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On Quasi Intuitionistic Α-Open Maps

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Abstract: We introduce the concept of quasi intuitionistic α-open function and quasi intuitionistic α-preopen functions. Further α-normal and α-quasi normal spaces are introduced in intuitionistic topological spaces.

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I. INTRODUCTION

In2011[6]introducedQuasiα-Closed,Stronglyα-ClosedandWeaklyαIrresolute Functions in topological spaces. In the present paper we define quasi intuitionistic α-open function, quasi intuitionistic α-preopen function, intuitionistic α-normal and intuitionistic α-quasi normal spaces and obtain their basicproperties.

II. PRELIMINARIES

Definition2.1.[4]AnintuitionisticsetAisanobjecthavingtheform<X,A1,A2>where A1 and A2 are subsets of X satisfying A1∩A2=φ. The set A1 is called the set of members of A, while A2 is called the set of nonmembers of A. Furthermore, let{Ai:i∈I}beanarbitrary familyofintuitionisticsetsinX, where$A_i = < X, A_i^1, A_i^2 >$ then

- φ∼= <X, φ, X >, X∼= <X, X, φ>
- A if $A_1 \subseteq B_1$and $A_2 \supseteq B_2$
- $\overline{A}$ =<X,A2,A1>
- A−B=A∩$\overline{B}$
- [ ] A = <X, A, A_1^c>
- <>A= <X, A_2^c, A_2>
- $\cap A_i = < X, \cap A_i^1, \cup A_i^2 >$and ,$\cup A_i = < X, \cup A_i^1, \cap A_i^2 >$.

Definition 2.2.[4] An intuitionistic topological space on a nonempty set X is a family τ of intuitionistic sets in X satisfying the following axioms:

- φ∼, X∼∈τ
- $G_1 \cap G_2 \in \tau$ for G1,G2 ∈τ
- ∪ Gi∈τfor any arbitraryfamily {Gi:i∈J}⊆τ

Inthiscasethepair(X,τ)iscalledintuitionistictopologicalspaceandanyintuitionistic set in τ is known as an intuitionistic open set in X, and the complement of intuitionistic open sets is known as intuitionistic closed set inX.

Definition 2.3.[10] Let (X, τ) be an intuitionistic topological space. An intuitionistic set A of X is said to be

- Intuitionistic semiopen if A ⊆I cl(I int(A))
- Intuitionistic preopen if A ⊆I int(I cl(A))
- Intuitionistic regular open if A =I int(I cl(A)).

Thefamilyofallintuitionisticpreopenandintuitionisticregularopensetsof(X,τ) aredenotedbyIPOS(X)andIROS(X)respectively.

Definition 2.4.[4] Let (X, τ)be an intuitionistic topological space on X and A =<X, A_1, A_2> be an intuitionistic set in X. Then the several topologies generated by (X, τ)are

- $\tau_{0,1}$= {[ ] A : A ∈ τ}

• $\tau_{0,2}$= {<> A : A ∈ τ}
• τ_1= {A1 : <X, A_1, A_2>∈τ }
• τ_2= {$(A_2)^C$: <X, A_1, A_2>∈ τ }

Definition 2.5.[4]

- If B = <Y, B_1, B_2>is an intuitionistic set in Y , then the preimage of B under f , denoted by f^{-1}(B), is the intuitionistic set in X defined by $f^{-1}(B)= <X,f^{-1}(B_1),f^{-1}(B_2)>$
- If A = <X, f(A_1), f(A_2)>is an intuitionistic set in X, then the image of A under f , denoted by f (A), is the intuitionistic set in Y defined by f(A)= <Y,f(A_1),f_ (A_2)> where f_ (A_2) = Y-(f (X – A_2)).
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III. ON QUASI INTUITIONISTIC A-OPENMAPS

Definition 3.1. An intuitionistic map f : (X, τ)→ (Y, σ) is said to be quasi intuitionistic α -open if the image of every intuitionistic α - open set in X is intuitionistic open in Y .

Theorem 3.2. Every quasi intuitionistic α-open map is intuitionistic open

Proof.Let U be intuitionistic open in X. Since every intuitionistic open set is intuitionistic α-open, U is intuitionistic α-open in X. Then f (U) is intuitionistic open in Y . Hence f isintuitionistic open.

Theorem3.3. An intuitionistic map f:(X,τ)→(Y,σ)is said to be quasi intuitionisticα-openifffforeverysubsetUof X, f(Iα int(U))⊂I int (f(U))

Proof. Let f be quasi intuitionistic α-open function. For an intuitionistic set U of X,I int(U) ⊂ U andIα int(U)isanintuitionisticα-openset.Hence,f(Iα int(U))⊂f(U).Asf(Iα int(U))isintuitionisticopen,f(Iαint(U)) ⊂I int(f(U)).
Conversely,assumef(Iαint(U))⊂Iint(f(U)).IfUisintuitionisticα-openinX thenf(U)=f(Iαint(U))⊂Iint(f(U)).ButweknowthatIint(f(U))⊂f(U).
Thereforef(U)=Iint(f(U)andsofisquasiintuitionisticα-open.

Lemma 3.4. An intuitionistic function f : (X, τ) → (Y, σ) is quasi intuitionistic α-open then Iα int f^{-1}(B)⊂f^{-1}(I int(B))for every set B of Y .

*Proof.*Let *B* be any intuitionistic set in *Y* and*Iα intf*$^{-1}$(*B*) is an intuitionistic *α*-open set in *X*.As *f* is quasi intuitionistic *α*-open, *f* (*Iα intf*$^{-1}$(*B*)) ⊂*I int f*(*f*$^{-1}$(*B*))⊂*I int*(*B*).ThusIα int f^{-1}(B)⊂f^{-1}(I int(B)).

Definition 3.5. An intuitionistic subset *S* is called intuitionistic*α*- neighbourhood of a point $x_\sim$in *X* if there exists an intuitionistic *α*-open set *U* such that $x_\sim \in U \subset S$

Theorem 3.6.*Let (X, τ)and (Y, σ) be intuitionistic topological space and f : (X, τ) → (Y, σ) be an intuitionistic function. Then the following are equivalent.*

(i) *f is quasi intuitionisticα-open.*
(ii) *ForeachsubsetUofX,f(Iα int(U))⊂I int(f(U)).*
(iii) *For each $x_\sim \in X$ and each intuitionistic α-neighbourhoodU of $x_\sim \in X$ there exists intuitionistic neighbourhoodV off($x_\sim$) in Y such that V ⊂f (U).*

Proof.(i))⇒(ii) By Theorem
(ii)⇒(iii) Assume (*ii*) holds. Let $x_\sim \in X$ and *U* be an arbitrary intuitionistic *α*- neighbourhood of $x_\sim \in X$. Then there exists an intuitionistic *α*-open set *V* in *X* such that $x_\sim \in V \subset U$. Then by (ii) *f* (*V*) = *f* (*I*(*V*)) ⊂*Iint*(*f* (*V*)) and hence*f*(*V*) = *Iint*(*f*(*V*)). Therefore it follows *f*(*V*) is intuitionistic open in *Y* such that*f* ($x_\sim$) ∈*f* (*V*) ⊂*f*(*U*). Hence (iii) holds.
(iii)⇒(i) Assume (iii) holds, let *U* be an arbitrary intuitionistic *α*-open set in *X*. Then for each $y_\sim \in f(U)$, by (iii) there exists intuitionistic neighbourhood*V* of $y_\sim$in *Y* such that *V* ⊂*f* (*U*). As *V* is an intuitionistic neighbourhood of $y_\sim$there exists intuitionistic open set *W* in *Y* such that *y* ∈ *W* ⊂ *V* . Thus,*f(U)* =∪ $W/_{y_\sim}$∈ *f(U)* which is intuitionistic open in Y. this implies *f* is intuitionistic*α*-open.

Theorem 3.7.*An intuitionistic function f : (X, τ) → (Y, σ) is quasi intuitionistic α-open iff for any subset B of Y and for any intuitionistic α-closed set F of X containingf^{-1}(B)thereexistsintuitionisticclosedsetGofYcontainingBsuch that f $^{-1}$(G) ⊂ F.*

*Proof.*Let *F* be quasi intuitionistic *α*-open function. Let *B Y* and *F* be intuitionistic *α*-closed set of *X* containing *f* $^{-1}$(*B*). Put *G* = *Y* - *f* (*X* - *F*). As*f*$^{-1}$(*B*)⊂ *F*wehave*B*⊂ *G*.As*f*isquasiintuitionistic*α*-open,*G*isintuitionistic closedin*Y*.Then*f*$^{-1}$(*G*)⊂*F*.Conversely,let*U* beintuitionistic*α*-openin*X*. Put*B*=*Y* -*f*(*U*)then*X* - *U*isintuitionistic*α*-

closedin$X$containing$f^{-1}(B)$.By hypothesis, there exists intuitionistic closed set $G$of Y such that $B \subset G$and$f^{-1}(G) \subset X - U$. Hence, $f(U) \subset Y - G$. Since $B \subset G$, $Y - G \subset Y - B = f(U)$ weobtain $f(U) = Y - G$which is intuitionistic open. Therefore it follows f is quasi intuitionisticα-openfunction.

Theorem 3.8.*Let (X, τ), (Y, σ) and (Z, σ) be intuitionistic topological space and $f : (X, \tau) \to (Y, \sigma)$, $g : (Y, \sigma) \to (Z, \eta)$ be two intuitionistic functions and $g \circ f : (X, \tau) \to (Z, \eta)$ be quasi intuitionistic α-open.Then*

(i). Iffisintuitionisticα-opensurjective,thengisquasiintuitionisticα-open.

(ii). Ifgisintuitionisticcontinuousandinjective,thenfisquasiintuitionistic α-open.

Proof. *(i).* Let$U$ beintuitionisticopenin$X$,then$f(U)$isintuitionisticα-open in Y. As $g \circ f$ is quasi intuitionistic α-open, $g(U) = g \circ f\,[f(U)]$ is intuitionistic open in Z. Hence g is quasi intuitionistic α-open.

(ii). Let V beintuitionistic α-open in X. As $g \circ f$ is quasi intuitionistic α-open, $g \circ f(V)$ is intuitionistic open in Z. Since $g$is intuitionistic continuous,
$f(V) = g(g \circ f(V))$ is intuitionistic openin$Z$.

IV. ON QUASI INTUITIONISTIC A-PREOPENFUNCTION

Definition4.1. Let(X,τ)beanintuitionistictopologicalspaceand$A=<X,A_1,A_2>$be an intuitionistic set in X. Then intuitionistic pre-interior of A,denotedby Ip-int(A)isdefinedastheunionofallintuitionisticpreopensetscontainedn$A$.

Definition 4.2. An intuitionistic map $f : (X, \tau) \to (Y, \sigma)$ is said to be quasi intuitionistic α-preopen if the image of every intuitionistic α-open set in X is intu- itionistic preopen in Y.

Theorem4.3.*An intuitionisticmap $f:(X,\tau)\to(Y,\sigma)$is said to be quasi intuitionisticα-preopeniffforeverysubsetUofX,$f(I\alpha\ int(U)) \subset Ipint(f(U))$*

*Proof.*Let f be quasi intuitionistic α-preopen function.In general we know that $Ipint(U) \subset U$and$I\alpha int(U)$isanintuitionisticα-openset.Hence,$f(I\alpha int(U)) \subset f(U)$.As$f(I\alpha int(U))$isintuitionisticpreopenthen$f(I\alpha int(U)) \subset Ipint(f(U))$.Conversely, assume $f(I\alpha int(U)) \subset Ipint(f(U))$.If$U$isintuitionistic$\alpha$-openin$X$then$f(U)=f(I\alpha int(U)) \subset Ipint(f(U))$.Butweknowthat$Ipint(f(U)) \subset f(U)$.Therefore$f(U)=Ipint(f(U))$.Therefore$f$isquasiintuitionistic$\alpha$-preopen.

Lemma4.4.*Anintuitionisticfunction$f:(X,\tau)\to(Y,\sigma)$isquasiintuitionistic α-preopen then $I\alpha intf^{-1}(G) \subset f^{-1}(Ipint(G))$ for every set tt of Y.*

*Proof.*Let G be an intuitionistic set of Y. Then $I\alpha intf^{-1}(G)$ is an intuitionistic α-open in X.As f is quasi intuitionistic α-preopen, $f\ (I\alpha intf^{-1}(G)) \subset Ipintf(f^{-1}(G)) \subset Ipint(G)$.Therefore $I\alpha intf^{-1}(G) \subset f^{-1}(Ipint(G))$

Definition4.5. Anintuitionisticset$S$iscalledintuitionisticpre-neighbourhoodof a point $x_{\sim}$in X if there exists an intuitionistic pre-open set U such that $x_{\sim} \in U \subset S$

Theorem 4.6.*Let $(X, \tau)$and (Y, σ) be intuitionistic topological space and $f : (X, \tau) \to (Y, \sigma)$ be an intuitionistic function. Then the following are equivalent.*

(i) *f is quasi intuitionisticα-preopen.*

(ii) *For each intuitionistic set U of X, $f(I\alpha int(U)) \subset Ipint(f(U))$.*

(iii) *For each $x\sim\in X$ and each intuitionistic α-neighbourhood$U$ of $x_{\sim} \in X$ there exists intuitionistic pre neighbourhood$V$ of $f(x_{\sim})$ in Y such that $V \subset f(U)$.*

Proof.(i)$\Rightarrow$(ii) By previous theorem

(ii)$\Rightarrow$(iii)Assumeforanintuitionisticsubset$U$of$X$,$f(I\alpha int(U)) \subset Ipint(f(U))$.

Let$x_{\sim} \in X$and$U$beanarbitraryintuitionisticα-neighbourhoodof$x_{\sim} \in X$.Then there exists an intuitionistic α-open set V in X such that $x_{\sim} \in V \subset U$. Then, $f(V)=f(I\alpha int(V)) \subset Ipint(f(V))$andhence$f(V)=Ipint(f(V))$.Therefore $f(V) = W$ is intuitionistic preopen in Y such that $f(x_{\sim}) \in W \subset f(U)$. Hence (iii) holds.

(iii)$\Rightarrow$(i) Assume (iii) holds, let U be intuitionistic α-open set in X. Then for every $y_{\sim} f(U)$, by (iii) there exists intuitionistic pre-neighbourhood$V$ of $y_{\sim}$in Y such that $V \subset f(U)$. As V is an intuitionistic pre-neighbourhood of $y_{\sim}$there exists intuitionistic preopen set in Y. This implies f is quasi intuitionistic α-preopen.

Theorem 4.7.*An intuitionistic function $f : (X, \tau) \to (Y, \sigma)$ is quasi intuitionistic α-preopen iff for any subset B of Y and for any intuitionistic α-closed set F of Xcontaining$f^{-1}(B)$thereexistsintuitionisticpreclosedset$G$of$Y$containing$B$ such that $f^{-1}(G) \subset F$*

*Proof.*Let F be quasi intuitionistic α-preopen function. Let B Y and F be intuitionistic α-closed set of X containing $f^{-1}(B)$. Put $G= Y-f(X -F)$. As $f^{-1}(B)\subset F$ we have $B \subset G$. Since f is quasi intuitionistic α-preopen, G is intuitionistic preclosed in Y. Then $f^{-1}(G) \subset F$. Conversely, let U be intuitionistic α-open in X. Put $B = Y - f(U)$ then $X - U$ is intuitionistivc α-closed in X containing $f^{-1}(B)$. By hypothesis, there exists intuitionistic preclosed set G of Y such that $B \subset G$ and $f^{-1}(G) \subset X - U$. Hence, $f(U)\subset Y - G$. On theotherhand $B \subset G$, $Y - G \subset Y - B = f(U)$. Thus $f(U) = Y - G$ which is intuitionistic preopen. Therefore f is quasi intuitionistic α-preopen function.

Lemma4.8. *Let (X,τ),(Y,σ) and (Z,σ) be intuitionistic topological space and f: $(X,\tau) \to (Y,\sigma)$, g:$(Y,\sigma) \to (Z, \eta)$ be two intuitionistic functions and $g : (X,\tau) \to (Z,\eta)$ be quasi intuitionistic α-preopen. Then*

- *If f is intuitionistic α-continuous, preopen then g is quasi intuitionistic α-preopen.*
- *If f is intuitionistic pre irresolute, f is quasi intuitionistic α-preopen.*

Proof. Let U be intuitionistic α-open in Y. Then since f is intuitionistic α-continuous, $f^{-1}(U)$ is intuitionistic α-open in X. Since g is quasi intuitionistic α-preopen, $g(U) = g \circ f[f^{-1}(U)]$ is intuitionistic preopen in Z. Hence g is quasi intuitionistic α-preopen.

- Let V be intuitionistic α-open in X then $gf(V)$ is intuitionistic preopen in Z. As g is intuitionistic pre irresolute, $f(V)=g^{-1}(g\circ f(V))$ is intuitionistic preopen in Y. Hence f is quasi intuitionistic α-preopen.

Theorem 4.9. *Let $f : (X,\tau) \to (Y, \sigma)$ and $g : (Y,\sigma) \to (Z, \eta)$ be two intuitionistic functions. Then the following statements are valid:*

- *If $f : (X, \tau) \to (Y, \sigma)$ is intuitionistic α-open and $g : (Y, \sigma) \to (Z, \eta)$ is Ipre-α-open,, then g $f : (X, \tau) \to (Z, \eta)$ is intuitionistic α-open.*
- *If $f : (X, \tau) \to (Y, \sigma)$ is Ipre-α-open and $g : (Y, \sigma) \to (Z, \eta)$ is quasi intuitionistic α-open.*
- *If $f : (X, \tau) \to (Y, \sigma)$ is quasi intuitionistic α-open and $g : (Y, \sigma) \to (Z, \eta)$ is intuitionistic preopen then $g\circ f : (X, \tau) \to (Z, \eta)$ is quasi intuitionistic α-preopen*
- *If $f : (X, \tau) \to (Y, \sigma)$ is intuitionistic α-open and $g : (Y, \sigma) \to (Z, \eta)$ is quasi intuitionistic α-open then $g \circ f : (X, \tau) \to (Z, \eta)$ is intuitionistic open.*

5. Intuitionistic α-Normal And α-Quasi Normal

Definition 5.1. An intuitionistic topological space (X, τ) is intuitionistic normal iff for every pair L, M of disjoint intuitionistic closed sets of X there exists intuitionistic open sets G and H such that $L \subset G$, $M \subset H$ and $G \subseteq H^C$.

Definition5.2. An intuitionistic topological space (X,τ) is intuitionistic α-normal if for every pair F_1, F_2 of disjoint intuitionistic closed sets of X there exists disjoint intuitionistic α-open sets U and V such that $F_1\subset U$ and $F_2\subset V$ and $U \subseteq V^C$.

Definition 5.3. An intuitionistic topological space (X, τ) is intuitionistic α-quasi normal iff for every pair of disjoint intuitionistic closed set A and intuitionistic α-closed set B of X there exists intuitionistic α-open sets U and V such that $A \subseteq U$, $B \subseteq V$ and $U \subseteq V^C$.

Theorem 5.4. *If (X,τ) is intuitionistic α-normal then for every pair of intuitionistic open sets U and V whose union is $X_\sim$ there exists intuitionistic α-closed sets A and B such that $A \subset U$, $B \subset V$ and $A \cup B = X_\sim$.*

Proof. Let U and V be a pair of intuitionistic open sets in intuitionistic α-normal space (X, τ) such that $U \cup V = X_\sim$. Then U^C and V^C are intuitionistic closed sets. Since (X, τ) is intuitionistic α-normal there exist intuitionistic α-open sets U_1 and V_1 such that $U^C \subset U1$, $V^C \subset V1$ and $U1 \subset V^C$. Let $A = U^C$ and $B = V^C$. Then A and B are intuitionistic α-closed sets such that $A \subset U$, $B \subset V$ and $A \cup B = X_\sim$.

Theorem 5.5. *An intuitionistic topological space (X, τ) is intuitionistic α-quasi normal iff every intuitionistic closed set A and intuitionistic α-open set V containing A there is intuitionistic α-open set U such that $A \subseteq U \subseteq Iacl(U) \subseteq V$*

Proof. Suppose (X, τ) is intuitionistic α quasi-normal in which A is intuitionistic closed and V is intuitionistic α-open containing A. Then V^C is intuitionistic α- closed such that $A\cap V^C = \varphi_\sim$. Since (X, τ) is intuitionistic α quasi-normal there exists intuitionistic α-open sets U and W such that $A \subseteq U$, $V^C \subseteq W$ and $U \subset W^C$.i.e. $A\subseteq U\subseteq W^C\subseteq V$. Since W^C is intuitionistic α-closed set U containing intuitionistic α-open set U, $U\subseteq Iacl(U)\subseteq W^C$. Therefore $A \subseteq U \subseteq Iacl(U)\subseteq V$. Conversely, let A and B be disjoint pair of intuitionistic closed set and intuitionistic α-closed set respectively. Then $A\cap B = \varphi \Longrightarrow A \subseteq B^C$ and B^C is intuitionistic α-open. Then by hypothesis, there exists intuitionistic α-open set U such that $A \subseteq U \subseteq I\alpha cl(U) \subseteq B^C$. This implies $A \subseteq U$, $B \subseteq [I\alpha cl(U)]^C$ and $U \subset I\alpha cl(U)$. Hence (X, τ) is intuitionisticα-quasinormal.

Theorem 5.6.*Intuitionistic α-quasi normality is a topological property*

*Proof.*Let (X, τ)be intuitionistic α quasi-normal and let (Y, σ) be intuitionistic α-homeomorphic image of (X, τ) under intuitionistic α-homeomorphism f .Toshow that (Y, σ) is intuitionistic α quasi-normal, let A and B be pair of disjoint intuitionistic closed and intuitionistic α-closed sets in Y .Since $f$is intuitionistic α-continuous,$f^{-1}(A)$and$f^{-1}(B)$areintuitionisticα-closedin$X$. Also$f^{-1}(A)\cap f^{-1}(B) = f^{-1}(A\cap B) = f^{-1}(\varphi_{\sim}) = \varphi_{\sim}$. So, $f^{-1}(A)$ and $f^{-1}(B)$are disjoint intuitionisticα-closedof$X$.Since$X$isintuitionisticα-quasinormal,thereexists intuitionisticα-opensets$U$and$V$suchthat$f^{-1}(A)\subseteq U$,$f^{-1}(B)\subseteq V$and$U\cap V = \varphi_{\sim}$. But $f^{-1}(A) \subseteq U \Rightarrow f(f^{-1}(A)) \subseteq f(U) \Rightarrow A \subseteq f(U)$. Similarly $B \subseteq f(V)$. Alsosincefisbijectiveintuitionisticα-open,f(U)andf(V)areintuitionisticα-opensetsofYsuchthat$f(U) \cap f(V) \subseteq f(U\cap V)=\varphi_{\sim} \Rightarrow f(U) \subset (f(V))^C$.Hence$(Y,\sigma)$ isintuitionisticαquasinormal.So,intuitionisticα-quasinormalisatopological property.

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