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Πg^B*-Continuity in Topological Space

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Abstract: In this Paper using πg^b*-closed set in topological spaces we introduce a new class of sets called π generalized ^ b*-continuous functions (briefly πg^b*-continuous functions). Further the concept of almost πg^b*-continuous function and πg^b*-irresolute function are discussed.

Key words: πg^b*-continuous function, πg^b*-irresoulte function, almost πg^b*-continuous function.

I. INTRODUCTION

Levine[10] and Andrijevic[2] introduced the concept of generalized open sets and b-open sets respectively in topological spaces. The class of b-open sets is contained in the class of semipre-open sets and contains the class of semi-open and the class of pre-open sets. Since then several researches were done and the notion of generalized semi-closed, generalized pre-closed and generalized semipre-open sets were investigated. In 1968 Zaitsev[18] defined π-closed sets.

Later Dontchev and Noiri[6] introduced the notion of πg-closed sets. Park defined πgp-closed sets. Then Aslim, Caksu and Noir[3] introduced the notion of πgs-closed sets. D. Sreeja and S. Janaki[17] studied The idea of πgb-closed sets and introduced the concept of πgb-continuity. Later the properties and characteristics of πgb-closed and πgb-continuity were introduced by Sinem Caglar and Gulhan Ashim[16]. Dhanya. R and A. Parvathi[4] introduced the concept of πgb*-closed sets and πgb*-continuity in topological spaces. Hussain[7] introduced the concept of almost continuity in topological spaces.

II. PRELIMINARIES

Throughout this paper (X,τ) represents non empty topological spaces on which no separation axioms are assumed unless otherwise mentioned. A subset A of a topological space (X,τ), cl(A) and int(A) denote the closure of A and interior of A respectively. (X,τ) will be replaced by X if there is no chance of confusion.

Definiton 2.1
Let (X,τ) be a topological space. A subset A of (X,τ) is called
(1) a **semi-closed set** if int(cl(A))⊆A.
(2) a **α-closed set** if cl(int(cl(A)))⊆A.
(3) a **pre-closed set** if cl(int(A))⊆A.
(4) a **semipre-closed set** if int(cl(int(A)))⊆A.
(5) a **regular-closed set** if A=cl(int(A)).
(6) a **b-closed set** if cl(int(A))∩int(cl(A))⊆A.
(7) a **b*-closed set** if int(cl(A))⊂U, whenever A⊂U and U is b-open.

the complements of the above mentioned sets are called semi-open, α-open, pre-open, semi-open, regular open, b-open, b*-open sets respectively. The intersection of all semi-closed (resp. α-closed, pre-closed, semipre-closed, regular-closed and b-closed) subsets of (X,τ) containing A is called the semi-closure (resp. α-closure, pre-closure, semipre-closure, regular-closure and b-closure) of A and is denoted by scl(A) (resp. αcl(A), pcl(A), spcl(A), rcl(A) and bcl(A)). A subset A of (X,τ) is called clopen if it is both open and closed in (X,τ).

Definition 2.2
A subset A of a space (X,τ) is called π-closed if A is finite intersection of regular closed sets.

Definition 2.3
A subset A of a space (X,τ) is called
(1) a **g-closed set** if cl(A)⊂U whenever A⊂U and U is open in (X,τ).
(2) a **gp-closed set** if pcl(A)⊂U whenever A⊂U and U is open in (X,τ).
(3) a **gs-closed set** if scl(A)⊂U whenever A⊂U and U is open in (X,τ).
(4) a **gb-closed set** if bcl(A)⊂U whenever A⊂U and U is open in (X,τ).
(5) a **gα-closed set** if αcl(A)⊂U whenever A⊂U and U is open in (X,τ).
(6) a **πg-closed set** if cl(A)⊂U whenever A⊂U and U is π-open in (X,τ).
(7) a **πgα-closed set** if αcl(A)⊂U whenever A⊂U and U is π-open in (X,τ).
(8) a **πgp-closed set** if pcl(A)⊂U whenever A⊂U and U is π-open in (X,τ).
(9) a **πgs-closed set** if scl(A)⊂U whenever A⊂U and U is π-open in (X,τ).
(10) a **πgb-closed set** if bcl(A)⊂U whenever A⊂U and U is π-open in (X,τ).

Complement of π-closed set is called π-open set.
Complement of g-closed, gp-closed, gs-closed, gb-closed, gα-closed, πgα-closed, πgp-closed, πgs-closed and πgb-closed sets are called g-open, gp-open, gs-open, gb-open,

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gα-open, πgα-open, πgp-open, πgs-open and πgb-open sets respectively.

Definition 2.4
A function f: (X,τ)→(Y,σ) is called continuous(resp.α-continuous, pre-continuous, g-continuous, regular continuous, gb- continuous, b*- continuous) if $f^{-1}(V)$ is closed (resp. α- closed, pre- closed, g- closed, regular closed, gb- closed, b*- closed) in (X,τ) for every closed set V in (Y,σ).

Definition 2.5
A function f: (X,τ)→(Y,σ) is called π-continuous(resp. πα-continuous, πgp-continuous, πg-continuous, πgb-continuous, πgb*- continuous) if $f^{-1}(V)$ is closed (resp. πα-closed, πgp- closed, πg- closed, πgb- closed, πgb*- closed) in (X,τ) for every closed set V in (Y,σ).

III. πg^b*-CONTINUITY

Definition 3.1
A function f : (X,τ) →(Y,σ) is called **πg^b*-continuous** if $f^{-1}(V)$ is πg^b*-closed in (X,τ) for every closed set V of (Y,σ).

Definition 3.2
A function f : (X,τ) →(Y,σ) is called πg^b*-irresolute if $f^{-1}(V)$ is πg^b*-closed in (X,τ) for every πg^b*-closed set V in (Y,σ)

Definition 3.3
A function f : (X,τ) →(Y,σ) is called πg^b*-closed if f(V) is πg^b*-closed in (Y,σ) for every πg^b*-closed set V in (X,τ).

Example 3.1(a)
Consider X={a,b,c,d}, τ={X,Φ,{a},{b},{a,b},{b,c},{a,b,c},{a,b,d}} and Y={a,b,c,d} with topology σ={Y,Φ,{a},{a,b}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=a; f(b)=b; f(c)=c, then f is πg^b*-continuous.

Example 3.2(a)
Consider X={a,b,c}, τ={X,Φ,{a},{b},{a,b}} and Y={a,b,c} with topology σ={Y,Φ,{a}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=a; f(b)=b; f(c)=c, then f is πg^b*-irresolute.

Theorem 3.1
Every continuous function is πg^b*-continuous.

Proof
Let f: (X,τ) →(Y,σ) be a continuous function. Let V be a closed set in Y. Since f is continuous $f^{-1}(V)$ is closed in X. As every closed set is πg^b*-closed. f^{-1} is πg^b*-closed. Hence f is πg^b*-continuous.

Remark 3.1
The converse of the above theorem need not be true as seen from the following example.

Example 3.1
Consider X={a,b,c}, τ={X,Φ,{a},{b},{a,b}} and Y={a,b,c} with topology σ={Y,Φ,{b,c}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=a; f(b)=b; f(c)=c, then f is πg^b*-continuous but it is not continuous.

Theorem 3.2
Every π-continuous function is πg^b*-continuous.

Proof
Let f: (X,τ) →(Y,σ) be a π-continuous function. Let V be a closed set in Y. Since f is π-continuous $f^{-1}(V)$ is π-closed in X. As every α-closed set is πg^b*-closed. f^{-1} is πg^b*-closed. Hence f is πg^b*-continuous.

Remark 3.2
The converse of the above theorem need not be true as seen from the following example.

Example 3.2
Consider X={a,b,c}, τ={X,Φ,{a},{b},{a,b},{b,c},{a,b,c},{a,b,d}} and Y={a,b,c,d} with topology σ={Y,Φ,{b},{b,c}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=a; f(b)=b; f(c)=c,f(d)=d then f is πg^b*-continuous but it is not π-continuous.

Theorem 3.3
Every α-continuous function is πg^b*-continuous.

Proof
Let f: (X,τ) →(Y,σ) be a α-continuous function. Let V be a closed set in Y. Since f is α-continuous $f^{-1}(V)$ is α-closed in X. As every α-closed set is πg^b*-closed. f^{-1} is πg^b*-closed. Hence f is πg^b*-continuous.

Remark 3.3
The converse of the above theorem need not be true as seen from the following example.

Example 3.3
Consider X={a,b,c}, τ={X,Φ,{a},{b},{a,b}} and Y={a,b,c} with topology σ={Y,Φ,{a},{c},{a,c}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=a; f(b)=b; f(c)=c, then f is πg^b*-continuous but it is not α-continuous.

Theorem 3.4
Every g-continuous function is πg^b*-continuous.

Proof
Let f: (X,τ) →(Y,σ) be a g-continuous function. Let V be a closed set in Y. Since f is g-continuous $f^{-1}(V)$ is g-closed in X. As every g-closed set is πg^b*-closed. $f^{-1}(V)$ is πg^b*-closed. Hence f is πg^b*-continuous.

Remark 3.4
The converse of the above theorem need not be true as seen from the following example.

Example 3.4
Consider X={a,b,c}, τ={X,Φ,{a},{b},{a,b}} and Y={a,b,c} with topology σ={Y,Φ,{a},{b,c}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=a; f(b)=b; f(c)=c. Then f is πg^b*-continuous but it is not g-continuous.

Theorem 3.5
Every pre continuous function is πg^b*-continuous.

Proof
Let f: (X,τ) →(Y,σ) be a pre continuous function. Let V be a closed set in Y. Since f is pre continuous $f^{-1}(V)$ is pre-closed in X. As every pre-closed set is πg^b*-closed. $f^{-1}(V)$ is πg^b*-closed. Hence f is πg^b*-continuous.

Remark 3.5
The converse of the above theorem need not be true as seen from the following example.

Example 3.5
Consider X={a,b,c,d}, τ={X,Φ,{a},{d},{a,d},{c,d},{a,c,d}} and Y={a,b,c,d} with topology σ={Y,Φ,{a},{b},{a,b},{b,c}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=b; f(b)=c; f(c)=a; f(d)=d. Then f is πg^b*-continuous but it is not pre-continuous.

Theorem 3.6
Every gb-continuous function is πg^b*-continuous.

Proof
Let f: (X,τ) →(Y,σ) be a gb-continuous function. Let V be a closed set in Y. Since f is gb-continuous $f^{-1}(V)$ is gb-closed in X. As every gb-closed set is πg^b*-closed. $f^{-1}(V)$ is πg^b*-closed. Hence f is πg^b*-continuous.

Remark 3.6
The converse of the above theorem need not be true as seen from the following example.

Example 3.6
Consider X={a,b,c,d}, τ={X,Φ,{b},{c,d},{b,c,d}} and Y={a,b,c,d} with topology σ={Y,Φ,{a,c,d}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=a; f(b)=b; f(c)=c; f(d)=d. Then f is πg^b*-continuous but it is not gb-continuous.

Theorem 3.7
Every πgα-continuous function is πg^b*-continuous.

Proof
Let f: (X,τ) →(Y,σ) be a πgα-continuous function. Let V be a closed set in Y. Since f is πgα-continuous $f^{-1}(V)$ is πgα-closed in X. As every πgα-closed set is πg^b*-closed. $f^{-1}(V)$ is πg^b*-closed. Hence f is πg^b*-continuous.

Remark 3.7
The converse of the above theorem need not be true as seen from the following example.

Example 3.7
Consider X={a,b,c}, τ={X,Φ,{a},{b},{a,b},{a,c}} and Y={a,b,c} with topology σ={Y,Φ,{a}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=b; f(b)=c; f(c)=c. Then f is πg^b*-continuous but it is not πgα-continuous.

Theorem 3.8
Every πg^b*-continuous function is πgb-continuous.

Proof
Let f: (X,τ) →(Y,σ) be a πg^b*-continuous function. Let V be a closed set in Y. Since f is πg^b*-continuous $f^{-1}(V)$ is πgb-closed in X. As every πg^b*-closed set is πgb-closed. $f^{-1}(V)$ is πgb-closed. Hence f is πgb-continuous.

Remark 3.8
The converse of the above theorem need not be true as seen from the following example.

Example 3.8
Consider X={a,b,c}, τ={X,Φ,{a},{b},{a,b},{a,c}} and Y={a,b,c} with topology σ={Y,Φ,{a}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=b; f(b)=b; f(c)=c. Then f is πgb-continuous but it is not πg^b*-continuous.

Theorem 3.9
Every πg^b*-continuous function is πgs-continuous.

Proof
Let f: (X,τ) →(Y,σ) be a πg^b*-continuous function. Let V be a closed set in Y. Since f is πg^b*-continuous $f^{-1}(V)$ is πgs-closed in X. As every πg^b*-closed set is πgb-closed. $f^{-1}(V)$ is πgs-closed. Hence f is πgs-continuous.

Remark 3.9
The converse of the above theorem need not be true as seen from the following example.

Example 3.9
Consider X={a,b,c}, τ={X,Φ,{a},{b},{a,b},{a,c}} and Y={a,b,c} with topology σ={Y,Φ,{a}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=b; f(b)=c; f(c)=a. Then f is πgs-continuous but it is not πg^b*-continuous.

Remark 3.10
πgp-continuous and πg^b*-continuous are independent of each other. It is shown in the following example.

Example 3.10
Let X={a,b,c}, τ={X,Φ,{a},{b},{a,b},{a,c}} and Y={a,b,c} with topology σ={Y,Φ,{b},{b,c}}. Let f:(X,τ)→(Y,σ) be defined by f(a)=a; f(b)=c; f(c)=b. Then f^{-1}{a}={a}πg^b*-continuous but it is not πgp-continuous and f^{-1}{a,c}={a,b} is πgp-continuous but it is not πg^b*-continuous.

Remark 3.11
πg-continuous and πg^b*-continuous are independent of each other. It is shown in the following example.

Example 3.11
Let X={a,b,c,d}, τ={X,Φ,{a},{b},{a,b},{b,c},{a,b,c},{a,b,d}} and Y={a,b,c,d} with topology σ={Y,Φ,{a},{c},{a,b},{a,c},{a,b,c}}. Let f: (X,τ)→(Y,σ) be an identity function. Then f^{-1}{a,b,d}={a,b,d} is πg-continuous but it is not πg^b*-continuous and f^{-1}{a}={a,b} is πg^b*-continuous but it is not πg-continuous.

IV. πg^b*-CONTINUITY AND ITS CHARACTERISTICS

Theorem 4.1
Let f: X → Y be a function. Then the following statements are equivalent:
(1) f is πg^b*-continuous;
(2) The inverse image of every open set in Y is πg^b*-open in X.

Proof
(1) ⇒(2)
Let U be open subset of X. Then (Y-U) is closed in Y. Since f is πg^b*-continuous, f^{-1}(Y-U)=X-f^{-1}(U) is πg^b*-closed in X. Hence f^{-1}(U) is πg^b*-open in X.
(2) ⇒(1)
Let V be a closed subset of Y. Then (Y-V) is open in Y, hence by hypothesis (2) f^{-1}(Y-U)=X-f^{-1}(V) is πg^b*-open in X. Hence f^{-1}(V) is πg^b*-closed in X. Therefore, f is πg^b*-continuous.

Theorem 4.2
Every πg^b*-irresolute function is πg^b*-continuous.

Proof
Let f: X→Y be πg^b*-irrseolute function. Let V be closed set in Y, then V is πg^b*-closed in Y. since f is πg^b*-

irresolute $f^{-1}(V)$ is πg^b*-closed in X. Hence f is πg^b*-continuous.

Remark 4.2

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

Example 4.2

Consider X=Y={a,b,c}, τ={X,Φ,{a},{b},{a,b}}, σ={X,Φ,{a}}. Let f: (X,τ) → (Y,σ) be the identity map. Then f is πg^b*-continuous but it is not πg^b*-irresolute.

Remark 4.3

Composition of two πg^b*-continuous is need not be πg^b*-continuous.

Example 4.3

Let X={a,b,c,d}, τ={X,Φ,{a},{b},{a,b},{a,b,c}}, σ={Y,Φ,{a},{c},{a,c}}, η={Z,Φ,{a},{b},{a,b},{a,b,d}}. Define f: (X,τ)→(X,σ) by f(a)=a; f(b)=d; f(c)=b; f(d)=c. Define g: (X,σ)→(X,η) by g(a)=a; g(b)=c; g(c)=b; g(d)=d. Then f and g are πg^b*-continuous but g∘f is not πg^b*-continuous.

Theorem 4.4

Let f: X→Y be a function. Then the following statements are equivalent:

(1) For each x ∈ X and each open set V containing f(x) there exists a πg^b*-open set U containing x sch that f(U) ⊂ V.

(2) f(πg^b*-cl(A)) ⊂ cl(f(A)) for every subset A of X.

Proof

(1) ⇒(2)

Let y ∈ f(πg^b*-cl(A)) then, there exists an x ∈ πg^b*-cl(A) such that y=f(x). we claim that y ∈ cl(f(A)) and let V be any open neighborhood of y. Since x ∈ πg^b*-cl(A) there exists an πg^b*-open set U such that x ∈ U and U∩A ≠Φ, f(U) ⊂ V. Since U∩A≠Φ, f(A)∩V≠Φ. Therefore, y=f(x) ∈ cl f(A). Hence f(πg^b* cl(A)). Hence f(πg^b*cl(A)) ⊂ cl f(A).

(2) ⇒(1)

Let x ∈X and V be any open set containing f(x). Let A=f^{-1}(Y-U), since f(πg^b*-cl(A)) ⊂ cl(f(A)) ⊂(Y-V) ⇒ πg^b*cl(A) ⊂ f^{-1}(Y-V)=A. Hence πg^b*-cl(A)=A. Since f(x) ∈ V ⇒x ∈ $f^{-1}(V)$ ⇒ x ∉ πg^b*-cl(A). Thus there exists an open set U containing x such that U∩A=Φ f(U)∩f(A)=Φ. Therefore f(U)⊂ V.

Definition 4.1

A topological space (X,τ) is πg^b*-space if every πg^b*-closed set is closed.

Theorem 4.5

Every πg^b*-space is πg^b*-$T_{1/2}$ space.

Proof

Let (X,τ) be a πg^b*-space and let A⊂X be πg^b*-closed set in X. Then A is closed⇒ A is b*-closed⇒ (X,τ) is a πg^b*-$T_{1/2}$ space.

Theorem 4.6

Let f: (X,τ)→(Y,σ) be a function then,

(1) If f is πg^b*-irresolute and X is πg^b*- $T_{1/2}$ space, then f is b*-irresolute.

(2) If f is πg^b*-continuous and X is πg^b*- $T_{1/2}$ space, then f is b*-continuous.

Proof

(1) Let V be b*-closed in Y, then V is πg^b*-closed in Y. Since f is πg^b*-irresolute, $f^{-1}(V)$ is πg^b*-closed in X. Since X is πg^b*-$T_{1/2}$ space, $f^{-1}(V)$ is b*-closed. Therefore f is b*-continuous.

(2) Let V be closed in Y. Since f is πg^b*-continuous, $f^{-1}(V)$ is πg^b*-closed in X. Since X is πg^b*- $T_{1/2}$ space, $f^{-1}(V)$ is b*-closed. Therefore f is b*-continuous.

Definition 4.2

A function f: X→Y is said to be almost πg^b*-continuous if $f^{-1}(V)$ is πg^b*-closed in X for every regular closed set V of Y.

Theorem 4.7

For a function f: X→Y, the following statements are equivalent:

(1) f is almost πg^b*-continuous.

(2) $f^{-1}(V)$ is πg^b*-open in X for every regular open set V of Y.

(3) f^{-1}(int(cl(V))) is πg^b*-open in X for every open set V of Y.

(4) f^{-1}(cl(int(V))) is πg^b*-closed in X for every closed set V of Y.

Proof

(1)⇒(2)

Suppose f is almost πg^b*-continuous. Let V be a regular open subset of Y. Since (Y-V) is regular closed and f is almost πg^b*-continuous, f^{-1}(Y-V) = X-$f^{-1}(V)$ is πg^b*-closed in X. Hence $f^{-1}(V)$ is πg^b*-open in X.

(2)⇒(1)

Let V be a regular closed subset of Y. Then (Y-V) is regular open. By the hypothesis, f^{-1}(Y-V)=X-$f^{-1}(V)$ is πg^b*-open in X. Hence $f^{-1}(V)$ is πg^b*-closed. Thus f is πg^b*-continuous.

(2)⇒ (3)

Let V be an open subset of Y. Then int(cl(V)) is regular open in Y. By the hypothesis, f^{-1}(int(cl(V))) is πg^b*-open in X.

(3)⇒(2)

Let V be a regular open subset of Y. Since V=int(cl(V)) and every regular open set is open then $f^{-1}(V)$ is πg^b*-open in X.

(3)⇒ (4)

Let V be a closed subset of Y. Then (Y-V) is open in Y. By the hypothesis, f^{-1}(int(cl(Y-V))) = f^{-1}(Y-cl(int(V))) = X-f^{-1}(cl(int(V))) is πg^b*-open in X. Therefore f^{-1}(cl(int(V))) is πg^b*-closed in X.

(4)⇒(3)

Let V be a open subset of Y. Then (Y-V) is closed. By the hypothesis f^{-1}(Y-cl(int(Y-V))) = X-f^{-1}(int(cl(V))) is πg^b*-closed in X. Therefore, f^{-1}(int(cl(V))) is πg^b*-open in X.

Theorem 4.8

Every πg^b*-continuous function is almost πg^b*-continuous.

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Proof

Let f: X→Y be πg^b*-continuous fnction. Let V be regular closed set in Y, then V is closed in Y. Since f is πg^b*-continuous function $f^{-1}(V)$ is πg^b*-clo3sed in X. Therefore f is almost πg^b*-continuous.

Theorem 4.9

Every almost b*-continuous function is almost πg^b*-continuous.

Proof

Let f: X→Y be almost b*-continuous function and let V be regular closed set in Y. Then $f^{-1}(V)$ b*-closed in X, hence $f^{-1}(V)$ is πg^b*-closed in X. Therefore f is almost πg^b*-continuous.

Theorem 4.10

Let X be a πg^b*-$T_{1/2}$ space. Then f: X→Y is almost πg^b*-continuous if and only if f is almost b*-continuous.

Proof

Suppose f: X→Y is almost πg^b*-continuous. Let A be a regular closed subset of Y. Then $f^{-1}(A)$ is πg^b*-closed in X. Since X is πg^b*-$T_{1/2}$ space, $f^{-1}(A)$ is b*-closed in X. Hence f is almost πg^b*-continuous.

Conversely, suppose that f: X→Y is almost b*-continuous and A be a regular closed subset of Y. Then $f^{-1}(A)$ is b*-closed in X. Since every b*-closed set is πg^b*-closed, $f^{-1}(A)$ is πg^b*-closed. Therefore, f is almost πg^b*-continuous.

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