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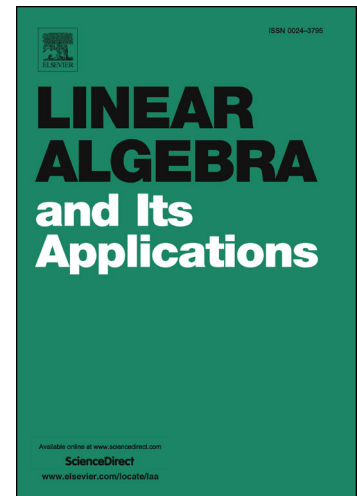
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## Sets of refined inertias of zero-nonzero patterns

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### Abstract

A set  $\mathbb{H}_n^*$  of refined inertias for zero-nonzero patterns is introduced that is analogous to the set  $\mathbb{H}_n$  previously considered for sign patterns. For  $n = 3$  and  $4$ , a complete characterization of irreducible zero-nonzero patterns that allow or require  $\mathbb{H}_n^*$  is given, and each zero-nonzero pattern that allows  $\mathbb{H}_n^*$  has a signing that allows  $\mathbb{H}_n$ . In contrast, for  $n \geq 5$  a family of irreducible zero-nonzero patterns is given that allows  $\mathbb{H}_n^*$  but for which no one signing allows  $\mathbb{H}_n$ .

*Keywords:* zero-nonzero pattern, sign pattern, refined inertia, eigenvalues, digraph

*2010 MSC:* 15B35, 15A18, 05C50, 05C20

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### 1. Introduction

The set of refined inertias  $\mathbb{H}_n$  is relevant to the study of dynamical systems, where the presence of nonzero pure imaginary eigenvalues can signal the onset of periodic solutions by Hopf bifurcation (see [1]). Previous papers (e.g., [1, 2, 3, 4, 5]) have focused on sign patterns that require or allow  $\mathbb{H}_n$ . Here the concepts in these papers are extended to zero-nonzero patterns. In particular, the set of refined inertias  $\mathbb{H}_n$  is expanded to a set  $\mathbb{H}_n^*$ , and we show that, for  $n \geq 5$ , there exist  $n \times n$  zero-nonzero patterns that allow  $\mathbb{H}_n^*$  and for which there does not exist a signing of these zero-nonzero patterns that allows  $\mathbb{H}_n$ . The implication of this is that there may be a difference in the use of refined inertias in the

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