Programmed quantum discrimination of qbits with added classical information

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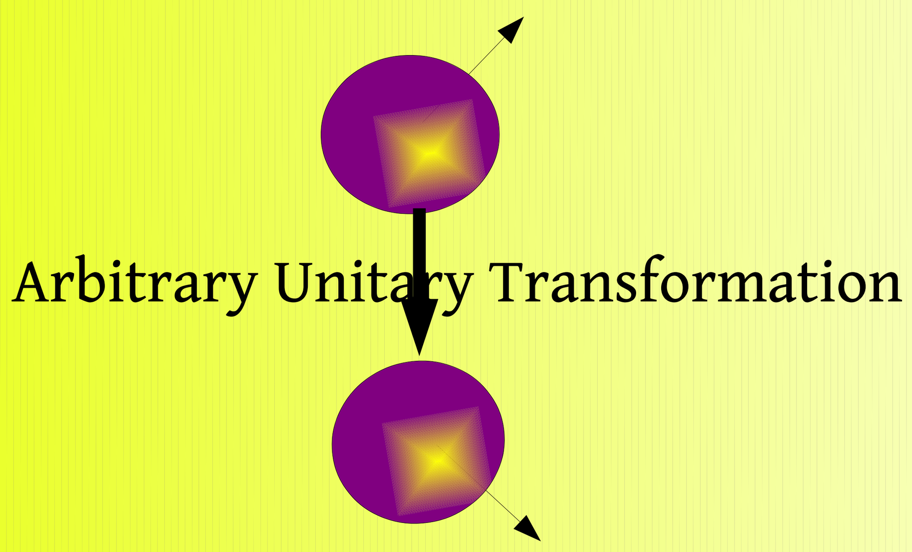
Advantages of programmed discrimination in data transmission and storage

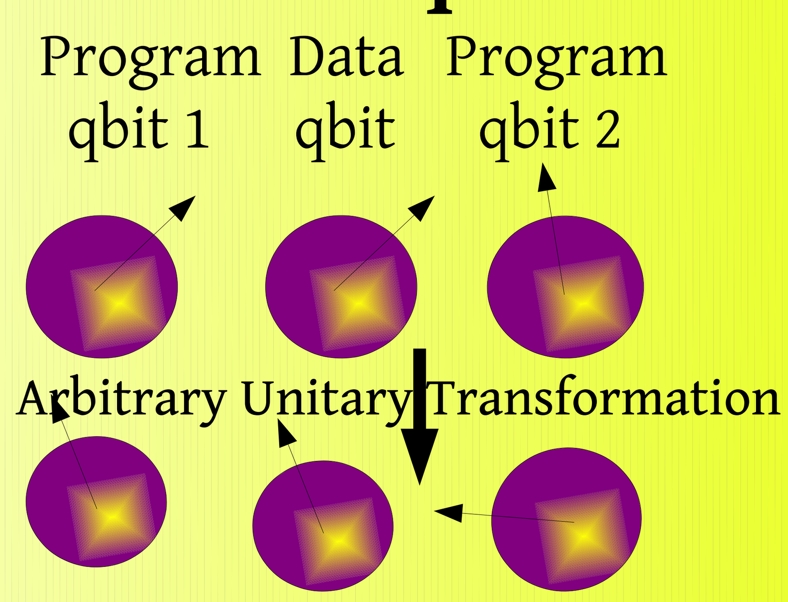
Single qbit



Discrimination ambiguous

(The data qbit is guaranteed to be the same as one of the program qbits)

Triad of qbits



Relationship maintained!

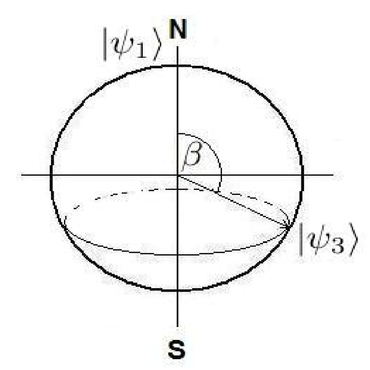
2 Types of Discrimination

Unambiguous
Best failure rate (without classical knowledge)
0.833

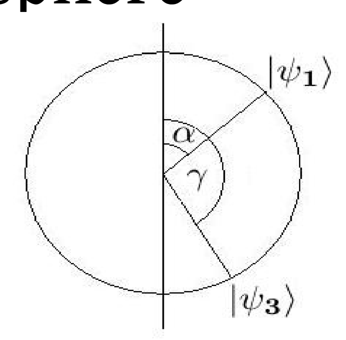
Optimal
Best error rate (without classical knowledge)
0.356

3 Types of Classical Knowledge

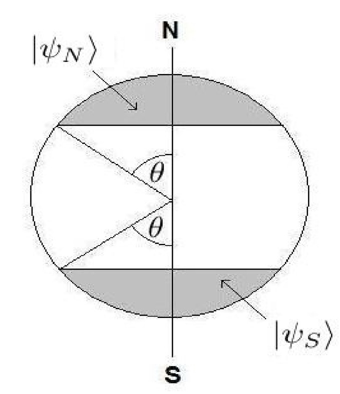
Known overlap between qbits



Both program qbits on the same known great circle of the Bloch sphere



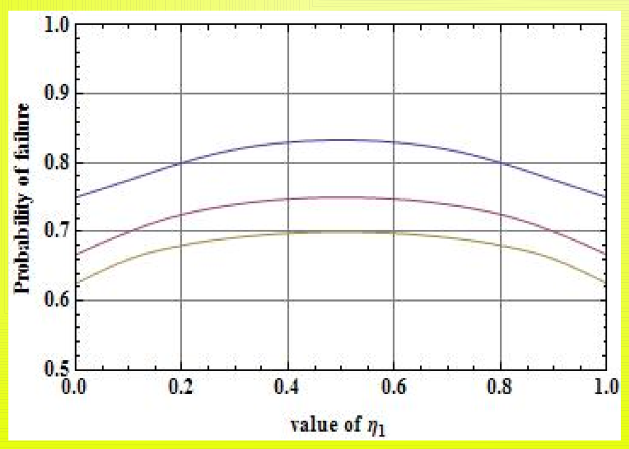
Program qbits confined to areas near the poles of the Bloch sphere



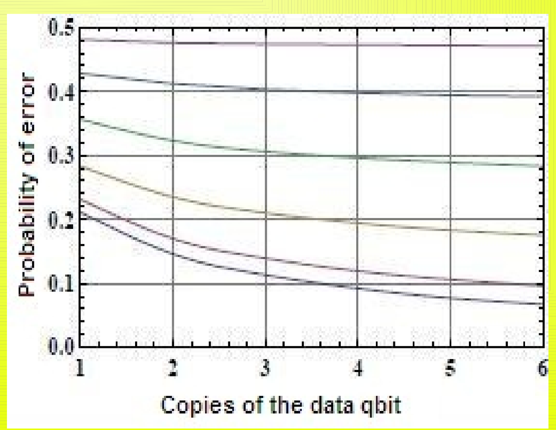
Using multiple copies of qbits

Both program and data qbits can be supplied in multiple copies.
This improves recognition rates (but not as much as you might expect!)

Failure rate for unambiguous discrimination (great circle)
upper: 1 data qbit
lower: 3 data qbits
η is P(data = prog1)



Optimum error for fixed overlap using 2 program qbits:
Small overlap (top)
Large overlap (bottom)



Efficiency in data communication and storage

These tables show the number of qbits needed to transmit one bit reliably. Table A is based on optimal recognition with random program qbits, and relies on Shannon's noisy channel theorem to correct errors. Table B uses unambiguous recognition, with orthogonal program qbits. The best configurations are coloured red.

Configuration	{1,n,1}	{2,n,2}	{3,n,3}
Data qbits (n)			
1	49	45	52
2	43	41	48
3	45	43	51
4	48	47	
5	53		
6	57		
7	62		

Table A

Configuration	{1,n,1}	{2,n,2}	{3,n,3}
Data qbits (n)			
1	9	13	16
2	8	11	14
3	8	11	
4	9	11	
5	10		
6	11		
7	12		

Table B

References:

J.A. Bergou, V. Buzek, E.Feldman, U. Herzog and M. Hillery Phys. Rev.**A73** 062334 (2006)
Programmable quantum-state discriminators with simple programs
A.J.T. Colin,S.M. Barnett and J. Jeffers, Eur. Phys. J. D. **63**,463-472 (2011)
Programmed discrimination of qbits with added classical information
A.J.T. Colin, Eur. Phys J. D. (in press, 2012)
Programmed discrimination of multiple sets of qbits with added classical information