DECOMPOSITIONS OF A C-ALGEBRA

G. C. RAO AND P. SUNDARAYYA

Received 12 April 2005; Revised 12 December 2005; Accepted 18 December 2005

We prove that if A is a C-algebra, then for each $a \in A$, $A_a = \{x \in A/x \leq a\}$ is itself a C-algebra and is isomorphic to the quotient algebra A/θ_a of A where $\theta_a = \{(x,y) \in A \times A/a \wedge x = a \wedge y\}$. If A is C-algebra with T, we prove that for every $a \in B(A)$, the centre of A, A is isomorphic to $A_a \times A_{a'}$ and that if A is isomorphic $A_1 \times A_2$, then there exists $a \in B(A)$ such that A_1 is isomorphic A_a and A_2 is isomorphic to $A_{a'}$. Using this decomposition theorem, we prove that if $a, b \in B(A)$ with $a \wedge b = F$, then A_a is isomorphic to A_b if and only if there exists an isomorphism ϕ on A such that $\phi(a) = b$.

Introduction

In [1], Guzmán and Squier introduced the variety of C-algebras as a class of algebras of type (2, 2, 1) satisfying certain identities and proved that this variety is generated by the 3-element algebra $C = \{T, F, U\}$ which is the algebraic semantic of the three valued conditional logic. In [3] Swamy et al. introduced the concept of the centre $B(A) = \{x \in A/x \vee x' = T\}$ of a C-algebra A with T and proved that $B(A)$ is a Boolean algebra with induced operations and is equivalent to the Boolean Centre of A. In [2], Rao and Sundarayya defined a partial ordering on a C-algebra A and the properties of A as a poset are studied.

In this paper, we prove that if A is a C-algebra, then for each $x \in A$, $A_x = \{s \in A/s \leq x\}$ is itself a C-algebra and is isomorphic to the quotient algebra A/θ_x, where $\theta_x = \{(s,t) \in A \times A/x \wedge s = x \wedge t\}$. If A is a C-algebra with T then, for every $a \in B(A)$, A is isomorphic to $A_a \times A_{a'}$ and conversely if A is isomorphic to $A_1 \times A_2$, then there exists an element $a \in B(A)$ such that A_1 is isomorphic to A_a and A_2 is isomorphic to $A_{a'}$. Using the above decomposition theorem we prove that for any $a, b \in B(A)$ with $a \wedge b = F$, A_a is isomorphic to A_b if and only if there exists an isomorphism on A which sends a to b.

1. Preliminaries

First, we recall the definition of a C-algebra and some results, which will be used in the later text.

Hindawi Publishing Corporation
International Journal of Mathematics and Mathematical Sciences
Volume 2006, Article ID 78981, Pages 1–8
DOI 10.1155/IJMMS/2006/78981

By a C-algebra we mean an algebra of type $(2,2,1)$ with operations $\wedge, \vee$, and $'$ satisfying the following properties:

(a) $x'' = x$;
(b) $(x \wedge y)' = x' \vee y'$;
(c) $(x \wedge y) \wedge z = x \wedge (y \wedge z)$;
(d) $x \wedge (y \vee z) = (x \wedge y) \vee (x \wedge z)$;
(e) $(x \vee y) \wedge z = (x \wedge z) \vee (x' \wedge y \wedge z)$;
(f) $x \vee (x \wedge y) = x$;
(g) $(x \wedge y) \vee (y \wedge x) = (y \wedge x) \vee (x \wedge y)$.

Clearly, every Boolean algebra is a C-algebra. The set $\{T, F, U\}$ is a C-algebra with operations $\wedge$, $\vee$, and $'$ given by

$\wedge$	T	F	U
T	T	F	U
F	F	F	F
U	U	U	U

$\vee$	T	F	U
T	T	T	T
F	T	F	U
U	U	U	U

X	X′
T	F
F	T
U	U

We denote this three-element C-algebra by C and the two-element C-algebra (Boolean algebra) $\{T, F\}$ by B. It can be observed that the identities (a), (b) imply that the variety of all C-algebras satisfies the dual statements of (b) to (g). In general $\wedge$ and $\vee$ are not commutative in C and the ordinary right distributive law of $\wedge$ over $\vee$ fails in C.

The following properties of a C-algebra can be verified directly [1, 3]:

(i) $x \wedge x = x$;
(ii) $x \wedge y = x \wedge (x' \vee y) = (x' \vee y) \wedge x$;
(iii) $x \vee (x' \wedge x) = (x' \wedge x) \vee x = x$;
(iv) $(x \vee x') \wedge y = (x \wedge y) \vee (x' \wedge y)$;
(v) $x \vee x' = x' \vee x$;
(vi) $x \vee y \vee x = x \vee y$;
(vii) $x \wedge x' \wedge y = x \wedge x'$.

If a C-algebra A has an identity for $\wedge$, then it is unique and we denote it by T. In this case, we say that A is a C-algebra with T. If we write F for T', then F is the identity for $\vee$. In a C-algebra, we have the following [1, 3]:

(viii) $x \vee y = F$ if and only if $x = y = F$;
(ix) if $x \vee y = T$, then $x \vee x' = T$;
(x) $x \vee T = x \vee x'$;
(xi) $T \vee x = T$ and $F \wedge x = F$;
(xii) for $a \in A$, $a' = a$ if and only if a is left zero of both $\wedge$ and $\vee$.

If there exists an element x in A such that $x' = x$, then it is unique and we denote it by U (U is called the uncertain element of A). An element $x \in A$ is called a central element of A if $x \vee x' = T$. The set $\{x \in A / x \vee x' = T\}$ of all central elements of A is called the centre of A and is denoted by $B(A)$. The set $B(A)$ of all central elements of A is a Boolean algebra with respect to the operations $\vee$, $\wedge$, and $'$ (of A) restricted to $B(A)$ [3].

For $x \in A$ define the relation θ_x on A by $\theta_x = \{(p,q) \in A \times A/x \wedge p = x \wedge q\}$ then θ_x is a congruence relation on A and $\theta_x \cap \theta_{x'} = \theta_x \vee_{x'}$ [1].

The relation $\leq$ defined on a C-algebra A by $x \leq y$ if $y \wedge x = x$ is a partial ordering on A in which, for every $x \in A$, the supremum of $\{x,x'\} = x \vee x'$, and the infimum of $\{x,x'\} = x \wedge x'$ [2]. If A is a C-algebra with T, $x \in B(A)$ and $y \in A$ are such that $x \wedge y = y \wedge x$, then $x \vee y$ is the lub of $\{x,y\}$ and in this case $y \vee x$ need not be the lub of x and y. For example, in the algebra C, $T \in B(C)$ and $T \wedge U = U \wedge T$ but $U \vee T = U$ is not the lub of $\{U,T\}$. If $x \leq y$, then $y \wedge x = x$ and hence $x \wedge y = x \wedge y \wedge x = x \wedge x = x$. Therefore $x \leq y$ if and only if $y \wedge x = x = x \wedge y$.

2. The C-algebra A_x

Recall that for every Boolean algebra B and $a \in B$ the set $(a] = \{x \in B/x \leq a\}([a) = \{x \in B/a \leq x\})$ is a Boolean algebra under the induced operations $\wedge$ and $\vee$ where complementation is defined by $x^* = a \wedge x'(x^* = a \vee x')$.

In this section, we prove that if A is a C-algebra and $x \in A$, then $A_x = \{s \in A/s \leq x\}$ is a C-algebra with $T(= x)$ under the induced operations and that A_x is isomorphic to a quotient algebra of A.

Theorem 2.1. *Let A be a C-algebra, $x \in A$, and $A_x = \{s \in A/s \leq x\}$. Then $\langle A_x, \wedge, \vee, *\rangle$ is a C-algebra with T where $\wedge$ and $\vee$ are the operations in A restricted to A_x, s^* is defined by $x \wedge s'$, and "x" is the identity for $\wedge$.*

Proof. Clearly A_x is closed under $\wedge$ and $\vee$. If $s \in A_x$, then $x \wedge s^* = x \wedge (x \wedge s') = (x \wedge x) \wedge s' = x \wedge s' = s^*$. So that $s^* \in A_x$ and $s^{**} = (s^*)^* = (x \wedge s')^* = x \wedge (x \wedge s')' = x \wedge (x' \vee s) = x \wedge s = s$ (since $s \leq x$).

Now, for $s,t \in A_x$, $(s \wedge t)^* = x \wedge (s \wedge t)' = x \wedge (s' \vee t') = (x \wedge s') \vee (x \wedge t') = s^* \vee t^*$.

Finally, for $s,t,u \in A_x$,

$$\begin{aligned}(s \vee t) \wedge u &= x \wedge ((s \vee t) \wedge u) = x \wedge ((s \wedge u) \vee (s' \wedge t \wedge u)) \\ &= ((x \wedge s) \wedge (x \wedge u)) \vee (x \wedge s' \wedge t \wedge u) \\ &= (s \wedge u) \vee (s^* \wedge t \wedge u).\end{aligned} \tag{2.1}$$

The remaining identities hold in A_x since they hold in A.

Hence $\langle A_x, \wedge, \vee, *\rangle$ is a C-algebra with "x" as the identity for $\wedge$. □

Observe that A_x is itself a C-algebra but it is not a subalgebra of A because the unary operation $*$ is not the restriction of $'$ to A_x. Now, we give some properties of A_x.

Theorem 2.2. *Let A be a C-algebra. Then the following hold:*
(i) $A_x = \{x \wedge s/s \in A\}$;
(ii) $A_x = A_y$ *if and only if* $x = y$;
(iii) $A_x \cap A_y \subseteq A_{x \wedge y}$;
(iv) $A_x \cap A_{x'} = A_{x \wedge x'}$;
(v) $(A_x)_{x \wedge y} = A_{x \wedge y}$.

Proof. (i), (ii), and (iii) can be verified routinely. We prove (iv) as follows. Let $s \in A_{x\wedge x'}$, then $(x \wedge x') \wedge s = s$ and hence $x \wedge s = x \wedge (x \wedge x' \wedge s) = x \wedge x' \wedge s = s$. Also we have $x' \wedge s = x' \wedge (x \wedge x' \wedge s) = s$, since $x \wedge x' = x' \wedge x$. Now we prove (v),

$$\begin{aligned}(A_x)_{x\wedge y} &= \{x \wedge y \wedge t/t \in A_x\} \quad \text{(by (i))} \\ &= \{x \wedge y \wedge x \wedge s/s \in A\} \\ &= \{x \wedge y \wedge s/s \in A\} = A_{x\wedge y}.\end{aligned} \tag{2.2}$$

□

Let A_1, A_2 be two C-algebras with T_1 and T_2. Then a mapping $f : A_1 \to A_2$ that preserves $\wedge$, $\vee$, $'$ and carries T_1 to T_2 is called a T-preserving C-algebra homomorphism. In future, we deal with C-algebras with T only and hence by a C-algebra homomorphism we mean a T-preserving C-algebra homomorphism. The following lemma can be verified routinely.

Lemma 2.3. *Let $f : A_1 \to A_2$ be a C-algebra homomorphism where A_1, A_2 are C-algebras with T_1 and T_2. Then*

(i) *if A_1 has the uncertain element U, then $f(U)$ is the uncertain element of A_2;*

(ii) *if $a \in B(A_1)$, then $f(a) \in B(A_2)$. The converse holds if f is one-one.*

Now we prove the following.

Theorem 2.4. *Let A be a C-algebra with T and $x \in A$, then the mapping α_x: $A \to A_x$ defined by $\alpha_x(s) = x \wedge s$ for all $s \in A$ is a homomorphism of A onto A_x with kernel θ_x and hence $A/\theta_x \cong A_x$.*

Proof. For $s \in A$, $x \wedge s \le x$ and hence $x \wedge s \in A_x$. Let $s, t \in A$, then

$$\begin{aligned}\alpha_x(s \wedge t) &= x \wedge s \wedge t = x \wedge s \wedge x \wedge t = \alpha_x(s) \wedge \alpha_x(t), \\ \alpha_x(s') &= x \wedge s' = x \wedge (x' \vee s') \quad \text{(by (ii) in the preliminaries)} \\ &= x \wedge (x \wedge s)' = (x \wedge s)^* = (\alpha_x(s))^*.\end{aligned} \tag{2.3}$$

Clearly, $\alpha_x(s \vee t) = \alpha_x(s) \vee \alpha_x(t)$ and $\alpha_x(T) = a$. Hence α_x is a C-algebra homomorphism. Now, for $s \in A_x$, we have $\alpha_x(s) = s$. Therefore α_x is onto homomorphism. Hence by the fundamental theorem of homomorphism $A/_{\text{Ker}}\alpha_x \cong A_x$ and Ker $\alpha_x = \{(s,t) \in A \times A/\alpha_x(s) = \alpha_x(t)\} = \{(s,t) \in A \times A/x \wedge s = x \wedge t\} = \theta_x$. Thus $A/\theta_x \cong A_x$. □

3. Decompositions of A

If B is a Boolean algebra and $a \in B$, then we know that B is isomorphic to $(a] \times [a)$. In this section we prove similar decompositions for a C-algebra. If A is a C-algebra with T and $a \in B(A)$, then we prove that A is isomorphic to $A_a x A_{a'}$ and conversely. We also prove that if $a, b \in B(A)$ and $a \wedge b = F$, then A_a is isomorphic to A_b if and only if there is an automorphism on A that carries a to b. First we prove the following.

Lemma 3.1. *Let A be a C-algebra with T, $a \in B(A)$ and $x, y \in A$. Then*

$$a \vee x = a \vee y, \qquad a' \vee x = a' \vee y \Longleftrightarrow x = y. \tag{3.1}$$

Proof. Let $a \in B(A)$ and $x, y \in A$. Assume that $a \vee x = a \vee y$ and $a' \vee x = a' \vee y$. Then

$$\begin{aligned} x = F \vee x &= (a \wedge a') \vee x = (a \vee x) \wedge (a' \vee x) \\ &= (a \vee y) \wedge (a' \vee y) = (a \wedge a') \vee y = F \vee y = y. \end{aligned} \tag{3.2}$$

The converse is trivial □

Note that Lemma 3.1 fails if $a \notin B(A)$. For example, in the C-algebra C, we have $U \notin B(C), U \vee T = U \vee F = U,$and $U' \vee T = U' \vee F = U$, but $T \neq F$.

Now we prove the following decomposition theorem.

Theorem 3.2. *If A is a C-algebra with T and $a \in B(A)$, then $A \cong A_a \times A_{a'}$.*

Proof. Define $\alpha : A \to A_a \times A_{a'}$ by

$$\alpha(x) = \left(\alpha_a(x), \alpha_{a'}(x)\right) \quad \forall x \in A. \tag{3.3}$$

Then, by Theorem 2.4, α is well defined and α is a homomorphism.

Now, $\alpha(x) = \alpha(y) \Rightarrow a \wedge x = a \wedge y$ and $a' \wedge x = a' \wedge y$. Hence $x = y$ (by the dual of Lemma 3.1). Finally, we prove α is onto. Let $(x, y) \in A_a \times A_{a'}$. Then $x \leq a$ and $y \leq a'$. So that $a \wedge x = x$ and $a' \wedge y = y$.

Thus, $a' \wedge x = a' \wedge a \wedge x = F$ and $a \wedge y = a \wedge a' \wedge y = F$.

Now,

$$\begin{aligned} x \vee y \in A, \quad \alpha(x \vee y) &= \left(\alpha_a(x \vee y), \alpha_{a'}(x \vee y)\right) \\ &= \left(a \wedge (x \vee y), a' \wedge (x \vee y)\right) \\ &= \left((a \wedge x) \vee (a \wedge y), (a' \wedge x) \vee (a' \wedge y)\right) \\ &= (x \vee F, F \vee y) = (x, y). \end{aligned} \tag{3.4}$$

Hence α is an isomorphism. □

Now we prove the converse of the above theorem in the following sense.

Theorem 3.3. *Let A, A_1, A_2 be C-algebras with T such that $A \cong A_1 \times A_2$. Then there exists an element $a \in B(A)$ such that*

$$A_1 \cong A_a, \qquad A_2 \cong A_{a'}. \tag{3.5}$$

Proof. Let $\phi : A \to A_1 \times A_2$ be an isomorphism and $a = \phi^{-1}(T_1, F_2)$ (when T_1, T_2 denote the $\wedge$-identities of A_1, A_2, resp.)

Now $(T_1, F_2) \in B(A_1) \times B(A_2) = B(A_1 \times A_2)$ and hence $a \in B(A)$.

Define $f : A_1 \to A_a$ by $f(x_1) = \phi^{-1}(x_1, F_2)$ for all $x_1 \in A_1$.

Now

$$\begin{aligned} a \wedge \phi^{-1}(x_1, F_2) &= \phi^{-1}(T_1, F_2) \wedge \phi^{-1}(x_1, F_2) \\ &= \phi^{-1}(x_1, F_2) \quad (\text{since } \phi^{-1} \text{ is a homomorphism}). \end{aligned} \tag{3.6}$$

Therefore $\phi^{-1}(x_1, F_2) \in A_a$. Thus f is well defined.

It can be routinely verified that f preserves $\wedge$, $\vee$ and that f is one-one.

Now we prove that f preserves the unary operation $'$.

Let $x_1 \in A_1$, then

$$\begin{aligned} f(x_1') &= \phi^{-1}(x_1', F_2) = \phi^{-1}(T_1 \wedge x_1', F_2 \wedge T_2) \\ &= \phi^{-1}(T_1, F_2) \wedge \phi^{-1}(x_1', T_2) \quad (\text{since } \phi^{-1} \text{ is homomorphism}) \\ &= a \wedge (\phi^{-1}(x_1, F_2))' = a \wedge f(x_1)' = (f(x_1))^*. \end{aligned} \tag{3.7}$$

Finally, we prove f is onto.

Let $x \in A_a$. Then $\phi(x) = (x_1, x_2)$ for some $x_1 \in A_1$, $x_2 \in A_2$.

Now

$$\begin{aligned} (x_1, x_2) &= \phi(x) = \phi(a \wedge x) = \phi(a) \wedge \phi(x) \\ &= (T_1, F_2) \wedge (x_1, x_2) = (x_1, F_2). \end{aligned} \tag{3.8}$$

Thus $x_2 = F_2$ and $f(x_1) = \phi^{-1}(x_1, F_2) = \phi^{-1}(x_1, x_2) = x$.

Hence f is onto. Thus $A_1 \cong A_a$. Similarly $A_2 \cong A_{a'}$. □

Finally, for $a, b \in B(A)$ with $a \wedge b = F$, we derive a necessary and sufficient condition for A_a to be isomorphic to A_b. First we prove the following lemmas.

Lemma 3.4. *If A is a C-algebra with T, $a \in B(A)$, $x \in A_a$, and $y \in A_{a'}$, then $x \vee y = y \vee x$.*

Proof. Let $x \in A_a$, $y \in A_{a'}$. Then $x \leq a$ and $y \leq a'$. Hence $a \wedge y = F = a' \wedge x$. Now

$$\begin{aligned} a \wedge (x \vee y) &= (a \wedge x) \vee (a \wedge y) = x \vee F = x, \\ a \wedge (y \vee x) &= (a \wedge y) \vee (a \wedge x) = F \vee x = x. \end{aligned} \tag{3.9}$$

Therefore, $a \wedge (x \vee y) = a \wedge (y \vee x)$. Similarly $a' \wedge (x \vee y) = a' \wedge (y \vee x)$.

By the dual of Lemma 3.1,

$$x \vee y = y \vee x. \tag{3.10}$$

□

LEMMA 3.5. *Let A be a C-algebra with T. Then, for $a, b \in B(A)$, $a \wedge b \in B(A_a)$.*

Proof. Clearly $a \wedge b \leq a$. Now

$$\begin{aligned}(a \wedge b) \vee (a \wedge b)^* &= (a \wedge b) \vee (a \wedge (a \wedge b)') \\ &= (a \wedge b) \vee [a \wedge (a' \vee b')] = (a \wedge b) \vee (a \wedge b') \\ &= a \wedge (b \vee b') = a \wedge T = a.\end{aligned} \tag{3.11}$$

Hence, $a \wedge b \in B(A_a)$. □

Now, we prove the theorem.

THEOREM 3.6. *Let A be a C-algebra with T and $a, b \in B(A)$ such that $a \wedge b = F$. Then A_a is isomorphic to A_b if and only if there exists an isomorphism $\alpha : A \to A$ such that $\alpha(a) = b$.*

Proof. Let $a, b \in B(A)$ with $a \wedge b = F$. Let $\phi : A_a \to A_b$ be an isomorphism.

Now $a' \wedge b = (a' \wedge b) \vee F = (a' \wedge b) \vee (a \wedge b) = (a' \vee a) \wedge b = b$ because $B(A)$ is a Boolean algebra. So that $b \in A_{a'}$ and $b^* = a' \wedge b'$. Similarly, $b' \wedge a = a$. Now by Theorems 2.2, 3.2, and Lemma 3.5, we have

(i) $A \cong A_a \times A_{a'} \cong A_a \times A_{a' \wedge b} \times A_{(a' \wedge b)^*} = A_a \times A_b \times A_{a' \wedge b'}$
under the isomorphism $x \overset{\beta}{\mapsto} (a \wedge x,\ b \wedge x,\ (a' \wedge b') \wedge x)$;

(ii) $A \cong A_b \times A_{b'} \cong A_b \times A_{b' \wedge a} \times A_{(b' \wedge a)^*} \cong A_b \times A_a \times A_{a' \wedge b'}$
under the isomorphism $x \overset{\gamma}{\mapsto} (b \wedge x,\ a \wedge x,\ (a' \wedge b') \wedge x)$;

(iii) $A_a \times A_b \times A_{a' \wedge b'} \cong A_b \times A_a \times A_{a' \wedge b'}$
under the isomorphism $(x, y, z) \overset{\delta}{\mapsto} (\phi(x), \phi^{-1}(y), z)$.

Now define $\alpha : A \to A$ by $\alpha = \gamma^{-1} \circ \delta \circ \beta$. Then α is an isomorphism of A onto A and

$$\begin{aligned}\alpha(a) &= (\gamma^{-1} \circ \delta \circ \beta)(a) = \gamma^{-1}(\delta(a, F, F)) \quad (\text{since } b \wedge a = F = a \wedge a') \\ &= \gamma^{-1}(b, F, F) \quad (\text{since } \phi\,(a) = b,\ \phi(F) = F) \\ &= b \quad (\text{since } \gamma(b) = (b, F, F)).\end{aligned} \tag{3.12}$$

Hence α is an isomorphism of A such that $\alpha(a) = b$.

Conversely, suppose that $\alpha : A \to A$ is an isomorphism such that $\alpha(a) = b$.

Let λ be the restriction of α to A_a. Now we prove that λ is an isomorphism of A_a onto A_b. For $x \in A_a$,

$$b \wedge \lambda(x) = b \wedge \alpha(x) = \alpha(a) \wedge \alpha(x) = \alpha(a \wedge x) = \alpha(x) = \lambda(x). \tag{3.13}$$

So that $\lambda(x) \in A_b$. Hence λ is well defined. Clearly λ is a homomorphism and one-one. Let $x \in A_b$. Since α is onto, there exists $y \in A$ such that $\alpha(y) = x$. Now $a \wedge y \in A_a$ and $\lambda(a \wedge y) = \alpha(a \wedge y) = \alpha(a) \wedge \alpha(y) = b \wedge x = x$ (since $x \leq b$).

Hence λ is an isomorphism of A_a onto A_b. □

Acknowledgments

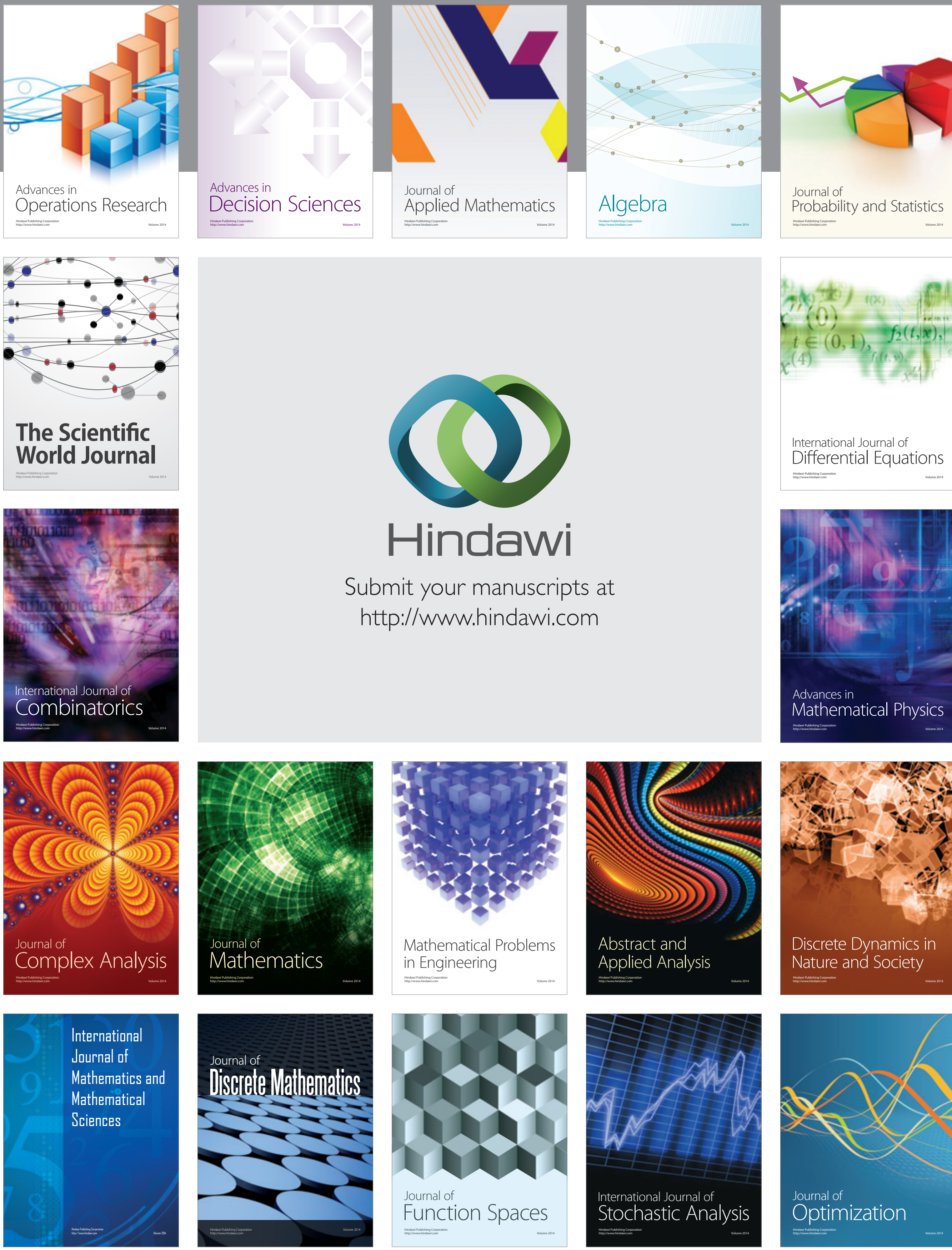
The authors thank Professor U. M. Swamy for his support and guidance in the preparation of this paper. The second author gratefully acknowledges University Grants Commission for their financial support in the form of UGC-JRF. We thank referees for their helpful suggestions.

References

[1] F. Guzmán and C. C. Squier, *The algebra of conditional logic*, Algebra Universalis **27** (1990), no. 1, 88–110.
[2] G. C. Rao and P. Sundarayya, *C-algebra as a poset*, International Journal of Mathematical Sciences, **4** (2005), no. 2, 225–236.
[3] U. M. Swamy, G. C. Rao, and R. V. G. Ravi Kumar, *Centre of a C-algebra*, Southeast Asian Bulletin of Mathematics **27** (2003), no. 2, 357–368.

G. C. Rao: Department of Mathematics, Andhra University, Visakhapatnam 530 003, India
E-mail address: gcraomaths@mail.yahoo.co.in

P. Sundarayya: Department of Mathematics, Andhra University, Visakhapatnam 530 003, India
E-mail address: psundarayya@yahoo.co.in


Advances in
Operations Research
Advances in
Decision Sciences
Journal of
Applied Mathematics
Algebra
Journal of
Probability and Statistics
The Scientific
World Journal
International Journal of
Differential Equations
Hindawi
Submit your manuscripts at
http://www.hindawi.com
International Journal of
Combinatorics
Advances in
Mathematical Physics
Journal of
Complex Analysis
Journal of
Mathematics
Mathematical Problems
in Engineering
Abstract and
Applied Analysis
Discrete Dynamics in
Nature and Society
International
Journal of
Mathematics and
Mathematical
Sciences
Journal of
Discrete Mathematics
Journal of
Function Spaces
International Journal of
Stochastic Analysis
Journal of
Optimization