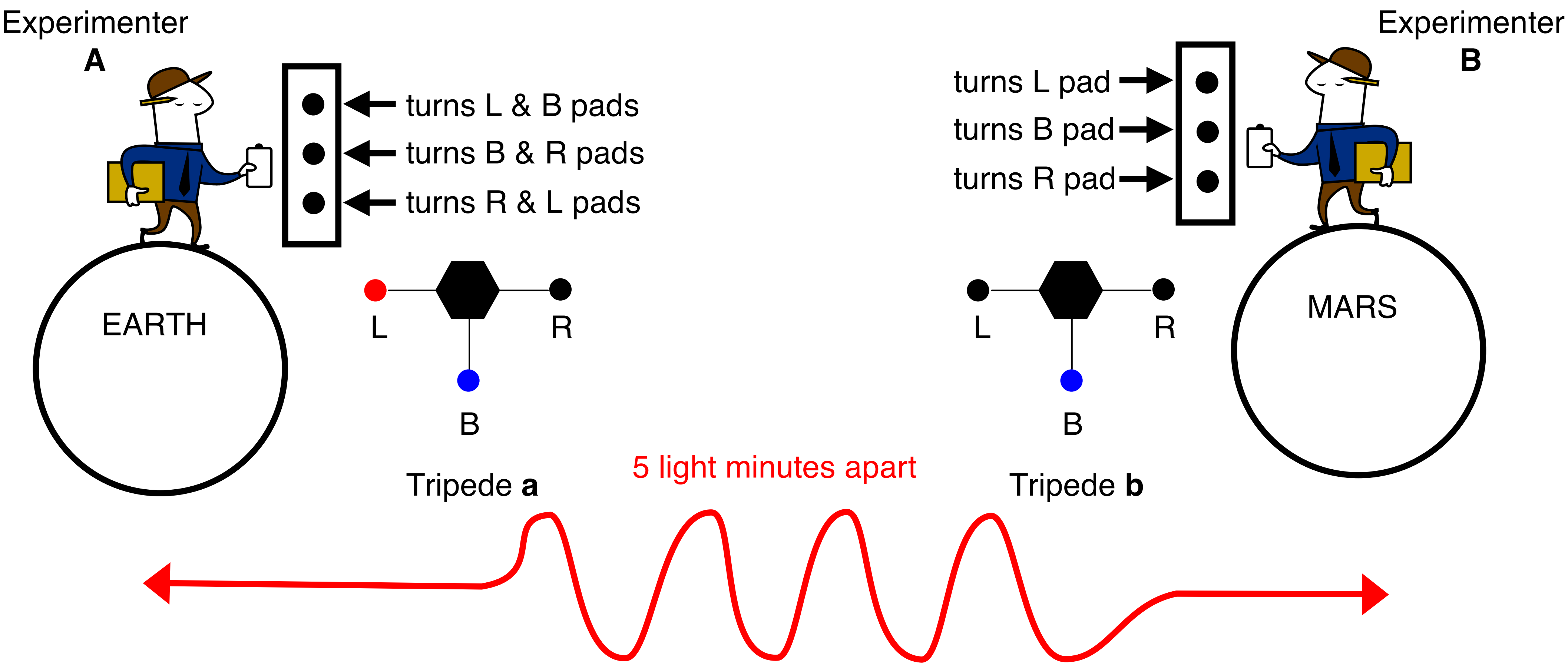


Turn *same* 2 pads on each, *not* necessarily in same order. *Corresponding* pads always have the same colours



One can do this in separate rooms or planets!
Einstein called it "spooky action at a distance"

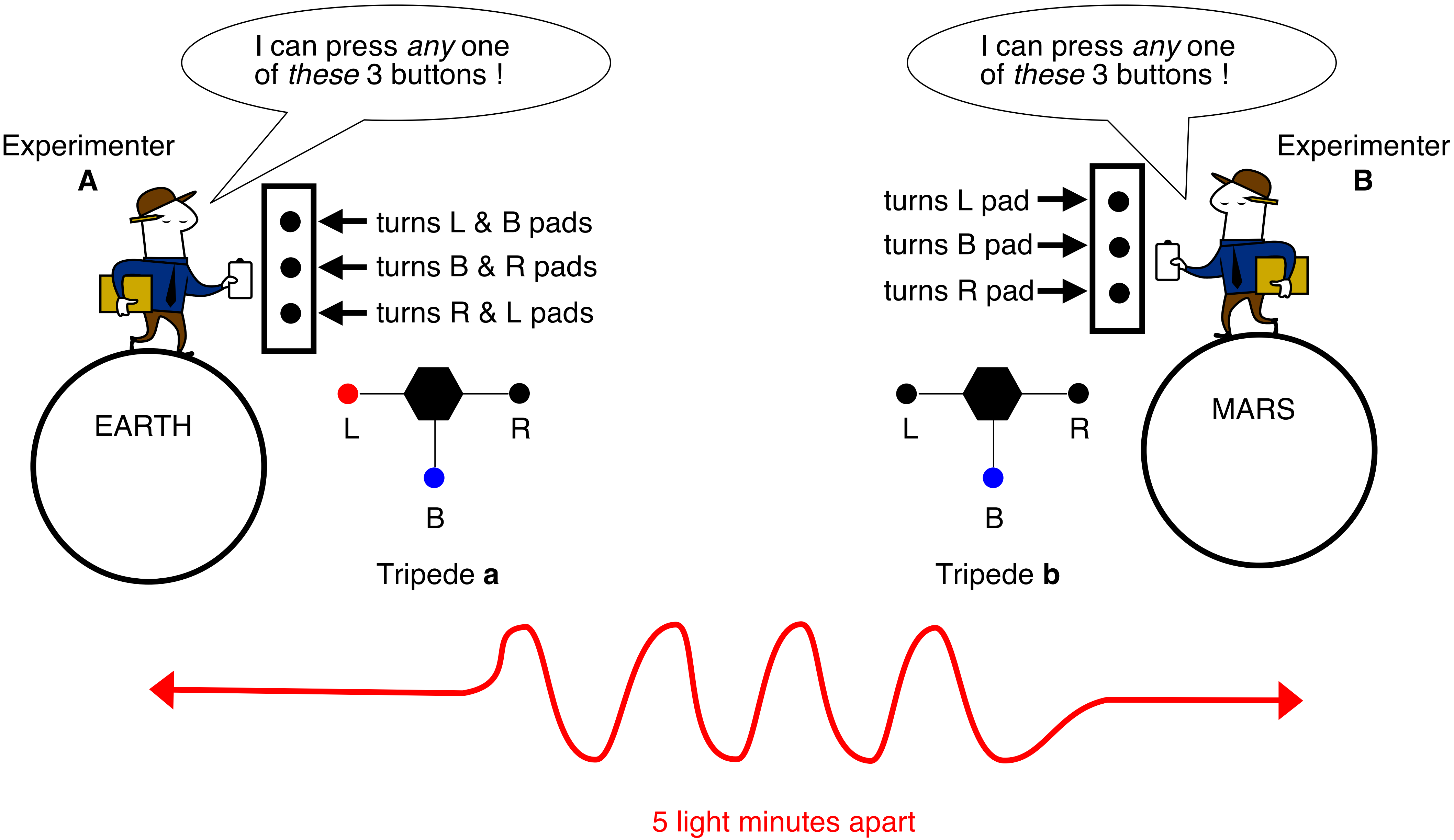
FIN AXIOM



FINITE SPEED OF COMMUNICATION (AS FOR LIGHT), SO
NO COMMUNICATION IF EXPERIMENTS DONE AT APPROXIMATELY THE “SAME” TIME

IN PARTICULAR,
a's RESPONSE IS INDEPENDENT OF **B**'s CHOICE OF BUTTON
b's RESPONSE IS INDEPENDENT OF **A**'s CHOICE OF BUTTON

EXPERIMENTERS' FREE WILL



THEOREM [FREE WILL FOR TRIPEDES !]
Assume SPIN, TWIN and FIN.
*If **A** and **B** can freely choose their buttons, then **a** and **b** are similarly free to choose some colours of their pads*

"Proof"

1. Suppose **a** and **b** are *not* free. (We aim to get a contradiction !)

Let $C_{\mathbf{a}}$ represent the colours of the two turned pads of **a**, and

$C_{\mathbf{b}}$ represent the colour of the single turned pad of **b** .

To give the idea of the proof, write

$$C_{\mathbf{a}} = C_{\mathbf{a}} \text{ (choice of button by } \mathbf{A}, \alpha),$$

$$C_{\mathbf{b}} = C_{\mathbf{b}} \text{ (choice of button by } \mathbf{B}, \beta).$$

This means $C_{\mathbf{a}}$ is determined by, is a function of, **A**'s choice and the entire *prior* history α of the universe accessible at that time and place.

Similarly for $C_{\mathbf{b}}$, **B** and β.

2. By Free Will for **A** and **B**,

B can make *any* of 3 choices, so $C_{\mathbf{b}}$ gives a colour for *every* pad of **b**.

A is allowed *any* of 3 choices, so $C_{\mathbf{a}}$ gives colours for *every* pair of pads of **a**

3. By FIN, β is independent of **A**'s choice of button and certainly of **B**'s ,
α is independent of **B**'s choice of button and certainly of **A**'s .
So we can ``fix'' α and β and write

$$C_{\mathbf{a}} = C_{\mathbf{a}} \text{ (choice of button by } \mathbf{A}),$$

$$C_{\mathbf{b}} = C_{\mathbf{b}} \text{ (choice of button by } \mathbf{B}).$$

4. By SPIN, the colouring $C_{\mathbf{a}}$ of each pair gives one red and one blue

5. By TWIN, the colouring $C_{\mathbf{b}}$ of pads and the colouring $C_{\mathbf{a}}$ of pairs of pads, are "consistent".

6. By 4 and 5, the colouring $C_{\mathbf{b}}$ of pads is a red*blue colouring.
This is *impossible* by the colouring paradox.

7. So the original assumption in 1 is false. The colours are *not* determined by the choice of pads turned and the entire previous histories of the universe.