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ANTI MULTI FUZZY SUBHEMIRINGS OF A HEMIRING

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ABSTRACT

In this paper, we made an attempt to study the algebraic nature of an anti multi fuzzy subhemiring of a hemiring.

Key Words: *Fuzzy subset, multi fuzzy subset, multi fuzzy subhemiring, anti multi fuzzy subhemiring, pseudo anti multi fuzzy coset.*

INTRODUCTION

There are many concepts of universal algebras generalizing an associative ring (*R ; + ; .*). Some of them in particular, nearrings and several kinds of semirings have been proven very useful. An algebra (R ; +, .) is said to be a semiring if (R; +) and (R ; .) are semigroups satisfying a. (b+c) = a. b+a. c and (b+c) .a = b. a+c. a for all a, b and c in R. A semiring R is said to be additively commutative if a+b = b+a for all a, b and c in R. A semiring R may have an identity 1, defined by 1.a = a = a.1 and a zero 0, defined by 0+a = a = a+0 and a.0 = 0 = 0.a for all a in R. A semiring R is said to be a hemiring if it is an additively commutative with zero. After the introduction of fuzzy sets by L.A.Zadeh[13], several researchers explored on the generalization of the concept of fuzzy sets. The notion of anti fuzzy left h-ideals in hemiring was introduced by Akram.M and K.H.Dar [1]. The notion of homomorphism and anti-homomorphism of fuzzy and anti-fuzzy ideal of a ring was introduced by N.Palaniappan & K.Arjunan[8]. In this paper, we introduce some Theorems in anti multi fuzzy subhemiring of a hemiring.

1.PRELIMINARIES

1.1 Definition: Let X be a non-empty set. A **fuzzy subset** A of X is a function $A : X \to [0, 1]$.

1.2 Definition: A **multi fuzzy subset** A of a set X is defined as an object of the form $A = \{\langle x, \mu_{A1}(x), \mu_{A2}(x), \mu_{A3}(x), \ldots, \mu_{An}(x)\rangle / x\in X\}$, where $\mu_{Ai} : X\to[0, 1]$ for all i. It is denoted as $A = \langle \mu_{A1}, \mu_{A2}, \mu_{A3}, \ldots, \mu_{An} \rangle$.

1.3 Definition: Let A and B be any two multi fuzzy subsets of a set X. We define the following relations and operations:

(i) $A \subseteq B$ if and only if $\mu_{Ai}(x) \le \mu_{Bi}(x)$ for all i and for all x in X.
(ii) A = B if and only if $\mu_{Ai}(x) = \mu_{Bi}(x)$ for all i and for all x in X.
(iii) $A^c = 1-A = \langle 1-\mu_{A1}, 1-\mu_{A2}, 1-\mu_{A3}, \ldots, 1-\mu_{An} \rangle$.
(iv) $A\cap B = \{\langle x, \min\{\mu_{A1}(x), \mu_{B1}(x)\}, \min\{\mu_{A2}(x), \mu_{B2}(x)\}, \ldots, \min\{\mu_{An}(x), \mu_{Bn}(x)\}\rangle / x\in X\}$.
(v) $A\cup B = \{\langle x, \max\{\mu_{A1}(x), \mu_{B1}(x)\}, \max\{\mu_{A2}(x), \mu_{B2}(x)\}, \ldots, \max\{\mu_{An}(x), \mu_{Bn}(x)\}\rangle / x\in X\}$.

1.4 Definition: Let (R, +, .) be a hemiring. A multi fuzzy subset A of R is said to be a multi fuzzy subhemiring of R if it satisfies the following conditions:

(i) $\mu_{Ai}(x+y) \ge \min(\mu_{Ai}(x), \mu_{Ai}(y))$ for all i,
(ii) $\mu_{Ai}(xy) \ge \min(\mu_{Ai}(x), \mu_{Ai}(y))$, for all i and for all x, y in R.

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1.5 Definition: Let (R, +, .) be a hemiring. A multi fuzzy subset A of R is said to be an anti multi fuzzy subhemiring of R if it satisfies the following conditions:

(i) $\mu_{Ai}(x+y) \le \max(\mu_{Ai}(x), \mu_{Ai}(y))$ for all i,

(ii) $\mu_{Ai}(xy) \le \max(\mu_{Ai}(x), \mu_{Ai}(y))$, for all i and for all x, y in R.

1.6 Definition: Let A and B be multi fuzzy subsets of sets G and H, respectively. The anti-product of A and B, denoted by A×B, is defined as $A\times B = \{\langle (x, y), \mu_{A1\times B1}(x, y), \mu_{A2\times B2}(x, y), \ldots, \mu_{An\times Bn}(x, y)\rangle$ / for all x in G and y in H}, where $\mu_{Ai\times Bi}(x, y) = \max\{\mu_{Ai}(x), \mu_{Bi}(y)\}$ for all i.

1.7 Definition: Let A be a multi fuzzy subset in a set S, the anti-strongest multi fuzzy relation on S, that is a multi fuzzy relation on A is V given by $\mu_{Vi}(x, y) = \max\{\mu_{Ai}(x), \mu_{Ai}(y)\}$, for all i and for all x, y in S.

1.8 Definition: Let (R, +, .) and (R^{l}, +, .) be any two hemirings. Let f: R → R^{l} be any function and A be an anti multi fuzzy subhemiring in R, V be an anti multi fuzzy subhemiring in f(R) = R^{l}, defined by $\mu_{Vi}(y) = \inf_{x\in f^{-1}(y)} \mu_{Ai}(x)$, for all i and for all x in R and y in R^{l}. Then A is called a preimage of V under f and is denoted by $f^{-1}(V)$.

1.9 Definition: Let A be an anti multi fuzzy subhemiring of a hemiring (R, +, .) and a in R. Then the pseudo anti multi fuzzy coset $(aA)^p$ is defined by $((a\mu_{Ai})^p)(x) = p(a)\mu_{Ai}(x)$, for all i and for every x in R and for some p in P.

2. PROPERTIES OF ANTI MULTI FUZZY SUBHEMIRING OF A HEMIRING

2.1 Theorem: Union of any two anti multi fuzzy subhemiring of a hemiring R is an anti multi fuzzy subhemiring of R.

Proof: Let A and B be any two anti multi fuzzy subhemirings of a hemiring R and x and y in R. Let A = {(x, $\mu_{A1}(x)$, $\mu_{A2}(x)$, …, $\mu_{An}(x)$) / x∈R} and B = {(x, $\mu_{B1}(x)$, $\mu_{B2}(x)$, …, $\mu_{Bn}(x)$) / x∈R} and also let C = A∪B = {(x, $\mu_{C1}(x)$, $\mu_{C2}(x)$, …, $\mu_{Cn}(x)$) / x∈R}, where $\max\{\mu_{Ai}(x), \mu_{Bi}(x)\} = \mu_{Ci}(x)$ for all i. Now, $\mu_{Ci}(x+y) \le \max\{\max(\mu_{Ai}(x), \mu_{Ai}(y)), \max(\mu_{Bi}(x), \mu_{Bi}(y))\} \le \max(\mu_{Ci}(x), \mu_{Ci}(y))$. Therefore, $\mu_{Ci}(x+y) \le \max(\mu_{Ci}(x), \mu_{Ci}(y))$, for all i and for all x, y in R. And, $\mu_{Ci}(xy) \le \max\{\max(\mu_{Ai}(x), \mu_{Ai}(y)), \max(\mu_{Bi}(x), \mu_{Bi}(y))\} \le \max(\mu_{Ci}(x), \mu_{Ci}(y))$. Therefore $\mu_{Ci}(xy) \le \max(\mu_{Ci}(x), \mu_{Ci}(y))$, for all i and for all x, y in R. Therefore C is an anti multi fuzzy subhemiring of a hemiring R.

2.2 Theorem: The union of a family of anti multi fuzzy subhemirings of hemiring R is an anti multi fuzzy subhemiring of R.

Proof: It is trivial.

2.3 Theorem: If A and B are any two anti multi fuzzy subhemirings of the hemirings R_1 and R_2 respectively, then anti-product A×B is an anti multi fuzzy subhemiring of $R_1\times R_2$.

Proof: Let A and B be two anti multi fuzzy subhemirings of the hemirings R_1 and R_2 respectively. Let x_1 and x_2 be in R_1, y_1 and y_2 be in R_2. Then (x_1, y_1) and (x_2, y_2) are in $R_1\times R_2$. Now, $\mu_{Ai\times Bi}[(x_1, y_1) + (x_2, y_2)] \le \max\{\max(\mu_{Ai}(x_1), \mu_{Ai}(x_2)), \max(\mu_{Bi}(y_1), \mu_{Bi}(y_2))\} \le \max(\mu_{Ai\times Bi}(x_1, y_1), \mu_{AixBi}(x_2, y_2))$. Therefore $\mu_{Ai\times Bi}[(x_1, y_1) + (x_2, y_2)] \le \max(\mu_{Ai\times Bi}(x_1, y_1), \mu_{Ai\times Bi}(x_2, y_2))$ for all i. Also $\mu_{Ai\times Bi}[(x_1, y_1)(x_2, y_2)] \le \max\{\max(\mu_{Ai}(x_1), \mu_{Ai}(x_2)), \max(\mu_{Bi}(y_1), \mu_{Bi}(y_2))\} \le \max(\mu_{AixBi}(x_1, y_1), \mu_{AixBi}(x_2, y_2))$. Therefore $\mu_{Ai\times Bi}[(x_1, y_1)(x_2, y_2)] \le \max(\mu_{AixBi}(x_1, y_1), \mu_{AixBi}(x_2, y_2))$ for all i. Hence A×B is an anti multi fuzzy subhemiring of hemiring of $R_1\times R_2$.

2.4 Theorem: Let A be a multi fuzzy subset of a hemiring R and V be the anti-strongest multi fuzzy relation of R. Then A is an anti multi fuzzy subhemiring of R if and only if V is an anti multi fuzzy subhemiring of R×R.

Proof: Suppose that A is an anti multi fuzzy subhemiring of a hemiring R. Then for any $x = (x_1, x_2)$ and $y = (y_1, y_2)$ are in R×R. We have, $\mu_{Vi}(x+y) = \max\{\mu_{Ai}(x_1+ y_1), \mu_{Ai}(x_2+y_2)) \le \max\{\max(\mu_{Ai}(x_1), \mu_{Ai}(y_1)), \max(\mu_{Ai}(x_2), \mu_{Ai}(y_2))\} \le \max(\mu_{Vi}(x_1, x_2), \mu_{Vi}(y_1, y_2)) = \max(\mu_{Vi}(x), \mu_{Vi}(y))$. Therefore $\mu_{Vi}(x+y) \le \max(\mu_{Vi}(x), \mu_{Vi}(y))$, for all i and for all x, y in R×R. And $\mu_{Vi}(xy) = \max\{\mu_{Ai}(x_1y_1), \mu_{Ai}(x_2y_2)\} \le \max\{\max(\mu_{Ai}(x_1), \mu_{Ai}(y_1)), \max(\mu_{Ai}(x_2), \mu_{Ai}(y_2))\} \le \max(\mu_{Vi}(x_1, x_2), \mu_{Vi}(y_1, y_2)) = \max(\mu_{Vi}(x), \mu_{Vi}(y))$. Therefore $\mu_{Vi}(xy) \le \max(\mu_{Vi}(x), \mu_{Vi}(y))$, for all i and for all x, y in R×R. This proves that V is an anti multi fuzzy subhemiring of R×R. Conversely assume that V is an anti multi fuzzy subhemiring of R×R, then for any $x = (x_1, x_2)$ and $y = (y_1, y_2)$ are in R×R, we have $\max\{\mu_{Ai}(x_1+y_1), \mu_{Ai}(x_2+y_2)\} = \mu_{Vi}(x+y) \le \max(\mu_{Vi}(x), \mu_{Vi}(y)) = \max(\mu_{Vi}(x_1, x_2), \mu_{Vi}(y_1, y_2)) = \max(\max\{(\mu_{Ai}(x_1), \mu_{Ai}(x_2)\}, \max\{\mu_{Ai}(y_1), \mu_{Ai}(y_2)\}$. If $x_2 = 0$, $y_2 = 0$, we get, $\mu_{Ai}(x_1+y_1) \le \max(\mu_{Ai}(x_1), \mu_{Ai}(y_1))$, for all i and for all x_1, y_1 in R. And $\max\{\mu_{Ai}(x_1y_1), \mu_{Ai}(x_2y_2)\} = \mu_{Vi}(xy) \le \max(\mu_{Vi}(x), \mu_{Vi}(y)) = \max(\mu_{Vi}(x_1, x_2), \mu_{Vi}(y_1, y_2)) = \max(\max\{\mu_{Ai}(x_1), \mu_{Ai}(x_2)\}, \max\{\mu_{Ai}(y_1), \mu_{Ai}(y_2)\}$. If $x_2 = 0$, $y_2 = 0$, we get $\mu_{Ai}(x_1y_1) \le \max(\mu_{Ai}(x_1), \mu_{Ai}(y_1))$, for all i and for all x_1, y_1 in R. Therefore A is an anti multi fuzzy subhemiring of R.

2.5 Theorem: A is an anti multi fuzzy subhemiring of a hemiring (R, +, .) if and only if $\mu_{Ai}(x+y) \leq \max(\mu_{Ai}(x), \mu_{Ai}(y))$, $\mu_{Ai}(xy) \leq \max(\mu_{Ai}(x), \mu_{Ai}(y))$, for all i and for all x, y in R.

Proof: It is trivial.

2.6 Theorem: If A is an anti multi fuzzy subhemiring of a hemiring (R, +, .), then $H = \{x / x \in R: \mu_{Ai}(x) = 0$, for all i$\}$ is either empty or is a subhemiring of R.

Proof: It is trivial.

2.7 Theorem: Let A be an anti multi fuzzy subhemiring of a hemiring (R, +, .). If $\mu_{Ai}(x+ y) = 1$, then either $\mu_{Ai}(x) = 1$ or $\mu_{Ai}(y) = 1$, for all i and for all x and y in R.

Proof: It is trivial.

2.8 Theorem: Let A be an anti multi fuzzy subhemiring of a hemiring (R, +, .), then the pseudo anti multi fuzzy coset $(aA)^p$ is an anti multi fuzzy subhemiring of a hemiring R, for every a in R.

Proof: Let A be an anti multi fuzzy subhemiring of a hemiring R. For every x and y in R, we have, $((a\mu_{Ai})^p)(x+y) \leq p(a) \max(\mu_{Ai}(x), \mu_{Ai}(y)) \leq \max(p(a)\mu_{Ai}(x), p(a)\mu_{Ai}(y)) = \max(((a\mu_{Ai})^p)(x), ((a\mu_{Ai})^p)(y))$. Therefore, $((a\mu_{Ai})^p)(x+y) \leq \max((a\mu_{Ai})^p)(x), ((a\mu_{Ai})^p)(y))$ for all i. Now, $((a\mu_{Ai})^p)(xy) \leq p(a) \max(\mu_{Ai}(x), \mu_{Ai}(y)) \leq \max (p(a)\mu_{Ai}(x), p(a)\mu_{Ai}(y)) = \max (((a\mu_{Ai})^p)(x), ((a\mu_{Ai})^p)(y))$. Therefore, $((a\mu_{Ai})^p)(xy) \leq \max(((a\mu_{Ai})^p)(x), ((a\mu_{Ai})^p)(y))$ for all i. Hence $(aA)^p$ is an anti multi fuzzy subhemiring of a hemiring R.

2.9 Theorem: Let (R, + , .) and (R^I, +, .) be any two hemirings. The homomorphic image of an anti multi fuzzy subhemiring of R is an anti multi fuzzy subhemiring of R^I.

Proof: Let $f: R \rightarrow R^I$ be a homomorphism. Then, $f(x+y) = f(x) + f(y)$ and $f(xy) = f(x)f(y)$, for all x and y in R. Let V = f(A), where A is an anti multi fuzzy subhemiring of R. Now, for f(x), f(y) in R^I, $\mu_{Vi}(f(x)+f(y)) \leq \mu_{Ai}(x+y) \leq \max (\mu_{Ai}(x), \mu_{Ai}(y))$, which implies that $\mu_{Vi}(f(x)+f(y)) \leq \max(\mu_{Vi}(f(x)), \mu_{Vi}(f(y)))$ for all i. Again, $\mu_{Vi}(f(x)f(y)) \leq \mu_{Ai}(xy) \leq \max (\mu_{Ai}(x), \mu_{Ai}(y))$, which implies that $\mu_{Vi}(f(x)f(y)) \leq \max (\mu_{Vi}(f(x)), \mu_{Vi}(f(y)))$ for all i. Hence V is an anti multi fuzzy subhemiring of R^I.

2.10 Theorem: Let (R, +, .) and (R^I, +, .) be any two hemirings. The homomorphic preimage of an anti multi fuzzy subhemiring of R^I is an anti multi fuzzy subhemiring of R.

Proof: Let V = f(A), where V is an anti multi fuzzy subhemiring of R^I. Let x and y in R. Then, $\mu_{Ai}(x+y) = \mu_{Vi}(f(x+y)) \leq \max (\mu_{Vi}(f(x)), \mu_{Vi}(f(y))) = \max (\mu_{Ai}(x), \mu_{Ai}(y))$, which implies that $\mu_{Ai}(x+y) \leq \max (\mu_{Ai}(x), \mu_{Ai}(y))$ for all i. Again, $\mu_{Ai}(xy) = \mu_{Vi}(f(xy)) \leq \max (\mu_{Vi}(f(x)), \mu_{Vi}(f(y))) = \max (\mu_{Ai}(x), \mu_{Ai}(y))$ which implies that $\mu_{Ai}(xy) \leq \max (\mu_{Ai}(x), \mu_{Ai}(y))$ for all i. Hence A is an anti multi fuzzy subhemiring of R.

2.11 Theorem: Let (R, +, .) and (R^I, +, .) be any two hemirings. The anti-homomorphic image of an anti multi fuzzy subhemiring of R is an anti multi fuzzy subhemiring of R^I.

Proof: Let $f: R \rightarrow R^I$ be an anti-homomorphism. Then, $f(x+y) = f(y)+f(x)$ and $f(xy) = f(y)f(x)$, for all x and y in R. Let V = f(A), where A is an anti multi fuzzy subhemiring of R. Now, for f(x), f(y) in R^I, $\mu_{Vi}(f(x)+f(y)) \leq \mu_{Ai}(y+x) \leq \max (\mu_{Ai}(y), \mu_{Ai}(x)) = \max (\mu_{Ai}(x), \mu_{Ai}(y))$ which implies that $\mu_{Vi}(f(x)+f(y)) \leq \max (\mu_{Vi}(f(x)), \mu_{Vi}(f(y)))$ for all i. Again, $\mu_{Vi}(f(x)f(y)) \leq \mu_{Ai}(yx) \leq \max (\mu_{Ai}(y), \mu_{Ai}(x)) = \max (\mu_{Ai}(x), \mu_{Ai}(y))$ which implies that $\mu_{Vi}(f(x)f(y)) \leq \max (\mu_{Vi}(f(x)), \mu_{Vi}(f(y)))$ for all i. Hence V is an anti multi fuzzy subhemiring of R^I.

2.12 Theorem: Let (R, + , .) and (R^I, +, .) be any two hemirings. The anti-homomorphic preimage of an anti multi fuzzy subhemiring of R^I is an anti multi fuzzy subhemiring of R.

Proof: Let V = f(A), where V is an anti multi fuzzy subhemiring of R^I. Let x and y in R. Then, $\mu_{Ai}(x+y) = \mu_{Vi}(f(x+y)) \leq \max (\mu_{Vi}(f(y)), \mu_{Vi}(f(x))) = \max (\mu_{Ai}(x), \mu_{Ai}(y))$ which implies that $\mu_{Ai}(x+y) \leq \max (\mu_{Ai}(x), \mu_{Ai}(y))$ for all i. Again, $\mu_{Ai}(xy) = \mu_{Vi}(f(xy)) \leq \max (\mu_{Vi}(f(y)), \mu_{Vi}(f(x))) = \max (\mu_{Ai}(x), \mu_{Ai}(y))$ which implies that $\mu_{Ai}(xy) \leq \max(\mu_{Ai}(x), \mu_{Ai}(y))$ for all i. Hence A is an anti multi fuzzy subhemiring of R.

2.13 Theorem: Let A be an anti multi fuzzy subhemiring of a hemiring H and f is an isomorphism from a hemiring R onto H. Then $A \circ f$ is an anti multi fuzzy subhemiring of R.

Proof: Let x and y in R. Then we have, $(\mu_{Ai}\circ f)(x+y) = \mu_{Ai}(f(x) + f(y)) \leq \max(\mu_{Ai}(f(x)), \mu_{Ai}(f(y))) \leq \max((\mu_{Ai}\circ f)(x), (\mu_{Ai}\circ f)(y))$ which implies that $(\mu_{Ai}\circ f)(x+y) \leq \max((\mu_{Ai}\circ f)(x), (\mu_{Ai}\circ f)(y))$ for all i. And $(\mu_{Ai}\circ f)(xy) = \mu_{Ai}(f(x)f(y)) \leq \max(\mu_{Ai}(f(x)), \mu_{Ai}(f(y))) \leq \max((\mu_{Ai}\circ f)(x), (\mu_{Ai}\circ f)(y))$ which implies that $(\mu_{Ai}\circ f)(xy) \leq \max((\mu_{Ai}\circ f)(x), (\mu_{Ai}\circ f)(y))$ for all i. Therefore A◦f is an anti multi fuzzy subhemiring of a hemiring R.

2.14 Theorem: Let A be an anti multi fuzzy subhemiring of a hemiring H and f is an anti-isomorphism from a hemiring R onto H. Then A◦f is an anti multi fuzzy subhemiring of R.

Proof: Let x and y in R. Then we have, $(\mu_{Ai}\circ f)(x+y) = \mu_{Ai}(f(y)+f(x)) \leq \max(\mu_{A}(f(x)), \mu_{Ai}(f(y))) \leq \max((\mu_{Ai}\circ f)(x), (\mu_{Ai}\circ f)(y))$, which implies that $(\mu_{Ai}\circ f)(x+y) \leq \max((\mu_{Ai}\circ f)(x), (\mu_{Ai}\circ f)(y))$ for all i. And $(\mu_{Ai}\circ f)(xy) = \mu_{Ai}(f(y)f(x)) \leq \max(\mu_{Ai}(f(x)), \mu_{Ai}(f(y))) \leq \max((\mu_{Ai}\circ f)(x), (\mu_{Ai}\circ f)(y))$, which implies that $(\mu_{Ai}\circ f)(xy) \leq \max((\mu_{Ai}\circ f)(x), (\mu_{Ai}\circ f)(y))$ for all i. Therefore A◦f is an anti multi fuzzy subhemiring of a hemiring R.

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