On Partition of Unities Generated by Entire Functions and Gabor Frames in $L^2(\mathbb{R}^d)$ and $\ell^2(\mathbb{Z}^d)$

We characterize the entire functions $P$ of $d$ variables, $d \geq 2$, for which the $\mathbb{Z}^d$-translates of $P \chi_{[0,N]^d}$ satisfy the partition of unity for some $N \in \mathbb{N}$. In contrast to the one-dimensional case, these entire functions are not necessarily periodic. In the case where $P$ is a trigonometric polynomial, we characterize the maximal smoothness of $P \chi_{[0,N]^d}$, as well as the function that achieves it. A number of especially attractive constructions are achieved, e.g., of trigonometric polynomials leading to any desired (finite) regularity for a fixed support size. As an application we obtain easy constructions of matrix-generated Gabor frames in $L^2(\mathbb{R}^d)$, with small support and high smoothness. By sampling this yields dual pairs of finite Gabor frames in $\ell^2(\mathbb{Z}^d)$.

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