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Entropic uncertainty relations for mutually unbiased operator frames

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Abstract

We develop an operator-frame formulation of entropic uncertainty relations in the Hilbert–Schmidt space of operators. For general continuous indexed operator frames, we derive an entropic uncertainty relation for the associated coefficient distributions by combining endpoint norm estimates with Riesz–Thorin interpolation. We then identify a distinguished class of mutually unbiased operator frames, defined through constant-modulus trace overlaps. Under suitable structural conditions, the corresponding coefficient amplitudes are related by a bilinear Fourier transform, leading to a stronger Hirschman–Beckner-type entropic uncertainty relation. As canonical realizations, we consider Weyl displacement operators and Wigner kernels, as well as Cartesian dyadic frames generated by position and momentum eigenstates. These examples recover familiar continuous-variable Fourier dualities while extending entropic uncertainty relations beyond measurement outcomes to operator representations themselves. © 2026 The Author(s). Published by IOP Publishing Ltd. Original content from this work may be used under the terms of the Creative Commons Attribution 4.0 license. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Author keywords

entropic uncertainty relations; frame theory; operator theory

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Abstract

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