# High-Confidence *vs* Unambiguous Discrimination of Bell-Like States in Linear Optical Quantum Networks


J A Bergou[1] and P Agarwal[1]

[1]*Department of Physics and Astronomy, Hunter College of the City University of New York, 695 Park Avenue, New York NY, USA. Contact Phone: +17327636812*

Contact Email: jbergou@hunter.cuny.edu


We consider the task of discriminating between Bell-like states, $|\psi\rangle = \alpha|00\rangle + \beta|11\rangle$ (and similar for the other three Bell states), using few-photon implementation in a linear optical quantum network and without the use of ancillary photons. This is a basic problem relevant in diverse settings, *e.g.*, in the measurement of the output of an entangling quantum circuit or for entanglement swapping in quantum repeaters. It is known that exact Bell states of two qubits, corresponding to $\alpha = \beta = \frac{1}{\sqrt{2}}$, can be unambiguously discriminated with an optimal success probability of 0.5 (see [1-4]). It is also known that in the other limit, $\alpha = 1$ and $\beta = 0$, corresponding to separable states, the states can be discriminated unambiguously with an optimal success probability of 1. Therefore, the expectation is that as we go from maximally entangled states toward separable states the success probability increases monotonically. In [5], we found the counterintuitive result that for Bell-like states the optimal probability can be only 0.25, and the two extremes emerge as singularities.

Here, we investigate this discontinuous and unphysical behavior of the average success probability further. We argue that unambiguous discrimination is a theoretical fiction, the constraints being overly limiting, binary and, ultimately, unphysical. In every realistic experimental setting, there are errors. We suggest the use a more physical figure of merit, discrimination with high confidence probability. Unambiguous discrimination corresponds to confidence probability C=1. Once this strict condition is relaxed, by using a high confidence probability, C<1 (*e.g.*, C=0.98 or similar), the singularity is replaced by a continuous function of the parameters.

## References


[1] N Lütkenhaus, J Calsamiglia and K-A Suominen, Phys. Rev. A **59**, 3295 (1999)

[2] J Calsamiglia and N Lütkenhaus, Appl. Phys. B **72**, 67 (2001)

[3] W P Grice, Phys. Rev. A **84**, 042331 (2011)

[4] F Ewert and P van Loock, Phys. Rev. Lett. **113**, 140403 (2014)

[5] D Fields, J A Bergou, M Hillery, S Santra and V S Malinovsky, Phys. Rev. A **106**, 023706 (2022)

[6] P Agarwal and J A Bergou, in preparation