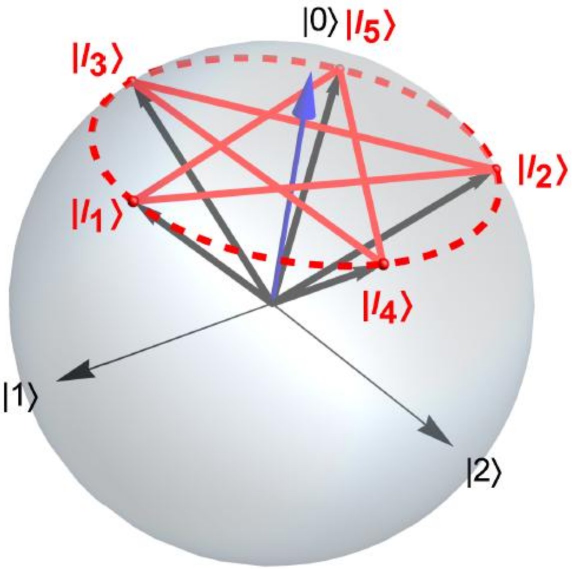
18 Mart 2016 KOBİT-0



KCBS Eşitsizliği

Zafer Gedik

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2007

PRL **101,** 020403 (2008) PHYSICAL REVIEW LETTERS week ending 11 JULY 2008

Simple Test for Hidden Variables in Spin-1 Systems

Alexander A. Klyachko,* M. Ali Can,† Sinem Binicioğlu, and Alexander S. Shumovsky
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(Received 1 June 2007; published 11 July 2008)

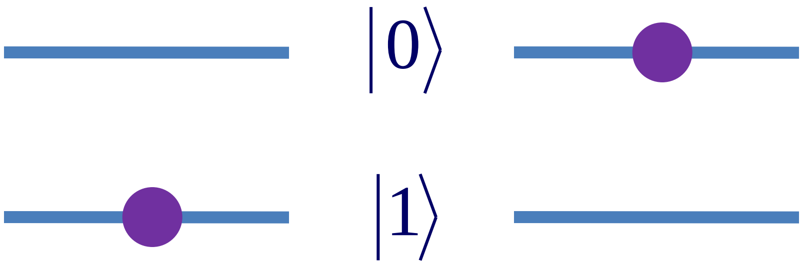
We resolve an old problem about the existence of hidden parameters in a three-dimensional quantum system by constructing an appropriate Bell's type inequality. This reveals the nonclassical nature of most spin-1 states. We shortly discuss some physical implications and an underlying cause of this nonclassical behavior, as well as a perspective of its experimental verification.

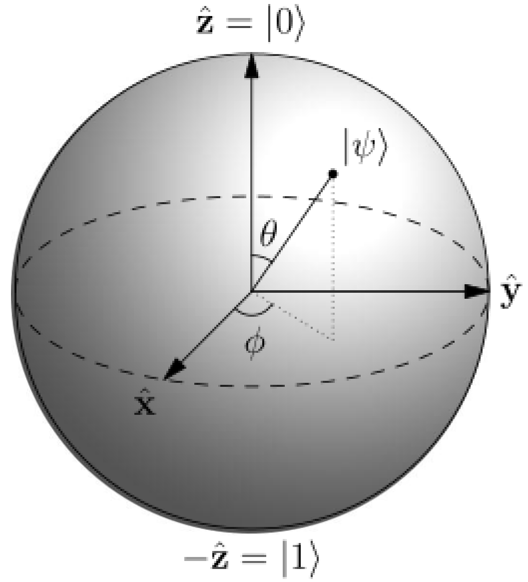
DOI: 10.1103/PhysRevLett.101.020403 PACS numbers: 03.65.Ud, 03.65.Ta

Physical Review Letters **101**, 020403 (2008)

kubit

$$|\psi\rangle = \cos\frac{\theta}{2}|0\rangle + e^{i\phi}\sin\frac{\theta}{2}|1\rangle$$





Bloch küresi

$$|\psi\rangle = |\hat{n}\rangle$$

gözlenebilirler

$$A = a_0 + \vec{a} \cdot \vec{\sigma}$$

özdeğerler

$$v(A) = a_0 \pm a$$

ortalama değer

$$\langle \hat{n} | A | \hat{n} \rangle = a_0 + \vec{a} \cdot \hat{n}$$

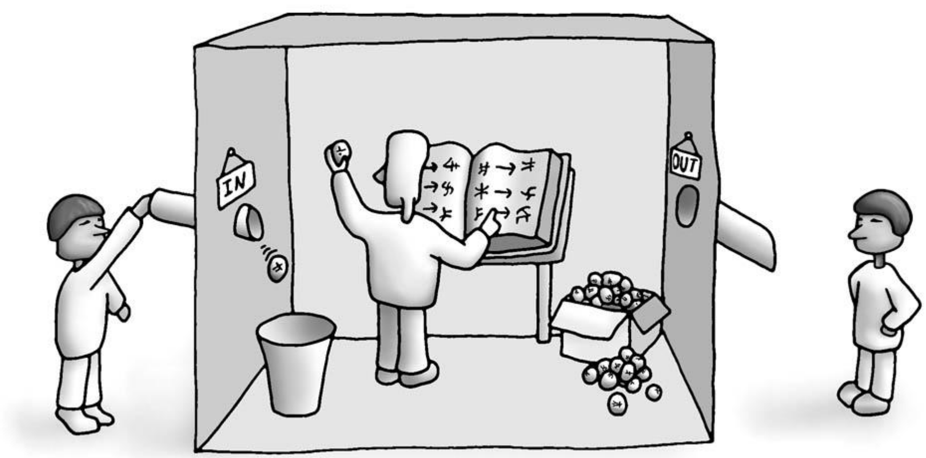
bir gizli değişken modeli

$$v_{\hat{n}}(A) = a_0 + a, \quad (\hat{m}+\hat{n})\cdot\vec{a} > 0 \;\; ise$$

$$v_{\hat{n}}(A) = a_0 - a, \quad (\hat{m}+\hat{n})\cdot\vec{a} < 0 \;\; ise$$

$$\int \frac{d\Omega_{\hat{m}}}{4\pi} v_{\hat{n}}(A) = a_0 + \vec{a}\cdot\hat{n}$$

Bell, Mermin



Çin odası tartışması

jolyon.co.uk

uyumlu gözlenebilirler

$$[A, B] = 0$$

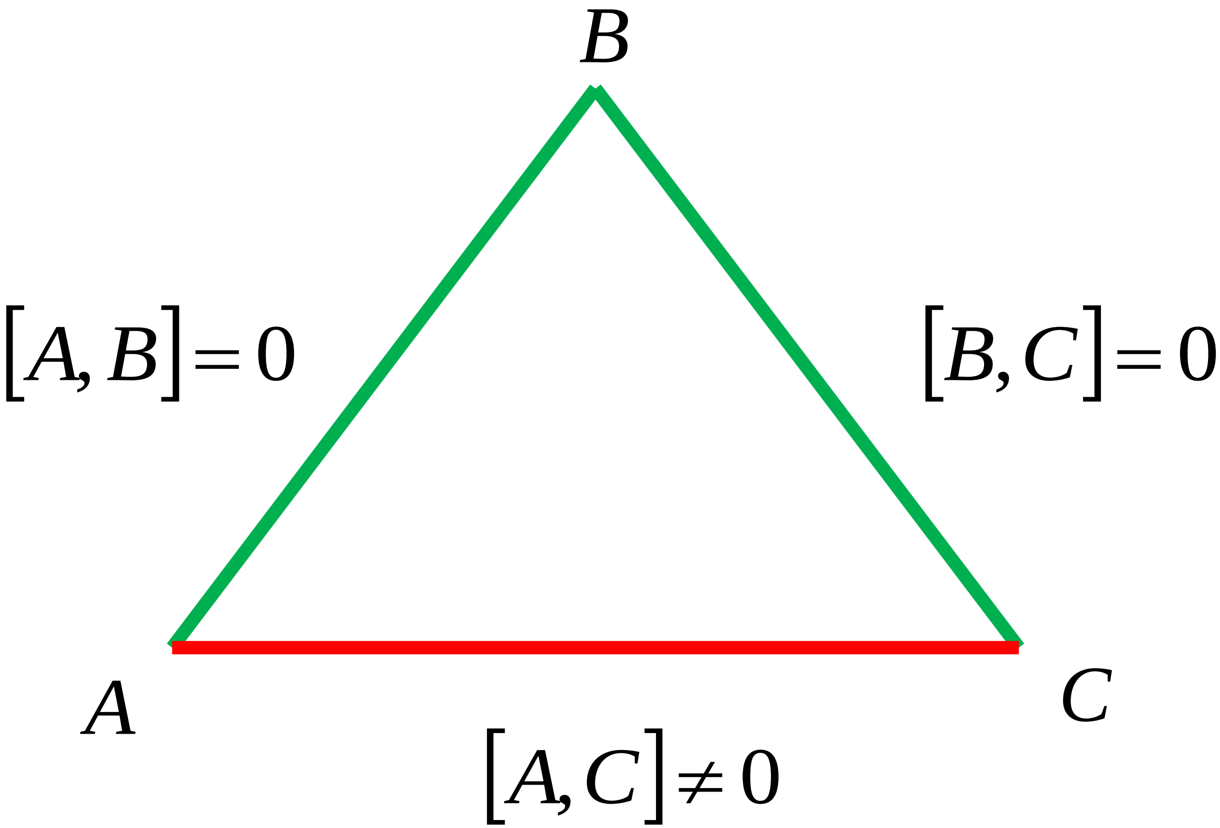
kubit

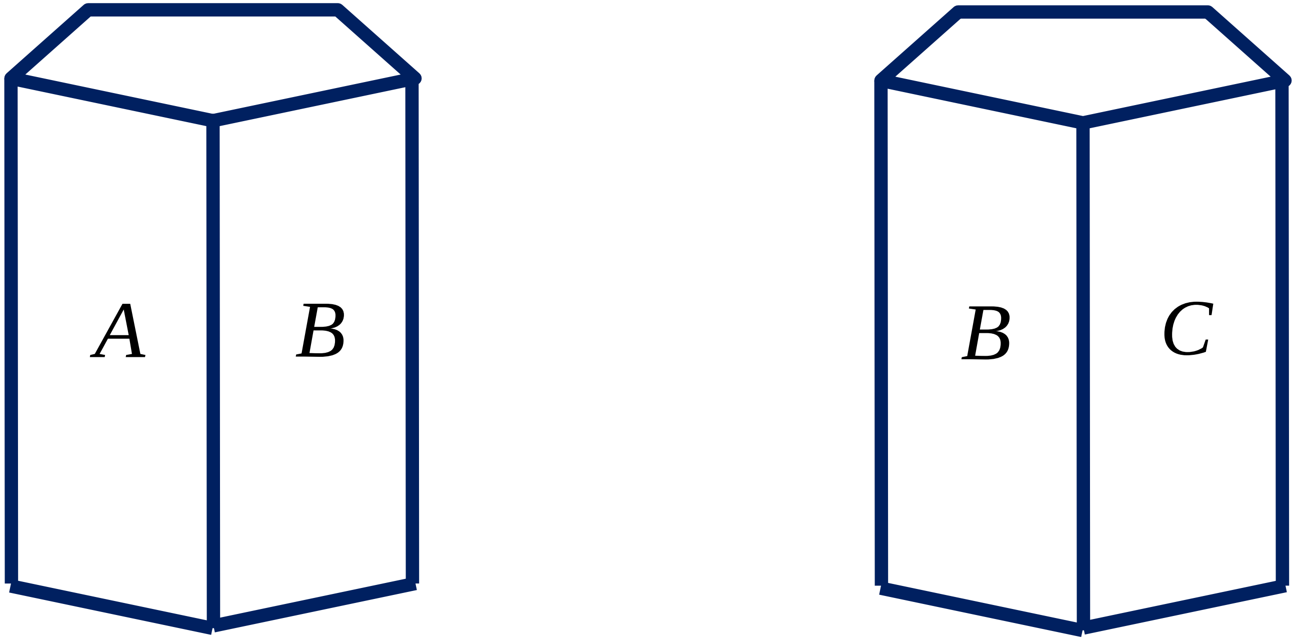
$$A = a_0 + \vec{a} \cdot \vec{\sigma}$$

$$B = b_0 + \vec{b} \cdot \vec{\sigma}$$

$$[A, B] = 0 \Leftrightarrow \vec{a} = \lambda \vec{b}$$

bağlamsallık





$$A, B, C, D, E = \pm 1$$

$$AB + BC + CD + DE + EA \geq -3$$

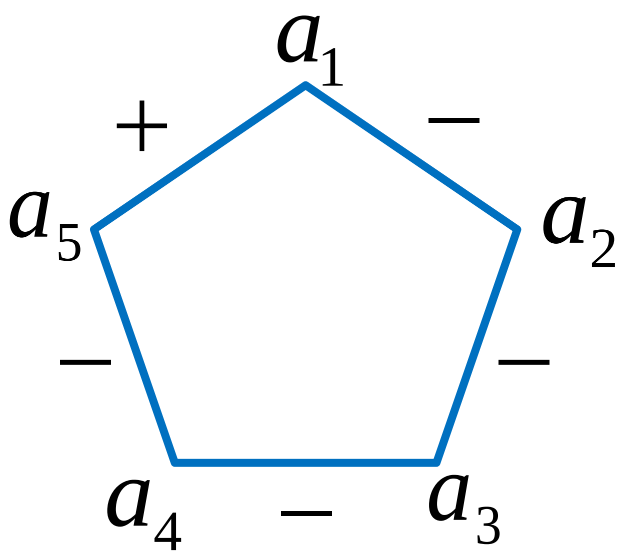
a_1

a_5 a_2

± 1

a_4 a_3

$$S \equiv a_1a_2 + a_2a_3 + a_3a_4 + a_4a_5 + a_5a_1$$



$$S \geq -3$$

Kliyaçko-Can-Binicioğlu-Şumovski

$$S = \langle A_1 A_2 \rangle + \langle A_2 A_3 \rangle + \langle A_3 A_4 \rangle + \langle A_4 A_5 \rangle + \langle A_5 A_1 \rangle$$

$$\downarrow$$

$$5 - 4\sqrt{5}$$

PRL **101,** 020403 (2008) PHYSICAL REVIEW LETTERS week ending 11 JULY 2008

Simple Test for Hidden Variables in Spin-1 Systems

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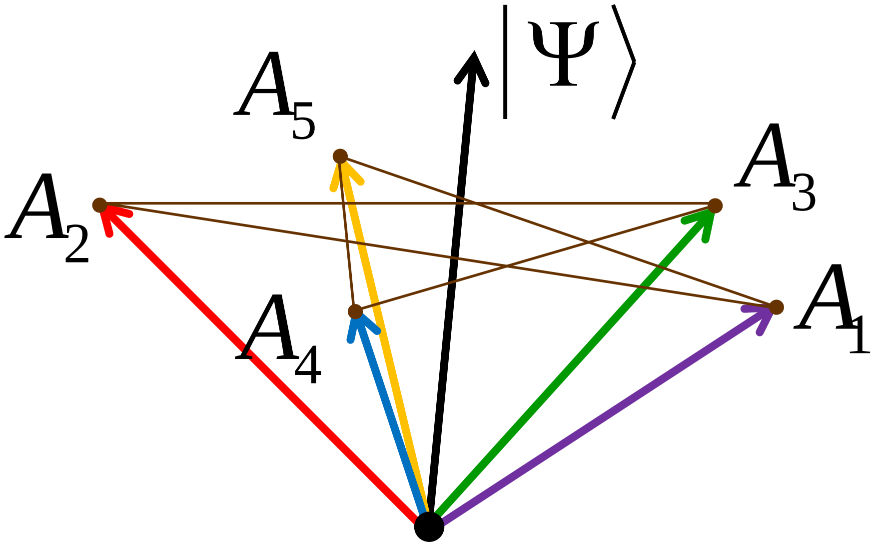
$$S = \langle A_1 A_2 \rangle + \langle A_2 A_3 \rangle + \langle A_3 A_4 \rangle + \langle A_4 A_5 \rangle + \langle A_5 A_1 \rangle$$

$$\downarrow$$

$$5 - 4\sqrt{5} \approx -3.94$$



$$A_i = 2S_i^{\,2} - I$$

spin-1

$$\langle \psi | = \left(\frac{354}{527}, \frac{357}{527}, -\frac{158}{527} \right)$$

$$A_i = 2|v_i\rangle\langle v_i| - I$$

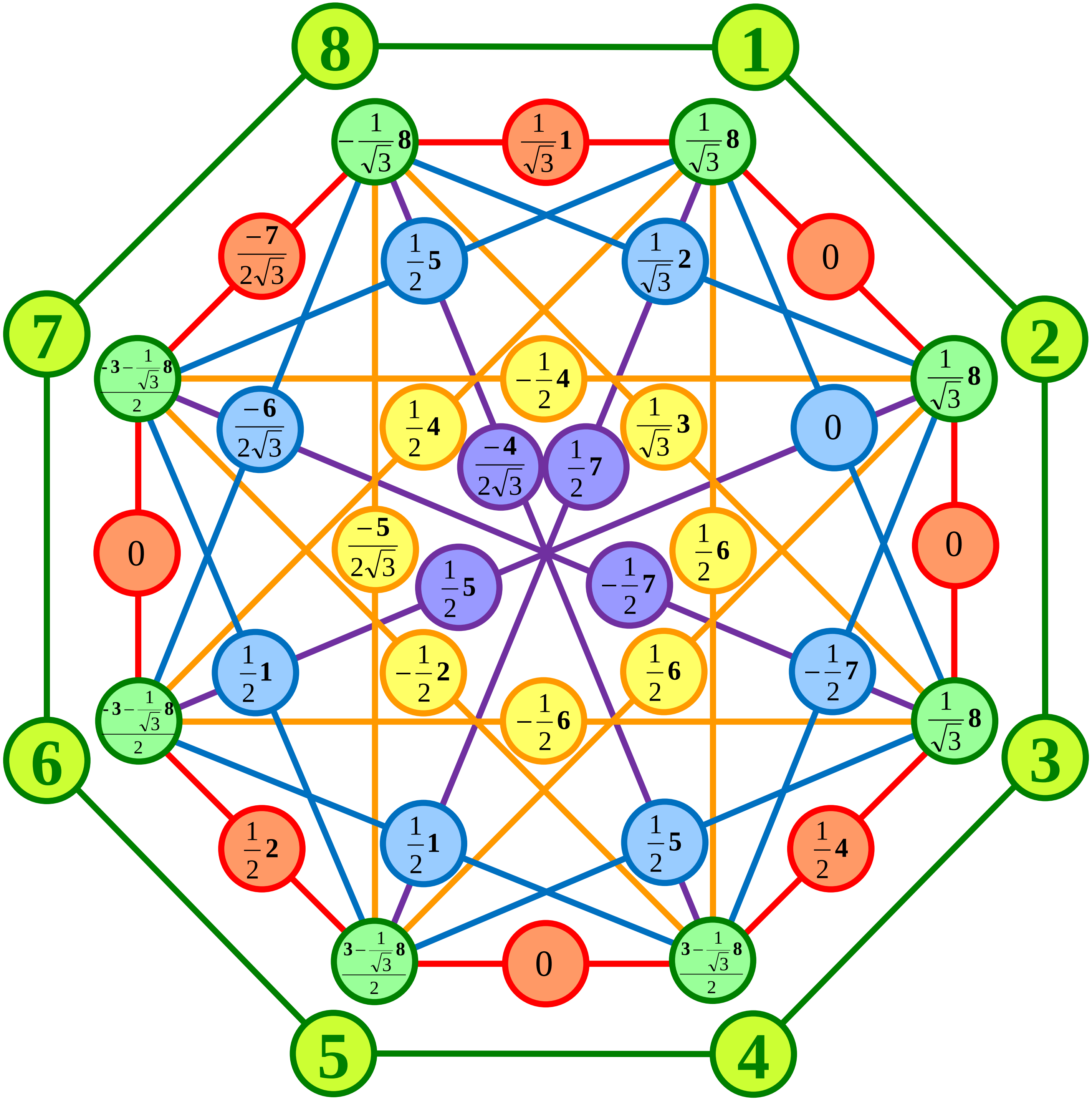
$$\langle v_1 | = (1,0,0)$$

$$\langle v_2 | = (0,1,0)$$

$$\langle v_3 | = \left(\frac{48}{73}, 0, -\frac{55}{73} \right) \quad \Longrightarrow \quad S = -3.941$$

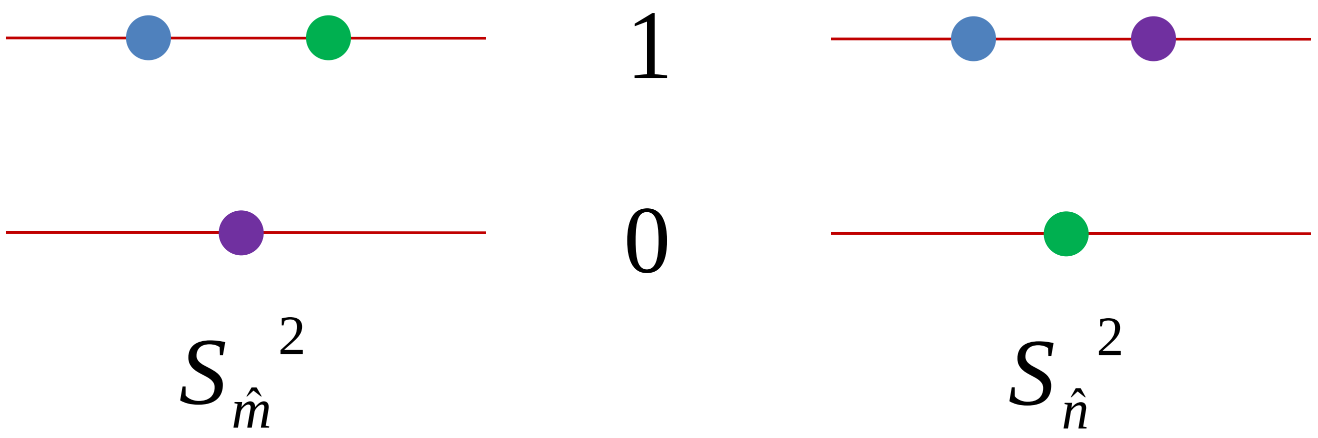
$$\langle v_4 | = \left(\frac{1925}{3277}, \frac{2052}{3277}, \frac{1680}{3277} \right)$$

$$\langle v_5 | = \left(0, \frac{140}{221}, -\frac{171}{221} \right)$$



8
1
$-\frac{1}{\sqrt{3}}$8
$\frac{1}{\sqrt{3}}$1
$\frac{1}{\sqrt{3}}$8
$\frac{-7}{2\sqrt{3}}$
$\frac{1}{2}$5
$\frac{1}{\sqrt{3}}$2
0
7
2
$\frac{-3-\frac{1}{\sqrt{3}}8}{2}$
$-\frac{1}{2}$4
$\frac{1}{\sqrt{3}}$8
$\frac{-6}{2\sqrt{3}}$
$\frac{1}{2}$4
$\frac{1}{\sqrt{3}}$3
0
$\frac{-4}{2\sqrt{3}}$
$\frac{1}{2}$7
0
$\frac{-5}{2\sqrt{3}}$
$\frac{1}{2}$6
0
$\frac{1}{2}$5
$-\frac{1}{2}$7
$\frac{1}{2}$1
$-\frac{1}{2}$2
$\frac{1}{2}$6
$-\frac{1}{2}$7
$\frac{-3-\frac{1}{\sqrt{3}}8}{2}$
$-\frac{1}{2}$6
$\frac{1}{\sqrt{3}}$8
6
3
$\frac{1}{2}$2
$\frac{1}{2}$1
$\frac{1}{2}$5
$\frac{1}{2}$4
$\frac{3-\frac{1}{\sqrt{3}}8}{2}$
0
$\frac{3-\frac{1}{\sqrt{3}}8}{2}$
5
4

$$A_i = 2S_i^{\,2} - I$$

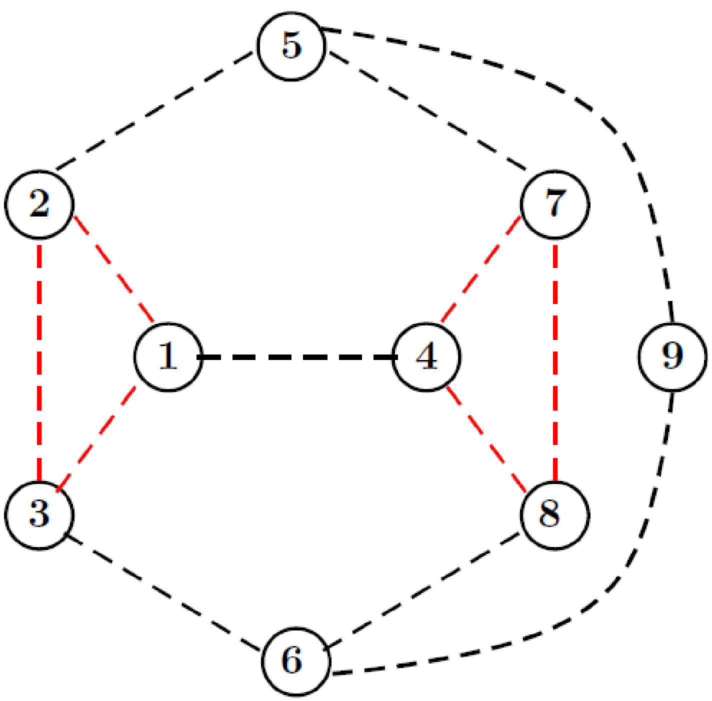


$$\hat{m} \perp \hat{n}$$

Experimental demonstration of quantum contextuality on an NMR qutrit

Shruti Dogra,* Kavita Dorai,† and Arvind‡
Department of Physical Sciences, Indian Institute of Science Education & Research (IISER) Mohali, Sector 81 SAS Nagar, Manauli PO 140306 Punjab India.

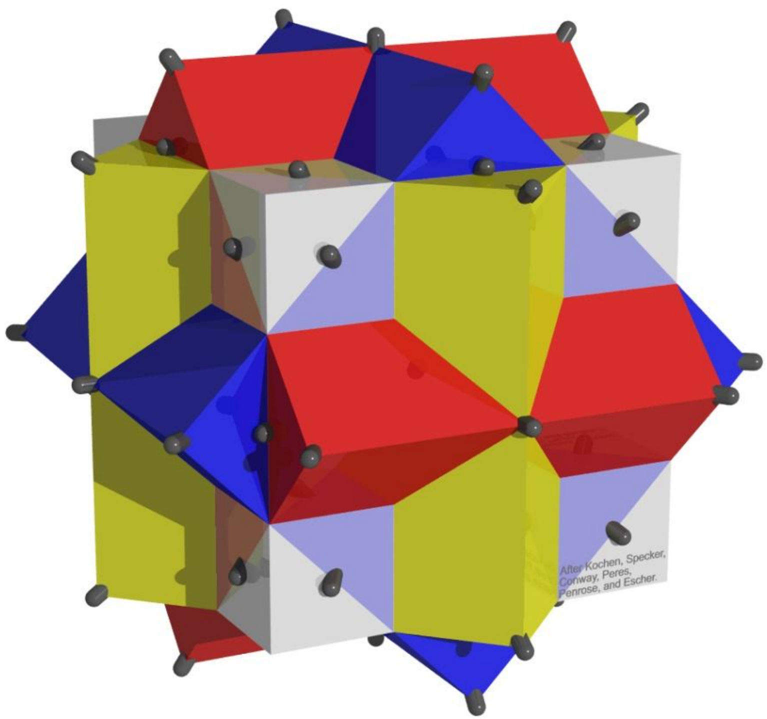
STATE-INDEPENDENT TEST WITH NINE OBSERVABLES



$$\sum_{i,j\in E(G)} \langle A_i A_j \rangle + \langle A_9 \rangle \geq -4$$

Kochen-Specker Teoremi

önceden belirlenemezlik



a

b ± 1 b'

a'

$$S \equiv ab + ab' + a'b - a'b'$$

$$= (a + a')\ b + (a - a')\ b'$$

$a = a'$ → $2ab$

$a \neq a'$ → $2ab'$

$$|S| \leq 2$$

Bell-Clauser-Horne-Shimony-Holt

Kuantum

$$S = \langle AB \rangle + \langle AB' \rangle + \langle A'B \rangle - \langle A'B' \rangle$$

$$\downarrow$$

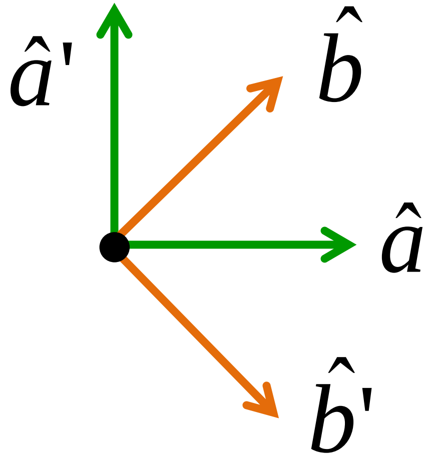
$$2\sqrt{2}$$

Bell-Clauser-Horne-Shimony-Holt

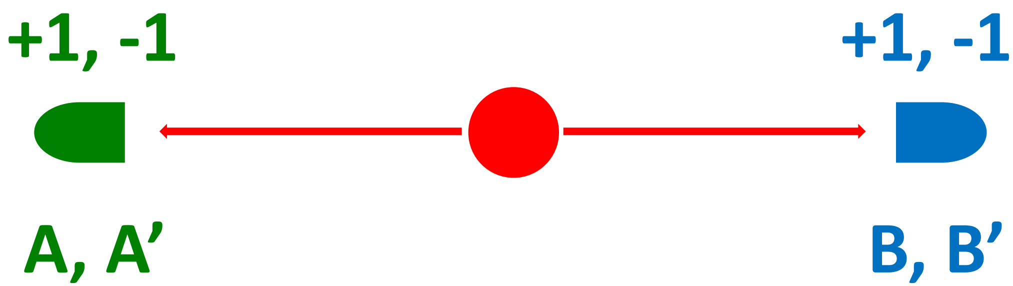
Kuantum

$$\left|\Psi\right\rangle = \frac{\left|\uparrow\downarrow\right\rangle - \left|\downarrow\uparrow\right\rangle}{\sqrt{2}}$$

$$A = \vec{\sigma}\cdot\hat{a},\quad A' = \vec{\sigma}\cdot\hat{a}',\quad B = \vec{\sigma}\cdot\hat{b},\quad B' = \vec{\sigma}\cdot\hat{b}'$$



Bell-Clauser-Horne-Shimony-Holt



$$E_{AB} = P_{AB}(=) - P_{AB}(\neq) = \langle AB \rangle$$

$$S = E_{AB} + E_{AB'} + E_{A'B} - E_{A'B'}$$

$$|S| \leq 2$$

Yerel Gerçeklik

nature COMMUNICATIONS

ARTICLE

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OPEN

Satisfying the Einstein–Podolsky–Rosen criterion with massive particles

J. Peise[1], I. Kruse[1], K. Lange[1], B. Lücke[1], L. Pezzè[2,3,4], J. Arlt[5], W. Ertmer[1], K. Hammerer[6], L. Santos[4], A. Smerzi[2,3,4] & C. Klempt[1]

In 1935, Einstein, Podolsky and Rosen (EPR) questioned the completeness of quantum mechanics by devising a quantum state of two massive particles with maximally correlated space and momentum coordinates. The EPR criterion qualifies such continuous-variable entangled states, where a measurement of one subsystem seemingly allows for a prediction of the second subsystem beyond the Heisenberg uncertainty relation. Up to now, continuous-variable EPR correlations have only been created with photons, while the demonstration of such strongly correlated states with massive particles is still outstanding. Here we report on the creation of an EPR-correlated two-mode squeezed state in an ultracold atomic ensemble. The state shows an EPR entanglement parameter of 0.18(3), which is 2.4 s.d. below the threshold 1/4 of the EPR criterion. We also present a full tomographic reconstruction of the underlying many-particle quantum state. The state presents a resource for tests of quantum nonlocality and a wide variety of applications in the field of continuous-variable quantum information and metrology.

arXiv: 1602.00440 [quant-ph]

Contextuality without nonlocality in a superconducting quantum system

Markus Jerger,[1] Yarema Reshitnyk,[2] Markus Oppliger,[3] Anton Potočnik,[3] Mintu Mondal,[3] Andreas Wallraff,[3] Kenneth Goodenough,[4] Stephanie Wehner,[4] Kristinn Juliusson,[5] Nathan K. Langford,[4,6] and Arkady Fedorov[1,2,*]

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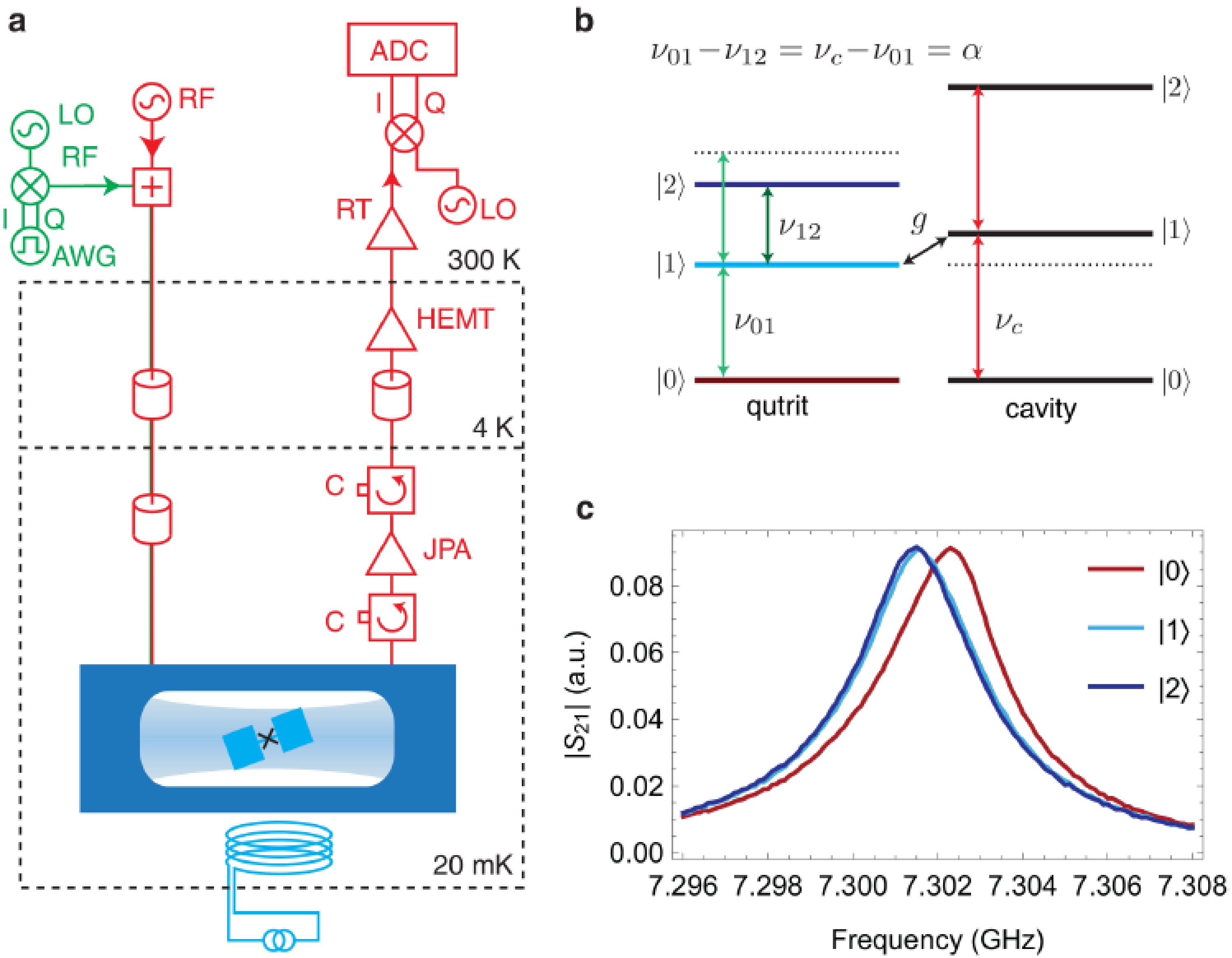
[5] *Quantronics, SPEC, IRAMIS, DSM, CEA Saclay, Gif-sur-Yvette, France*

[6] *Kavli Institute of Nanoscience, Delft University of Technology, P.O. Box 5046, 2600 GA Delft, Netherlands*



a
ADC
I
Q
RF
LO
RF
I
Q
AWG
RT
LO
300 K
HEMT
4 K
C
JPA
C
20 mK
b
$\nu_{01} - \nu_{12} = \nu_c - \nu_{01} = \alpha$
$|2\rangle$
$|1\rangle$
$|0\rangle$
ν_{12}
ν_{01}
g
ν_c
qutrit
cavity
c
$|S_{21}|$ (a.u.)
0.00
0.02
0.04
0.06
0.08
7.296
7.298
7.300
7.302
7.304
7.306
7.308
Frequency (GHz)

ARTICLE

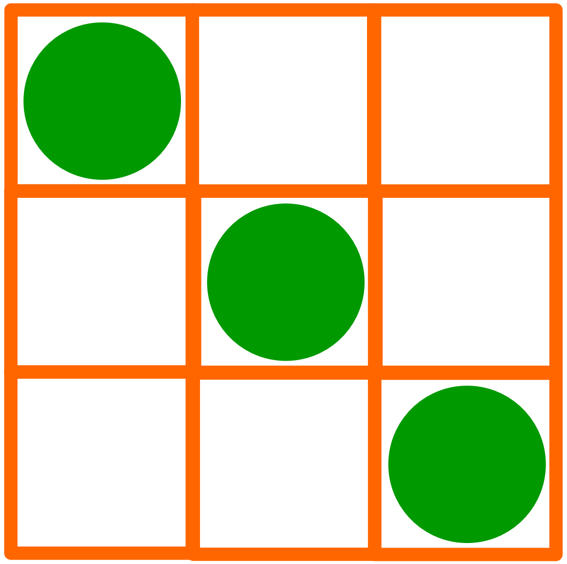
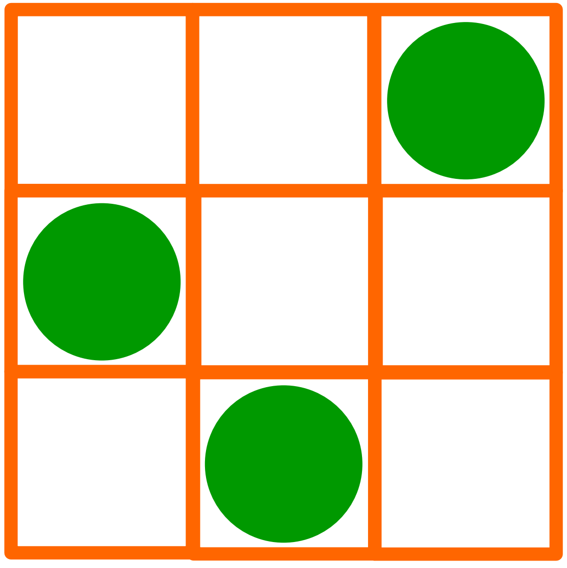
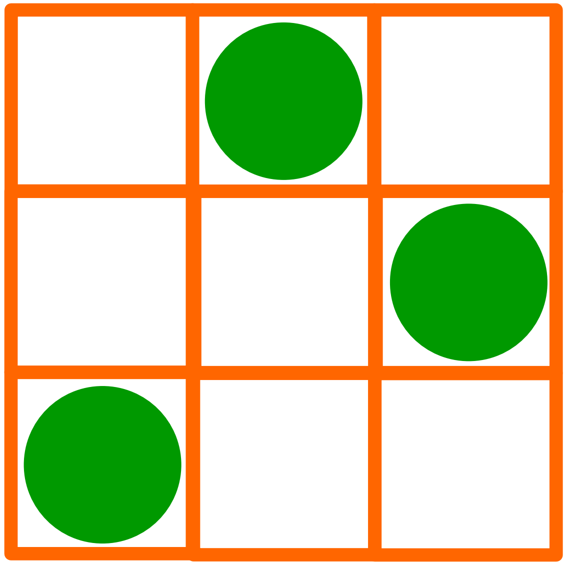
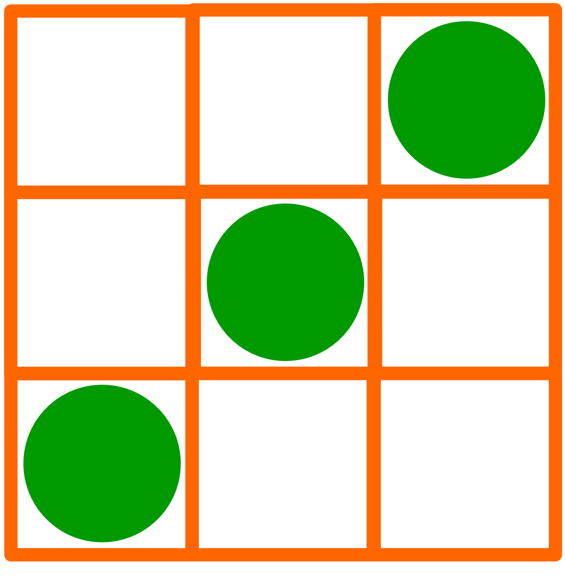
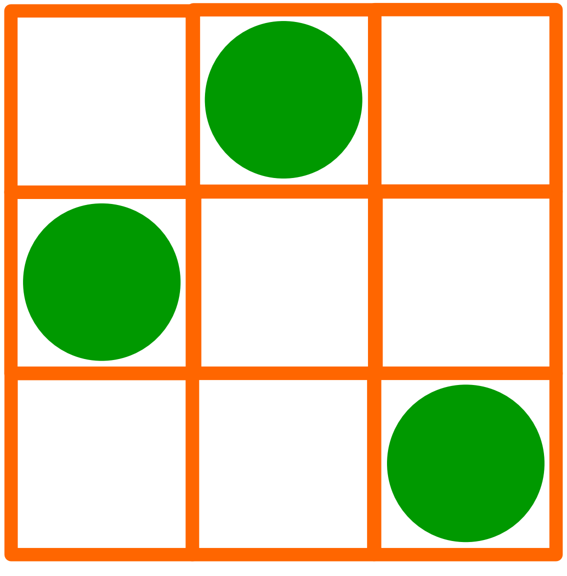
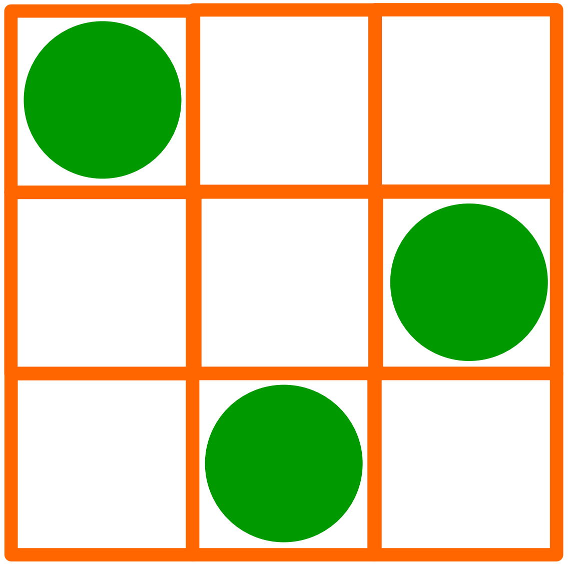
doi:10.1038/nature13460

Contextuality supplies the 'magic' for quantum computation

Mark Howard[1,2], Joel Wallman[2], Victor Veitch[2,3] & Joseph Emerson[2]

Quantum computers promise dramatic advantages over their classical counterparts, but the source of the power in quantum computing has remained elusive. Here we prove a remarkable equivalence between the onset of contextuality and the possibility of universal quantum computation via 'magic state' distillation, which is the leading model for experimentally realizing a fault-tolerant quantum computer. This is a conceptually satisfying link, because contextuality, which precludes a simple 'hidden variable' model of quantum mechanics, provides one of the fundamental characterizations of uniquely quantum phenomena. Furthermore, this connection suggests a unifying paradigm for the resources of quantum information: the non-locality of quantum theory is a particular kind of contextuality, and non-locality is already known to be a critical resource for achieving advantages with quantum communication. In addition to clarifying these fundamental issues, this work advances the resource framework for quantum computation, which has a number of practical applications, such as characterizing the efficiency and trade-offs between distinct theoretical and experimental schemes for achieving robust quantum computation, and putting bounds on the overhead cost for the classical simulation of quantum algorithms.

BİR ALGORİTMA

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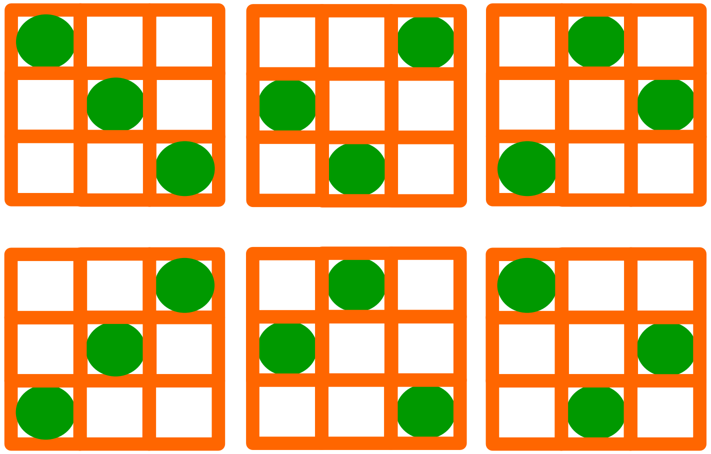

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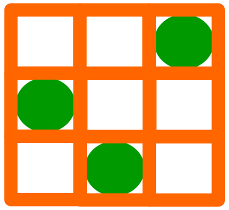
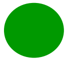
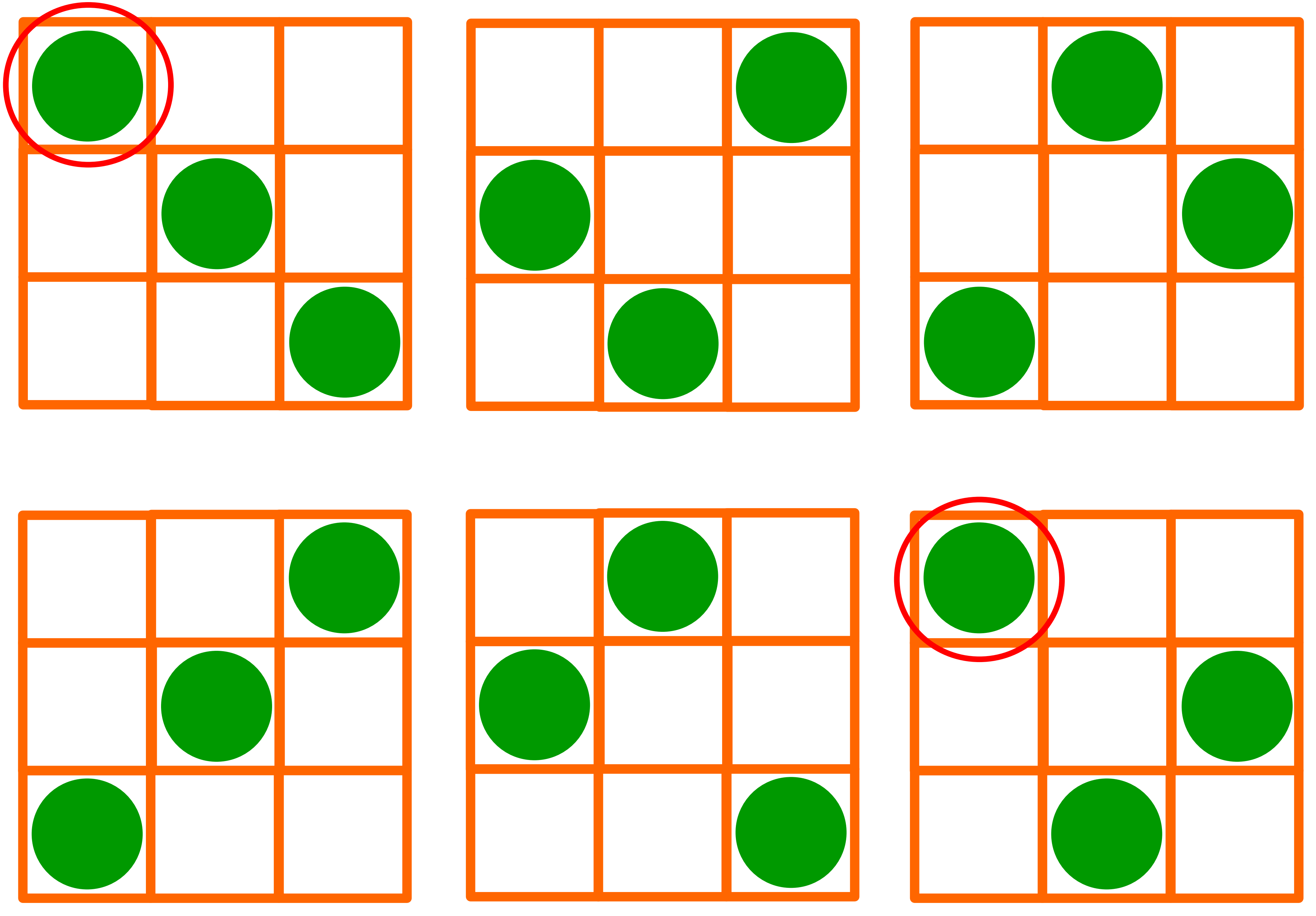


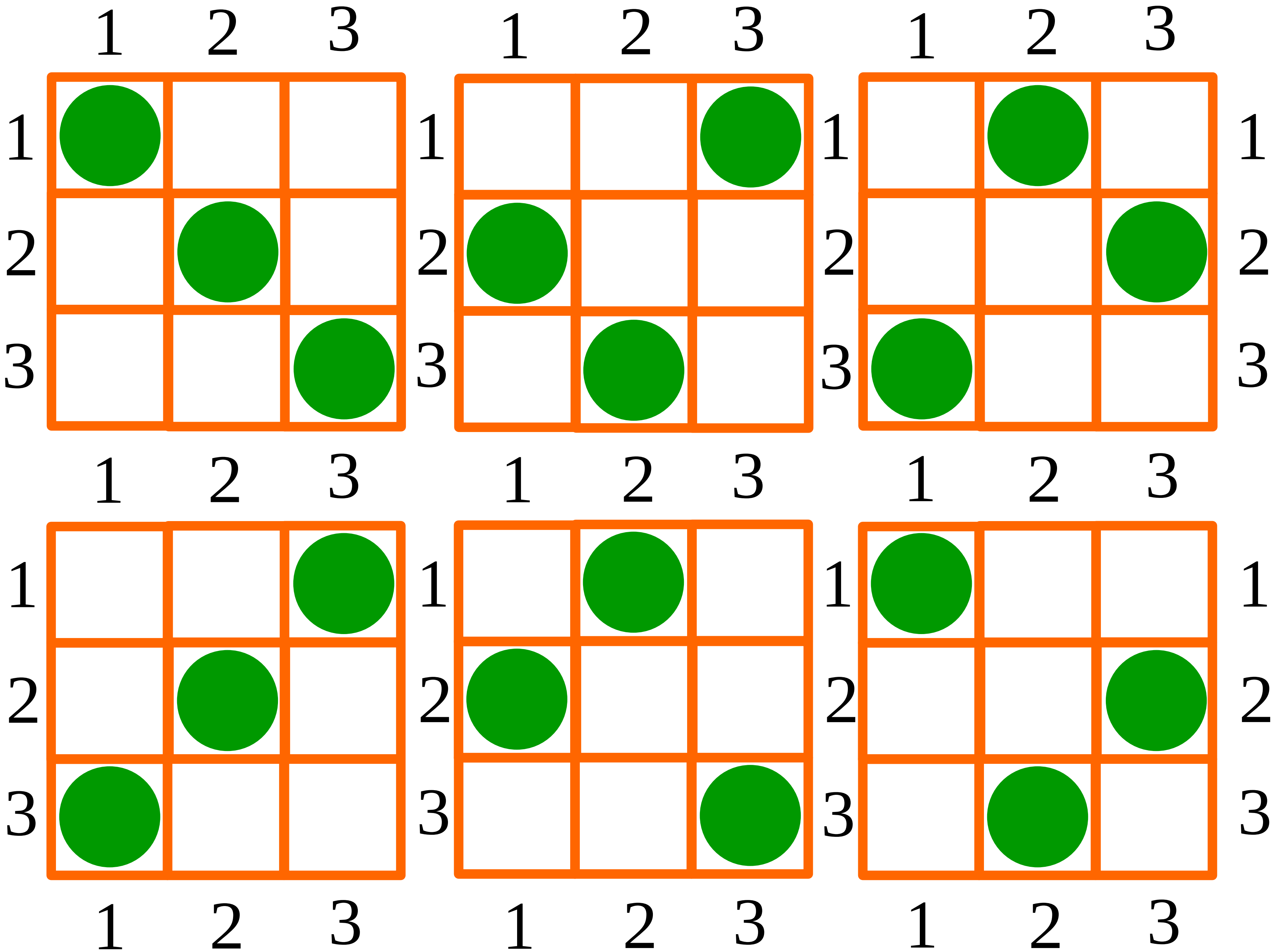
‘nin

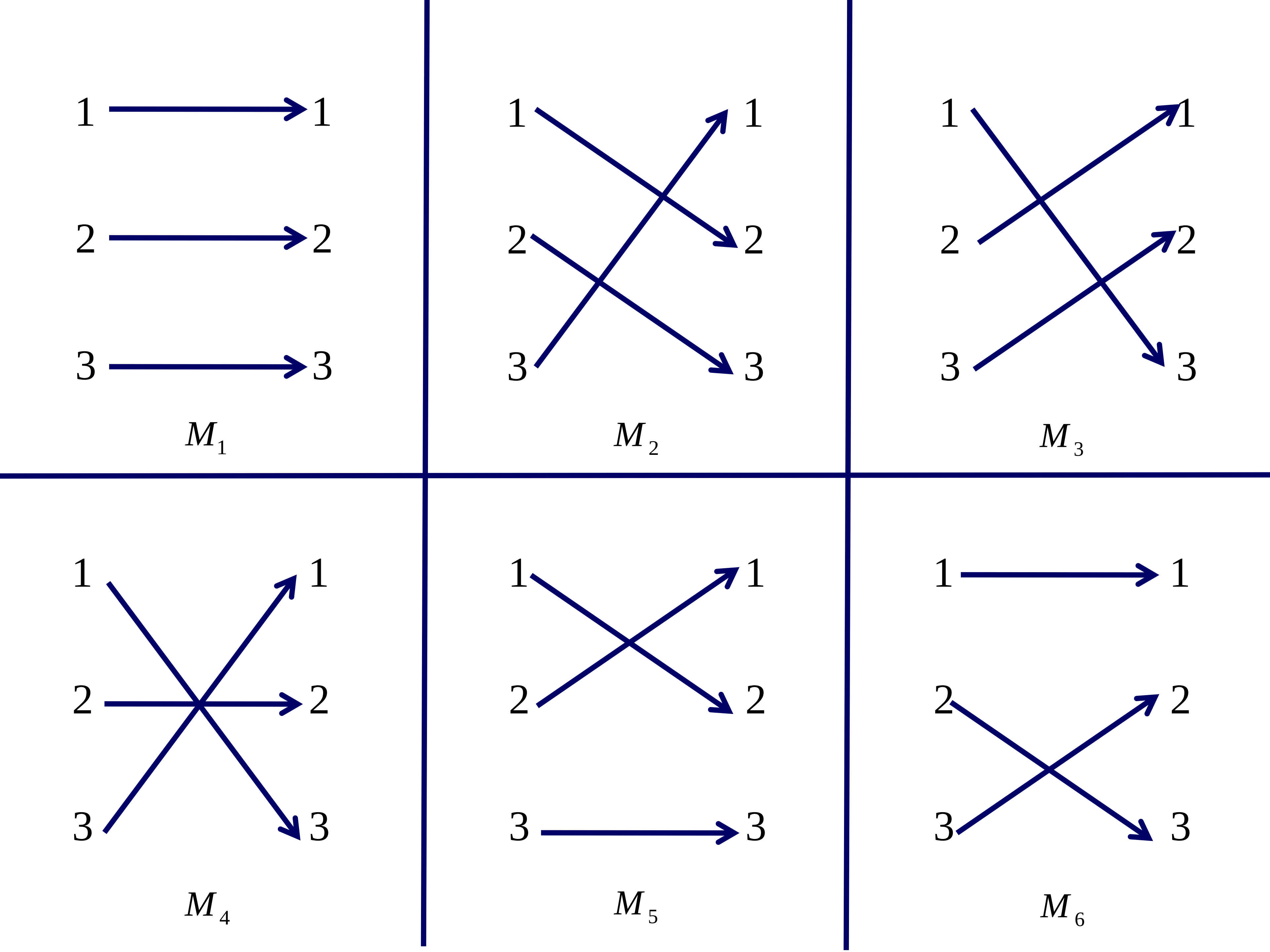
ilk satırda mı yoksa ikinci satırda mı olduğunu belirlemek.

klasik çözüm

iki  ‘un yerini bilmek gerekli




1 2 3
1 2 3
1 2 3


1 2 3
1 2 3
M_1
M_2
M_3
M_4
M_5
M_6

$$1 \rightarrow \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$$

$$2 \rightarrow \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$$

$$3 \rightarrow \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

kuantum trit

kütrit

$$M_1 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$M_2 = \begin{pmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix}$$

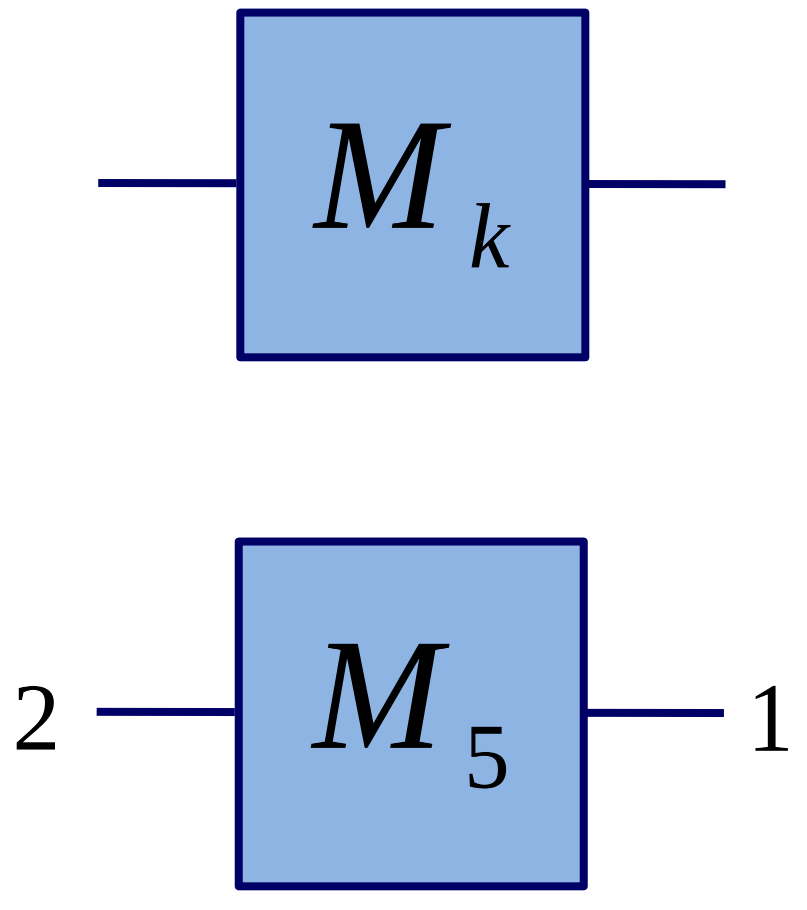
$$M_3 = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix}$$

$$M_4 = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{pmatrix}$$

$$M_5 = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$M_6 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

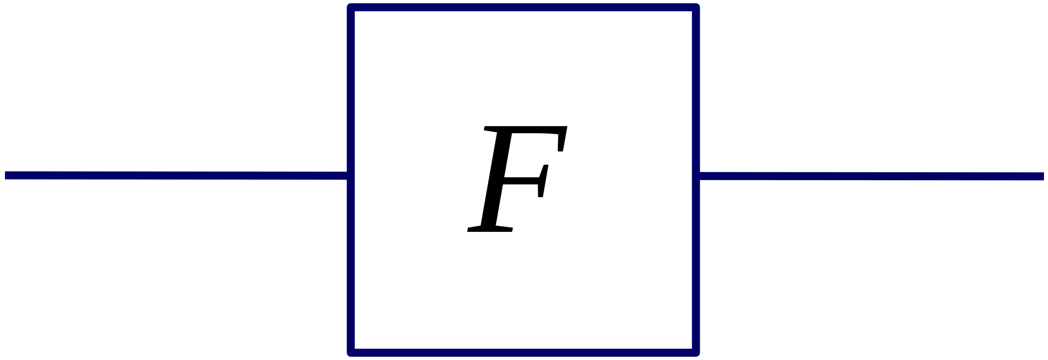
devre şeması



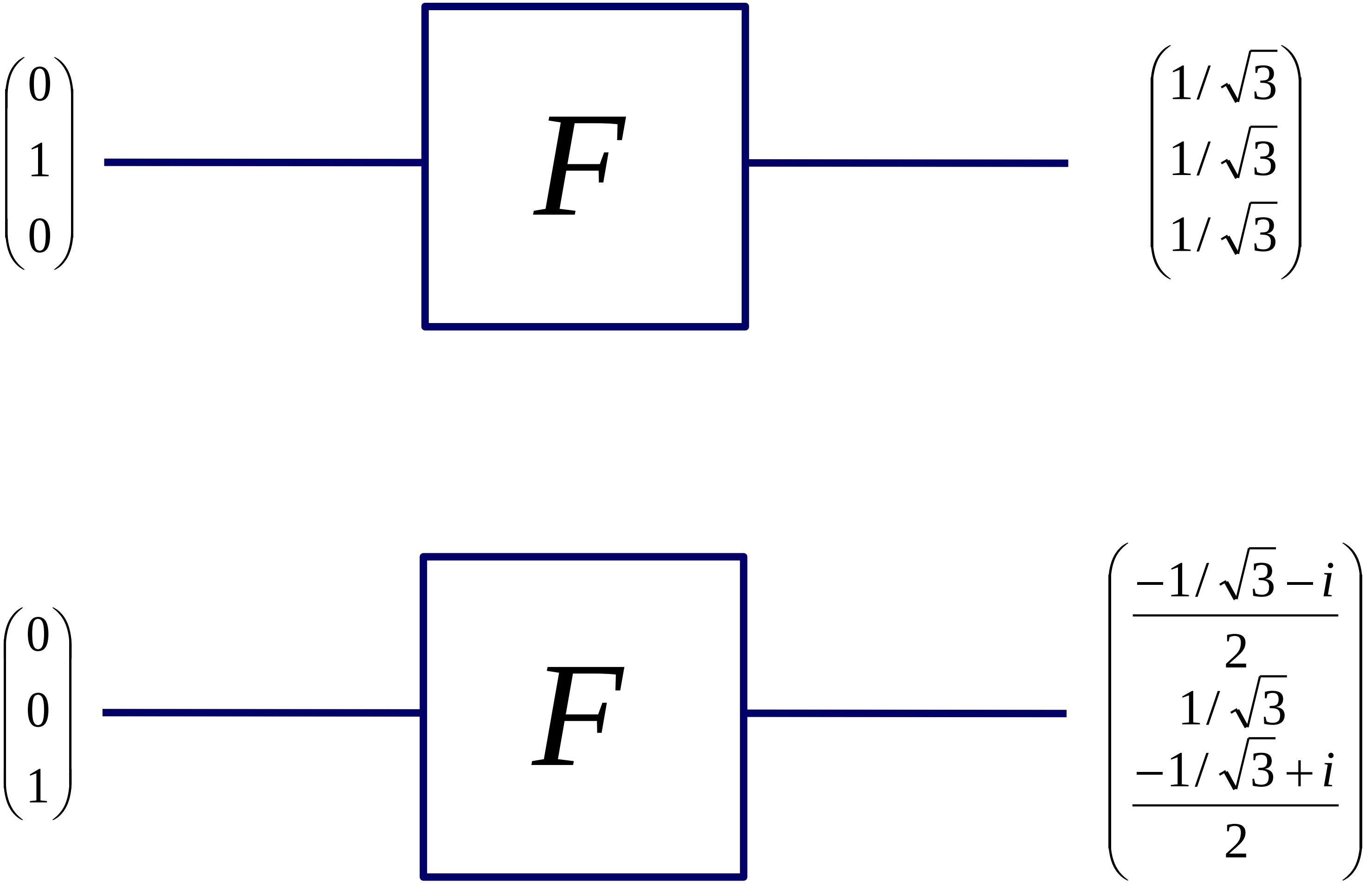
sihirli dönüşüm

$$F = \begin{pmatrix} \frac{-1/\sqrt{3}+i}{2} & 1/\sqrt{3} & \frac{-1/\sqrt{3}-i}{2} \\ 1/\sqrt{3} & 1/\sqrt{3} & 1/\sqrt{3} \\ \frac{-1/\sqrt{3}-i}{2} & 1/\sqrt{3} & \frac{-1/\sqrt{3}+i}{2} \end{pmatrix}$$

$$\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$$

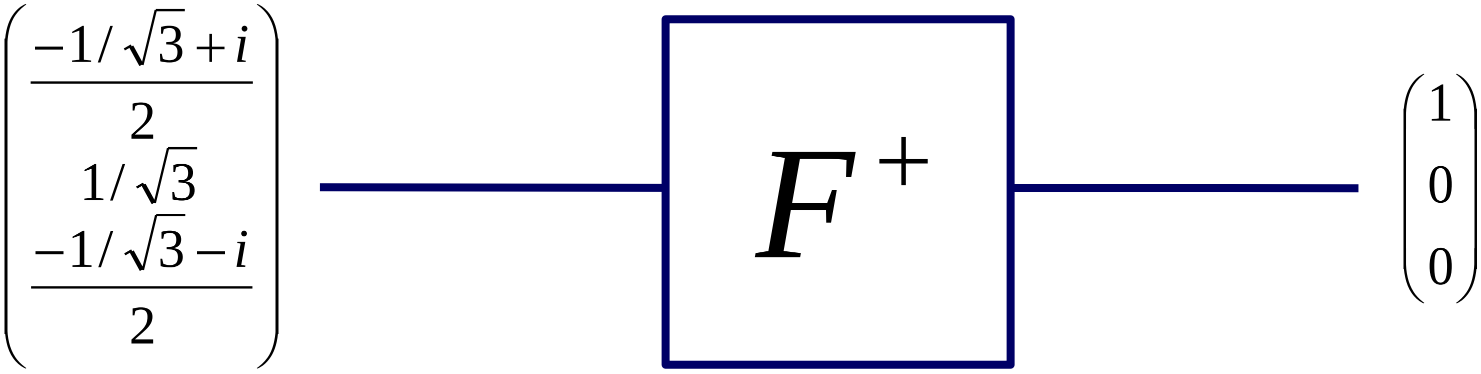


$$\begin{pmatrix} \frac{-1/\sqrt{3}+i}{2} \\ 1/\sqrt{3} \\ \frac{-1/\sqrt{3}-i}{2} \end{pmatrix}$$

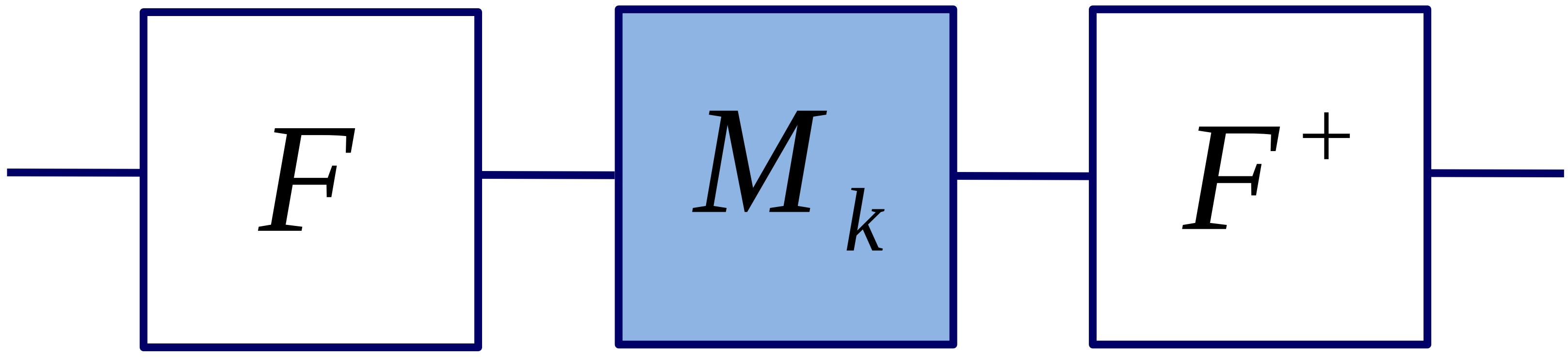


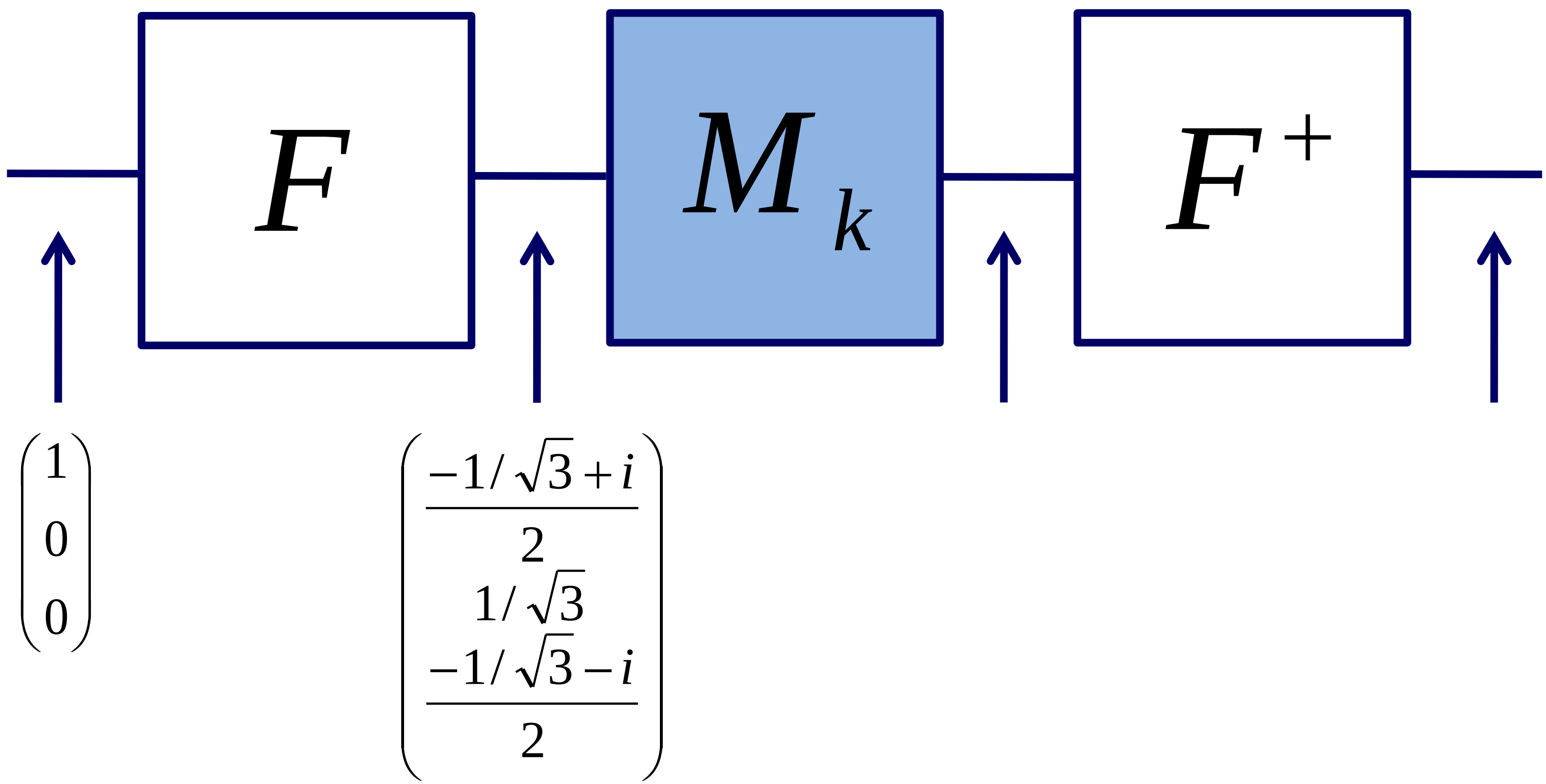
$\begin{pmatrix}0\\1\\0\end{pmatrix}$
F
$\begin{pmatrix}1/\sqrt{3}\\1/\sqrt{3}\\1/\sqrt{3}\end{pmatrix}$
$\begin{pmatrix}0\\0\\1\end{pmatrix}$
F
$\begin{pmatrix}\frac{-1/\sqrt{3}-i}{2}\\1/\sqrt{3}\\\frac{-1/\sqrt{3}+i}{2}\end{pmatrix}$

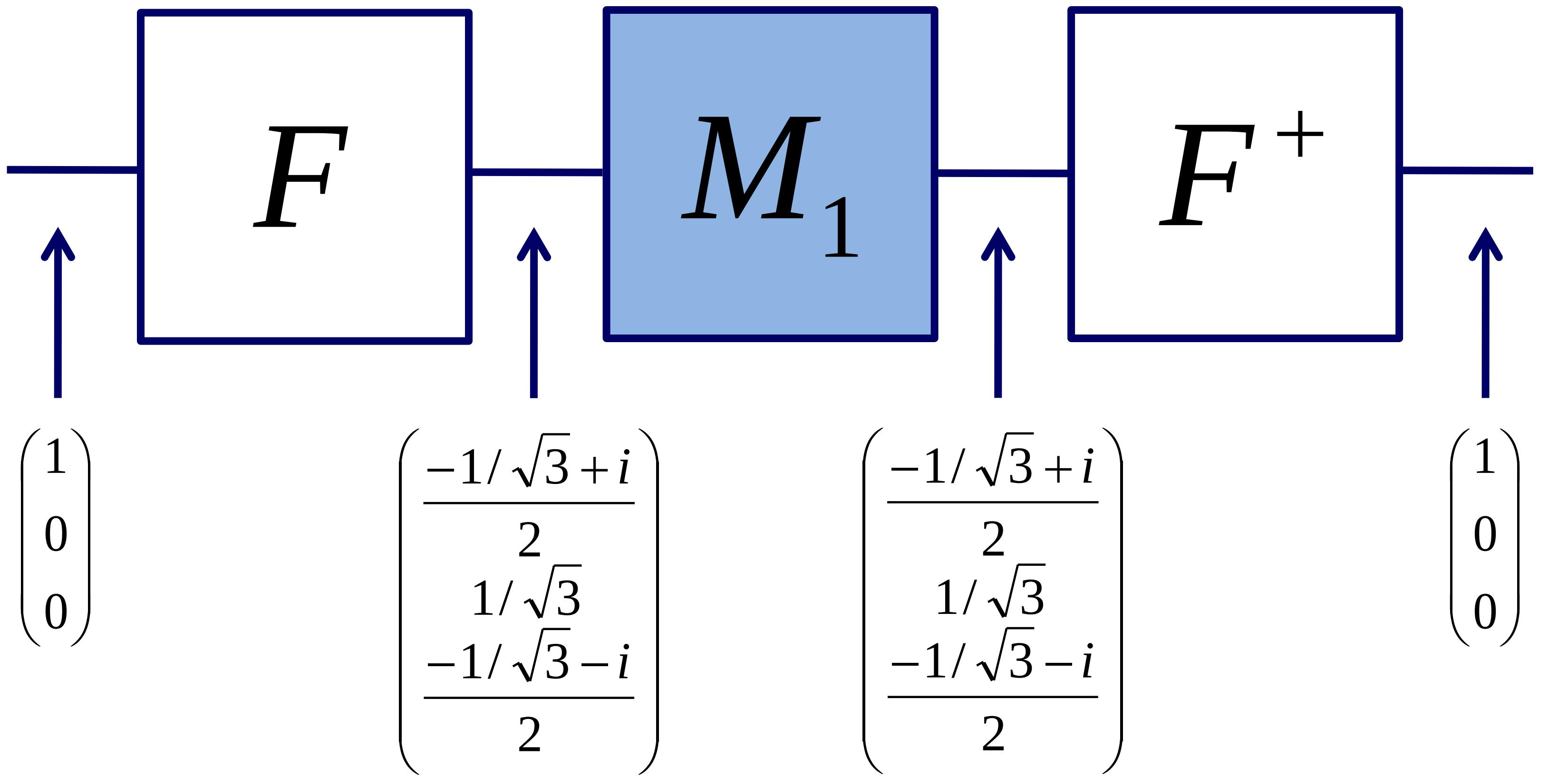
$$F^+ = \begin{pmatrix} \frac{-1/\sqrt{3} - i}{2} & 1/\sqrt{3} & \frac{-1/\sqrt{3} + i}{2} \\ 1/\sqrt{3} & 1/\sqrt{3} & 1/\sqrt{3} \\ \frac{-1/\sqrt{3} + i}{2} & 1/\sqrt{3} & \frac{-1/\sqrt{3} - i}{2} \end{pmatrix}$$



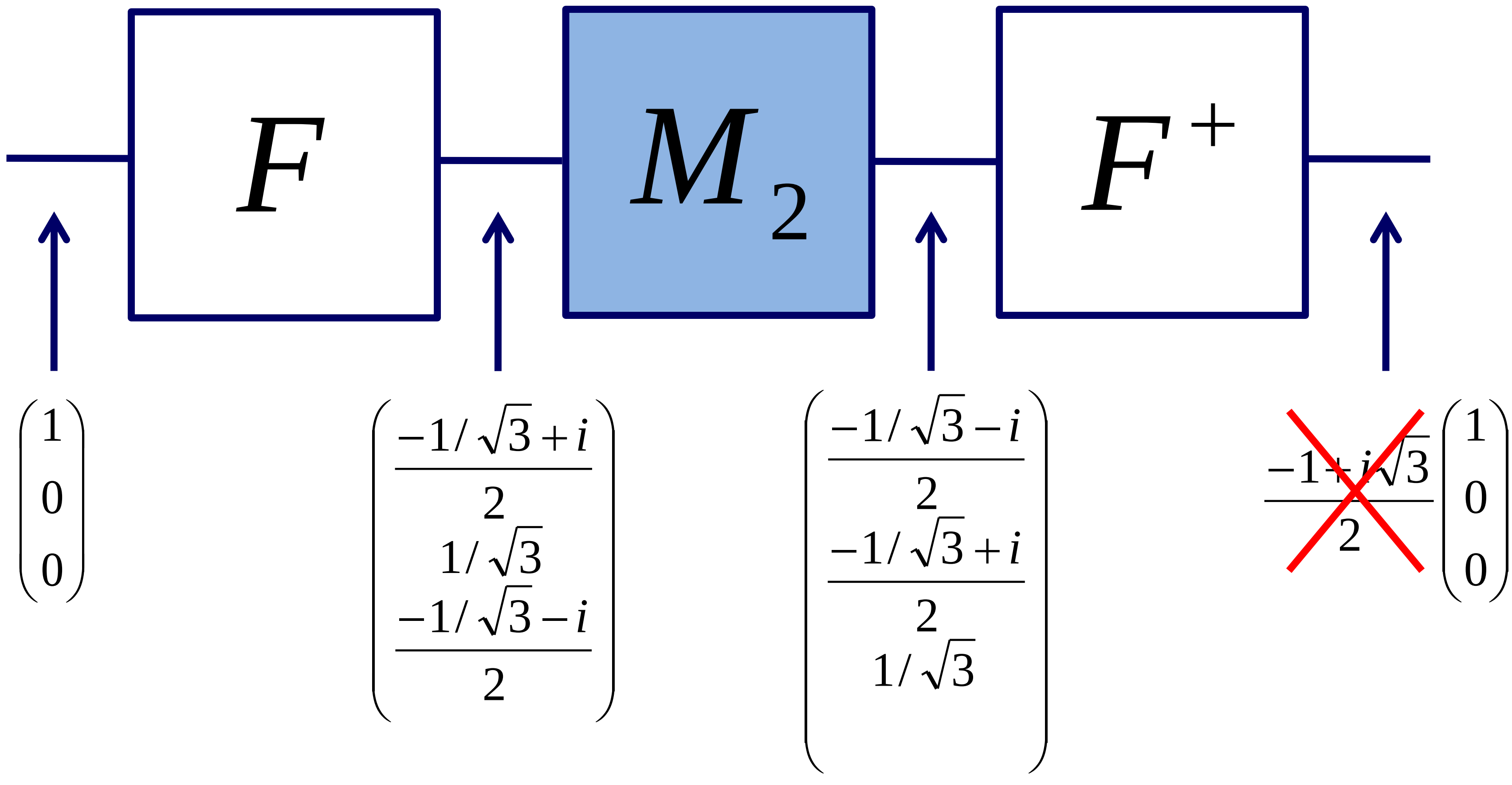
devre tasarımı



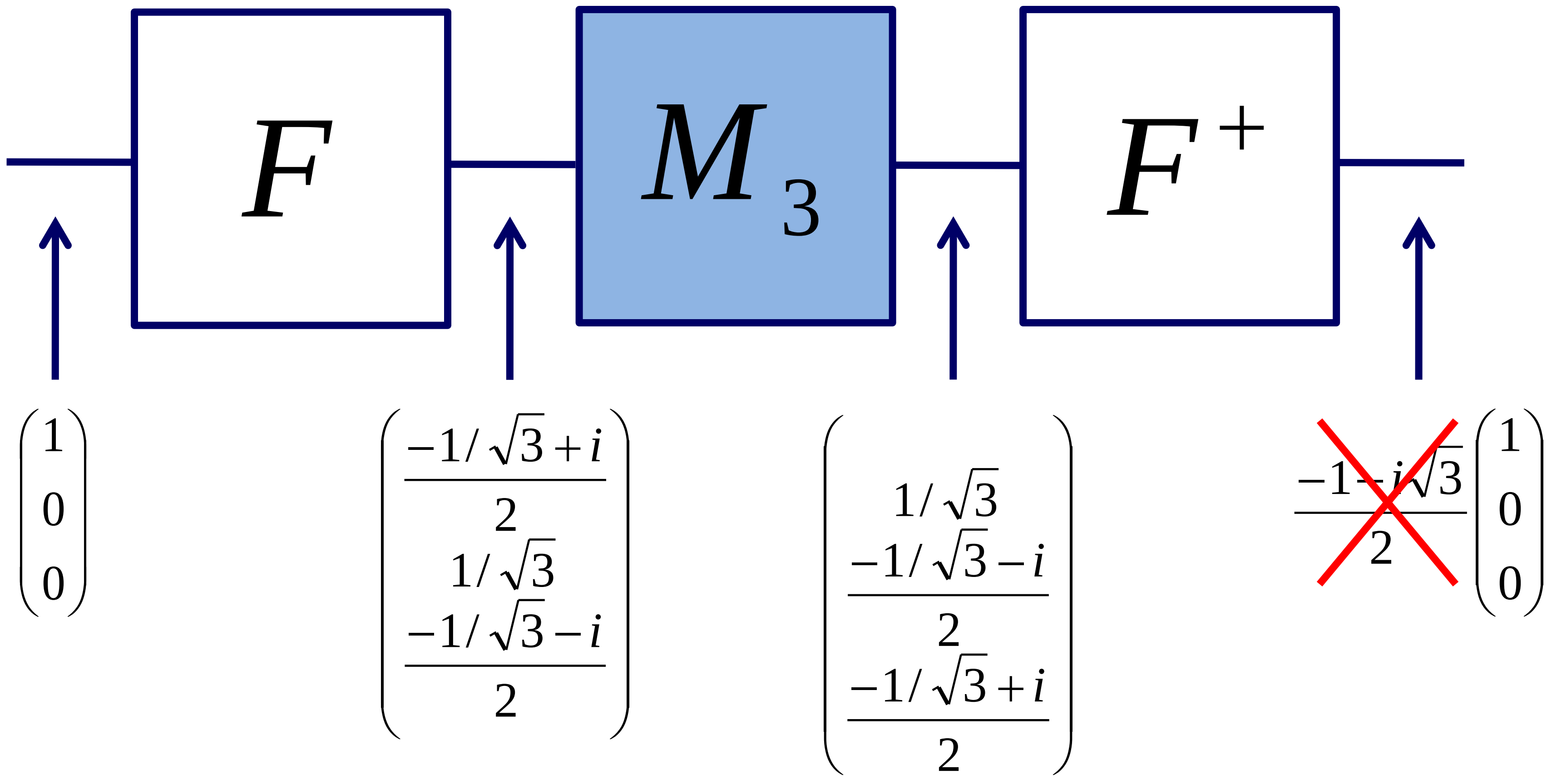

F
M k
F +
1
0
0
−1/√3 + i
2
1/√3
−1/√3 − i
2



F
M1
F+
(1, 0, 0)
((−1/√3+i)/2, 1/√3, (−1/√3−i)/2)
((−1/√3+i)/2, 1/√3, (−1/√3−i)/2)
(1, 0, 0)



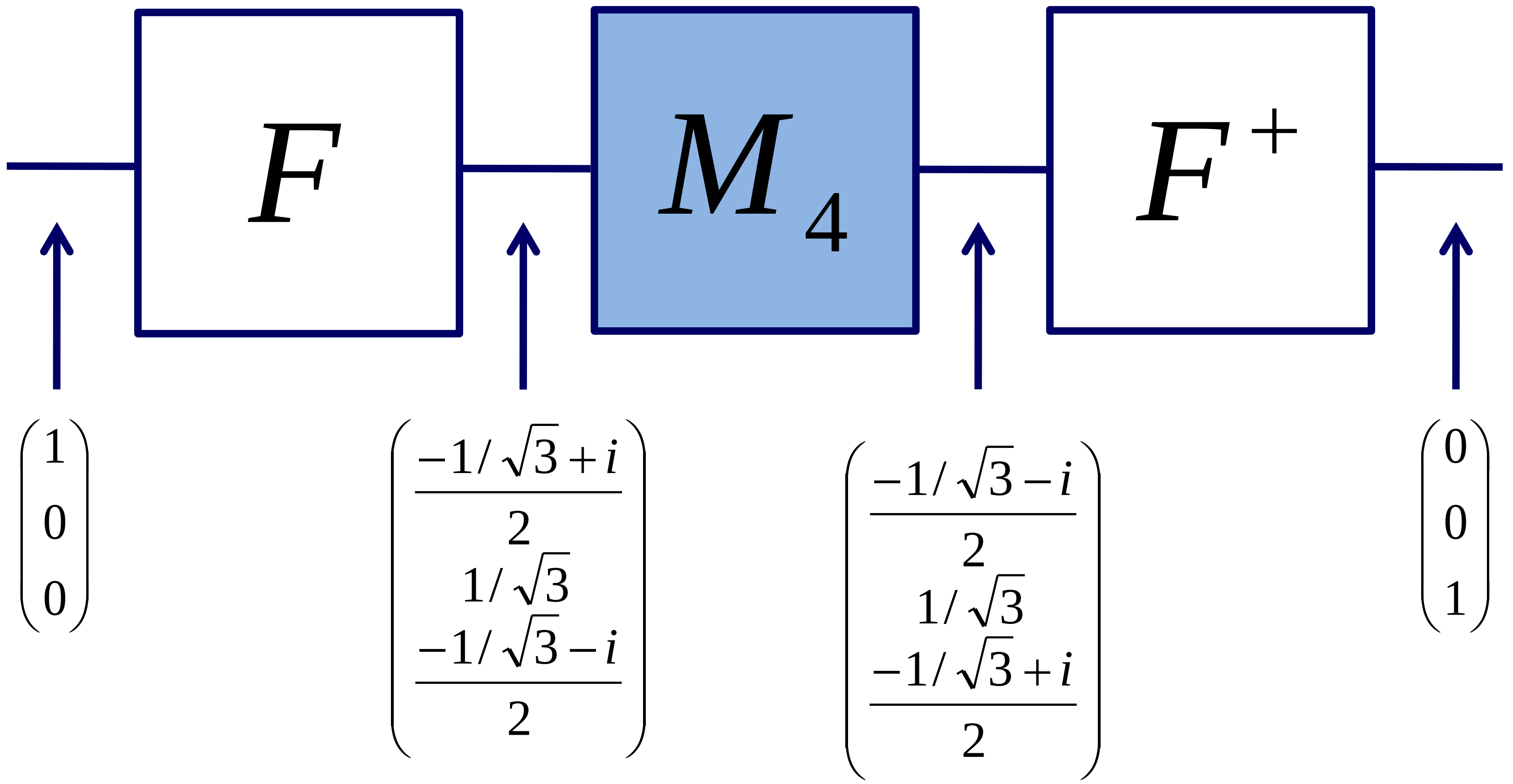
F
M_2
F^+
$\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$
$\begin{pmatrix} \frac{-1/\sqrt{3}+i}{2} \\ 1/\sqrt{3} \\ \frac{-1/\sqrt{3}-i}{2} \end{pmatrix}$
$\begin{pmatrix} \frac{-1/\sqrt{3}-i}{2} \\ \frac{-1/\sqrt{3}+i}{2} \\ 1/\sqrt{3} \end{pmatrix}$
$\frac{-1+i\sqrt{3}}{2}\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

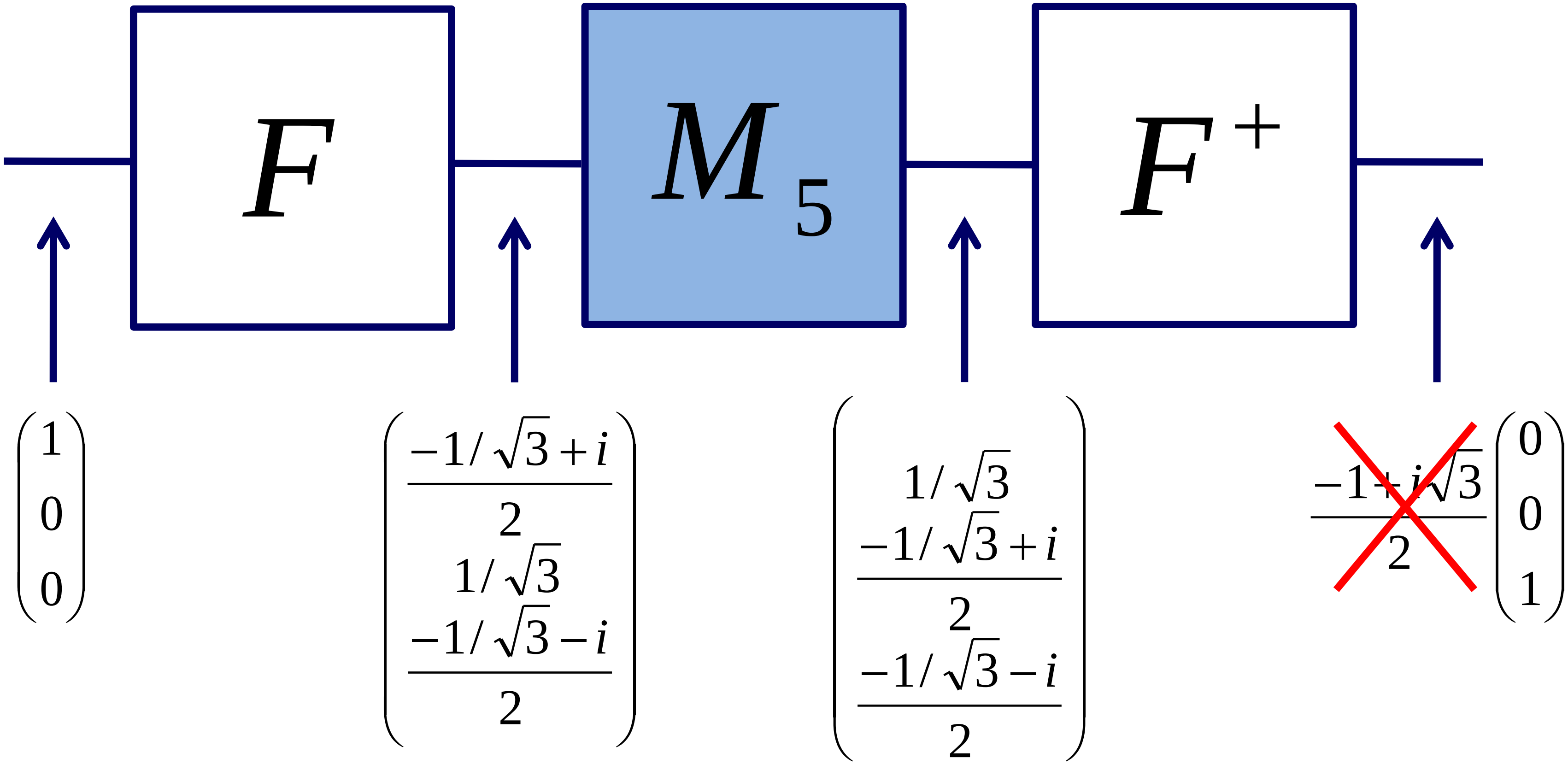

F
M_3
F^+
$\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$
$\begin{pmatrix} \frac{-1/\sqrt{3}+i}{2} \\ 1/\sqrt{3} \\ \frac{-1/\sqrt{3}-i}{2} \end{pmatrix}$
$\begin{pmatrix} 1/\sqrt{3} \\ \frac{-1/\sqrt{3}-i}{2} \\ \frac{-1/\sqrt{3}+i}{2} \end{pmatrix}$
$\frac{-1-i\sqrt{3}}{2}\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

çift permütasyonlar 1’i 1’e götürür!

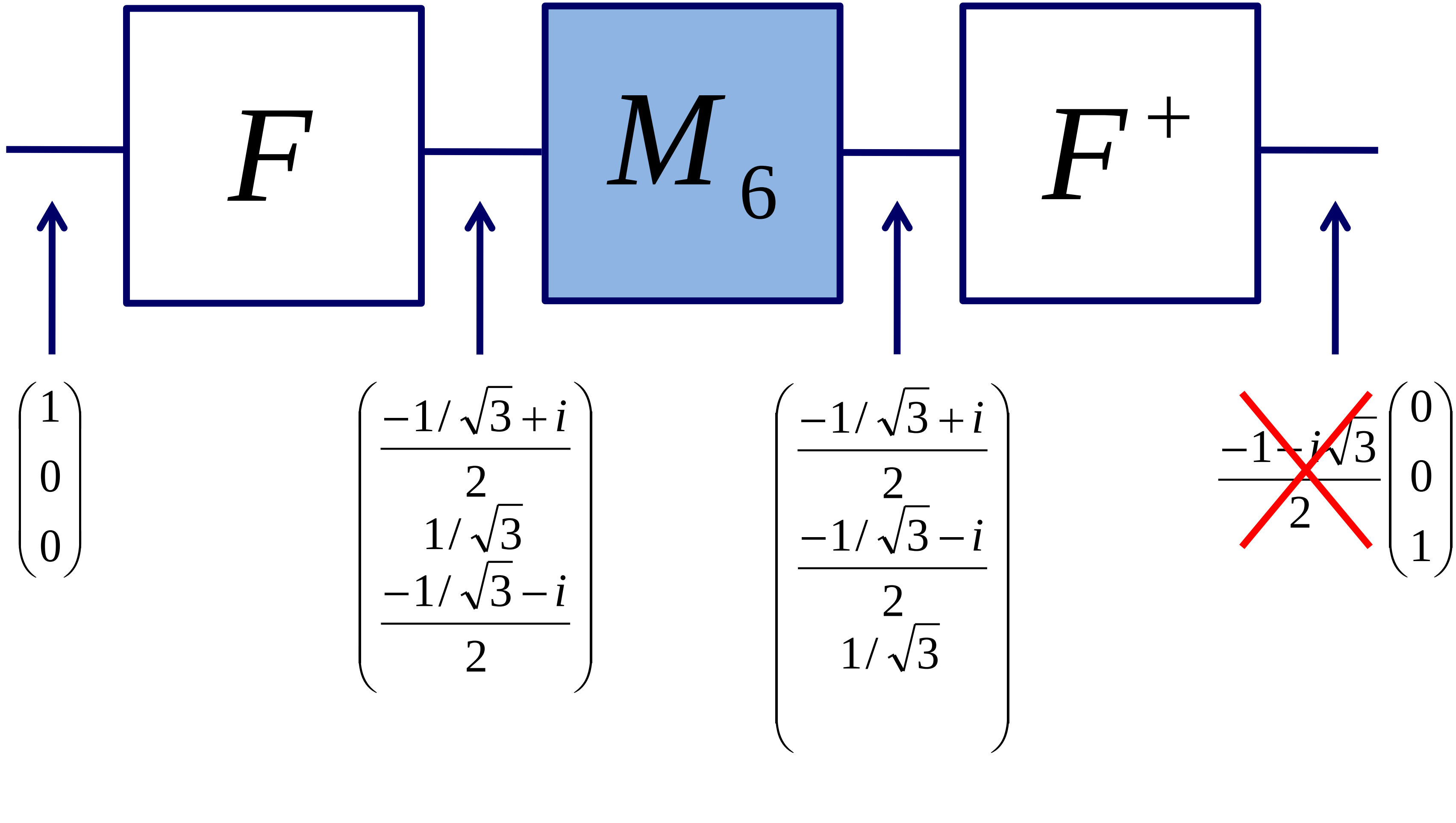
$$\begin{pmatrix}1\\0\\0\end{pmatrix} \xrightarrow{M_1, M_2, M_3} \begin{pmatrix}1\\0\\0\end{pmatrix}$$

1 **1**


F
M4
F+
(1, 0, 0)
((−1/√3+i)/2, 1/√3, (−1/√3−i)/2)
((−1/√3−i)/2, 1/√3, (−1/√3+i)/2)
(0, 0, 1)



F
M_5
F^+
$\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$
$\begin{pmatrix} \frac{-1/\sqrt{3}+i}{2} \\ 1/\sqrt{3} \\ \frac{-1/\sqrt{3}-i}{2} \end{pmatrix}$
$\begin{pmatrix} 1/\sqrt{3} \\ \frac{-1/\sqrt{3}+i}{2} \\ \frac{-1/\sqrt{3}-i}{2} \end{pmatrix}$
$\frac{-1+i\sqrt{3}}{2}\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$



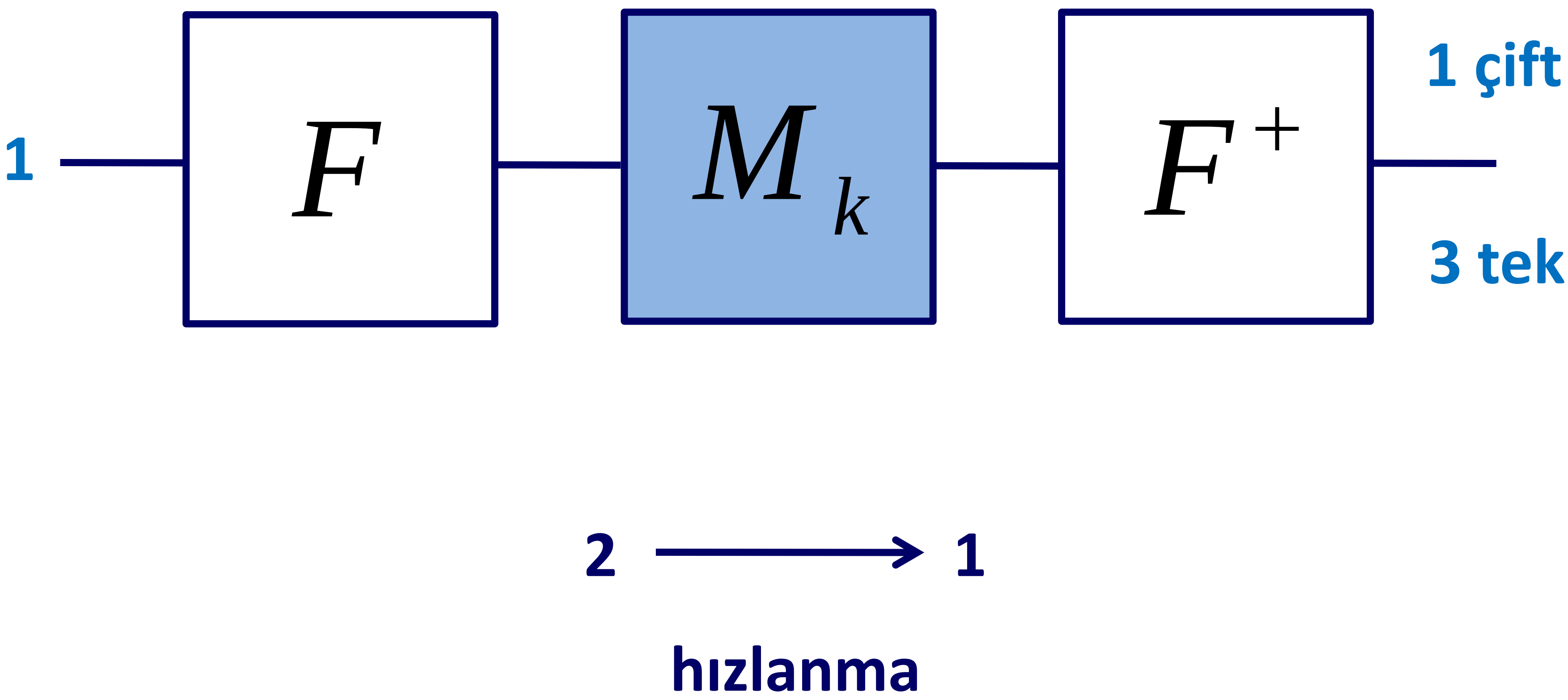
F
M6
F+

tek permütasyonlar 1’i 3’e götürür!

$$\begin{pmatrix}1\\0\\0\end{pmatrix} \xrightarrow{M_4, M_5, M_6} \begin{pmatrix}0\\0\\1\end{pmatrix}$$

1 **3**

permütasyonun tek mi çift mi olduğunu tek M_k ile belirleyebiliriz.



DÖRT DENEY

Physics Letters A **378**, 3452 (2014)

Determining the parity of a permutation using an experimental NMR qutrit

Shruti Dogra, Arvind, Kavita Dorai *

Department of Physical Sciences, Indian Institute of Science Education & Research (IISER) Mohali, Sector 81 SAS Nagar, Manauli PO, 140306 Punjab, India

arXiv:1406.3579 [quant-ph]

Computational speed-up in a single qudit NMR quantum information processor

I. A. Silva,[1,*] B. Çakmak,[2,*] G. Karpat,[3,*] E. L. G. Vidoto,[1] D. O. Soares-Pinto,[1] E. R. deAzevedo,[1] F. F. Fanchini,[3] and Z. Gedik[2]

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Demonstration of quantum permutation algorithm with a single photon ququart

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Feiran Wang, Yunlong Wang, Ruifeng Liu, Dongxu Chen, Pei Zhang, Hong Gao & Fuli Li

We report an experiment to demonstrate a quantum permutation determining algorithm with linear optical system. By employing photon's polarization and spatial mode, we realize the quantum ququart states and all the essential permutation transformations. The quantum permutation determining algorithm displays the speedup of quantum algorithm by determining the parity of the permutation in only one step of evaluation compared with two for classical algorithm. This experiment is accomplished in single photon level and the method exhibits universality in high-dimensional quantum computation.

Linear optical demonstration of quantum speed-up with a single qudit

L it

Xiang Zhan,[1] Jian Li,[1] Hao Qin,[1] Zhi-hao Bian,[1] and Peng Xue[1,2,3,*]

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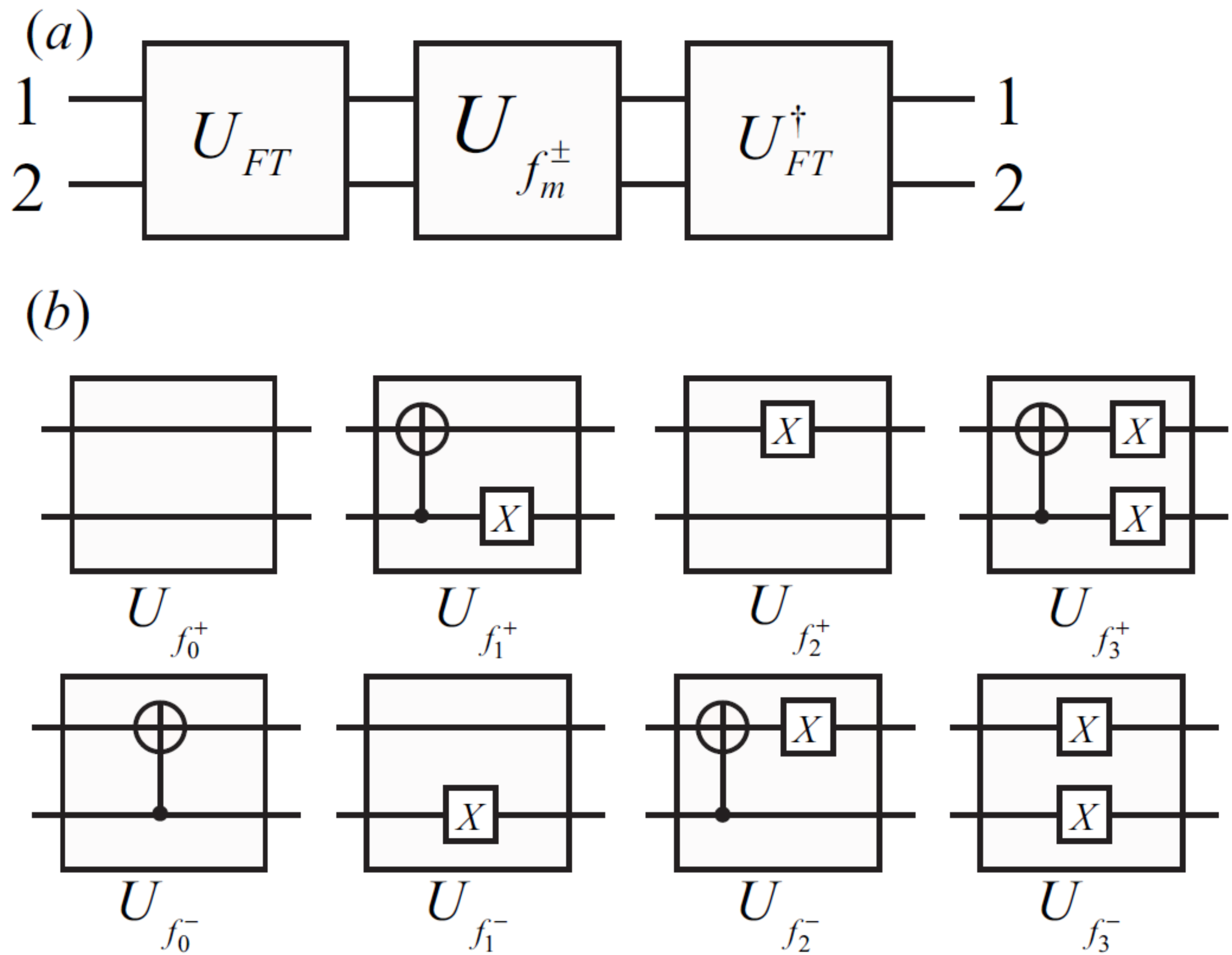
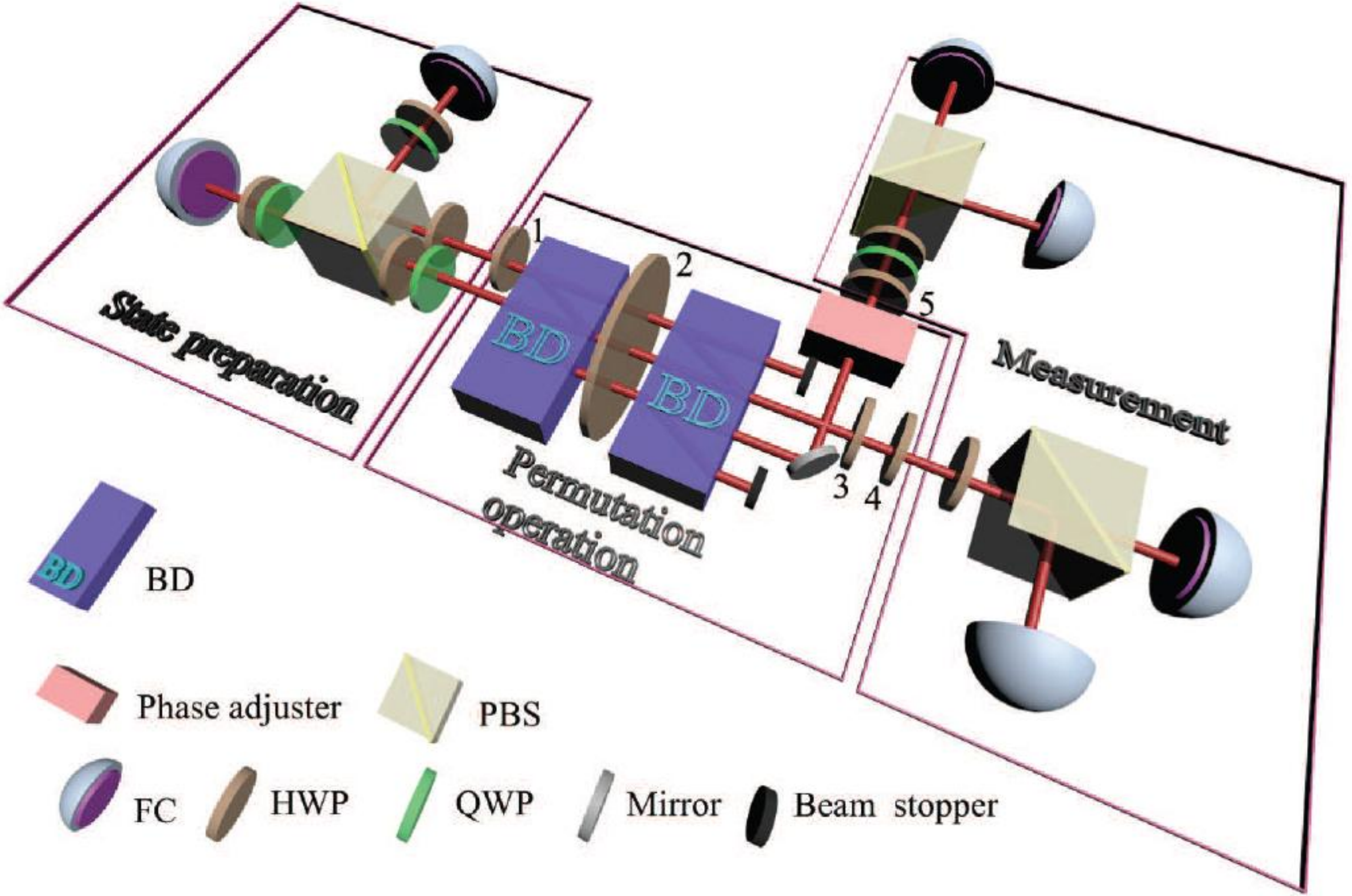
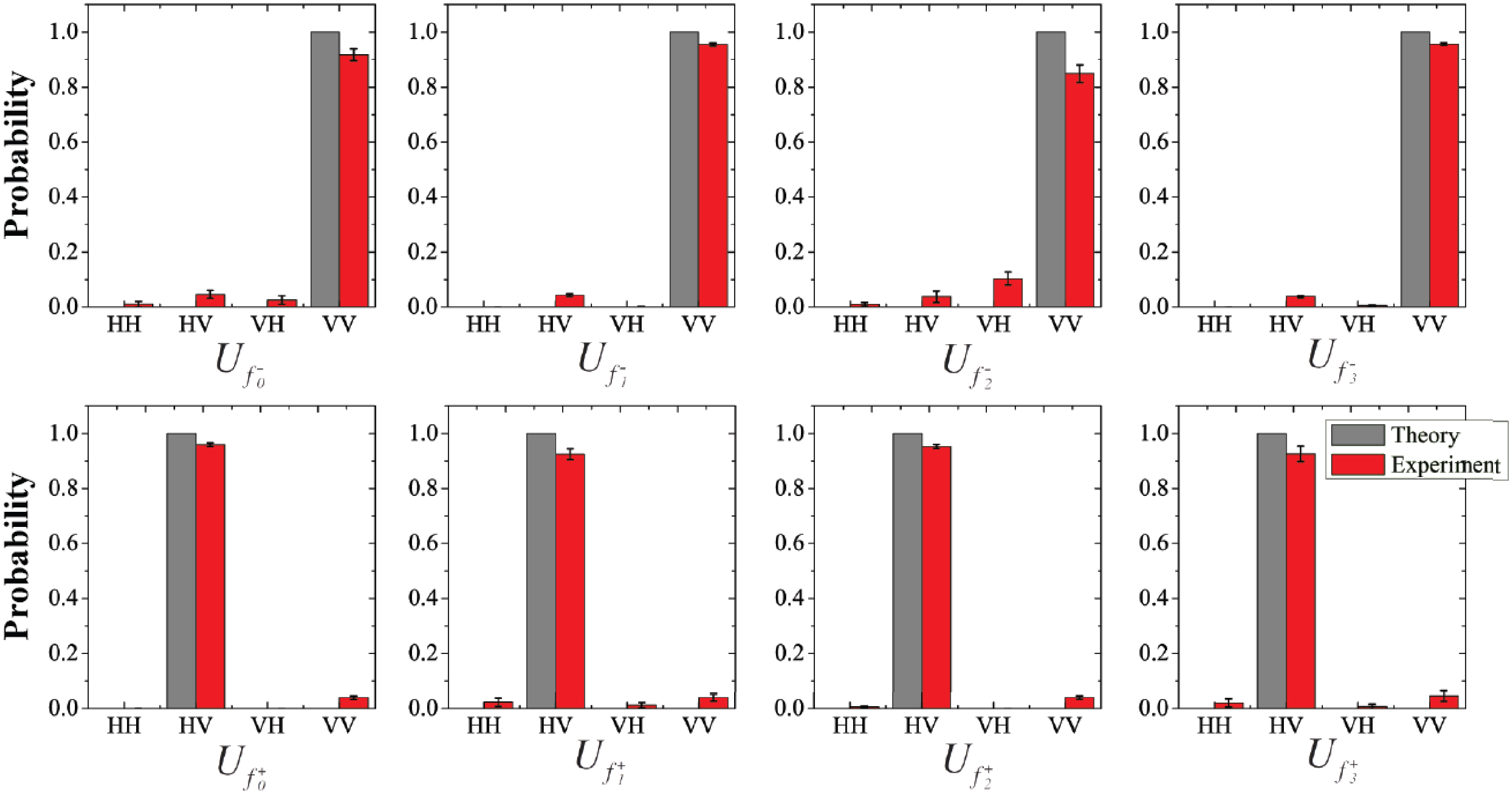


FIG. 1: The circuit model of Gedik's algorithm: - The upper line denotes the first qubit, and the lower one for second.



State preparation
Permutation operation
Measurement
BD
BD
1
2
3
4
5
BD
Phase adjuster
PBS
FC
HWP
QWP
Mirror
Beam stopper


Probability
1.0
0.8
0.6
0.4
0.2
0.0
HH
HV
VH
VV
$U_{f_0^-}$
$U_{f_1^-}$
$U_{f_2^-}$
$U_{f_3^-}$
$U_{f_0^+}$
$U_{f_1^+}$
$U_{f_2^+}$
$U_{f_3^+}$
Theory
Experiment

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Computational speed-up with a single qudit

Z. Gedik[1], I. A. Silva[2], B. Çakmak[1], G. Karpat[3,4], E. L. G. Vidoto[2], D. O. Soares-Pinto[2], E. R. deAzevedo[2] & F. F. Fanchini[3]

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Quantum algorithms are known for providing more efficient solutions to certain computational tasks than any corresponding classical algorithm. Here we show that a single qudit is sufficient to

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