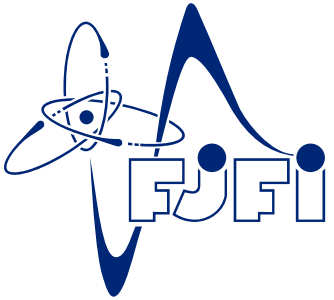
# Kuantum Sistemlerinde Klasik Olmayan Zamansal İlintiler

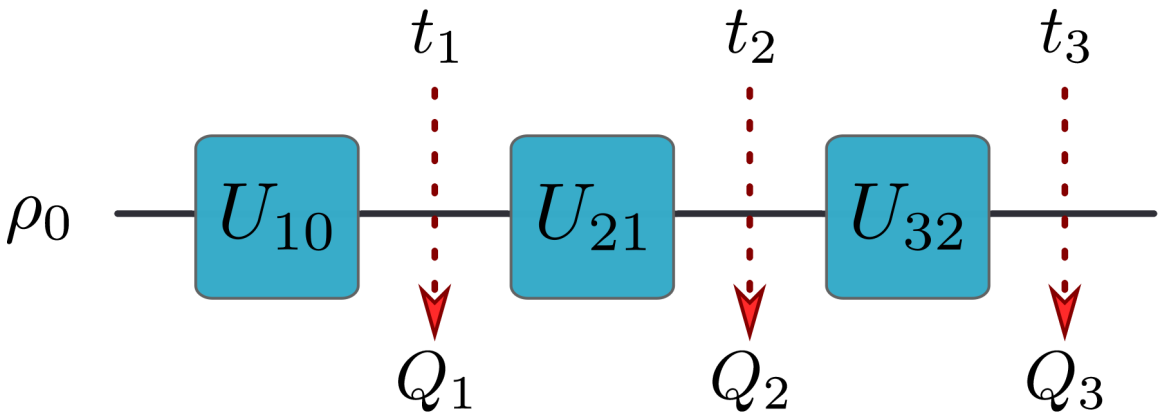
İskender Yalçınkaya

Prag Çek Teknik Üniversitesi, Nükleer Bilimler ve Fizik Mühendisliği Fakültesi




KOBİT 2
2-3 Şubat 2018
Mimar Sinan Güzel Sanatlar Üniversitesi

# Zamansal İlintiler




$$Q_i = \pm 1$$

$$C_{ij} = Q_i Q_j$$

$$f = Q_1 Q_2 + Q_2 Q_3 - Q_1 Q_3$$

$$K = \langle Q_1 Q_2 \rangle + \langle Q_2 Q_3 \rangle - \langle Q_1 Q_3 \rangle$$

$$-3 \leq K \leq 1$$ → Leggett-Garg eşitsizliği

# Zamansal İlintiler

## Makro gerçeklik (Macrorealism)

I. Önceden var olma

$$C_{12} \Leftrightarrow P_{12}(Q_3, Q_2, Q_1)$$
$$C_{23} \Leftrightarrow P_{23}(Q_3, Q_2, Q_1)$$
$$C_{13} \Leftrightarrow P_{13}(Q_3, Q_2, Q_1)$$

II. Ölçüm pasif yapılabilir.

$$\begin{aligned} & P_{12}(Q_3, Q_2, Q_1) \\ = & P_{23}(Q_3, Q_2, Q_1) \\ = & P_{13}(Q_3, Q_2, Q_1) \\ = & P(Q_3, Q_2, Q_1) \end{aligned}$$

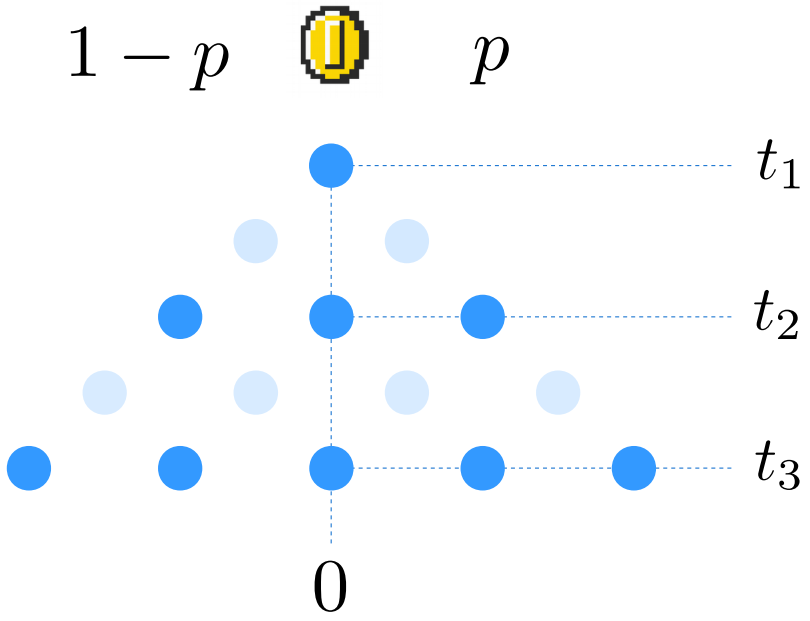
| $Q_1$ | $Q_2$ | $Q_3$ |
|---|---|---|
| + | + | + |
| + | + | - |
| ⋮ | ⋮ | ⋮ |
| - | - | - |

$$K = \langle Q_1 Q_2 \rangle + \langle Q_2 Q_3 \rangle - \overbrace{\langle (Q_1 Q_2)(Q_2 Q_3) \rangle}^{C'_{13}}$$

$C_{ij} = Q_i Q_j$ ➡ Ayrı deneyler

İhlal ⇔ $C'_{13} \neq C_{13}$

# Rastgele yürüyüş




$Q_i$ : Merkezde mi?

Evet $+1$

Hayır $-1$

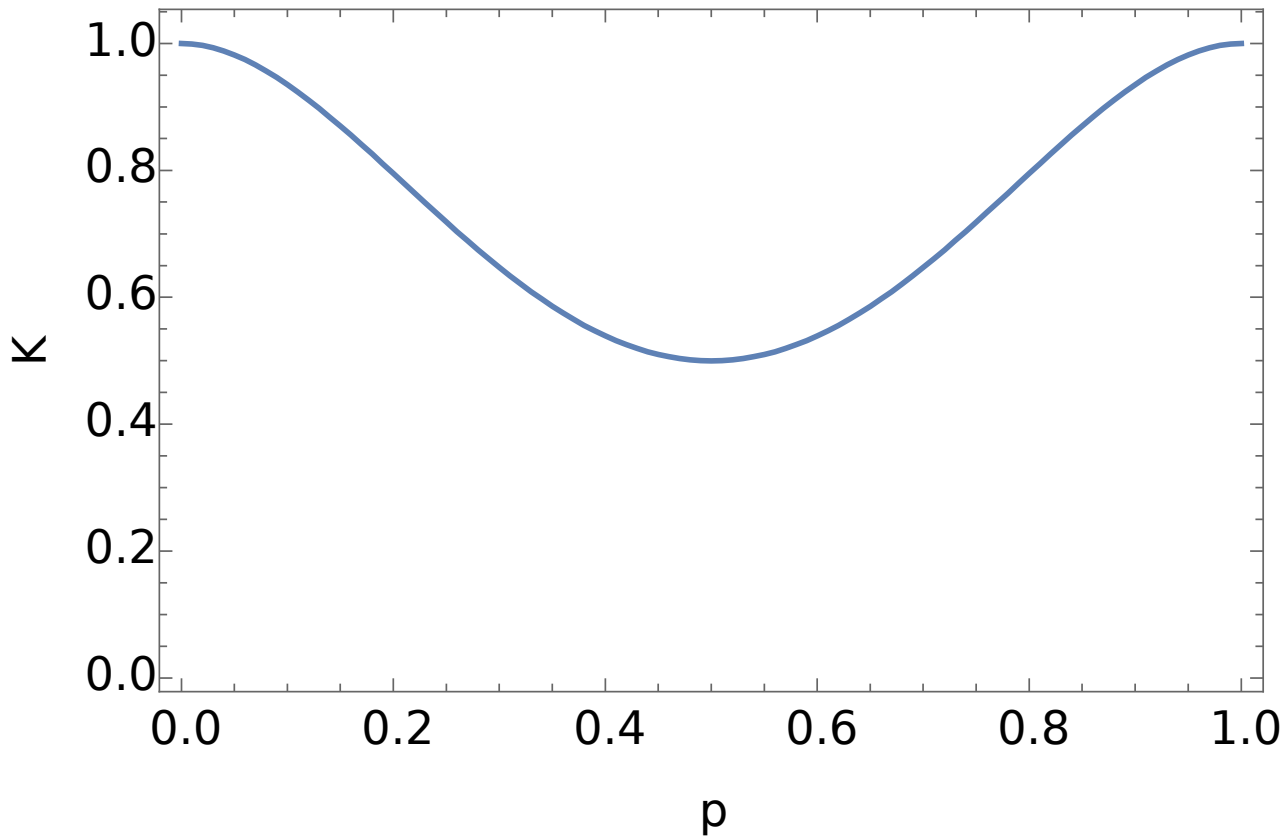
$$Q_1 \equiv +1$$

$$K = \langle Q_2 \rangle + \langle Q_2 Q_3 \rangle - \langle Q_3 \rangle$$

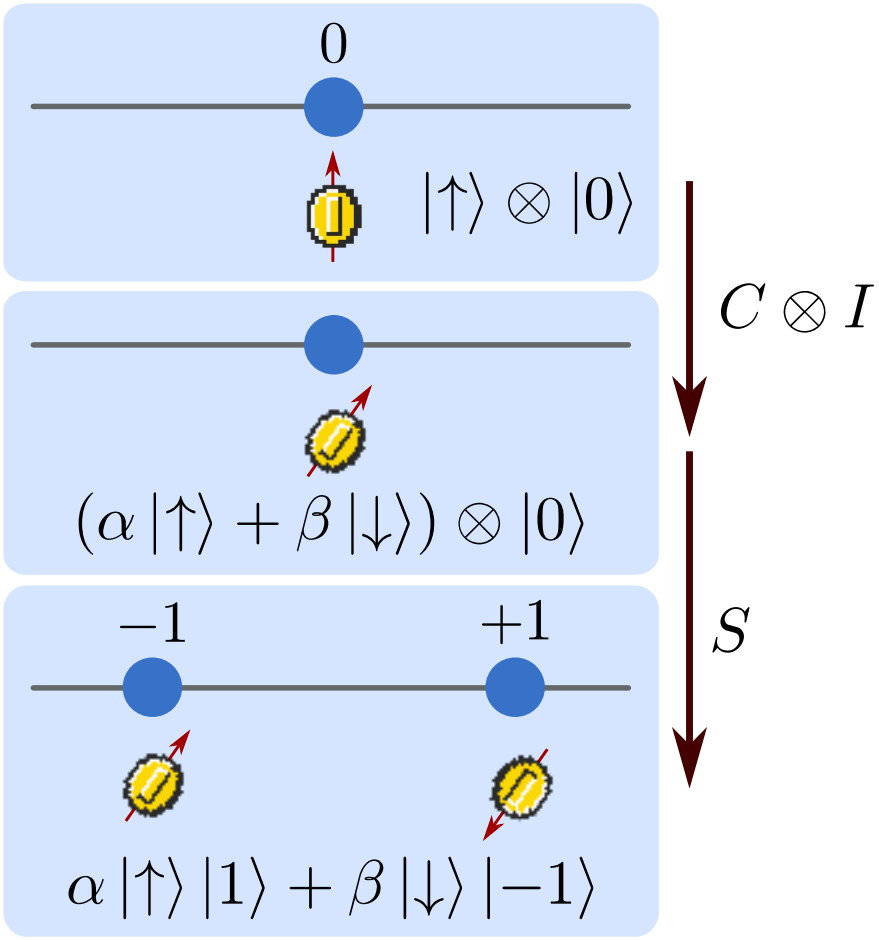
$$K = \sum_{Q_2} Q_2 P(Q_2) + \sum_{Q_2,Q_3} Q_2 Q_3 P(Q_2,Q_3) - \sum_{Q_3} Q_3 P(Q_3)$$

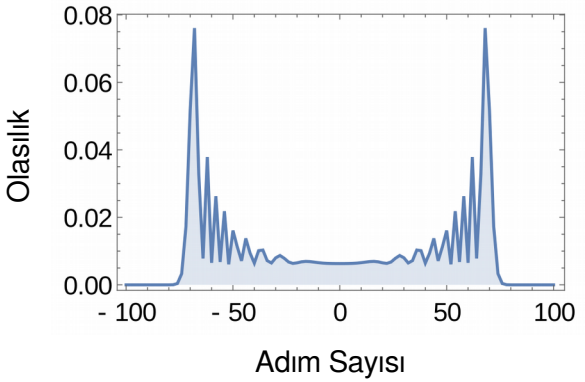
$Q_3$ $P(Q_2,Q_3)$ $Q_2$ $P(Q_2,Q_3)$

# Rastgele yürüyüş



# Kuantum yürüyüşü

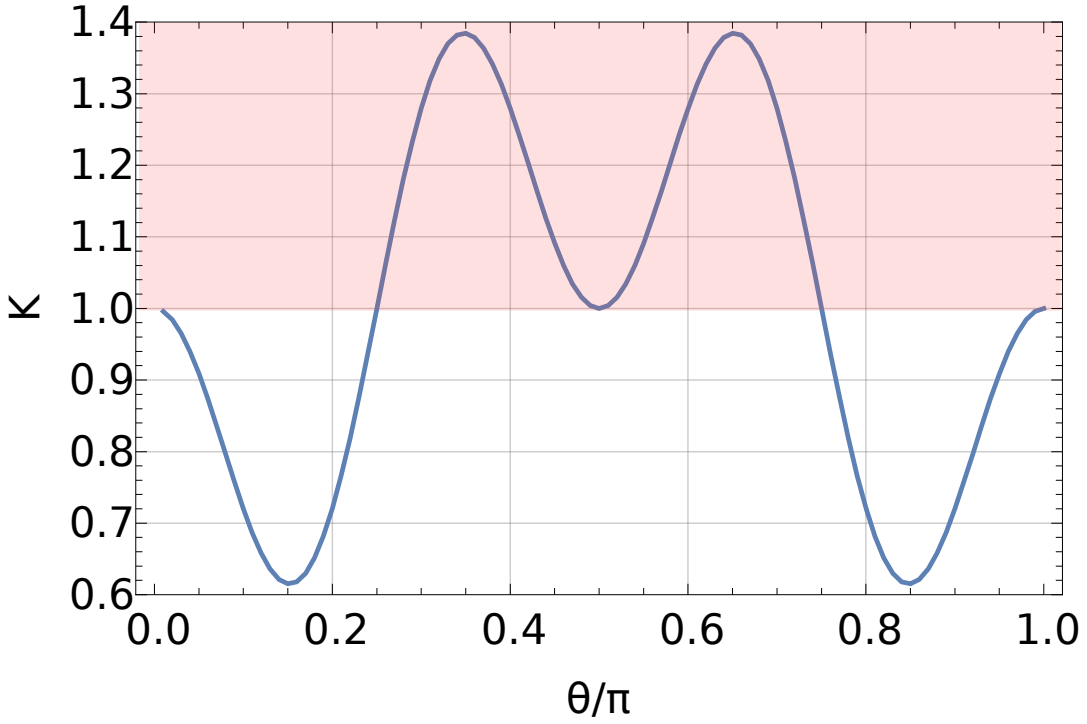


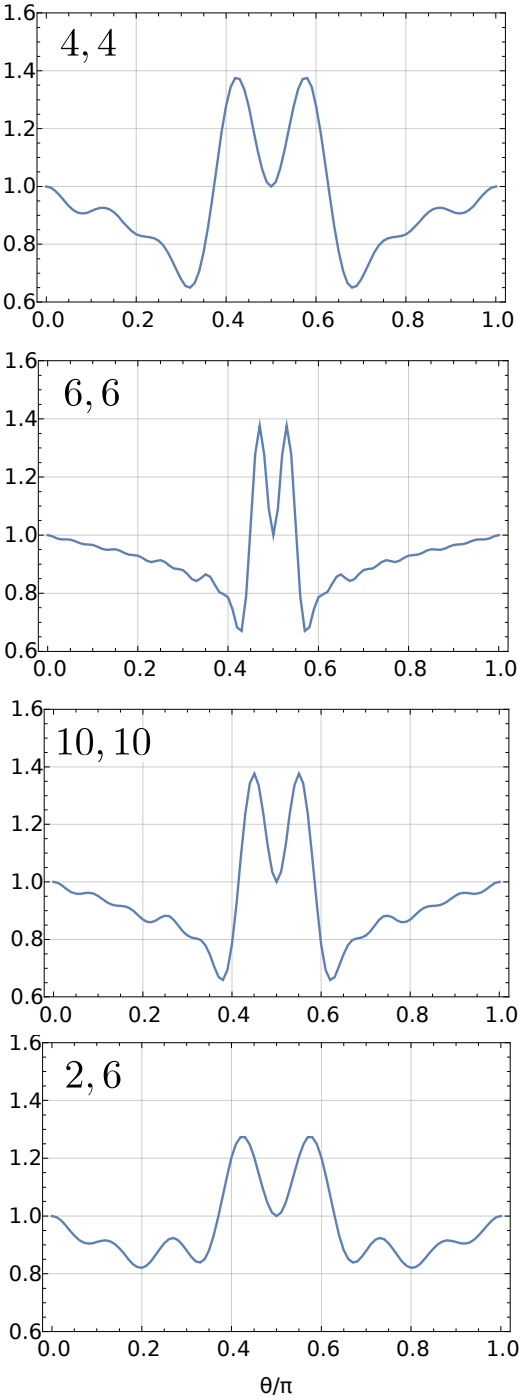




$$C = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$$

$$S |\uparrow, n\rangle = |0, n+1\rangle$$
$$S |\downarrow, n\rangle = |0, n-1\rangle$$

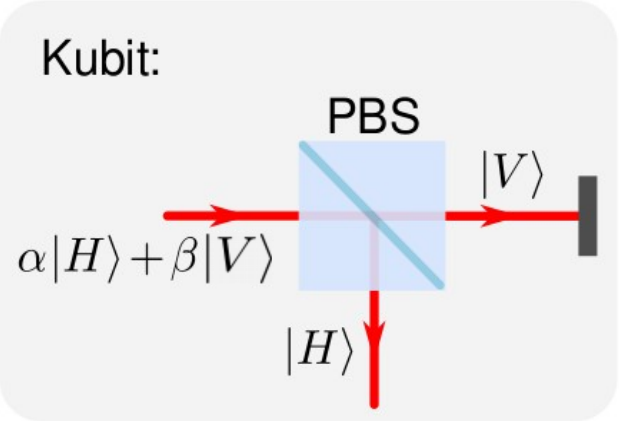
# Kuantum yürüyüşü

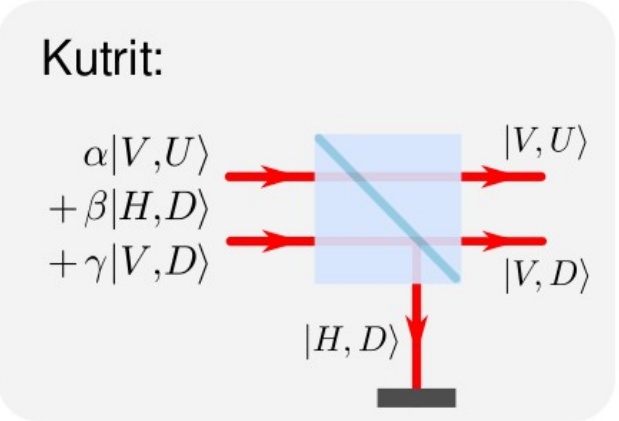


# İdeal Negatif Ölçümler

Fotonik bir sistemde:

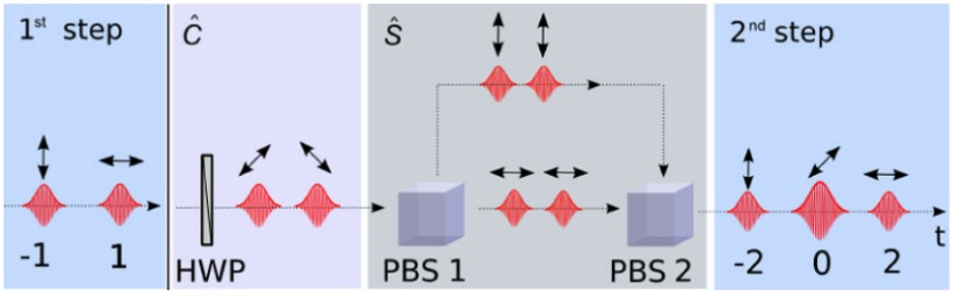


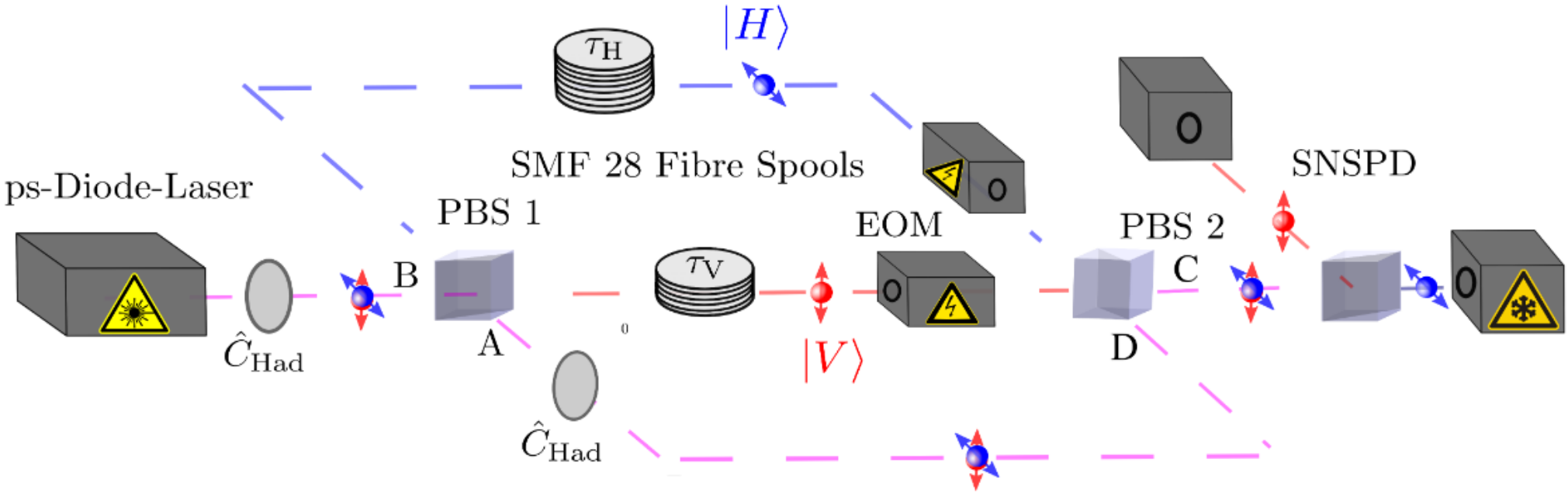

$$\Pi_2 = \mathbb{I} - |V\rangle\langle V|$$

$$\Pi_3 = \mathbb{I} - |H,D\rangle\langle H,D|$$

# Deney




A. Schreiber ve arkadaşları, Phys. Rev. Lett. 104, 050502 (2010).




T. Nitche ve arkadaşları, 2017 Conference on Lasers and Electro-Optics (CLEO), San Jose, CA, 2017, pp. 1-2.

EOM:

$$\hat{\pi} = \left(\hat{I}_P - |N\rangle\langle N|\right) \otimes \hat{I}_C$$

# Problemler

**1 -** Adil seçme açığı (Fair-sampling loophole)

LETTER

doi:10.1038/nature12012

## Bell violation using entangled photons without the fair–sampling assumption

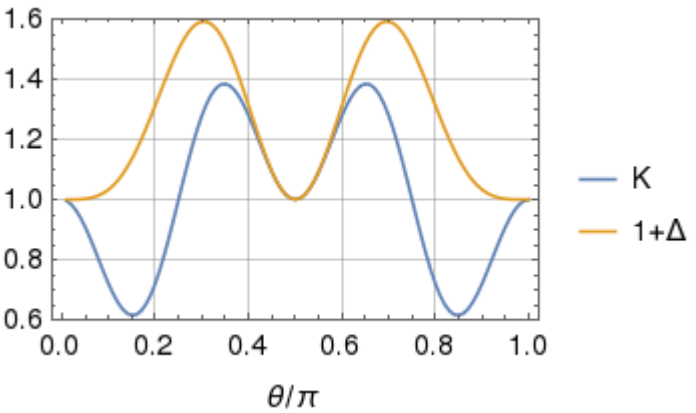
Marissa Giustina[1,2]*, Alexandra Mech[1,2]*, Sven Ramelow[1,2]*, Bernhard Wittmann[1,2]*, Johannes Kofler[1,3], Jörn Beyer[4], Adriana Lita[5], Brice Calkins[5], Thomas Gerrits[5], Sae Woo Nam[5], Rupert Ursin[1] & Anton Zeilinger[1,2]

**2 -** Ölçümler arası "işaretleşme" (No-signalling-in-time) açığı

$$\delta(n_3) = P(n_3) - \sum_{n_2} P(n_3,n_2)$$

$$\Rightarrow K \leq 1 + \Delta$$

Sözde olasılıklar (Quasi-probabilities)



# Teşekkürler