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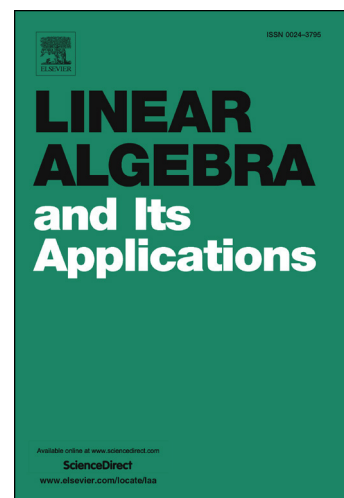
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# Combinatorial methods for the spectral $p$ -norm of hypermatrices

V. Nikiforov\*

## Abstract

The spectral  $p$ -norm of  $r$ -matrices generalizes the spectral 2-norm of 2-matrices. In 1911 Schur gave an upper bound on the spectral 2-norm of 2-matrices, which was extended in 1934 by Hardy, Littlewood, and Pólya to  $r$ -matrices. Recently, Kolotilina, and independently the author, strengthened Schur's bound for 2-matrices. The main result of this paper extends the latter result to  $r$ -matrices, thereby improving the result of Hardy, Littlewood, and Pólya.

The proof is based on combinatorial concepts like  $r$ -partite  $r$ -matrix and *symmetrant* of a matrix, which appear to be instrumental in the study of the spectral  $p$ -norm in general. Thus, another application shows that the spectral  $p$ -norm and the  $p$ -spectral radius of a symmetric nonnegative  $r$ -matrix are equal whenever  $p \geq r$ . This result contributes to a classical area of analysis, initiated by Mazur and Orlicz back in 1930.

Additionally, a number of bounds are given on the  $p$ -spectral radius and the spectral  $p$ -norm of  $r$ -matrices and  $r$ -graphs.

**Keywords:** spectral norm; hypermatrix; Schur's bound;  $p$ -spectral radius; nonnegative hypermatrix; hypergraph.

**AMS classification:** 05C50, 05C65, 15A18, 15A42, 15A60, 15A69.

## 1 Introduction

In this paper we study the spectral  $p$ -norm of hypermatrices and its applications to spectral hypergraph theory. Recall that the spectral 2-norm  $\|A\|_2$  of an  $m \times n$  matrix  $A := [a_{i,j}]$  is defined as

$$\|A\|_2 := \max \left\{ \left| \sum_{i,j} a_{i,j} x_j y_i \right| : |x_1|^2 + \cdots + |x_n|^2 = 1 \text{ and } |y_1|^2 + \cdots + |y_m|^2 = 1 \right\}.$$

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