On alignment of chiralities of distant frameworks

L Diósi (Budapest)

Reflections $\mathbb{C}, \mathbb{P}, \mathbb{T}$ $\exists$ in Classical physics

$h \equiv \{p_1, p_2, \ldots p_n\}$ $\exists$

$\rightsquigarrow \mathbb{C}h, \mathbb{P}h, \mathbb{T}h$ $\exists$

Reflections $\mathbb{C}, \mathbb{P}, \mathbb{T}$ $\nexists$ in Q-physics

- in Rel. QFT (particle physics)
- in QM

Is there any link between non-trivial behaviour of $\mathbb{C}, \mathbb{P}, \mathbb{T}$ in RQFT & QM?

2004 July 13, Waterloo (Canada)
Perimeter Institute

C, P, T in particle physics (RQFT)

1957: Lüders, Pauli	(th.)	$\mathbb{CPT}\ \exists$
Wu	(exp.)	$\mathbb{P}(\beta\text{-decay})\ \nexists$
Lee, Yang	(th.)	$\mathbb{CP}\ \exists$
Landau, Salam	(th.)	$\mathbb{C}\nu = \tilde{\nu}$, $\mathbb{CP}\tilde{\nu} = \nu$
		$\mathbb{C}\nu, \mathbb{P}\nu, \mathbb{C}\tilde{\nu}, \mathbb{P}\tilde{\nu}\ \nexists$

→

1964: Christenson et al.	(exp.)	$\mathbb{CP}(K^0\text{-decay})\ \nexists$

NOW: $\mathbb{C}, \mathbb{P}, \mathbb{T}\ \nexists$; $\mathbb{CPT}\ \exists$

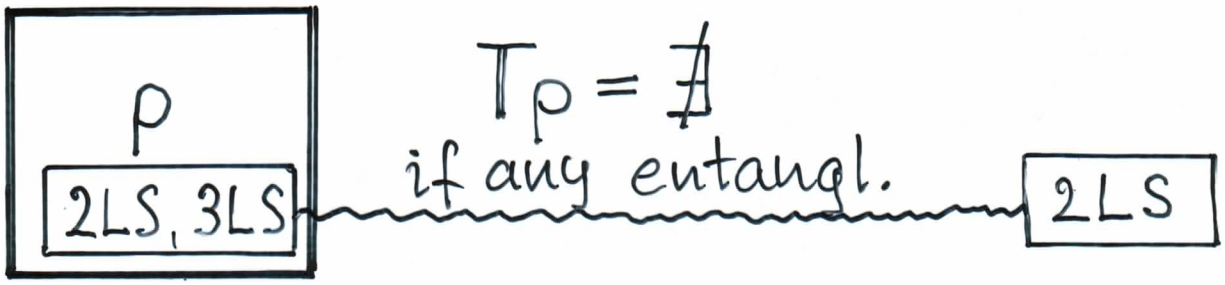
Feynman: Classical communication does not guarantee alignment of distant chiralities.

Does Q-communication do?

C, P, T in QM

1955 - 1995 Stinespring, Kraus, Peres, Horodecki (th.): $\mathbb{T}\ \nexists$ because of entanglement

$\mathbb{T}\rho = \nexists$ if ρ has "sufficient" entanglement with RestOfWorld.



$\rightsquigarrow \mathbb{CPT}\rho = \nexists$

Conflict: CPT $\exists$ in RQFT!

Can Q-communication beat
C- " -
to align distant chiralities?

A & B share ensemble of 2 qbits in entangled state ρ. They need not to know ρ itself.
By LMCC they determine 15 param's

$$\langle \vec{\sigma}_A \rangle, \langle \vec{\sigma}_B \rangle, \langle \vec{\sigma}_A \circ \vec{\sigma}_B \rangle,$$

where $\vec{\sigma}_B = \begin{Bmatrix} + \\ - \end{Bmatrix} U \vec{\sigma}_A U^\dagger$ if $\begin{cases} \text{aligned} \\ \text{opposite} \end{cases}$

A (or B) calculates test state $\frac{1}{4}[1 \otimes 1 +$

$$+ \langle \vec{\sigma}_A \rangle \vec{\sigma}_{A/B} \otimes 1 + 1 \otimes \langle \vec{\sigma}_B \rangle \vec{\sigma}_{A/B} + \vec{\sigma}_{A/B} \langle \vec{\sigma}_A \circ \vec{\sigma}_B \rangle \vec{\sigma}_{A/B}]$$

≥ 0 (aligned)
$\not\geq 0$ (opposite)

Does it mean we can align distant chiralities by Q-communication?
No!

Summary

- Neither C- nor Q-communication will guarantee chirality alignment.
- Contrary to C-, Q-communication guarantees time-arrow alignment.
- While CPT is symmetry in RQFT, elementary QM forbids T (and thus CPT as well) if entanglement with ROW is "too" strong.

1985 Summers, Werner
QFT vacuum spatially entangled

2002 Beckman, Gottesman, Kitaev, Preskill
Non-Abel gauge fields spatially ent.

2004 Plenio, Eisert, Dreißig, Cramer
In QFT vacuum

$$\mathrm{Ent}(\square : \mathrm{ROW}) \sim \mathrm{surf}(\square)$$