

Special Groups: Boolean-theoretic Methods In The Theory Of Quadratic Forms

ORDERINGS AND SIGNATURES OF HIGHER LEVEL ON MULTIRINGS AND HYPERFIELDS

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ABSTRACT. Multirings are objects like rings but with multi-valued addition. They are a variant of other objects called hyperrings, defined by Krasner [12], [13]. In [16] the second author defines multirings, introduces a certain special class of multirings called real reduced multirings, defines a natural reflection $A \mapsto Q_{\text{real}}(A)$ from the category of multirings satisfying $-1 \notin \Sigma A^{\times 2}$ to the full subcategory of real reduced multirings, provides an elementary first-order description of these objects, and proves that these objects are precisely the spaces of signs, also known as abstract real spectra, considered earlier in [1], [15]. In the present paper we extend results of E. Becker and others concerning orderings of higher level on fields and rings to orderings of higher level on hyperfields and multirings and, in the process of doing this, we establish higher level analogs of the results in [16]. In particular, we introduce a class of multirings called ℓ -real reduced multirings, define a natural reflection $A \mapsto Q_{\ell\text{-real}}(A)$ from the category of multirings satisfying $-1 \notin \Sigma A^{\times 2}$ to the full subcategory of ℓ -real reduced multirings, and provide an elementary first-order description of these objects. The relationship between ℓ -real reduced hyperfields and the spaces of signatures defined by Mulcahy and Powers [20], [21], [22] is also examined.

1. INTRODUCTION

There has been considerable interest recently in hyperfields, hyperrings and multirings. This interest derives not so much from the actual objects themselves as from the success achieved in using these objects to understand and explain other objects and phenomena. Hyperfields and hyperrings arise in the study of the algebraic structure of the adèle class space of a global field and in exploring the deeper relationship between algebraic number fields and algebraic function fields [7], [8]. Hyperfields occur naturally in the context of quadratic form theory and spaces of orderings [16], Milnor K-theory [17], tropical geometry [23], commutative algebras over fields with semi-linear homomorphisms, abelian groups with injective homomorphisms, as well as non-desarguesian plane projective geometries [7]. Multirings are considered in [16], and spaces of signs, also known as abstract real spectra, objects which arise naturally in the study of constructible sets in real geometry [1], [15], are shown to be multirings of a particular sort. Hyperrings and hyperfields were introduced first by Krasner [12], [13] in connection with his work on valued fields. Multirings and multirings were introduced later and independently in [16]. All of these objects are very natural and very useful.

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