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Characterization of the Trace by Young's Inequality

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Abstract: Let φ be a positive linear functional on the algebra of $n \times n$ complex matrices and p, q be positive numbers such that $\frac{1}{p} + \frac{1}{q} = 1$. We prove that if for any pair A, B of positive semi-definite $n \times n$ matrices the inequality

$$\varphi(|AB|) \leq \frac{\varphi(A^p)}{p} + \frac{\varphi(B^q)}{q}$$

holds, then φ is a positive scalar multiple of the trace.

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