

# The Equational Classes Generated By Single Functionally Precomplete Algebras

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## MONOTONE CLONES, RESIDUAL SMALLNESS AND CONGRUENCE DISTRIBUTIVITY

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Corresponding to each ordered set there is a variety, determined up to equivalence, generated by an algebra whose term operations are all the monotone operations on the ordered set. We produce several characterisations of the finite bounded ordered sets for which the corresponding variety is congruence-distributive. In particular, we find that congruence-distributivity, congruence-modularity, and residual smallness are equivalent for these varieties.

### 0. INTRODUCTION

We say that an algebra  $\mathbf{A} = \langle P, f_i (i \in I) \rangle$  is *monotone* with respect to an ordered set  $\mathbf{P} = \langle P, \leq \rangle$  if every fundamental operation  $f_i$  of  $\mathbf{A}$  preserves the order of  $\mathbf{P}$ . An algebra  $\mathbf{A}$  is *order-primal* with respect to  $\mathbf{P}$  if  $\mathbf{A}$  is monotone with respect to  $\mathbf{P}$  and the clone  $\mathbf{M}(\mathbf{P})$ , consisting of all operations monotone with respect to  $\mathbf{P}$ , is identical with the clone of term operations of  $\mathbf{A}$ . An algebra order-primal with respect to  $\mathbf{P}$  will be denoted by  $\mathbf{A}(\mathbf{P})$ . We say that  $\mathbf{P}$  is *bounded* if it has a least and a largest element. The variety  $\mathcal{V}(\mathbf{A}(\mathbf{P}))$  generated by an order-primal algebra for a (bounded) ordered set  $\mathbf{P}$  will be called a (*bounded*) *order-primal variety*.

Martynjuk [15] proved that the order-primal algebra corresponding to a finite bounded ordered set  $\mathbf{P}$  is *pre-primal*; that is,  $\mathbf{M}(\mathbf{P})$  together with any operation over  $\mathbf{P}$  that lies outside of  $\mathbf{M}(\mathbf{P})$  generates the clone of all operations on  $\mathbf{P}$ . Of the six classes of pre-primal algebras delineated in Rosenberg [20], those associated with bounded ordered sets are the only ones for which answers to straightforward questions about the algebra, its clone, and the variety it generates, are often very difficult to answer. For general studies of the varieties generated by pre-primal algebras, consult Denecke [7], Knoebel [13] and Lau [14].

Our motive for writing this paper was to prove that the SI conjecture holds for the bounded order-primal varieties. The SI conjecture is the statement that a variety  $\mathcal{V}$

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283

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