INTUITIONISTIC FUZZY ω SUPRA CLOSED SETS IN IFST SPACES

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Abstract: ***Necla Turanl introduced the concept of Intuitionistic fuzzy supra topological space which is a special case of Intuitionistic fuzzy topological space. Aim of this paper is we introduced in Intuitionistic fuzzy ω supra closed sets in Intuitionistic fuzzy supra topological space.and also we studied about properties and characterization of Intuitionistic fuzzy ω supra open sets and Intuitionistic fuzzy ω supra closed sets in Intuitionistic fuzzy supra topological spaces***

Key Words: Intuitionistic fuzzy semi supra open set, Intuitionistic fuzzy semi supra closed set, Intuitionistic fuzzy ω supra open sets, Intuitionistic fuzzy ω supra closed sets, Intuitionistic fuzzy supra topological spaces

1. INTRODUCTION

Topology is a classical subjects, as a generalization topological spaces many type of topological spaces introduced over the year. C.L. Chang [4] was introduced and developed fuzzy topological space by using L.A. Zadeh's[21] fuzzy sets. Coker[5] introduced the notion of Intuitionistic fuzzy topological spaces by using Atanassov's[2] Intuitionistic fuzzy set

A.S. Mashhour et al. introduced the supra topological spaces and studied in the year 1983. M. E. AbdEl-Monsef et al. [1] introduced the fuzzy supra topological spaces and studied fuzzy supra-continuous functions and obtained some properties and characterizations.In 2003 Necla Turanl [20] introduced the concept of Intuitionistic fuzzy supra topological space.

In 2015 M. Parimala[12] et al. introduced Intuitionistic fuzzy semi supra open sets in Intuitionistic fuzzy supra topological spaces. Aim of this paper is we introduced and studied about Intuitionistic fuzzy ω supra closed sets in Intuitionistic fuzzy supra topological spaces and its properties are discussed details.

2. PRELIMINARIES

Definition 2.1: [3]

An Intuitionistic fuzzy set (IF for short) A is an object having the form

$A = \{\langle x, \mu_A(x), \nu_A(x)\rangle : x \in X\}$

where the functions μ_A:X⟶[0,1] and ν_A:X⟶ [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 ∈ X to the set A respectively, and $0 \le \mu_A(x) + \nu_A(x) \le 1$ for each x ∈ X.

Obviously, every fuzzy set A on a nonempty set X is an IFS of the following form

$A =\{\langle x, \mu_A(x), 1- \mu_A(x)\rangle: x \in X\}$.

Definition 2.2: [3]

Let A and B be two Intuitionistic fuzzy sets of the form

$A =\{\langle x, \mu_A(x), \nu_A(x)\rangle: x \in X\}$ and $B=\{\langle x, \mu_B(x), \nu_B(x)\rangle : x\in X\}$. Then,

(i) $A \subseteq B$ if and only if $\mu_A(x) \le \mu_B(x)$ and $\nu_A(x) \ge \nu_B(x)$ for all x ∈ X,

(ii) A = B if and only if $A \subseteq B$ and $A \supseteq B$,

(iii) $A^C = \{\langle x, \nu_A(x), \mu_A(x)\rangle: x \in X\}$,

(iv) $A \cup B = \{\langle x, \mu_A(x) \vee \mu_B(x), \nu_A(x) \wedge \nu_B(x)\rangle: x \in X\}$,

(v) $A \cap B = \{\langle x, \mu_A(x) \wedge \mu_B(x), \nu_A(x) \vee \nu_B(x)\rangle: x \in X\}$.

(vi) $[\ ]A = \{\langle x, \mu_A(x), 1 - \mu_A(x)\rangle , x \in X\}$;

(vii) $\langle\rangle A = \{\langle x, 1 - \nu_A(x), \nu_A(x)\rangle , x \in X\}$;

The Intuitionistic fuzzy sets $0\sim = \langle x, 0, 1\rangle$ and $1\sim = \langle x, 1, 0\rangle$ are respectively the empty set and the whole set of X

Definition 2.3. [3]

Let {Ai : i ∈ J } be an arbitrary family of Intuitionistic fuzzy sets in X. Then

(i) $\cap A_i = \{\langle x,\wedge\mu_{Ai}(x),\vee \nu_{Ai}(x) \rangle : x \in X\}$;

(ii) $\cup A_i = \{\langle x,\vee\mu_{Ai}(x),\wedge \nu_{Ai}(x) \rangle : x \in X\}$.

Definition 2.4. [3]

Since our main purpose is to construct the tools for developing Intuitionistic fuzzy topological spaces, we must introduce the Intuitionistic fuzzy sets 0~ and 1~ in X as follows:

$0\sim = \{\langle x, 0, 1\rangle: x \in X\}$ and $1\sim = \{\langle x, 1, 0\rangle : x \in X\}$.

Definition 2.5:[3]

Let A,B,C are Intuitionistic fuzzy sets in X. Then

(i) $A \subseteq B$ and $C \subseteq D \Longrightarrow A \cup C \subseteq B \cup D$ and $A \cap C \subseteq B \cap D$,

(ii) $A \subseteq B$ and $A \subseteq C \Longrightarrow A \subseteq B \cap C$,

(iii) $A \subseteq C$ and $B \subseteq C \Longrightarrow A \cup B \subseteq C$,

(iv) $A \subseteq B$ and $B \subseteq C \Longrightarrow A \subseteq C$,

(v) $\overline{A \cup B} = \bar{A} \cap \bar{B}$

(vi) $\overline{A \cap B} = \bar{A} \cup \bar{B}$,

(vii) $A \subseteq B \Longrightarrow \bar{B} \subseteq \bar{A}$,

(viii) $\overline{(\bar{A})} = A$,
(ix) $\bar{1}\sim = 0\sim$,
(x) $\bar{0}\sim = 1\sim$.

Definition 2.6.[4]

Let f be a mapping from an ordinary set X into an ordinary set Y ,
If B ={⟨y, $\mu_B(y)$, $\nu_B(y)$ ⟩ : y ∈ Y } is an Intuitionistic fuzzy set in Y , then the inverse image of B under f is an Intuitionistic fuzzy set defined by $f^{-1}(B) = \{\langle x, f^{-1}(\mu_B)(x), f^{-1}(\nu_B)(x) \rangle : x \in X\}$
The image of Intuitionistic fuzzy set A = {⟨y, $\mu_A(y)$, $\nu_A(y)$ ⟩ : y ∈ Y } under f is an Intuitionistic fuzzy set defined by
$f(A) = \{\langle y, f(\mu_A)(y), f(\nu_A)(y) \rangle : y \in Y \}$.

Definition 2.7[4]

Let A, Ai (i ∈ J) be Intuitionistic fuzzy sets in X, B, Bi (i ∈ K) be Intuitionistic fuzzy sets in Y and f : X → Y is a function. Then
(i) $A_1 \subseteq A_2 \Rightarrow f(A_1) \subseteq f(A_2)$,
(ii) $B_1 \subseteq B_2 \Rightarrow f^{-1}(B_1) \subseteq f^{-1}(B_2)$,
(iii) $A \subseteq f^{-1}(f(A))$ { If f is injective, then $A = f^{-1}(f(A))$},
(iv) $f(f^{-1}(B)) \subseteq B$ {If f is surjective, then $f(f^{-1}(B))=B$},
(v) $f^{-1}(\cup B_j) = \cup f^{-1}(B_j)$
(vi) $f^{-1}(\cap B_j) = \cap f^{-1}(B_j)$
(vii) $f(\cup B_j) = \cup f(B_j)$
(viii) $f(\cap B_j) \subseteq \cap f(B_j)$ { If *f* is injective, then $f(\cap B_j) = \cap f(B_j)$}
(ix) $f^{-1}(1\sim) = 1\sim$,
(x) $f^{-1}(0\sim) = 0\sim$,
(xi) f (1∼) = 1∼ , if f is surjective
(xii) f (0∼) = 0∼,
(xiii) $\overline{f(A)} \subseteq f(\bar{A})$, if f is surjective,
(xiv) $f^{-1}(\bar{B}) = \overline{f^{-1}(B)}$.

Definition 2.8[21]

A family τ_μ Intuitionistic fuzzy sets on X is called an Intuitionistic fuzzy supra topology(in short,IFST) on X if $0\sim \in \tau_\mu, 1\sim \in \tau_\mu$ and τ_μ is closed under arbitrary suprema.
Then we call the pair (X,τ_μ) an Intuitionistic fuzzy supra topological space (in short,IFSTS).
Each member of τ_μ is called an Intuitionistic fuzzy supra open set and the complement of an Intuitionistic fuzzy supra open set is called an Intuitionistic fuzzy supra closed set.

Definition 2.9[21]

The Intuitionistic fuzzy supra closure of a set A is denoted by S-cl(A) and is defined as
S-cl (A) = ∩ {B : B is Intuitionistic fuzzy supra closed and A ⊆ B} .
The Intuitionistic fuzzy supra interior of a set A is denoted by S-int(A) and isdefined as
S-int(A) = ∪{B : B is Intuitionistic fuzzy supra open and A ⊇ B}

Definition 2.10 [21]

(i). ¬ (AqB) ⇔ $A \subseteq B^C$.
(ii). A is an Intuitionistic fuzzy supra closed set in X ⇔ S-cl (A) = A.
(iii). A is an Intuitionistic fuzzy supra open set in X ⇔S-int (A) = A.
(iv). $S\text{-}cl(A^C) = (S\text{-}int(A))^C$.
(v). $S\text{-}int(A^C) = (S\text{-}cl(A))^C$.
(vi). A ⊆ B ⟹ S-int(A) ⊆ S-int(B).
(vii). A ⊆ B ⟹ S-cl(A) ⊆ S-cl(B).
(viii). S-cl(A∪B) =S-cl(A)∪S-cl(B).
(ix). S-int(A∩ B) = S-int(A)∩ S-int(B).

Definition 2.11

Let (X, τ_μ) be an Intuitionistic fuzzy supra topological space.An IFS A ∈ IF(X) is called
Intuitionistic fuzzy semi-supra open[12] iff A ⊆ S-cl(S-int(A)),

Definition 2.12: [21]

Let (X, τμ) and (Y, σμ) be two Intuitionistic fuzzy supra topological spaces and let f: X→Y be a function. Then f is said to be
(i) Intuitionistic fuzzy supra continuous if the pre image of each Intuitionistic fuzzy supra open set of Y is an Intuitionistic fuzzy supra open set in X.
(ii) Intuitionistic fuzzy supra closed if the image of each Intuitionistic fuzzy supra closed set in X is an Intuitionistic fuzzy supra closed set in Y.

(iii) Intuitionistic fuzzy supra open if the image of each Intuitionistic fuzzy supra open set in X is an Intuitionistic fuzzy supra open set in Y.

Definition 2.13. [12]

Let (X, τμ) be a Intuitionistic fuzzy supra topological space. Then A is called Intuitionistic fuzzy supra semi open set(IFS supra open set for short) if A ⊆ S-cl(S-int(A)).

Definition 2.14. [12]

Let (X, τμ) be a Intuitionistic fuzzy supra topological space. Then A is called Intuitionistic fuzzy semi supra closed set(IFS supra-closed set for short) if S-int(S-cl(A)) ⊆ A.

Definition 2.15. [12]

Let A be a Intuitionistic fuzzy set of a Intuitionistic fuzzy supra topological space (X, τμ). Then,
i). The Intuitionistic fuzzy supra semi closure of A is defined as
IFS supra-cl(A) = ∩{K: K is a IFS-supra closed in X and A ⊆K}
ii).The Intuitionistic fuzzy supra semi interior of A is defined as
IFS-int(A) = ∪{G: G is a IFS-supra open in X and G ⊆ A}

3. INTUITIONISTIC FUZZY ω SUPRA CLOSED SETS

In this section, we introduce the concept of Intuitionistic fuzzy ω supra closed sets (Shortly IFω-supra closed set) and some of their properties. Throughout this paper (X, τμ) represent a Intuitionistic fuzzy supra topological spaces.

Definition 3.1.

Let (X, τμ) be a Intuitionistic fuzzy supra topological space. Then A is called Intuitionistic fuzzy supra ω closed set(IFω-supra closed set for short) if S-cl(A) ⊆ G whenever A ⊆ G and G is Intuitionistic fuzzy semi supra open set.

Theorem 3.2.

Every Intuitionistic fuzzy supra closed set is IFω-supra closed set, but the converse may not be true.

Proof:

If A is any Intuitionistic fuzzy set in X and G is any IFS-supra open set containing A, then S-cl (A) ⊆ G. Hence A is IFω-supra closed set. The converse of the above theorem need not be true as seen from the following example.

Example 3.3.

Let X = {a, b} and τμ = {0~, 1~, A_1, A_2, $A_1 \cup A_2$} be an Intuitionistic fuzzy supra topology on X, where A_1={ x,< 0.3,0.5>,< 0.6, 0.7 > }, A_2={ x,< 0.5,0.3>,< 0.4, 0.5 > }.
Then the Intuitionistic fuzzy set A = { x,<0.3,0.3>,<0.3,0.3>}is Intuitionistic fuzzy ω supra closed but it is not Intuitionistic fuzzy supra closed.

Proposition 3.4.

The concepts of IFω-supra closed sets and IFS-supra closed sets are independent.

Example 3.5.

Let X = {a,b} and τμ={0~, 1~, A_1, A_2,$A_1 \cup A_2$}is a Intuitionistic fuzzy supra topology and
(X, τμ) is a Intuitionistic fuzzy supra topological spaces.
where A_1={ x,< 0.2,0.4>,< 0.5, 0.6 > }, A_2={ x,< 0.4,0.2>,< 0.3, 0.4 > }.
Then the Intuitionistic fuzzy set A = { x,< 0.2,0.2>,< 0.2,0.2>}Then the set A is IFω-supra closed set but A is not a IFS-supra closed set.

Example 3.6.

Let X = {a,b} and τμ={0~, 1~, A_1, A_2,$A_1 \cup A_2$}is a Intuitionistic fuzzy supra topology and
(X, τμ) is a Intuitionistic fuzzy supra topological spaces.
where A_1={ x,< 0.2,0.4>,< 0.5, 0.6 > }, A_2={ x,< 0.4,0.2>,< 0.3, 0.4 >}.
Then the Intuitionistic fuzzy set A = { x,<0.4,0.4>,<0.4,0.4>}Then the set A is IFS-supra closed set but A is not a IFω-supra closed.

Theorem 3.7.

If A and B are IFω-supra closed sets, then A ∪ B is IFω-supra closed set.

Proof:

If A ∪ B ⊆ G and G is IFS-supra open set, then A ⊆ G and B ⊆ G. Since A and B are IFω-supra closed sets, S-cl(A) ⊆ G and S-cl(B) ⊆ G and hence S-cl(A) ∪ S-cl(B) ⊆ G. This implies S-cl(A ∪ B) ⊆ G. Thus A ∪ B is IFω-supra closed set in X.

Theorem 3.8.

A Intuitionistic fuzzy set A is IFω-supra closed set then S-cl(A) – A does not contain any nonempty Intuitionistic fuzzy supra closed sets.

Proof:

Suppose that A is IFω-supra closed set. Let F be a Intuitionistic fuzzy supra closed subset of S-cl(A) – A. Then A ⊆ F^C.But A is IFω-supra closed set. Therefore S-cl(A) ⊆ F^C. Consequently F ⊆ $(S\text{-cl}(A))^C$. We have F ⊆ S-cl(A). Thus F ⊆ S-cl(A)∩$(S\text{-cl}(A))^C$ = ϕ. Hence F is empty.

Theorem 3.9.

A Intuitionistic fuzzy set A is IFω-supra closed set if and only if S-cl(A) – A contains no non-empty IFS-supra closed set.

Proof:

Suppose that A is IFω-supra closed set. Let H be a IFS-supra closed subset of S-cl(A) – A. Then A ⊆ H^C. Since A is IFω-supra closed set, we have S-cl(A) ⊆ H^C. Consequently H ⊆$(S\text{-cl}(A))^C$. Hence H ⊆ S-cl(A)∩$(S\text{-cl}(A))^C$ = ϕ. Therefore H is empty.
Conversely, suppose that S-cl(A) – A contains no nonempty IFS-supra closed set. Let A ⊆ G and that G be IFS-supra open. If S-cl(A) ⊈ G, then S-cl(A)∩G^C is a non-empty IFS-supra closed subset of S-cl(A) – A. Hence A is IFω-supra closed set.

Corollary 3.10.

A IFω-supra closed set A is IFS-supra closed if and only if IFS supra-cl(A) – A is IFS-supra closed.

Proof:

Let A be any IFω-supra closed set. If A is IFS-supra closed set, then IFS supra -cl(A) – A = ϕ. Therefore IFS supra-cl(A) – A is IFS-supra closed set.
Conversely, suppose that S-cl(A) – A is IFS-supra closed set. But A is IFω-supra closed set and S-cl(A) – A contains IFS-supra closed. By theorem 3.9, IFS supra -cl(A) – A = ϕ. Therefore IFS supra -cl(A) = A. Hence A is IFS-supra closed set.

Theorem 3.11.

Suppose that B ⊆ A ⊆ X, B is a IFω-supra closed set relative to A and that A is IFω-supra closed set in X. Then B is IFω-supra closed set in X.

Proof:

Let B ⊆ G, where G is IFS-supra open in X. We have B ⊆ A∩G and A∩G is IFS-supra open in A. But B is a IFω-supra closed set relative to A. Hence S-clA(B) ⊆ A∩G. Since S-clA(B) = A∩S-cl(B). We have A∩S-cl(B) ⊆A∩G.It implies A⊆G∪$(S\text{-cl}(B))^C$and G∪$(S\text{-cl}(B))^C$ is a IFS-supra open set in X. Since A is IFω-supra closed in X, we have S-cl(A) ⊆ G∪$(S\text{-cl}(B))^C$.Hence S-cl(B) ⊆ G∪$(S\text{-cl}(B))^C$ and S-cl(B) ⊆ G. Therefore B is IFω-supra closed set relative to X.

Theorem 3.12.
If A is IFω-supra closed and A ⊆ B ⊆ S-cl(A),then B is IFω-supra closed.
Proof:
Since B ⊆ S-cl(A), we have S-cl(B) ⊆ S-cl(A) and S-cl(B) – B ⊆ S-cl(A) – A. But A is IFω-supra closed. Hence S-cl(A)–A has no non-empty IFS-supra closed subsets, neither does S-cl(B) – B. By theorem 3.9, B is IFω-supra closed.
Theorem 3.13.
Let A ⊆ Y ⊆ X and suppose that A is IFω-supra closed in X. Then A is IFω-supra closed relative to Y.
Proof:
Let A ⊆ Y∩G where G is IFS-supra open in X. Then A ⊆G and hence S-cl(A) ⊆ G. This implies, Y ∩ S-cl(A) ⊆Y∩G. Thus A is IFω-supra closed relative to Y.
Theorem 3.14.
If A is IFS-supra open and IFω-supra closed, then A is Intuitionistic fuzzy supra closed set.
Proof:
Since A is IFS-supra open and IFω-supra closed, then S-cl(A) ⊆ A. Therefore S-cl(A) =A. Hence A is Intuitionistic fuzzy supra closed.

4. INTUITIONISTIC FUZZY SUPRA ω OPEN SETS

In this section, we introduce and study about Intuitionistic fuzzy supra ω open sets and some of their properties.
Definition 4.1.
A Intuitionistic fuzzy set A in X is called IFω-supra open in X if A^C is IFω-supra closed in X.
Theorem 4.2.
A Intuitionistic fuzzy set A is IFω-supra open if and only if F ⊆ S-int(A) where F is IFS-supra closed and F ⊆ A.
Proof:
Suppose that F ⊆ S-int(A) where F is IFS-supra closed and F ⊆ A. Let A^C ⊆ G where G is IFS-supra open. Then G^C ⊆ A and G^C is IFS-supra closed. Therefore G^C ⊆ S-int(A). Since G^C ⊆ S-int(A), we have $(S\text{-}int(A))^C$ ⊆ G. This implies S-cl($(A)^C$)⊆ G. Thus A^C is IFω-supra closed. Hence A is IFω-supra open .
Conversely, suppose that A is IFω-supra open , F ⊆ A and F is IFS supra -closed.Then Fc is IFS-supra open and A^C ⊆ F^C. ThereforeS-cl($(A)^C$) ⊆ F^C. But S-cl($(A)^C$) = $(S\text{-}int(A))^C$. Hence F ⊆S-int(A).
Theorem 4.3.
A Intuitionistic fuzzy set A is IFω-supra open in X if and only if G = X whenever G is IFS-supra open and (S-int(A)∪A^C) ⊆ G.
Proof:
Let A be a IFω-supra open , G be IFS-supra open and (S-int(A)∪A^C) ⊆ G. This implies G^C ⊆ $(S\text{-}int(A))^C$ ∩$((A)^C)^C$= $(S\text{-}int(A))^C$ – A^C = S-cl($(A)^C$) – A^C. Since A^C is IFω-supra closed
and G^C is IFS-supra closed, By theorem 3.12, it follows that G^C =ϕ. Therefore X = G.
Conversely, suppose that F is IFS-supra closed and F ⊆ A. Then S-int(A) ∪ A^C ⊆ S-int(A) ∪ F^C. This implies S-int(A) ∪ F^C = X and hence F ⊆ S-int(A). Therefore A is IFω-supra open .
Theorem 4.4.
If S-int(A) ⊆ B ⊆ A and if A is IFω-supra open ,then B is IFω-supra open .
Proof:
Suppose that S-int(A) ⊆ B ⊆ A and A is IFω-supra open .Then A^C ⊆B^C ⊆ S-cl(A^C) and since A^C is IFω-supra closed. We have By theorem 3.9, B^C is IFω-supra closed. Hence B is IFω-supra open .
Theorem 4.5.
A Intuitionistic fuzzy set A is IFω-supra closed, if and only if S-cl(A) – A is IFω-supra open .
Proof:
Suppose that A is IFω-supra closed set. Let H be a IFS supra -closed subset of S-cl(A) – A. Then A ⊆ H^C. Since A is IFω-supra closed set, we have S-cl(A) ⊆ H^C. Consequently H ⊆$(S\text{-}cl(A))^C$. Hence S ⊆ S-cl(A)∩$(S\text{-}cl(A))^C$ = ϕ. Therefore H is empty.
Conversely, suppose that S-cl(A) – A contains no nonempty IFS-supra closed set. Let A ⊆ G and that G be IFS-supra open. If S-cl(A) ⊈ G, then S-cl(A) ∩ G^C is a non-empty IFS-supra closed subset of S-cl(A) – A. Hence A is IFω-supra closed set.
Theorem 4.6.
A Intuitionistic fuzzy set A is IFω-supra closed, if and only if S-cl(A) – A is IFω-supra open.
Proof:
Suppose that A is IFω-supra closed. Let F ⊆ S-cl(A) – A Where F is IFS supra -closed. By theorem 3.9, F = ϕ. Therefore F ⊆ S-int((S-cl(A) – A) and by Theorem 4.2, we have S-cl(A) – A is IFω-supra open. Conversely, let A ⊆ G where G is a IFS supra -open set. Then S-cl(A) ∩ G^C ⊆ S-cl(A) ∩ A^C = S-cl(A) – A. Since S-cl(A)⊆ G^C is IFS supra -closed and S-cl(A) – A is IFω-supra open. By Theorem4.2, we have S-cl(A)∩G^C ⊆ S-int(S-cl(A) – A =ϕ. Hence
A is IFω-supra closed.
Theorem 4.7.
For a subset A⊆X the following are equivalent:
(i) A is IFω-supra closed.
(ii) S-cl(A) –A contains no non-empty IFS supra closed set.
(iii) S-cl(A) –A is IFω-supra open set.

Proof:
Follows from theorem 3.9 and Theorem 4.5.

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