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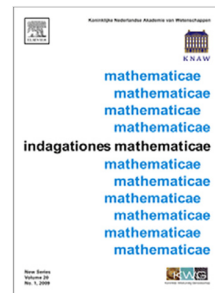
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OPERATOR NORM AND LOWER BOUND OF FOUR-DIMENSIONAL MATRICES

GHOLAMREZA TALEBI

ABSTRACT. Motivated by the work "Hardy's inequality in several variables" in *J. Math. Anal. Appl.*, 252 (2) (2000), 989-993, an extension of Copson's discrete inequality to multiple series is obtained. As an application of such extension, we consider the boundedness problem of four-dimensional matrices on the space \mathcal{L}_p of double sequences. The operator norms of Cesàro, Copson and Nörlund four-dimensional matrices as operators selfmap of \mathcal{L}_p are established. Further, a general upper estimate and lower estimate is obtained for the lower bounds of some four-dimensional matrices.

1. INTRODUCTION AND PRELIMINARIES

By Ω , we denote the space of all real or complex valued double sequences which is the vector space with coordinatewise addition and scalar multiplication. Any vector subspace of Ω is called as the double sequence space. Consider a sequence $x = (x_{n,m}) \in \Omega$. If there is an $\ell \in \mathbb{C}$ such that for each $\varepsilon > 0$ there exists $n_0 = n_0(\varepsilon) \in \mathbb{N}$ such that

$$|x_{n,m} - \ell| < \varepsilon$$

for all $n, m > n_0$, then we call that the double sequence $x = (x_{n,m})$ is convergent in the Pringsheim's sense to the limit ℓ and write $p\text{-}\lim_{n,m \rightarrow \infty} x_{n,m} = \ell$, [5], where \mathbb{C} denotes the complex field. Also, we say that

$$s = \sum_{n=0}^{\infty} \sum_{m=0}^{\infty} x_{n,m},$$

if the sequence of partial sums $(s_{n,m})$, defined by

$$s_{n,m} := \sum_{j=0}^n \sum_{k=0}^m x_{j,k}, \quad (n, m = 0, 1, 2, \dots),$$

is convergent in the Pringsheim's sense to limit s . In such a case, we say that the double series converges to s . A double sequence $x = (x_{nm})$ of real or complex numbers is said to be bounded if

$$\|x\|_{\infty} := \sup_{n,m} |x_{nm}| < \infty.$$

The space of bounded double sequences is denoted by \mathcal{M}_u . Also the space \mathcal{L}_p of double sequences [1] is defined by

$$\mathcal{L}_p = \left\{ (x_{nm}) \in \Omega, \sum_{n,m} |x_{nm}|^p < \infty \right\}, \quad (1 \leq p < \infty).$$

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