ON INTUITIONISTIC β-OPEN SETS

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Abstract: In this paper the properties of Intuitionistic β-open set (for short Iβ-open sets) are studied. Its relation with other existing forms of intuitionistic weak open sets is established. Also intuitionistic β-closure (for short Iβcl) and intuitionistic β-interior (for short Iβ int) of an intuitionistic set are defined and their properties are investigated. Further the theorems which exhibit the characterizations of Iβ-open set in intuitionistic topological spaces are proved and some of the interesting properties of Iβ-open sets are obtained.

Keywords: Iβ-open sets, β-closed sets, Iβ- closure, Iβ- interior.

Introduction: In 1986, Atanassov[4] introduced the concept of Intuitionistic fuzzy sets as a generalization of fuzzy sets. Later in 1996, Coker [5] introduced the concept of Intuitionistic set and Intuitionistic points. This is a discrete form of intuitionistic fuzzy sets where all the sets are crisp set. In 2000, Coker [7] also introduced the concept of "intuitionistic topological space" and investigated basic properties of continuous functions and compactness. N. Levine [10] introduced semi open sets and semi continuity in topological space and M.E. Abd EI. Monsef et.al [1] introduced "β-open sets and β-continuous mapping" and discussed some basic properties.

D. Andrijevic[3] introduced and discussed some more properties of semi preopen set in topological space. Gnanambal Ilango and Selvanayaki [9], introduced generalized pre regular closed sets in intuitionistic topological spaces.

In this paper intutionistic β-open sets is introduced and intuitionistic β-interior and intuitionistic β-closure are defined and some basic properties are investigated.

Preliminaries: Let us recall some basic definitions and results which are useful for this sequel. Throughout the present study, a space X means an intuitionistic topological space.

Definition 2.1 [5]: Let X is a non empty set. An intuitionistic set (IS for short) A is an object having the form $A = < X, A_1, A_2 >$, where A_1 and A_2 are subsets of X satisfying $A_1 \cap A_2 = \phi$. The set A_1 is called the set of members of A, while A_2 is called the set of non-members of A.

Definition 2.2 [5]: Let X be a non empty set and let A, B are intuitionistic sets in the form

$A = < X, A_1, A_2 >$, $B = < X, B_1, B_2 >$ respectively. Then

1. $A \subseteq B$ iff $A_1 \subseteq B_1$ and $B_2 \subseteq A_2$
2. $A = B$ iff $A \subseteq B$ and $B \subseteq A$
3. $A^c = < X, A_2, A_1 >$
4. $[\,]\, A = < X, A_1, (A_1)^c >$
5. $A - B = A \cap B^C$.
6. $\phi_\sim = < X, \phi, X >$, $X_\sim = < X, X, \phi >$
7. $A \cup B = < X, A_1 \cup B_1, A_2 \cap B_2 >$.
8. $A \cap B = < X, A_1 \cap B_1, A_2 \cup B_2 >$.

Furthermore, let $\{A_\alpha : \alpha \in J\}$ be an arbitrary family of intuitionistic sets in X, where $A_\alpha = < X, A_\alpha^{(1)}, A_\alpha^{(2)} >$. Then

(i) $\cap A_\alpha = < X, \cap A_\alpha^{(1)}, \cup A_\alpha^{(2)} >$.

(j) $\cup A_\alpha = < X, \cup A_\alpha^{(1)}, \cap A_\alpha^{(2)} >$.

Definition 2.3 [6]: An intuitionistic topology (for short IT) on a non empty set X is a family of IS's in X satisfying the following axioms.

1. $\phi_\sim, X_\sim \in \tau$
2. $G_1 \cap G_2 \in \tau$ for any $G_1, G_2 \in \tau$.
3. $\cup G_\alpha$ for any arbitrary family $\{G_i\ G_\alpha/\alpha \in J\} \subseteq \tau$ where (X, τ) is called an intuitionistic topological space (for short ITS(X)) and any intuitionistic set in is called an intuitionistic open set (for short IOS) in X. The complement A^c of an IOS A is called an intuitionistic closed set (for short ICS) in X.

Definition 2.4[7]: Let (X, τ) be an intuitionistic topological space (for short ITS(X)) and $A = < X, A_1, A_2 >$ be an IS in X. Then the interior and closure of A are defined by $Icl(A) = \cap\{K : K$ is an ICS in X and $A \subseteq K\}$, $Iint(A) = \cup\{G : G$ is an IOS in X and $G \subseteq A\}$. It can be shown that Icl(A) is an ICS and Iint(A) is an IOS in X and A is an ICS in X iff Icl(A) = A and is an IOS in X iff Iint(A) = A.

Definition 2.5[5]: Let X be a non empty set and $P \in X$. Then the IS P defined by $P = < X, \{p\}, \{p\}^c >$ is called an intuitionistic point (IP for short) in X. The intuitionistic point P is said to be contained in $A = < X, A_1, A_2 >$ (i.e $p \in A$) if and only if $p \in A_1$.

Definition 2.6[12]: Let (X,τ) be an ITS(X). An intuitionistic set A of X is said to be

1. Intuitionistic semiopen if $A \subseteq Icl(Iint(A))$.
2. Intuitionistic preopen if $A \subseteq Iint(Icl(A))$.
3. Intuitionistic regular open if $A = Iint(Icl(A))$.
4. Intuitionistic α-open if $A \subseteq Iint(Icl(Iint(A)))$.

The family of all intuitionistic pre-open, intuitionistic regular open and intuitionistic α-open sets of (X,τ) are denoted by IPOS, IROS and IαOS respectively.

Definition 2.7 [9]: Let (X,τ) be an ITS(X) and let $A = < X, A_1, A_2 >$ be IS in X. Then A is said to be

1. Intuitionistic generalized closed (Ig-closed) if Icl(A)⊆ U whenever A⊆ U and U is intuitionistic open in X.
2. Intuitionistic generalized preclosed (Igp-closed) if Ipcl (A) ⊆ U whenever A⊆ U and U is intuitionistic open in X.
3. Intuitionistic regular generalized closed (Irg-closed) if Icl(A)⊆ U whenever A⊆U and U is intuitionistic regular open in X.
4. Intuitionistic generalized α-closed (Igα-closed) if Iαcl(A)⊆U whenever A⊆ U and U is intuitionistic open in X.

On Intuitionistic β-Open Sets: Here intuitionistic β-open set is defined and its relation with existing intuitionistic sets is seen and its basic properties are studied.

Definition 3.1: A subset A of an intuitionistic topological space X is intuitionistic β-open set, if there exists a intuitionistic preopen set U in X, such that U ⊆ A ⊆ Icl(U). The family of all intuitionistic β-open sets in X will be denoted by IβOS(X).

Theorem 3.2: A subset A=< X, A_1, A_2 > of an ITS(X) is intuitionistic β-open set if and only if A ⊆ Icl (Iint (Icl(A))).

Proof: Necessity: Let A = < X, A_1, A_2 > be a intuitionistic β-open set, then there exist an intuitionistic pre-open set B, such that B ⊆ A ⊆ Icl(B) which implies Icl(A)=Icl(B) and hence Icl(Iint(Icl(A)))=Icl(Iint(Icl(B))). Since B is intuitionistic pre-open we have IB⊆Iint(Icl(B)) and hence A⊆Icl(B)⊆Icl(Iint(Icl(A))) which implies A⊆Icl(Iint(Icl(A))). Hence A is intuitionistic β-open set.

Sufficiency: Let A⊆Icl(Iint(Icl(A))), then we have Iint(Icl(A))⊆A, so Iint(Icl(A))⊆A⊆Icl(Iint(Icl(A))). Let B=Iint(Icl(A)), which implies IB⊆A⊆Icl(B)). Hence A is intuitionistic β-open in ITS(X).

Remark 3.3: The complement of an intuitionistic β-open set is called intuitionistic β-closed.

Theorem 3.4: Every intuitionistic open set is intuitionistic β-open set.

Proof: Let A be a intuitionistic open set in intuitionistic topological space, the Iint(A)=A implies IU⊆Iint(A)=A⊆Icl(U), implies IU⊆Iint(A)⊆Icl(U). Hence A is intuitionistic β-open set (IβO(X) for short).

The converse of the above theorem need not be true as seen from the following example.

Example 3.5: Let X= {a, b} with τ={$X_\sim$,$\phi_\sim$, A, B, C, D} where A=<X, {a},{ϕ}>, B=<X,{b}, ϕ} and C=<X, ϕ,{b}>, D= < X, {ϕ}, {ϕ}>.

Then the intutionistic set <X, {a},{b}> belongs to IβO(X) but not intuitionistic open sets in (X,τ).

Theorem 3.6: Every intuitionistic semi open set is intuitionistic β-open set.

Proof: Let A be a intuitionistic semi open set in intuitionistic topological space, then we have Iint(A)= Iint(cl(A)), therefore A⊆Icl(Iint⊆Icl(A)). Hence A is intuitionistic β-open set.

The converse of the above theorem need not be true as seen from the following example.

Example 3.7: Let X={a, b, c} with τ={ $X_\sim$, $\phi_\sim$, A, B, C, D, E, F} where A=<X, ϕ, {a, b}>, B=<X,{c},{a, b} and C=<X, ϕ,{b, c}>, D=<X,{c},{b}>, E=<X,{a, c},{b}> and F=<X, ϕ,{b}>.

Then the intuitionistic set U= <X, {a}, {b}> is a intuitionistic β-open set in ITS(X), but not intuitionistic semi open in (X, τ).

Theorem 3.8: Every intuitionistic pre-open set is a intuitionistic β-open set.

Proof: Let A be intuitionistic pre-open set in ITS(X), then A⊆Iint(Icl(A)) implies Iint(A)⊆Iint(Icl(A)) implies (Iint(Icl(A)))⊆ Icl(Iint(Icl(A))) implies Iint(Icl(A))⊆A⊆ Icl(Iint(Icl(A))) implies A⊆ Icl(Iint(Icl(A))). Hence A is intuitionistic β-open set in ITS(X).

The converse of the above theorm need not be true as seen from the following example.

Example 3.9: Let X={a, b, c} with τ={ $X_\sim$, $\phi_\sim$, A, B, C, D, E, F} where A=<X, ϕ, {a, b}>, B=<X,{c},{a, b} and C=<X, ϕ,{b, c}>, D=<X,{c},{b}>, E=<X,{a, c},{b}> and F=<X, ϕ,{b}>.

Let U= < X, ϕ,{a} > is a intuitionistic β-open set in ITS(X), but not in intuitionistic pre open sets in intuitionistic topological space (X, τ).

Corollary 3.10: Every intuitionistic α-open set is intuitionistic pre-open in ITS(X).

Corollary 3.11: Every intuitionistic α-open set is intuitionistic semi-open in ITS(X).

Theorem 3.12: Every intuitionistic α-open set is intuitionistic β-open in ITS(X).

Proof: Let A be a intuitionistic α-open set in ITS(X), WKT every intuitionistic α-open set is intuitionistic semi-open set from above theorem, therefore A⊆(Icl(IintA)) implies A⊆Icl(Iint(Icl(A)). Hence A is intuitionistic β-open set in ITS(X).

The converse of the above theorem need not be true as seen from the following example.

Example 3.13: Let X={a, b, c} with τ={ $X_\sim$, $\phi_\sim$, A, B, C, D, E, F} where A=<X, ϕ, {a, b}>, B=< X,{c},{a, b}> and C=<X, ϕ,{b, c}>, D=<X,{c},{b}>, E=<X,{a, c},{b}> and F=<X, ϕ,{b}>.

Let V= <X, ϕ ,{a}> is a intuitionistic β-open set in ITS(X), but not in intuitionistic α- open sets in intuitionistic topological space (X, τ).

Theorem 3.14: Every intuitionistic regular-open set is a intuitionistic β-open in ITS(X).

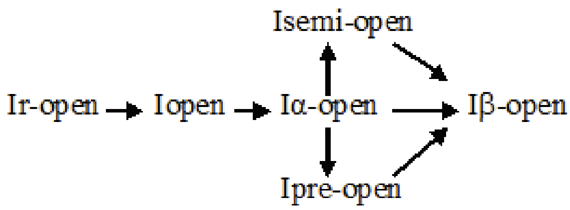
Proof: Let A be a intuitionistic regular-open set in ITS(X), then A=Iint(Icl(A)) implies A⊆Icl(Iint(Icl(A))). Hence A is intuitionistic β-open set in ITS(X).

The converse of the above theorem need not be true from the following example.

Example 3.15: Let X={a, b, c} with τ={ X~, ϕ~, A, B, C, D, E, F} where A=<X, ϕ, {a, b}>, B=<X,{c},{a, b} and C=<X, ϕ,{b, c}>, D=<X,{c},{b}>, E=<X,{a, c},{b}> and F=<X, ϕ,{b}>.

Let V= <X, {a}, {c}> is an intuitionistic β-open set in ITS(X), but not an intuitionistic regular- open sets in ITS(X).

The following diagram shows that relationship between Iβ-open sets and some other intuitionistic sets.



A→B represents A implies B but not conversely

Remark 3.16: The intersection of two Iβ-open sets need not be Iβ-open as seen from the following example.

Example 3.17: Let X= {a, b} with intuitionistic topology τ={X~, ϕ~, < X, {b}, ϕ >, < X, ϕ, {a} >}. The subset A = < X, {b}, ϕ > and B=< X, {a}, ϕ> both are Iβ-open sets in ITS(X). But the A∩B=<X,ϕ, ϕ> is not in Iβ-open set.

Theorem 3.18: Let A be a intuitionistic β-open set in ITS(X) and suppose A⊆B⊆Icl(A), then B is a intuitionistic β-open set in ITS(X).

Proof: Since A is a intuitionistic β-open set in ITS(X), then there exists a intuitionistic pre open set U in X. such that U⊆A⊆Icl(U), as A⊆B, U⊆A⊆B implies that U⊆B, also Icl(A)⊆Icl(Icl(U))=Icl(U) and thus B⊆Icl(U), hence U⊆B⊆Icl(U) which implies that B is a intuitionistic β-open set in ITS(X).

Theorem 3.19: If A is intuitionistic β-open set which is intuitionistic semi-closed set in ITS(X), is intuitionistic semi open set in ITS(X).

Proof: Let A = < X, A_1, A_2 > is a intuitionistic semi-closed, then Iint(Icl(A)) ⊆ A implies Iint(Icl(A)) ⊆ Iint(A) implies Icl(Iint(Icl(A))) ⊆ Icl(Iint(A)). Since A is a intuitionistic β-open A⊆Icl(Iint(Icl(A))), therefore A⊆Icl(Iint(Icl(A))) ⊆ Icl(Iint(A)) which implies A ⊆ Icl(Iint(A)). Therefore A is intuitionistic semi open set in ITS(X).

Theorem 3.20: If B is intuitionistic β-closed and intuitionistic semi-open in ITS(X), then B is intuitionistic semi closed set in ITS(X).

Proof: Let B = < X, B_1, B_2 > is a intuitionistic semi-open, then B⊆Icl(Iint(A)) implies Icl(A) ⊆ Icl(Iint(B)) implies Iint(Icl(B))⊆Iint(Icl(Iint(B))). Since B is a intuitionistic β-closed, Iint(Icl(Iint(B))) ⊆ B therefore Iint(Icl(B)) ⊆ Iint(Icl(Iint(B))) ⊆ B which implies Iint(Icl(A)) ⊆ B. Therefore B is intuitionistic semi-closed set in ITS(X).

Intuitionistic β-Closure and Intuitionistic β-Interior: Analogous to the definitions of β-closure and β-interior in general topology, here is defined Iβ-closure and Iβ-interior in intuitionistic topological space.

Definition 4.1: Let (X,τ) be an intuitionistic topological space and let A= < X, A_1, A_2> be an intuitionistic set of X, then Iβ-cl(A)=∩{F: F is intuitionistic β-closed in X and A⊆F}.

Definition 4.2: Let (X, τ) be an intuitionistic topological space and let A=< X, A_1, A_2> be an intuitionistic set of X, then Iβ-int(A)=U{F: F is intuitionistic β-open in X and F⊆A}.

Lemma 4.3: Let A and B be an intuitionistic sets of an ITS(X), then the following results are obvious.

1. Iβ-cl(X)=X and Iβ-cl(ϕ)=ϕ
2. If A⊆B, then Iβ-cl(A)⊆ Iβ-cl(B)
3. Iβ-cl(Iβ-cl(A))= Iβ-cl(A)
4. Iβ-int(Iβ-in(A))= Iβ-int(A)

Theorem 4.4: Let A=<X, A_1, A_2> be an intuitionistic sets of an ITS(X), then Iβ-cl(A) = AU Iint(Icl(Iint(A))).

Proof: We observe that

Iint(Icl(Iint(AUIint(Icl(Iint(A))))))
⊆Iint(Icl(Iint(AU(Icl(Iint(A))))
⊆ Iint(Icl(IintA U Icl(Iint(A))))
=Iint(Icl(Iint(A)))

Iβ-cl(A) ⊆AU Iint(Icl(Iint(A)))→ (i)

On the other hand Iβ-cl(A) is intuitionistic β-closed, so

Iint(Icl(Iint(A))) ⊆ Iint(Icl(Iint(Iβ-cl(A))))
⊆ Iβ-cl(A) and hence

AUIint(Icl(Iint(A))) ⊆ Iβ-cl(A) → (ii)

From (i) and (ii) we have

Iβ-cl(A) = AU Iint(Icl(Iint(A))).

Theorem 4.5: Let A=<X, A_1, A_2> be an intuitionistic set of intuitionistic topological space (X,τ), then Iβ-int (A)=A∩ Icl (Iint (Icl (A))).

Proof: We observe that

A∩ Icl (Iint (Icl (A)))=Icl (Iint (Icl (A))
⊆Icl(Iint(Icl(A)∩Iint(Icl(A)))
⊆Icl(Iint(Icl(A∩Iint(Icl(A))))

Here A ∩ Icl (Iint (Icl (A))) Iβ-open and hence

A ∩ Icl (Iint (Icl (A))) ⊆ Iβ-int (A) → (i).

On the other hand since Iβ-int(A) is intuitionistic β-open , we have

Iβ-int(A)⊆ Icl(Iint(Icl(Iβ-int(A))))
⊆ Icl(Iint(Icl(A)))
⊆ A Icl (Iint (Icl (A))) → (ii)

From (i) and (ii) we have

Iβ-int (A) =A∩ Icl (Iint (Icl (A))).

Theorem 4.6: Let A=<X, A_1, A_2> be an intuitionistic set of ITS(X), then Iβ-int (Iβ-cl(A)) = Iβ-cl(Iβ-int(A)).

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Proof: Let A=<X, A_1, A_2> be subset of intuitionistic topological space (X,τ).Then we have to prove that Iβ-int(Iβ-cl(A)) = Iβ-cl(Iβ-int(A)).
By applying theorem 4.3 and 4.4 we have
Iβ-int(Iβ-cl(A))
= Iβ-cl(A) ∩ Icl (Iint (Icl(Iβ-cl(A))))
=(AUIint(Icl(Iint(A))))∩(Icl(Iint(Icl(Iβ-cl(A)))))
=(AU Iint(Icl(Iint(A)))) ∩ Icl (Iint (Icl((A)))
=(A∩Icl (Iint (Icl(A)))) U (Iint(Icl (Iint (A))))
= Iβ-int(A) U Iint (Icl (Iint (Iβ-int(A)))
= Iβ-cl(Iβ-int (A)).

Theorem 4.7: Let A=<X, A_1, A_2> be subset of ITS(X). Then Icl(Iβ-int(A))) = Iβ-int(Icl(A)) = Icl(Iint(Icl(A)))

Proof: Since A=<X, A_1, A_2> be subset of ITS(X), Then we take Icl(Iβ-int(A)) = Icl (Icl (Iint (Icl(A))))
= Icl (Iint (Icl(A))) →(1).
Take Iβ-int(Icl(A)) = Icl (Iint (Icl (Icl(A))))
= Icl (Iint (Icl(A))) →(2)
From (1) and (2) we have Icl(Iβ-int(A))) = Iβ-int(Icl(A)) = Icl(Iint(Icl(A))).

Theorem 4.8: Let A=<X, A_1, A_2> be subset of ITS(X). Then Iint(Iβ-cl(A))) = Iβ-cl (Iint (A)) = (Iint (Icl (Icl (A))) .

Proof: obvious.

Corollary 4.9: Let A=<X, A_1, A_2> be subset of ITS(X), then the following results are hold.

1. Iscl(A) = A U Iint(Icl(A))
2. Isint(A) = A ∩ Icl(Iint(A))
3. Ipcl(A) = A U Icl(Iint(A))
4. Ipint(A) = A ∩Iint(Icl(A)).

Theorem 4.10: Let A=<X, A_1, A_2> be subset of ITS(X). Then Isint(Iβ-cl(A)))= Iβ-cl(Isint(A)) =Iscl(Isint(A)) .

Proof: Let A=<X, A_1, A_2> be subset of ITS(X), then applying 4.8 we have Isint (Iβ-cl(A)) = Iβ-cl(A) ∩ Icl(Iint(Iβ-cl(A)))
= Iβ-cl(A ∩Icl(Iint(A)))
= Iβ-cl (Isint(A)) →(1).
we take
Iscl(Isint(A))=Isint(A) U Iint(Icl (Isint(A)))
= Isint (A U Iint (Icl(A)))
= Isint(A U Icl (Iint (Icl(A))))
= Isint (Iβ-cl(A)) →(2).
From (1) and (2) we have
Isint(Iβ-cl(A)))=Iβ-cl(Isint(A))
=Iscl(Isint(A)).

Theorem 4.11: Let A=<X, A_1, A_2> be subset of ITS(X). Then Iscl(Iβ-int(A)) = Iβ-int (Iscl(A)) =Isint (Iscl(A)) .

Proof: obvious.

Theorem 4.12: Let A=<X, A_1, A_2> be subset of ITS(X). Then Ipcl (Iβ-int(A)) = Iβ-int(Ipcl(A))
= (A U Icl(Iint(A))) ∩ Icl(Iint(Icl(A))).

Proof: Let A=<X, A_1, A_2> be subset of ITS(X), then we take
Ipcl(Iβ-int(A))
=Iβ-int(A)UIcl(Iint(Iβ-int(A)))
= Iβ-int(A U Icl(Iint(A)))
= Iβ-int(Ipcl(A)) →(1).
Take Iβ-int(Ipcl(A))
= Ipcl(A)∩ Iint(Icl(Iint(Ipcl(A))))
= (A U Icl(Iint(A)))∩Iint(Icl(Iint(Ipcl(A)))))
= (AUIcl(Iint(A)))∩Iint(Icl(Iint(Icl(Iint(A))))
= (A U Icl(Iint(A))) ∩ Iint(Icl(Iint(Icl(A))))
= (A U Icl(Iint(A))) ∩ (Icl(Iint(Icl(A))))→(2)
From (1) and (2)
Ipcl(Iβ-int(A)))=Iβint(Ipcl(A))
=(AUIcl(Iint(A)))∩ Icl(Iint(Icl(A))).

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