

Philosophy of QM 24.111

Fifth lecture.

A PUZZLE ABOUT LOCALITY

How does the Bell's Theorem definition of locality

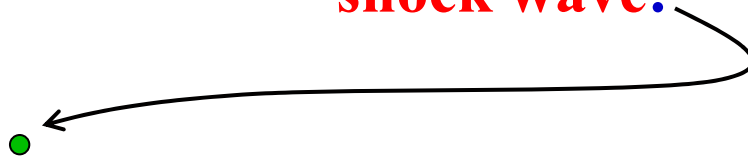
$$\text{Prob}(x, y \mid \theta_L, \theta_R, \lambda)$$
$$= \text{Prob}(x \mid \theta_L, \lambda) \text{Prob}(y \mid \theta_R, \lambda)$$

match up to

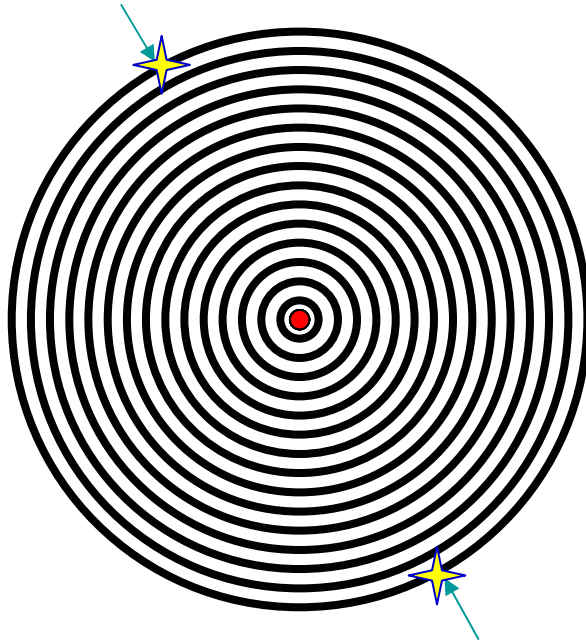
- our intuitive understanding of this notion;
- the kind of “locality” that features in special relativity?

SOME HYPOTHETICAL PHYSICS

Unstable particle;
when it “explodes”, it
sends out a **spherical**
shock wave:

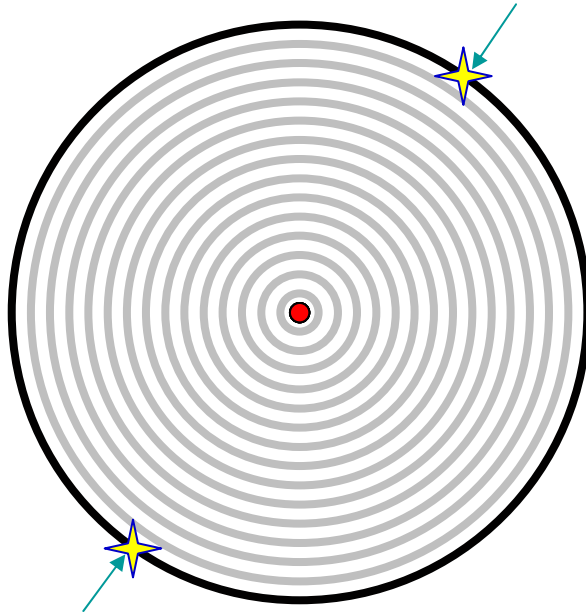


SOME HYPOTHETICAL PHYSICS



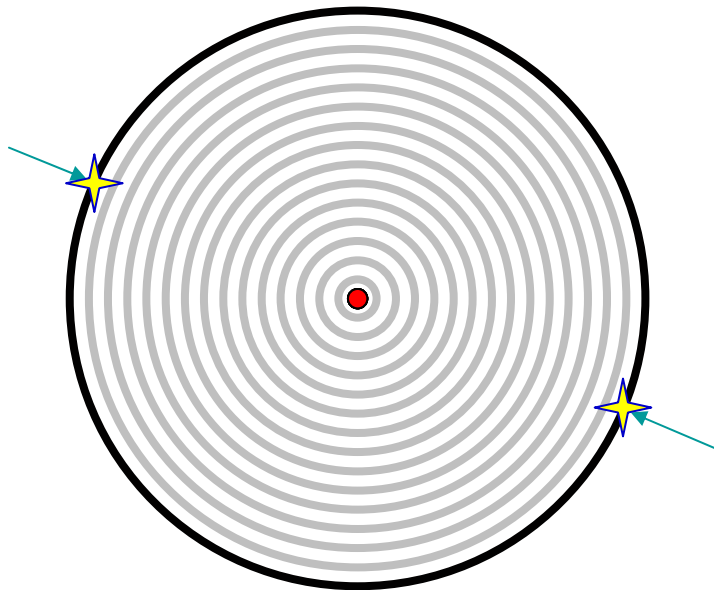
When the shock wave reaches a certain critical distance, two localized “flashes” appear on its surface, at **opposite positions**, with their axis **randomly determined**:

SOME HYPOTHETICAL PHYSICS



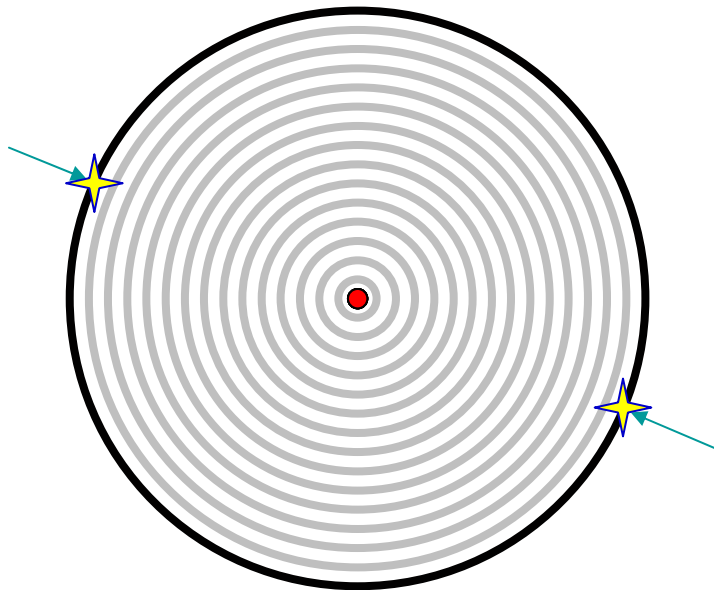
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SOME HYPOTHETICAL PHYSICS



Bell-locality is violated in this example. Why?

Is our intuitive notion of locality (no “action at a distance”) violated?

Is special relativity violated?



TWO PATH REVISITED:

Our examination of the two-path experiment left us with two **different** problems:

- What is the particle doing when we do not observe which path it follows? Does it somehow follow both paths? Neither path?
- How can we construct a theory that will give us the right prediction?

We will now focus on the *second* problem—
it is much easier than the first!

WHAT SPECIAL RELATIVITY FORBIDS:

Five options:

Faster-than-light mass/energy transport

Faster-than-light information transfer

Faster-than-light signalling

Faster-than-light causation

Dynamical laws that are not Lorentz-invariant

