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ON Ω_{gb}^{+} -closed sets in simple extension topological spaces

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ABSTRACT

This paper serves as a platform to discuss and bring out the concept of kernel, separation axiom and continuity of Ω_{gb}^{+} and $\mho_{gb}^{+}$ -closed sets, under the light of simple extension topological spaces.

1. Introduction

A new class of generalized open sets called b-open sets in topological spaces was defined by Andrijevic [2]. The class of all b open sets generates the same topology as the class of all pre-open sets. In 1986, Maki [11] introduced the concept of generalized Λ sets and defined the associated closure operators by using the work of Levine [8] and Dunhem [5]. Caldas and Dontchev [3] introduced Λ_s-sets, V_s-sets, $g\Lambda_s$-sets and gV_s-sets. Ganster and et al. [6] introduced the notion of pre Λ-sets and pre V-sets and obtained new topologies via these sets. M.E. Abd El-Monsef et al. [1] defined $b\Lambda$-sets and bV-sets on a topological space and proved that it forms a topology. In 1963 Levine [9] introduced the concept of a simple extension of a topology τ as $\tau(B) = \{(B\cap O)\cup O' / O, O' \in \tau$ and $B \notin \tau\}$. Sr. I. Arockiarani and F. Nirmala Irudayam [12] introduced the concept of b^+-open sets in extended topological spaces. Caldas and Jafari[4] introduced the notions of Λ_δ–T_0, Λ_δ–T_1 and Λ_δ–T_2 topological spaces. S. Reena and F. Nirmala Irudayam [14] devised a new form of continuity and T. Noiri, Sr. I. Arockiarani and F. Nirmala Irudayam [13] coined the idea of Ω_{gb}^{+*}, $\mho_{gb}^{+*}$ sets in simple extended topological spaces. T. Madhumathi and F. Nirmala Irudayam [10] proposed the idea of $\Omega_{gb}^{+}(S)$ and $\mho_{gb}^{+}(S)$ sets in simple extension ideal topological spaces.

2. Preliminaries

All through the paper the space X is a SETS in which no separation axioms are assumed unless and otherwise stated.

Definition 2.1

A subset A of a topological space (X,τ) is said to be,

(i) b-open set[2], if $A \subseteq cl(int(A)) \cup int(cl(A))$ and b-closed set $cl(int(A)) \cup int(cl(A)) \subseteq A$.

(ii) a generalized closed (briefly g-closed) [7] if $cl(A) \subseteq U$ whenever $A \subseteq U$ and U is open.

(iii) a generalized b-closed (briefly bg-closed) [6] if $bcl(A) \subseteq U$ whenever $A \subseteq U$ and U is open.

(iv) πgb-closed[15] if $bcl(A) \subset A$ whenever $A \subset U$ and U is π-open in (X,τ). By $\pi GBC(X,\tau)$ we mean the family of all πgb-closed subsets of the space (X,τ)

Definition 2.2[12]: A subset A of a topological space (X,τ) is said to be,

(i) b^+-open set if $A \subseteq cl^+(int(A)) \cup int(cl^+(A))$ and b-closed set $cl^+(int(A)) \cup int(cl^+(A)) \subseteq A$.

(ii) a generalized$^+$ closed (briefly g^+-closed) if $cl^+(A) \subseteq U$ whenever $A \subseteq U$ and U is open.

(iii) a generalized b^+-closed (briefly bg^+-closed) if $bcl^+(A) \subseteq U$ whenever $A \subseteq U$ and U is open.

(iv) πgb^+-closed[14] if $bcl^+(A) \subset A$ whenever $A \subset U$ and U is π^+-open in (X,τ^+). By $\pi GB^+C(X,\tau^+)$ we mean the family of all πgb^+-closed subsets of the space (X,τ^+).

Definition 2.3[10]: Let S be a subset of a topological space (X, τ^+) we define the sets $\Omega_{gb}^{+}(S)$ and $\mho_{gb}^{+}(S)$ as follows, $\Omega_{gb}^{+}(S) = \cap\{G | G \in \pi GB^+O(X,\tau^+)$ and $S \subseteq G\}$, $\mho_{gb}^{+}(S) = \cup\{F | F \in \pi GB^+C(X,\tau^+)$ and $S \supseteq F\}$.

Definition 2.4[14]: A function $f: (X,\tau^+) \rightarrow (Y,\sigma^+)$ is called

(i) π^+-irresolute if $f^{-1}(V)$ is π^+-closed in (X,τ^+) for every π^+-closed set V of (Y,σ^+).

(ii) b^+-irresolute if for each b^+-open set V in (Y,σ^+), $f^{-1}(V)$ is b^+-open in (X,τ^+).

(iii) b^+-continuous if for each open set V in (Y,σ^+), $f^{-1}(V)$ is b^+-open in (X,τ^+).

3. Ω_{gb}^{+} -KERNEL

Definition 3.1: Let (X, τ^+) be a topological space, $A \subset X$. Then Ω_{gb}^{+}-kernal of A is defined by $\Omega_{gb}^{+}\text{-Ker}(A) = \cap\{G / G \in \Omega_{gb}^{+}O(X, \tau^+)$ and $A \subset G\}$

Definition 3.2: A point $x \in X$ is called Ω_{gb}^{+}-cluster point of A if for every Ω_{gb}^{+}-open set U containing x, $A \cap U \neq \phi$.

Let (X,τ^+) be a topological space and A,B be subsets of X, Let $x,y \in X$ then we have the following lemmas.

Lemma 3.3: $A \subset \Omega_{gb}^{+}\text{-Ker}(A)$

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Proof: Let $x \notin \Omega_{gb}^{+}$-Ker(A) then there exists $V \in \Omega_{gb}^{+}O(X, \tau^{+})$ such that $A \subset V$ and $x \notin V$. Hence $x \notin A$.

Lemma 3.4: If $A \subset B$, then Ω_{gb}^{+}-Ker(A) $\subset \Omega_{gb}^{+}$-Ker(B).

Proof: Let $x \notin \Omega_{gb}^{+}$-Ker(B).Then there exists $G \in \Omega_{gb}^{+}O(X,\tau^{+})$ such that $B \subset G$ and $x \notin G$. Since $A \subset B$, $A \subset G$ and hence $x \notin \Omega_{gb}^{+}$-Ker(A).

Lemma 3.5: Ω_{gb}^{+}-Ker(A) = Ω_{gb}^{+}-Ker(Ω_{gb}^{+}-Ker(A)).

Proof: Let $x \in \Omega_{gb}^{+}$-Ker(Ω_{gb}^{+}-Ker(A)) then for every Ω_{gb}^{+}-open set, $G \supset \Omega_{gb}^{+}$-Ker(A), $x \in G$. Since $A \subset \Omega_{gb}^{+}$-Ker(A), for every Ω_{gb}^{+}-open set $G \supset A$, $x \in G$. Hence $x \in \Omega_{gb}^{+}$- Ker(A). Therefore Ω_{gb}^{+}-Ker(Ω_{gb}^{+}-Ker(A)) $\subset \Omega_{gb}^{+}$-Ker(A). Also Ω_{gb}^{+}-Ker(A) $\subset \Omega_{gb}^{+}$-Ker(Ω_{gb}^{+}-Ker(A). Hence Ω_{gb}^{+}-Ker(A) = Ω_{gb}^{+}-Ker(Ω_{gb}^{+}-Ker(A)).

Lemma 3.6: $y \in \Omega_{gb}^{+}$ -Ker({x}) if $x \in \Omega_{gb}^{+}$-cl({y})

Proof: Let $y \notin \Omega_{gb}^{+}$-Ker({x}) $\Leftrightarrow$ there exists a Ω_{gb}^{+}-open set $V \supset \{x\}$ such that $y \notin V$ $\Leftrightarrow$ there exists a Ω_{gb}^{+} -open set $V \supset \{x\}$ such that $\{y\} \cap V = \phi \Leftrightarrow$ x is not a Ω_{gb}^{+}-cluster point of {y} $\Leftrightarrow$ $x \notin \Omega_{gb}^{+}$-cl({y})

4. Ω_{gb}^{+}-T_k SPACES

Definition 4.1: (X, τ^{+}) is Ω_{gb}^{+}-T_0 if for each pair of distinct points x, y of X, there exists a Ω_{gb}^{+}-open set containing one of points but not the other.

Theorem 4.2: (X, τ^{+}) is Ω_{gb}^{+}-T_0 iff for each pair of distinct points x,y of X, Ω_{gb}^{+}-cl({x}) $\neq \Omega_{gb}^{+}$ -cl({y}).

Proof: Necessity: Let (X, τ^{+}) be a Ω_{gb}^{+}-T_0 space. Let $x, y \in X$ such that $x \neq y$. Then there exists a Ω_{gb}^{+}-open set V containing one of the points but not the other, say $x \in V$ and $y \notin V$. Then V^c is Ω_{gb}^{+}-closed set containing y but not x. But Ω_{gb}^{+}-cl({y}) is the smallest Ω_{gb}^{+}-closed set containing y. Therefore Ω_{gb}^{+}-cl({y}) $\subset V^c$. Hence $x \notin \Omega_{gb}^{+}$-cl{y}.Thus Ω_{gb}^{+}-cl({x}) $\neq \Omega_{gb}^{+}$-cl({y}).Sufficiency: Suppose $x,y \in X$, $x \neq y$ and Ω_{gb}^{+} -cl({x}) $\neq \Omega_{gb}^{+}$ -cl({y}).Let $z \in X$ such that $z \in \Omega_{gb}^{+}$-cl({x}) but $z \notin \Omega_{gb}^{+}$-cl({y}). If $x \in \Omega_{gb}^{+}$-cl({y}),then Ω_{gb}^{+}-cl({x}) $\subset \Omega_{gb}^{+}$-cl({y}) and hence $z \in \Omega_{gb}^{+}$ -cl({y}).This is a contradiction. Therefore $x \notin \Omega_{gb}^{+}$ -cl({y}).That implies $x \in (\Omega_{gb}^{+}$ -cl({y}))^c. Therefore (Ω_{gb}^{+}-cl({y}))^c is a Ω_{gb}^{+} -open set containing x but not y. Hence (X, τ^{+}) is Ω_{gb}^{+}-T_0

Definition 4.3: (X, τ^{+}) is Ω_{gb}^{+}-T_1 if for any pair of distinct points x,y of X, there is a Ω_{gb}^{+}-open set U in X such that $x \in U$ and $y \notin U$ and there is a Ω_{gb}^{+}-open set V in X such that $y \in V$ and $x \notin V$.

Remark 4.4: Every Ω_{gb}^{+}- T_1 space is Ω_{gb}^{+}- T_0 space. But the converse need not be true.For example, let X = {a, b, c}, τ ={X,Φ,{a},{a,b}} and B={b}, τ^{+} ={X,Φ,{a},{b},{a,b}} . Then (X, τ^{+}) is Ω_{gb}^{+} - T_0 space but not Ω_{gb}^{+} -T_1 space.

Theorem 4.5: In a space(X,τ^{+}), the following are equivalent

(1) (X, τ^{+}) is Ω_{gb}^{+} - T_1

(2) For every $x \in X$, {x} = Ω_{gb}^{+}-cl({x}).

(3) The intersection of all Ω_{gb}^{+} -open sets containing the point x in X is {x}.

Proof: (1) $\Rightarrow$ (2): Suppose $y \neq x$ in X. Then there exists a Ω_{gb}^{+} -open set V such that $x \in V$ and $y \notin V$. If $x \in \Omega_{gb}^{+}$- cl({y}),then x is a cluster point of {y}.That implies for every Ω_{gb}^{+}-open set U containing x,$\{y\} \cap U \neq \phi$. Here V is a Ω_{gb}^{+}-open set containing x. Therefore $\{y\} \cap V \neq \phi$ implies $y \in V$. This is a contradiction. Thus $x \notin \Omega_{gb}^{+}$ -cl({y}). Hence for a point x. $y \notin \Omega_{gb}^{+}$-cl({x}).Thus{x}=Ω_{gb}^{+}-cl({x}). (2)$\Rightarrow$(3): $x \in \Omega_{gb}^{+}$ -cl({y}) $\Leftrightarrow$ x is a Ω_{gb}^{+}-cluster point of {x} $\Leftrightarrow$ for every Ω_{gb}^{+} -open set U containing x, $\{x\} \cap U \neq \phi$ if and only if $x \in \cap\{G/G \in \Omega_{gb}^{+}\text{-}O(X,\tau^{+})$ and $\{x\} \subset G\}$. ThereforeΩ_{gb}^{+}-cl({x})=$\cap\{G/G \in \Omega_{gb}^{+}\text{-}O(X,\tau^{+})and\{x\} \subset G\}$. (2),{x}=$\cap\{G/G \in \Omega_{gb}^{+}\text{-}O(X,\tau^{+})and\{x\} \subset G\}$. (3) $\Rightarrow$(1): Let $x \neq y$ in X. By (3),and{{x} $\subset$G}. Hence there exists one Ω_{gb}^{+} -open set V containing x but not y. Similarly, there exists one Ω_{gb}^{+} -open set U containing y but not x. Hence (X,τ) is Ω_{gb}^{+}-T_1.

Theorem 4.6: A space (X, τ^{+}) is Ω_{gb}^{+} -T_1 if the singletons are Ω_{gb}^{+} -closed sets

Proof: Suppose (X, τ^{+}) is Ω_{gb}^{+} - T_1. Let $x \in X$ and $y \in \{x\}^c$. Then $x \neq y$ and so there exists a Ω_{gb}^{+}-open set U_y such that $y \in U_y$ but $x \notin U_y$. Therefore $y \in U_y \subset \{x\}^c$. That is, $\{x\}^c = \cup\{U_y/y \in \{x\}^c\}$ is Ω_{gb}^{+}-open. Hence {x} is Ω_{gb}^{+} -closed. Conversely, let $x, y \in X$ with $x \neq y$. Then $y \in \{x\}^c$ and $\{x\}^c$ is a Ω_{gb}^{+}-open set containing y but not x. Similarly $\{y\}^c$ is a Ω_{gb}^{+} - open set containing x but not y. Hence (X, τ^{+}) is a Ω_{gb}^{+} - T_1.

Definition 4.7: (X, τ^{+}) is Ω_{gb}^{+}- T_2 if for each pair of distinct points x and y in X there exists a Ω_{gb}^{+} -open set U and a Ω_{gb}^{+} -open set V in X such that $x \in U$, $y \in V$ and $U \cap V = \phi$.

Remark 4.8: Every Ω_{gb}^{+}- T_2 space is Ω_{gb}^{+} - T_1.

Theorem 4.9: For a topological space (X, τ^{+}),the following are equivalent:

(1) (X, τ^{+}) is Ω_{gb}^{+}- T_2.

(2) If $x \in X$,then for each $y \neq x$, there is a Ω_{gb}^{+} -open set U containing x such that $y \notin \Omega_{gb}^{+}$-cl(U).

(3) For each $x \in X$, {x}=$\cap$\{ Ω_{gb}^{+}-cl(U) |U is a Ω_{gb}^{+} -open set containing x\}.

Proof: (1)$\rightarrow$ (2): Let $x \in X$. Then for each $y \neq x$,there exists Ω_{gb}^{+} -open sets A and B such that $x \in A$,$y \in B$ and $A \cap B = \phi$. Then $x \in A \subset X\text{-}B$. Take X-B=F. Then F is Ω_{gb}^{+} closed. $A \subset F$ and $y \notin F$. That implies $y \notin \cap\{F/F$ is Ω_{gb}^{+} -closed and $A \subset F\}$= Ω_{gb}^{+}-cl(A). (2)$\rightarrow$ (1): Let $x,y \in X$ and $x \neq y$. By (2),there exists a Ω_{gb}^{+} -open set U containing x such that $y \notin \Omega_{gb}^{+}$ - cl(U). Therefore $y \in$ X-(Ω_{gb}^{+} -cl(U)), X-(Ω_{gb}^{+} -cl(U)) is Ω_{gb}^{+} -open and $\notin$ X-(Ω_{gb}^{+} -cl(U)). Also $U \cap$ X-(Ω_{gb}^{+} -cl(U))= ϕ. Hence (X, τ^{+}) is Ω_{gb}^{+} -T_2. (3)$\leftrightarrow$(1): Obvious.

5. Ω_{gb}^{+} -CONTINUOUS AND Ω_{gb}^{+} -IRRESOLUTE FUNCTIONS

Definition 5.1: A function f: $(X,\tau^{+}) \rightarrow (Y,\sigma^{+})$ is called Ω_{gb}^{+}-continuous if every $f^{-1}(V)$ is Ω_{gb}^{+}-closed in (X,τ^{+}) for every closed set V of (Y,σ^{+}).

Definition 5.2: A function f: $(X,\tau^{+}) \rightarrow (Y,\sigma^{+})$ is called Ω_{gb}^{+}-irresolute if $f^{-1}(V)$ is Ω_{gb}^{+}-closed in (X,τ^{+}) for every Ω_{gb}^{+}-closed set V in (Y,σ^{+}).

Definition 5.3: A function f: X→ Y is said to be pre b^+-closed if f(U) is b^+closed in Y for each b^+closed set in X.

Remark 5.4: Composition of two $\Omega_{gb}{}^+$ –continuous functions need not be $\Omega_{gb}{}^+$–continuous.

Example 5.5: Let X={a,b,c},τ ={X, ϕ,{a},{a,c}} and B={c}, τ^+ ={X,Φ,{a},{c},{a,b}}. σ ={ X, ϕ, X,{a},{a,b}} and B={b}, σ^+ ={X,Φ,{a},{b},{a,b}}. η ={ X, ϕ,{c},{a,c}} and B={b}, η^+ ={X,Φ,{b},{c},{a,c},{b,c}.Define f:(X,τ)→(X,σ) by f(a)=a, f(b)=c,f(c)=b. Define g:(X,σ)→(X,η) by g(a)=a, g(b)=b, g(c)=c. Then f and g are $\Omega_{gb}{}^+$-continuous but gof is not $\Omega_{gb}{}^+$-continuous.

Proposition 5.6: Let f:(X,τ)→(Y,σ) be π^+-irresolute and pre b^+-closed. Then f(A) is $\Omega_{gb}{}^+$-closed in Y for every $\Omega_{gb}{}^+$-closed set A of X.

Proof: Let A be $\Omega_{gb}{}^+$- closed in X. Let f(A)⊂V is π- open inY. Then A⊂f^{-1}(V) and A is $\Omega_{gb}{}^+$-closed in X implies b^+cl(A)⊂f^{-1}(V). Hence f(bcl(A)) ⊂V. Since f is pre b^+ closed, b^+ cl(f(A)) ⊂ b^+cl(f(b^+cl(A))) =f(b^+cl(A)) ⊂V. Hence f(A) is $\Omega_{gb}{}^+$- closed in Y.

Definition 5.7: A topological space X is a $\Omega_{gb}{}^+$- space if every $\Omega_{gb}{}^+$- closed set is closed.

Proposition 5.8: Every $\Omega_{gb}{}^+$- space is $\Omega_{gb}{}^+$- $T_{1/2}$ space.

Theorem 5.9: Let f:(X,τ)→(Y,σ) be a function.

(1) If f is $\Omega_{gb}{}^+$- irresolute and X is $\Omega_{gb}{}^+$- $T_{1/2}$ space,then f is b^+-irrusolute.
(2) If f is $\Omega_{gb}{}^+$- continuous and X is $\Omega_{gb}{}^+$- $T_{1/2}$ space,then f is b^+-continuous.

Proof: (1) Let V be b^+-closed in Y. Since f is $\Omega_{gb}{}^+$-irresolute, f^{-1}(V) is $\Omega_{gb}{}^+$-closed in X. Since X is $\Omega_{gb}{}^+$-$T_{1/2}$ space, f^{-1}(V) is b^+-closed in X. Hence f is b^+-irresolute. (2) Let V be closed in Y. Since f is $\Omega_{gb}{}^+$-continuous, f^{-1}(V) is $\Omega_{gb}{}^+$-closed in X. By assumption, it is b^+-closed . Hence f is b^+-continuous.

Definition 5.10: A function f: (X,τ^+)→(Y,σ^+) is π^+-open map if f(F) is π^+-open in Y for every π^+-open in X.

Theorem 5.11: If the bijective f: (X,τ^+)→(Y,σ^+) is b^+-irresolute and π^+-open map, then f is $\Omega_{gb}{}^+$-irresolute.

Proof: Let V be $\Omega_{gb}{}^+$-closed in Y. Let f^{-1}(V) ⊂ U where U is π^+-open in X. Hence V ⊂ f(U) and f(U) is π^+-open implies b^+cl(V) ⊂ f(U). Since f is b^+-irresolute, (f^{-1}(b^+cl(V))) is b^+-closed. Hence b^+cl(f^{-1}(V)) ⊂ b^+cl(f^{-1}(b^+cl(V))) = f^{-1}(b^+cl(V)) ⊂ U. Therefore, f is $\Omega_{gb}{}^+$-irresolute.

Theorem 5.12: If f:X→Y is π^+-open, b^+-irresolute, pre b^+-closed surjective function. If X is $\Omega_{gb}{}^+$- $T_{1/2}$ space, then Y is $\Omega_{gb}{}^+$- $T_{1/2}$ space.

Proof: Let F be a $\Omega_{gb}{}^+$-closed set in Y. Let f^{-1}(F) ⊂ U where U is π^+-open in X. Then F⊂ f(U) and F is a $\Omega_{gb}{}^+$- closed set in Y implies b^+cl(F) ⊂ f(U). Since f is b^+-irresolute, b^+cl(f^{-1}(F)) ⊂ b^+cl(f^{-1}(b^+cl(F))) = f^{-1}(b^+cl(F)) ⊂ U. Therefore f^{-1}(F) is $\Omega_{gb}{}^+$-closed in X. Since X is $\Omega_{gb}{}^+$- $T_{1/2}$ space, f^{-1}(F) is b^+-closed in X. Since f is pre b^+-closed, f(f^{-1}(F))=F is b^+-closed in Y. Hence Y is $\Omega_{gb}{}^+$- $T_{1/2}$ space.

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