Title: On the tensor product structure of general covariant systems

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Series: Quantum Foundations

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Abstract: Defining a generic quantum system requires, together with a Hilbert space and a Hamiltonian, the introduction of an algebra of observables, or equivalently a tensor product structure. Assuming a background time variable, Cotler, Penington and Ranard showed that the Hamiltonian selects an almost-unique tensor product structure. This result has been advocated by Carrol and collaborators as supporting the Everettian interpretation of quantum mechanics and providing a pivotal tool for quantum gravity. In this talk I argue against this, on the basis of the fact that the Cotler-Penington-Ranard result does not hold in the generic background-independent case where the Hamiltonian is replaced by a Hamiltonian constrain. This reinforces the understanding that entropy and entanglement, that in the quantum theory depend on the tensor product structure, are quantities that are observable dependent. To conclude, I would like to pose the question of whether clocks can be thought as a resource, and how thinking of time in terms of physical clocks can inform our interpretation of quantum mechanics

Iñaki Garay & Gabriel Carrol

Wheeler

deWitt — Everett

$C|\psi\rangle = 0$

TIME

– RQM – Wheeler

$\{\mathcal{H}, H, \{A_i\}\}$

$C|\psi\rangle = 0$

TIME

RELATIONALITY

deWitt – Everett – Oxford – Pitts (Carroll)

$\{\mathcal{H}, H\}$

Iñaki Garay & Gabriel Carrol

QBism — RQM — Wheeler   deWitt — Ev

$\{\mathcal{H}, H, \{A_i\}\}$ $C|\psi\rangle = 0$ {

TIME

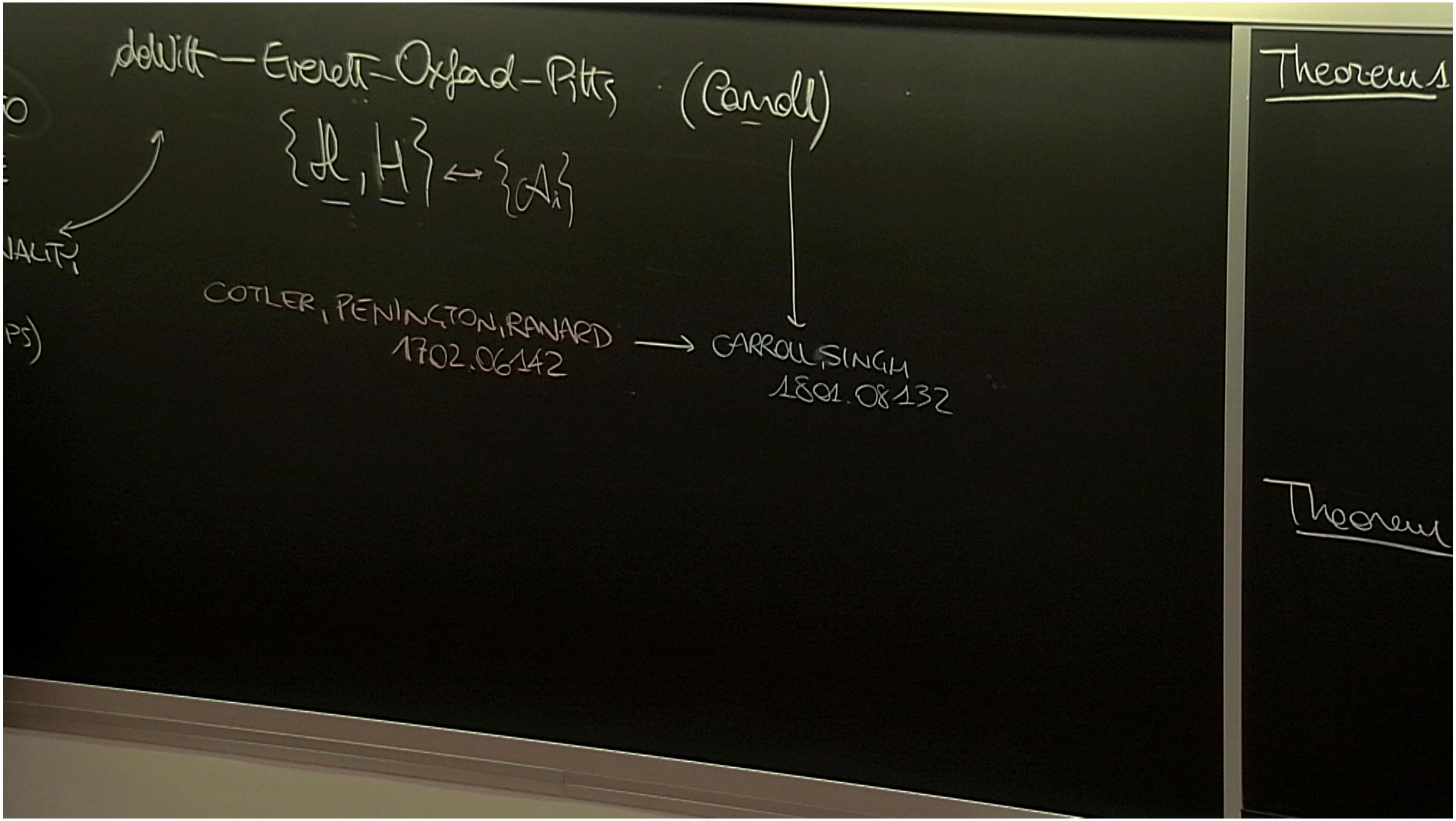
$\Updownarrow$

RELATIONALITY

- ZANARDI, LIDAR, LLOYD
  0308043

TENSOR PRODUCT STRUCTURE (TPS)

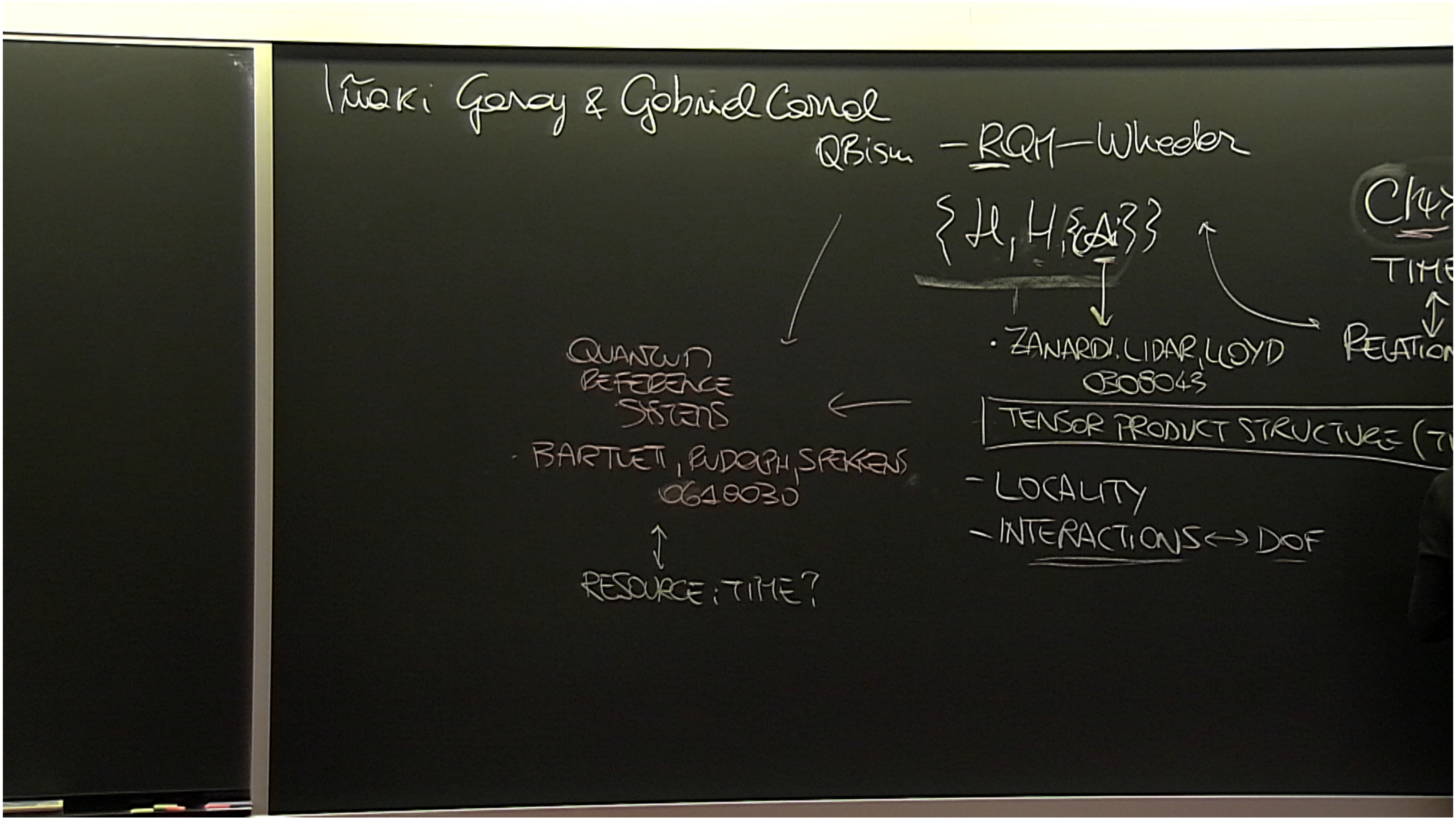
- LOCALITY
- INTERACTIONS $\leftrightarrow$ DOF

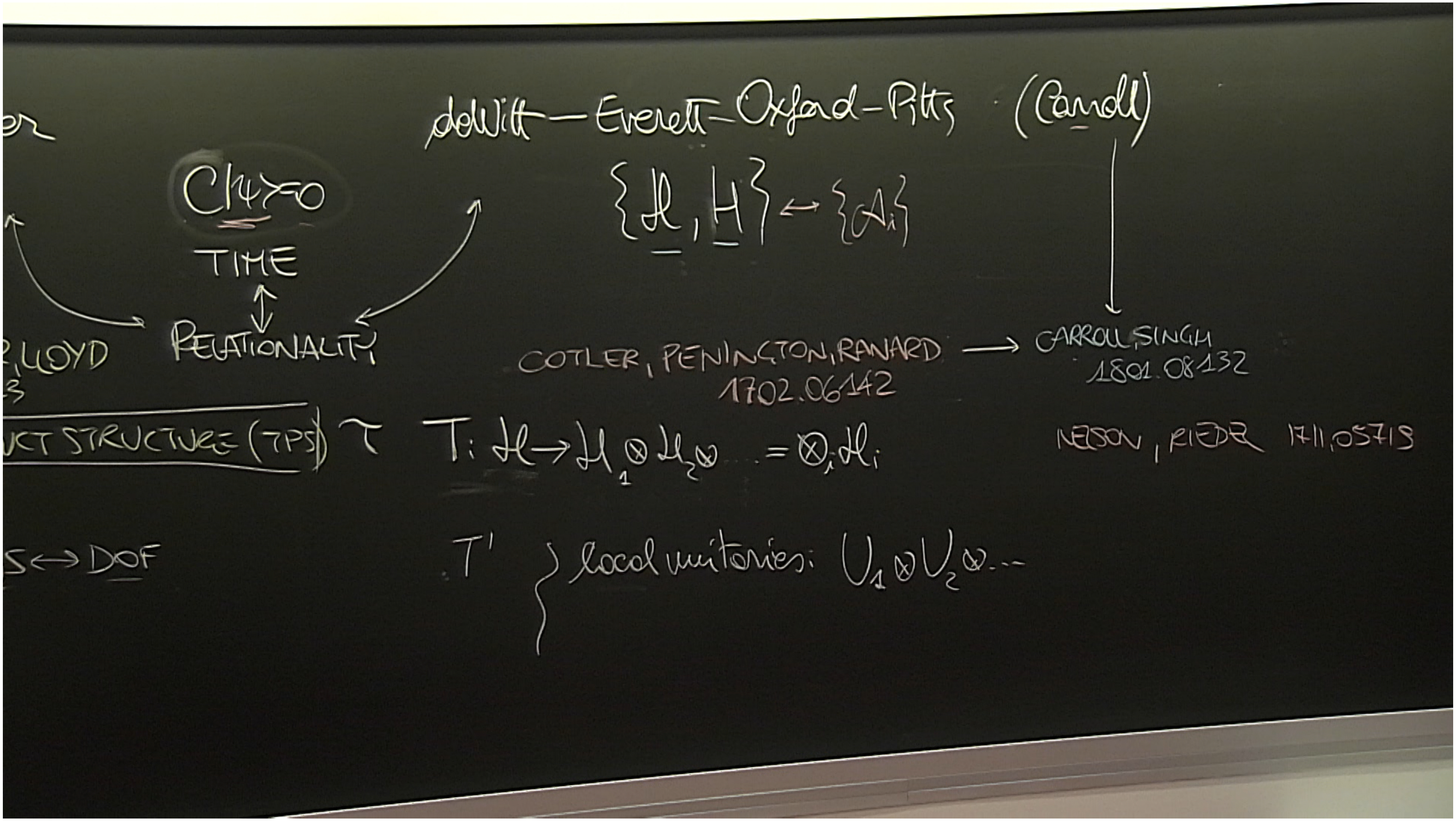

deWitt — Everett — Oxford — Pitts
(Carroll)
{ℋ, H} ↔ {A_i}
COTLER, PENINGTON, RANARD
1702.06142
CARROLL, SINGH
1801.08132
Theorem 1
Theorem

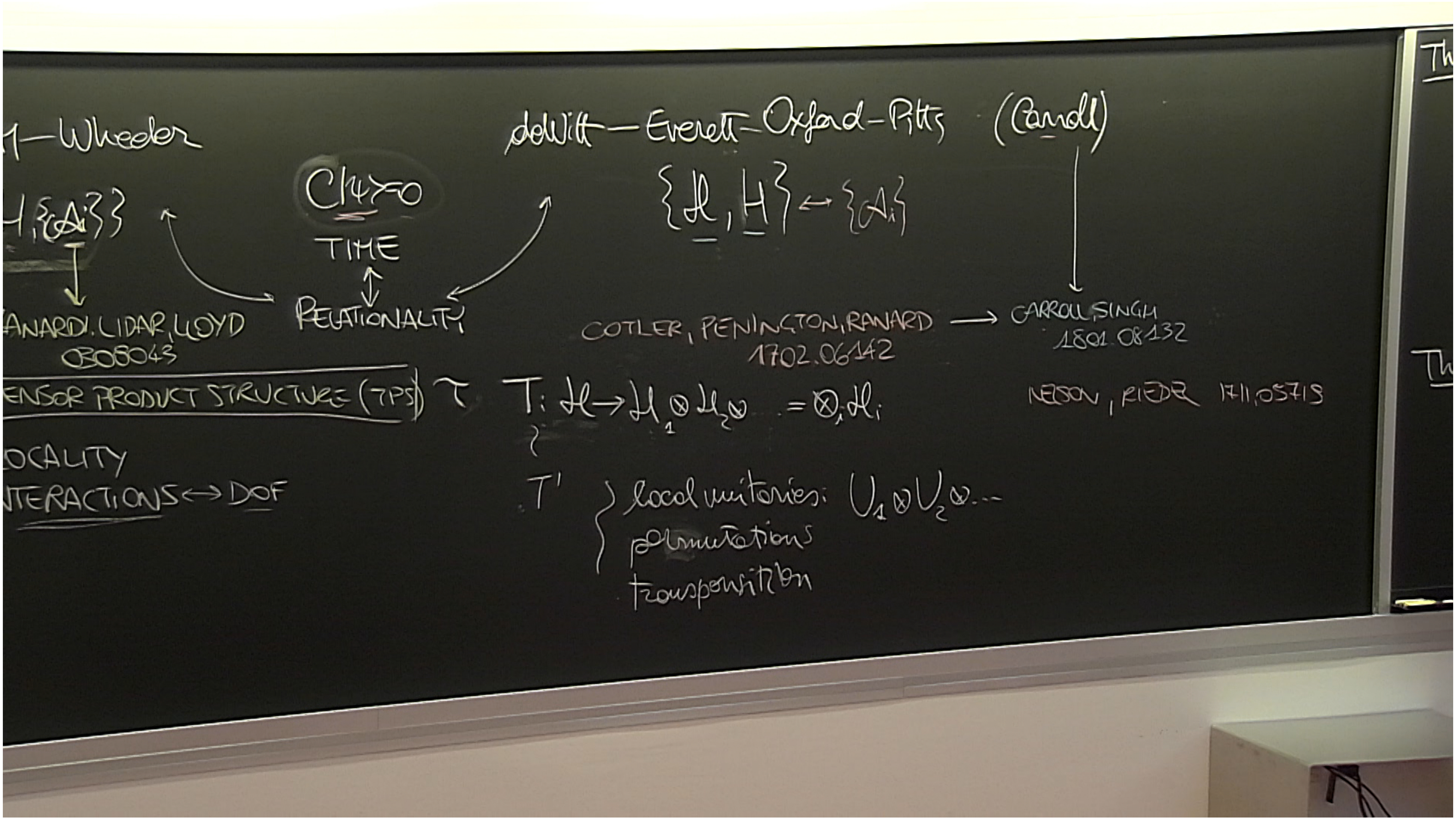
Theorem 1: Consider a given subspace S of Hermitian Hamiltonians respect to a given fixed TPS. Be $G \subset U(N)$ s.t. $\forall A \in S$ $GAG^{-1} \in S$. If $\exists H_0 \in S$ that can be put in Jordan form, and $i[V, H_0] = \left\{ \begin{matrix} 0 \\ V \end{matrix} \right. \in S$ for $V \in \mu(N)$

$\Rightarrow$ if $\exists H$ with a finite # of duals
then also almost all H_i in the same subspace
have finite # duals

Theorem 2: for $S_{\mathbb{C}}$ complex [....] $\Rightarrow$ # of complex dual is constant
for almost all matrices $\in S_{\mathbb{C}}$


Iñaki
QBism — RQM — Wheeler
{H, H, {Ai}}
· ZANARDI, LIDAR, LLOYD
0308043
TENSOR PRODUCT STRUCTURE
— LOCALITY
— INTERACTIONS ↔ DOF
QUANTUM REFERENCE SYSTEMS
· BARTLETT, RUDOLPH, SPEKKENS
0610030
RESOURCE: TIME?


deWitt — Everett — Oxford — Pitts (Carroll)
$\{\mathcal{H}, H\} \leftarrow \{A_i\}$
TIME
RELATIONALITY
LLOYD
COTLER, PENINGTON, RANARD
1702.06142
CARROLL, SINGH
1801.08132
STRUCTURE (TPS)
$T: \mathcal{H} \to \mathcal{H}_1 \otimes \mathcal{H}_2 \otimes \ldots = \otimes_i \mathcal{H}_i$
NELSON, RIEDEL 1711.05719
S ↔ DOF
T' local unitaries: $U_1 \otimes U_2 \otimes \ldots$



-Wheeler
H, {A_i}}
C|ψ>=0
TIME
RELATIONALITY
deWitt — Everett — Oxford — Pitts (Carroll)
{ℋ, H} ↔ {A_i}
RANARD, LIDAR, LLOYD
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COTLER, PENINGTON, RANARD
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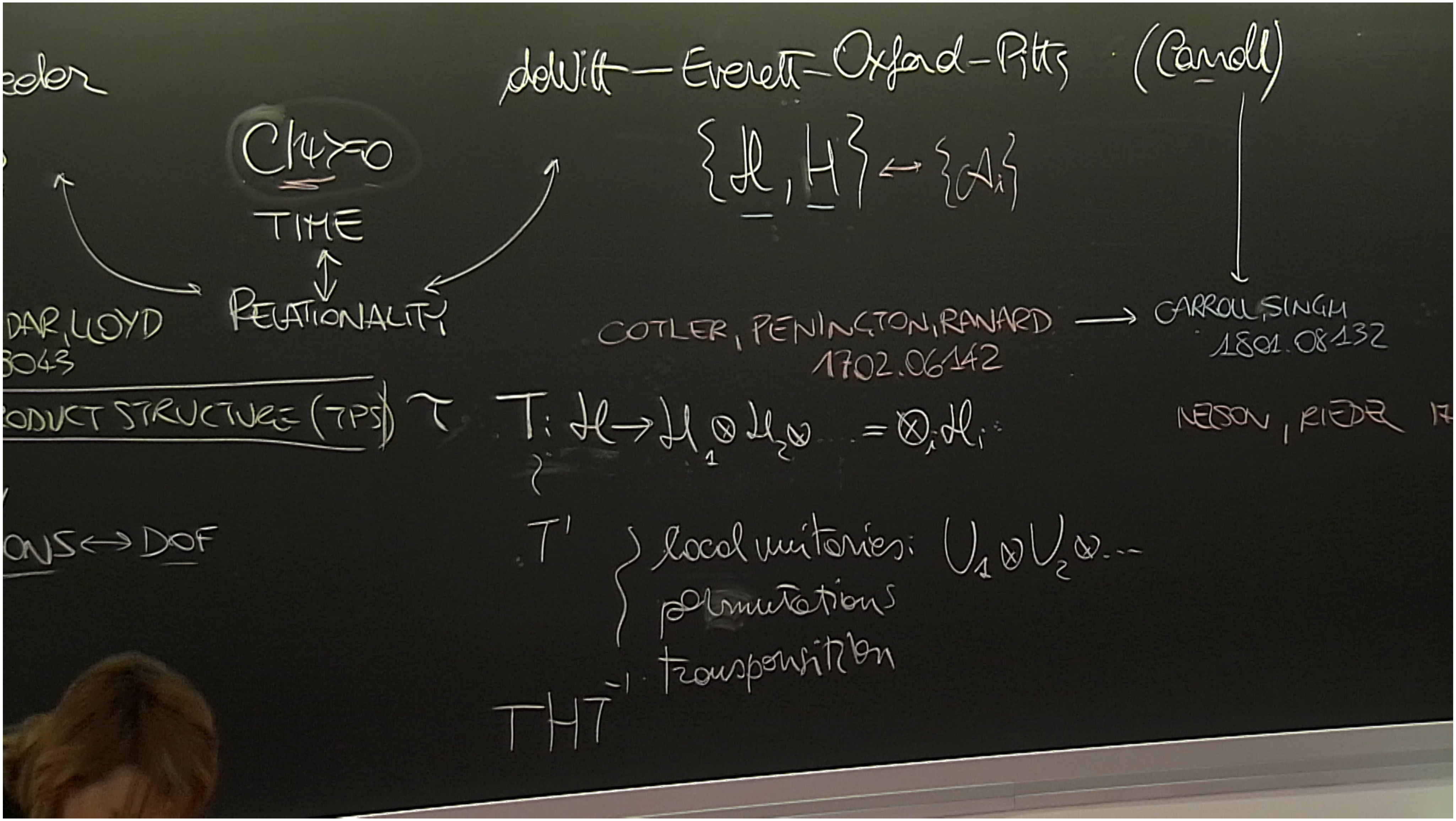
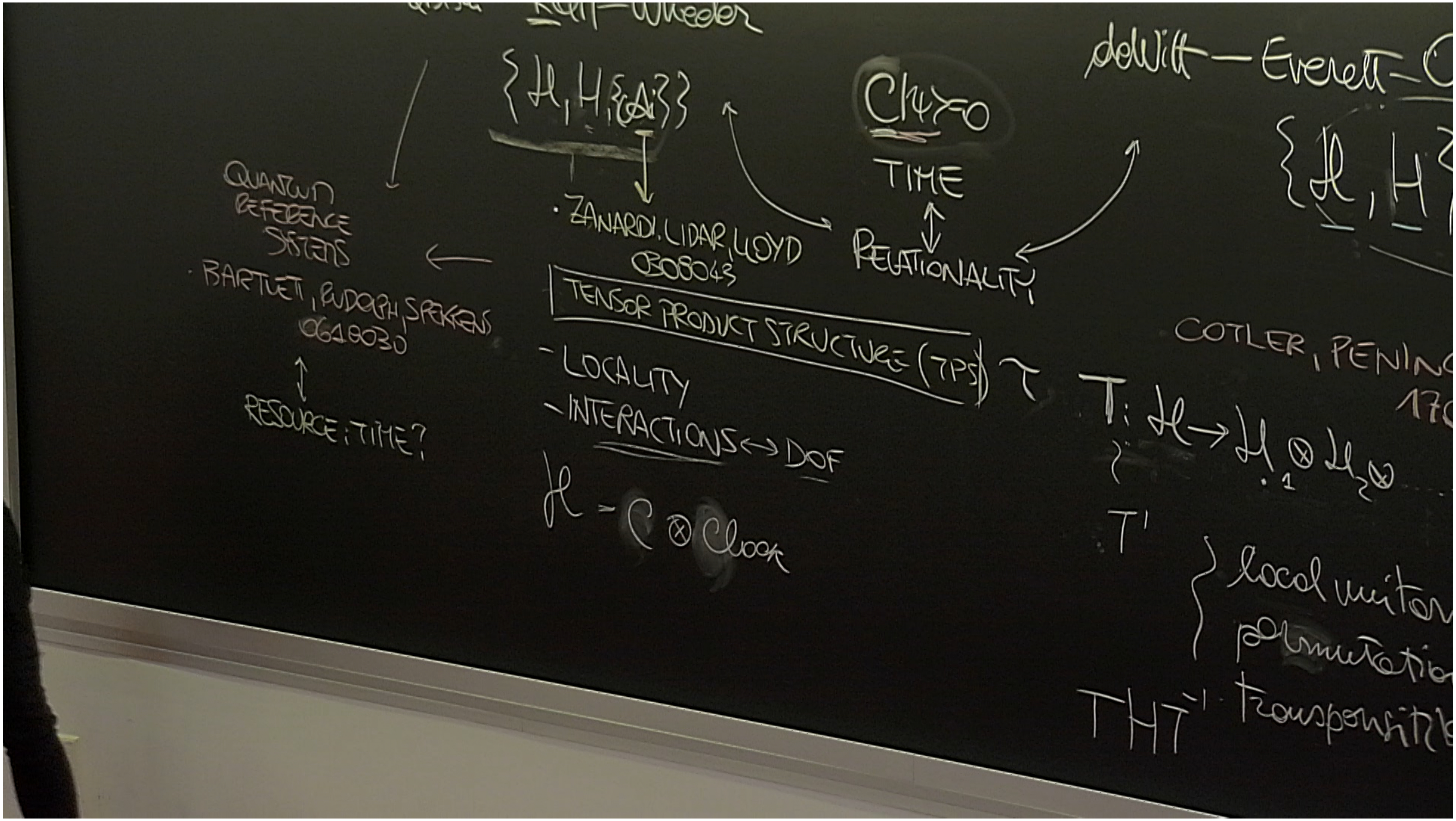
CARROLL, SINGH
1801.08132
TENSOR PRODUCT STRUCTURE (TPS) T
T: ℋ → ℋ_1 ⊗ ℋ_2 ⊗ = ⊗_i ℋ_i
NELSON, RIEDEL 1711.05719
LOCALITY
INTERACTIONS ↔ DOF
T'
local unitaries: U_1 ⊗ U_2 ⊗ ...
permutations
transposition


deWitt — Everett — Oxford — Pitts (Carroll)
TIME
RELATIONALITY
DAR, LLOYD
COTLER, PENINGTON, RANARD
1702.06142
CARROLL, SINGH
1801.08132
PRODUCT STRUCTURE (TPS)
NELSON, RIEDEL
local unitaries
permutations
transposition
DOF



deWitt — Everett
TIME
RELATIONALITY
QUANTUM REFERENCE SYSTEMS
BARTLETT, RUDOLPH, SPEKKENS
0610030
RESOURCE: TIME?
ZANARDI, LIDAR, LLOYD
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TENSOR PRODUCT STRUCTURE (TPS)
- LOCALITY
- INTERACTIONS ↔ DOF
Clock