Global Journal of Pure and Applied Mathematics.
ISSN 0973-1768 Volume 13, Number 9 (2017), pp. 5479-5489

http://www.ripublication.com

On Intuitionistic Fuzzy 2-absorbing Ideals in a Comutative Ring

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Abstract

In this paper, we give some definitions of intuitionistic fuzzy 2-absorbing ideal, intuitionistic fuzzy 2-absorbing primary ideal and intuitionistic fuzzy semi 2-absorbing ideal. We also proved some properties of such ideals. For example, we show that an intuitionistic fuzzy set $A = (\mu A, \nu A)$ of commutative rings R is an intuitionistic fuzzy 2-absorbing ideal of R if and only if the set $A^{(\alpha,\beta)}$ is a 2-absorbing ideal of $B^{(\alpha,\beta)}$ for $(\alpha, \beta) \leq (\mu A(0), \nu A(0))$.

2010 Mathematics Subject Classiftcation : 03F55, 20N25, 08A72.

Keywords: intuitionistic fuzzy sets, intuitionistic fuzzy 2-absorbing (2-absorbing primary, semi 2-absorbing) ideal.

1 INTRODUCTION

We assume throughout this paper that all rings are commutative with $1 \neq 0$. Let R be a commutative rings. The notion of an intuitionistic fuzzy set was introduced by Ataanassov [3]. An intuitionistic fuzzy set is a generalization of a fuzzy set introduced by Zadeh [16]. While fuzzy sets give the degree of membership of an element in a given set, intuitionistic fuzzy set give the degree of a member- ship and a degree of non-membership.

Furthermore the sum of tow degree is not greater then. Many authors has been combining fuzzy set theory and intuition- istic fuzzy sets (IF-sets for short) [14], with other mathematical theories such as group theory [7], ring theory [9,10] and [11].

In this paper, some properties of intuitionistic fuzzy 2-absorbing ideals, 2-absorbing primary ideals and semi 2-absorbing ideals are discussed. Our paper is organized as follow. In section 2, we review some results and definitions about fuzzy set, intuitionistic fuzzy set, 2-absorbing ideals, 2-absorbing primary ideals and semi 2-absorbing ideals. In the section 3, we introduced definitions of intuitionistic fuzzy 2-absorbing ideals. We proved some properties of such ideals. For example, we show that an intuitionistic fuzzy set $A = (\mu_A, \nu_A)$ of commutative rings R is an intuitionistic fuzzy 2-absorbing ideal of R if and only if the set $A^{(\alpha,\beta)}$ is

a 2-absorbing ideal of $B^{(\alpha,\beta)}$ for $(\alpha, \beta) \leq (\mu_A(0), \nu_A(0))$. Finally, a conclusion is

stated at the end.

2 BASIC RESULTS ON INTUITIONISTIC FUZZY SETS AND 2-ABSORBING IDEALS

In this section, some definitions and results are given that we need for prove our main results. A fuzzy set of R is a function $\mu : R \to [0, 1]$. Let μ be a fuzzy set of R. For $\alpha \in [0, 1]$, the set $\mu_\alpha = \{x \in R | \mu(x) \geq \alpha\}$ is called an α-level cut set of μ.

Let μ and γ be two fuzzy sets on X. Then μ is called a fuzzy subset of γ if

$\mu(x) \leq \gamma(x)$ for all $x \in X$ and it is written as $\mu \subseteq \gamma$.

Definition 2.1. [15] A fuzzy set μ in a ring R is called a fuzzy subring of R if it satisfies:

(i) $(\forall x, y \in R)(\mu(x - y) \geq \mu(x) \wedge \mu(y))$ and

(ii) $(\forall x, y \in R)(\mu(xy) \geq \mu(x) \wedge \mu(y))$.

Definition 2.2. [15] A fuzzy set μ in a ring R is called a fuzzy ideal of R if it satisfies:

(i) $(\forall x, y \in R)(\mu(x - y) \geq \mu(x) \wedge \mu(y))$ and

(ii) $(\forall x, y \in R)(\mu(xy) \geq \mu(x))$.

Definition 2.3. [3] An intuitionistic fuzzy set (IF-set for short)A in a ring R is an object having the form

$$A = \{< x, \mu_A(x), \upsilon_A(x) > | x \in R\}.$$

where the functions $\mu_A : R \to [0, 1]$ and $\nu_A : R \to [0, 1]$ denote the degree of membership (namely $\mu_A(x)$) and the degree of non-membership (namely $\nu_A(x)$) of each element $x \in R$ for the set A, respectively, and $0 \leq \mu_A(x) + \nu_A(x) \leq 1$ for all $x \in R$.

Example 1. [13] Let X be the set of all countries with elective governments. Assume that we know for every country $x \in X$ the percentage of the electorate who have voted for the corresponding government. Let it be denoted by $M(x)$ and let $\mu(x) = \frac{M(x)}{100}$. Let $\nu(x) = 1 - \mu(x)$. This number corresponds to that part of electorate who have not voted for the government. By means of the fuzzy set theory we cannot consider this value in more detail. However, if we define $\nu(x)$ as the number of votes given to parties or persons outside the government, then we can show the part of electorate who have not voted at all and the corresponding number will be $1-\mu(x)-\nu(x)$. Thus, we can construct the set $\{(x, \mu(x), \nu(x)) | x \in X\}$ and obviously, $0 \leq \mu(x) + \nu(x) \leq 1$.

For the sake of simplicity, we shall use the symbol $A = (\mu_A, \nu_A)$ for the IF-set $A = \{< x, \mu_A(x), \nu_A(x) > | x \in R\}$. Let IFS(R) be the set of all IF-sets of R. In the following we give some properties of IF-sets.

Proposition 2.4. Let $A = (\mu_A, \nu_A)$ and $B = (\mu_B, \nu_B)$ be two IF-sets in a ring R. *Then*

(i) $A \subseteq B \Leftrightarrow (\forall x \in X)(\mu_A(x) \leq \mu_B(x), \nu_A(x) \geq \nu_B(x))$.

(ii) $A = B \Leftrightarrow A \subseteq B$ *and* $B \subseteq A$.

(iii) $A \cup B = \{\mu_A \vee \mu_B, \nu_A \wedge \nu_B\}$

(iv) $A \cap B = \{\mu_A \wedge \mu_B, \nu_A \vee \nu_B\}$

(v) $0_\sim = (0, 1)$ *and* $1_\sim = (1, 0)$.

Let $A = (\mu_A, \nu_A)$ and $B = (\mu_B, \nu_B)$ be two IF-sets in a ring R. Then

$A = (\mu_A, \nu_A)$ is called an intuitionistic fuzzy subset(IF-subset for short) of $B = (\mu_B, \nu_B)$ if $A \subseteq B$. From [6] we give a definition of IF-subring. It is a generalization of definition2.1.

Definition 2.5. An IF-set $A = (\mu_A, \nu_A)$ in a ring R is called an IF-subring of R

if it satisfies the following condition:

(i) $(\forall x, y \in R)(\mu_A(x-y) \geq \mu_A(x) \wedge \mu_A(y))$.

(ii) $(\forall x, y \in R)(\mu_A(xy) \geq \mu_A(x) \wedge \mu_A(y))$.

(iii) $(\forall x, y \in R)(\nu_A(x-y) \leq \nu_A(x) \vee \nu_A(y))$.

(iv) $(\forall x, y \in R)(\nu_A(xy) \leq \nu_A(x) \vee \nu_A(y))$.

From [6] we give a definition of IF-ideal. It is a generalization of definition 2.2.

Definition 2.6. An IF-set $A = (\mu_A, \nu_A)$ in a ring R is called an IF-ideal of R if it satisfies the following condition:

(i) $(\forall x, y \in R)(\mu_A(x-y) \geq \mu_A(x) \wedge \mu_A(y))$.

(ii) $(\forall x, y \in R)(\mu_A(xy) \geq \mu_A(y))$.

(iii) $(\forall x, y \in R)(\nu_A(x-y) \leq \nu_A(x) \vee \nu_A(y))$.

(iv) $(\forall x, y \in R)(\nu_A(xy) \leq \nu_A(y))$.

In the following we give a definition of (α, β)-level cut and (α, β)-level strong cut. It is a generalization of α-level cut and α-level strong cut.

Definition 2.7. [1,2] Let $A = (\mu_A, \nu_A)$ be an IF-set in a ring R and $\alpha, \beta \in [0, 1]$ be such that $\alpha + \beta \leq 1$. The (α, β)-level cut $A^{(\alpha,\beta)}$ will be $\{x \in R | \mu_A(x) \geq \alpha, \nu_A(x) \leq \beta\}$. Analogously, the (α, β)-level strong cut $As^{(\alpha,\beta)}$ be $\{x \in R | \mu_A(x) > \alpha, \nu_A(x) < \beta\}$ and finally $A^{(0,0)} = \{x \in R | \mu_A(x) = 0, \nu_A(x) = 0\}$.

In the rest of the paper $B = (\mu_B, \nu_B)$ is always IF-subring of a commutative ring R.

Definition 2.8. [12] Let $A = (\mu_A, \nu_A)$ be an IF-set of R and $B = (\mu_B, \nu_B)$ be an IF-subring of R such that $A \subseteq B$. Then the IF-set $A = (\mu_A, \nu_A)$ is called an IF-ideal of $B = (\mu_B, \nu_B)$ if it satisfies the following condition:

(i)$(\forall x, y \in R)\mu_A(x - y) \geq \mu_A(x) \wedge \mu_A(y)$.

(ii)$(\forall x, y \in R)\mu_A(xy) \geq \mu_B(x) \wedge \mu_A(y)$.

(iii)$(\forall x, y \in R)\nu_A(x - y) \leq \nu_A(x) \vee \nu_A(y)$.

(iv)$(\forall x, y \in R)\nu_A(xy) \leq \nu_B(x) \vee \nu_A(y)$.

Definition 2.9. [12] Let $A = (\mu_A, \nu_A)$ be an IF-ideal of $B = (\mu_B, \nu_B)$. The Intuitionistic fuzzy nil radical (IF nil radical for short) of $A = (\mu_A, \nu_A)$ is defined to be an IF-set $R(A) = (\mu_{R(A)}, \nu_{R(A)})$ of $B = (\mu_B, \nu_B)$ defined by

$$\mu_{R(A)}(x) = (\vee_{n \epsilon N} \mu_A(x)) \wedge \mu_B(x)$$

and

$$\nu_{R(A)}(x) = (\wedge_{n \epsilon N} \nu_A(x)^n) \vee \nu_B(x)$$

for all $x \in R$ and some $n \in \mathbf{N}$

Proposition 2.10. *[*12] For every IF-ideal $A = (\mu_A, \nu_A)$ and $C = (\mu_C, \nu_C)$ of $B = (\mu_B, \nu_B)$, we *have*

(i) $A \subseteq R(A)$

(ii) $A \subseteq C$ implies $R(A) \subseteq R(C)$ and

(iii) $R((R(A))) = R(A)$

Definition 2.11. [12] A non-constant IF-ideal $A = (\mu_A, \nu_A)$ of $B = (\mu_B, \nu_B)$ is said to be prime IF-ideal of $B = (\mu_B, \nu_B)$ if it satisfies:

$$\mu_A(xy) \wedge \mu_B(x) \wedge \mu_B(y) \leq \mu_A(x) \vee \mu_A(y)$$

and

$$\nu_A(xy) \vee \nu_B(x) \vee \nu_B(y) \geq \nu_A(x) \wedge \nu_A(y)$$

for all $x, y \in R$.

Definition 2.12. [12] A non-constant IF-ideal $A = (\mu_A, \nu_A)$ of $B = (\mu_B, \nu_B)$ is said to be primary IF-ideal of $B = (\mu_B, \nu_B)$ if it satisfies:

$$\mu_A(xy) \wedge \mu_B(x) \wedge \mu_B(y) \leq \mu_A(x) \vee (\vee_{n\in N} \mu_A(y)^n)$$

and

$$\nu_A(xy) \vee \nu_B(x) \vee \nu_B(y) \geq \nu_A(x) \wedge (\wedge_{n\in N} \nu_A(y)^n)$$

for all $x, y \in R$ and for all $n \in$ N.

Definition 2.13. [12] An IF-ideal $A = (\mu_A, \nu_A)$ of $B = (\mu_B, \nu_B)$ is said to be semi prime IF-ideal of $B = (\mu_B, \nu_B)$ if $R(A) = A$, that is,

$$(\forall x \in R)(\mu_{R(A)}(x) = \mu_A(x) \text{ and } \nu_{R(A)}(x) = \nu_A(x)).$$

In the following we give definitions of 2-absorbing, 2-absorbing primary and semi-2-absorbing ideals that we need in main results.

Definition 2.14. [5] A nonzero proper ideal I of R is called a 2-absorbing ideal of R if whenever $a, b, c \in R$ and $abc \in I$, then $ab \in I$ or $ac \in I$ or $bc \in I$.

Note that every prime ideal is a 2-absorbing ideals but the converse is not true.

Definition 2.15. [8] A proper ideal I of R is called a 2-absorbing primary ideal of R if whenever $a, b, c \in R$ and $abc \in I$, then $ab \in I$ or $ac \in \sqrt{I}$ or $bc \in \sqrt{I}$.

For example every 2-absorbing ideal is 2-absorbing primary and every primary ideal is a 2-absorbing primary ideal.

Definition 2.16. [4] A proper ideal is to be said semi 2-absorbing ideal of R if $x^3 \in I$ for x $\in R$ implies $x^2 \in I$.

For example we have, every semi prime ideal is semi-2-absorbing ideal.

3 INTUITIONISTIC FUZZY 2-ABSORBING, 2-ABSORBING PRIMARY AND SEMI 2-ABSORBING IDEALS

we start this section by a characterization of intuitionistic fuzzy ideal, 2-absorbing ideals of IF-subring. For this we need the following key definition and lemma.

Definition 3.1. A non-constant IF-ideal $A = (\mu_A, \nu_A)$ of $B = (\mu_B , \nu_B)$ is said to be intuitionistic fuzzy 2-absorbing ideal of $B = (\mu_B , \nu_B)$ if it is satisfies:

$$\mu_A(xyz) \wedge \mu_B (xy) \wedge \mu_B (xz) \wedge \mu_B (yz) \leq \mu_A(xy) \vee \mu_A(xz) \vee \mu_A(yz)$$

and

$$\nu_A(xyz) \vee \nu_B (xy) \vee \nu_B (xz) \vee \nu_B (yz) \geq \nu_A(xy) \wedge \nu_A(xz) \wedge \nu_A(yz)$$

for all $x, y, z \in R$ and for all $n \in \mathbb{N}$.

For example every intuitionistic fuzzy prime ideal is a intuitionistic fuzzy 2-absorbing ideal.

Lemma 3.2. *[*12, theorem 5.1] Let $B = (\mu_{B_s} , \nu_B)$ be an IF-ideal of R. then $A = (\mu_A, \nu_A)$ is an IF-ideal of $B = (\mu_B , \nu_B)$ if and only if $A^{(\alpha,\beta)}$ and $A^{(\alpha,\beta)}$ are,if they are non-empty, ideals of $B^{(\alpha,\beta)}$ *a*nd $B^{(\alpha,\beta)}$*for* $(\alpha, \beta) \leq (\mu_A \ (0), \nu_A \ (0))$.

In the following theorem we give a characterization of intuitionistic fuzzy 2-absorbing ideal.

Theorem 3.3. $A = (\mu_A, \nu_A)$ is an intuitionistic fuzzy 2-absorbing ideal of $B = (\mu_B , \nu_B)$ if and only if $A^{(\alpha,\beta)}$ is 2-absorbing ideal of $B^{(\alpha,\beta)}$ *for* $(\alpha, \beta) \leq (\mu_A(0), \nu_A(0))$.

Proof. $\Rightarrow$) suppose that $A = (\mu_A, \nu_A)$ is a 2-absorbing IF-ideal of $B = (\mu_B , \nu_B)$ and let $(\alpha, \beta) \leq (\mu_A(0), \nu_A(0))$. By Lemma3.2, $A^{(\alpha,\beta)}$ is an ideal of $B^{(\alpha,\beta)}$. We show that $A^{(\alpha,\beta)}$ is a 2-absorbing ideal of $B^{(\alpha,\beta)}$. For this, let $x, y, z \in B^{(\alpha,\beta)}$ with $xyz \in A^{(\alpha,\beta)}$. Then

$$\mu_B (xy) \geq \alpha, \nu_B (xy) \leq \beta; \mu_B (xz) \geq \alpha, \nu_B (xz) \leq \beta; \mu_B (yz) \geq \alpha, \nu_B (yz) \leq \beta$$

$\mu_A(xyz) \geq \alpha$, $\nu_A(xyz) \leq \beta$, Hence by definition3.1

$$\mu_A(xy) \vee \mu_A(xz) \vee \mu_A(yz) \geq \mu_A(xyz) \wedge \mu_B (xy) \wedge \mu_B (xz) \wedge \mu_B (yz) \geq \alpha$$

and

$$\nu_A(xy) \wedge \nu_A(xz) \wedge \nu_A(yz) \leq \nu_A(xyz) \vee \nu_B (xy) \vee \nu_B (xz) \vee \nu_B (yz) \leq \beta$$

Therefore, either $xy \in A^{(\alpha,\beta)}$ or $xz \in A^{(\alpha,\beta)}$ or $yz \in A^{(\alpha,\beta)}$. This show that $A^{(\alpha,\beta)}$ is a 2-absorbing ideal of $B^{(\alpha,\beta)}$

$\Leftarrow$) Conversely suppose that $A^{(\alpha,\beta)}$ is a 2-absorbing ideal of $B^{(\alpha,\beta)}$ for $(\alpha, \beta) \leq (\mu_A(0),$

$\nu_A(0)$). By Lemma3.2 $A = (\mu_A, \nu_A)$ is a IF-ideal of $B = (\mu_B, \nu_B)$. The proof of the theorem will be complete if we show that

and

$$\mu_A(xyz) \wedge \mu_B(xy) \wedge \mu_B(xz) \wedge \mu_B(yz) \leq \mu_A(xy) \wedge \mu_A(xz) \wedge \mu_A(yz)$$

$$\nu_A(xyz) \vee \nu_B(xy) \vee \nu_B(xz) \vee \nu_B(yz) \geq \nu_A(xy) \vee \nu_A(xz) \vee \nu_A(yz)$$

suppose if possible,

$$\mu_A(xyz) \wedge \mu_B(xy) \wedge \mu_B(xz) \wedge \mu_B(yz) > \mu_A(xy) \wedge \mu_A(xz) \wedge \mu_A(yz)$$

and

$$\nu_A(xyz) \vee \nu_B(xy) \vee \nu_B(xz) \vee \nu_B(yz) < \nu_A(xy) \vee \nu_A(xz) \vee \nu_A(yz)$$

since $A = (\mu_A, \nu_A)$ is a 2-absorbing ideal of $B^{(\alpha,\beta)}$ for $(\alpha, \beta) \leq (\mu_A(0), \nu_A(0))$ for $x, y, z \in B^{(\alpha,\beta)}$ with $xyz \in A^{(\alpha,\beta)}$. Let us choose α, β such that

$$\mu_A(xyz) \wedge \mu_B(xy) \wedge \mu_B(xz) \wedge \mu_B(yz) \geq \alpha > \mu_A(xy) \vee \mu_A(xz) \vee \mu_A(yz)$$

and

$$\nu_A(xyz) \vee \nu_B(xy) \vee \nu_B(xz) \vee \nu_B(yz) \leq \beta < \nu_A(xy) \wedge \nu_A(xz) \wedge \nu_A(yz)$$

It following that $xyz \in A^{(\alpha,\beta)}$ implies $xy \notin A^{(\alpha,\beta)}$ and $xz \notin A^{(\alpha,\beta)}$ and $yz \notin A^{(\alpha,\beta)}$ therefore our assumption is wrong and we conclude the theorem. ■

Corollary 3.4. [12, theorem 7.1] $A = (\mu_A, \nu_A)$ is a prime IF-ideal of $B = (\mu_B, \nu_B)$ if and only if $A^{(\alpha,\beta)}$ is a prime ideal of $B^{(\alpha,\beta)}$ for $(\alpha, \beta) \leq (\mu_A(0), \nu_A(0))$.

In the following we give a definition of intuitionistic fuzzy 2-absorbing primary ideal.

Definition 3.5. A non-constant IF-ideal $A = (\mu_A, \nu_A)$ of $B = (\mu_B, \nu_B)$ is said to be intuitionistic fuzzy 2-absorbing primary ideal of $B = (\mu_B, \nu_B)$

if it satisfies:

$$\mu_A(xyz) \wedge \mu_B(xy) \wedge \mu_B(xz) \wedge \mu_B(yz) \leq \mu_A(xy) \vee (\vee_{n \in N} \mu_A(xz)^n) \vee (\vee_{n \in N} \mu_A(yz)^n)$$

and

$$\nu_A(xyz) \vee \nu_B(xy) \vee \nu_B(xz) \vee \nu_B(yz) \geq \nu_A(xy) \wedge (\wedge_{n \in N} \nu_A(xz)^n) \wedge (\wedge_{n \in N} \nu_A(yz)^n)$$

for all $x, y, z \in r$ and for all $n \in$ N

Similar to Theorem3.3 we give a characterization of intuitionistic fuzzy 2- absorbing primary ideal.

Theorem 3.6. $A = (\mu_A, \nu_A)$ is an intuitionistic fuzzy 2-absorbing primary ideal of $B = (\mu_B, \nu_B)$ if and only if $A^{(\alpha,\beta)}$ is a 2-absorbing primary ideal of $B^{(\alpha,\beta)}$ for $(\alpha, \beta) \leq (\mu_A(0), \nu_A(0))$

Corollary 3.7. [12, theorem 7.2] $A = (\mu_A, \nu_A)$ is a primary IF-ideal of $B = (\mu_B, \nu_B)$ if and only if $A^{(\alpha,\beta)}$ is a primary ideal of $B^{(\alpha,\beta)}$ for $(\alpha, \beta) \leq (\mu_A(0), \nu_A(0))$.

Definition 3.8. An IF-ideal $A = (\mu_A, \nu_A)$ of $B = (\mu_B, \nu_B)$ if it is satisfies:

$\mu_A(x^3) \wedge \mu_B(x^2) \leq \mu_A(x^2)$ and $\nu_A(x^3) \vee \nu_B(x^2) \geq \nu_A(x^2)$ for all $x \in R$.

Similar to Theorem3.3, we give a characterization of intuitionistic fuzzy semi 2-absorbing ideal.

Theorem 3.9. $A = (\mu_A, \nu_A)$ is an intuitionistic fuzzy semi 2-absorbing primary ideal of $B = (\mu_B, \nu_B)$ if and only if $A^{(\alpha,\beta)}$ is a semi 2-absorbing ideal of $B^{(\alpha,\beta)}$ for $(\alpha, \beta) \leq (\mu_A(0), \nu_A(0))$

Corollary 3.10. [12, theorem 7.3] $A = (\mu_A, \nu_A)$ is a semi prime IF-ideal of $B = (\mu_B, \nu_B)$ if and only if $A^{(\alpha,\beta)}$ is a semi prime ideal of $B^{(\alpha,\beta)}$ for $(\alpha, \beta) \leq (\mu_A(0), \nu_A(0))$.

In the end we study the rings that every intuitionistic fuzzy ideal is 2-absorbing or 2-absorbing primary or semi 2-absorbing.

Definition 3.11. Let R be a ring and IFI(R) the set of all intuitionistic fuzzy ideal (for short IF-ideal) of R.

1. R is called 2-absorbing IF-ring if for all $I \in$ IFI(R), I is 2-absorbing.
2. R is called 2-absorbing primary IF-ring if for all $I \in$ IFI (R), I is 2- absorbing primary.
3. R is called semi 2-absorbing IF-ring if for all $I \in$ IFI(R), I is semi 2- absorbing

Form Theorem3.3, Theorem3.6and Theorem3.9, we have the following proposition. It is a characterization of such rings given in Definition3.11.

Proposition 3.12. Let R be a ring and I$\in$IFI(R).

(i) R is 2-absorbing IF-ring if and only if the set I $^{(\alpha,\beta)}$ is 2-absorbing ideal of R, for $(\alpha, \beta) \leq (\mu_I(0), \nu_I(0))$.

(ii) R is 2-absorbing primary IF-ring if and only if the set I$^{(\alpha,\beta)}$ is 2-absorbing primary ideal of R, for $(\alpha, \beta) \leq (\mu_{\mathrm{I}}(0), \nu_{\mathrm{I}}(0))$.

(iii) R is semi-2-absorbing IF-ring if and only if the set I$^{(\alpha,\beta)}$ is semi-2-absorbing ideal of R, for $(\alpha, \beta) \leq (\mu_{\mathrm{I}}(0), \nu_{\mathrm{I}}(0))$.

4 CONCLUSION

The study of properties of Intuitionistic fuzzy sets on a ring is a meaningful research topic for IFS theory. In this paper we concentrated our study on algebric properties of IFS with respect to a ring. For future work, it would be interesting to extend the existing work in the framework fuzzy soft set.

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