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# On Strongly αg*p-Irresolute Functions in Topological Spaces

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**Abstract - In this paper, we introduce and investigate the notion of strongly αg*p -irresolute functions. We obtain fundamental properties and characterization of strongly αg*p -irresolute functions and discuss the relationships between strongly αg*p -irresolute functions and other related functions .**

**Keywords: strongly αg*p -irresolute, strongly α -irresolute, strongly β- αg*p irresolute.**

**Mathematics Subject Classification:** 54C05,54C08,54C10.

## 1.INTRODUCTION

Dontchev[4] introduced the notion of contra continuous functions in 1996. Jafari and Noiri[9] introduced contra precontinuous functions. Ekici.E[6] introduced almost contra precontinuous functions in 2004.. Dontchev and Noiri [5] introduced and investigated contra semi-continuous functions and RC continuous functions between topological spaces.Veerakumar [25] also introduced contra pre semi-continuous functions. Recently, S.Sekar and P.Jayakumar[20] introduced contra gp*-continuous functions. In this paper we introduce and study the new class of functions called contra αg*p-continuous and almost contra αg*p- continuous functions in topological spaces. Also we define the notions of contra αg*p-irresolute, contra αg*p-closed functions,αg*p-locally indiscrete space and study some of their properties.

## 2. PRELIMINARIES

Throughout this paper (X, τ), (Y, σ) and (Z, η) (or simply X , Y, and Z) represent the non-empty topological spaces on which no separation axioms are assumed, unless otherwise mentioned. For a subset A of X, the closure of A and interior of A will be denoted by cl (A) and int(A) respectively.The union of all αg*p-open sets of X contained in A is called αg*p-interior of A and it is denoted by αg*p-int (A).The intersection of all αg*p-closed sets of X containing A is called αg*p-closure of A and it is denoted by αg*p-cl(A).
Also the collection of all αg*p-open subsets of X containing a fixed point x is denoted by αg*p-O(X,x).

**Definitions 2.1:** A subset A of a topological space (X, τ) is called
(i) preopen [13] if A ⊆ int (cl (A)) and preclosed if cl (int(A)) ⊆ A.
(ii) semi-open [11] if A ⊆ cl (int (A)) and semi-closed if int (cl (A)) ⊆ A.
(iii) α-open [14] if A ⊆ int (cl (int (A))) and α-closed if cl(int(cl(A))) ⊆ A .
(iv) semi-preopen [1] (β-open) if A ⊆cl(int(cl(A))) and semi-preclosed (β-closed ) if int (cl (int (A))) ⊆ A .

**Definition 2.2**: A subset A of a topological space (X, τ) is called
(i) generalized preclosed (briefly,gp-closed)[12] if pcl(A) ⊆ U whenever A ⊆ U and U is open in X.
(ii) generalized semi-preclosed (briefly, gsp-closed)[3] if spcl(A) ⊆ U whenever A ⊆ U and U is open in X .
(iii) generalized pre regularclosed (briefly, gpr-closed)[7] if pcl(A) ⊆ U whenever A ⊆ U and U is regular open in X .
(iv) generalized star preclosed (briefly, g*p-closed set) [23] if pcl (A) ⊆ U whenever A ⊆ U and U is g-open in X.
(v) generalized pre star closed (briefly, gp*-closed set) [10] if cl (A) ⊆ U whenever A ⊆ U and U is gp-open in X.
(vi) pre semi-closed [24] if spcl (A) ⊆ U whenever A ⊆ U and U is αg-open in X.
**Definition 2.3:**[18] A subset A of a topological space (X, τ) is called alpha generalized star preclosed set (briefly, αg*p-closed) if pcl(A) ⊆ U whenever A ⊆U and U is αg-open in X .

**Definition 2.4:**[17] A function f : (X, τ) → (Y, σ) is called αg*p-continuous if f -1(V) is αg*p-closed set in (X, τ ) for every closed set V in (Y, σ).

**Definition 2.5:**[17] A function f : (X, τ) →(Y, σ) is called αg*p-irresolute if f -1(V) is αg*p-closed set in (X, τ) for every αg*p-closed set V in (Y, σ).

**Definition 2.6:** A function f : (X, τ) → (Y, σ) is called
i) contra continuous [4] if f -1(V) is closed set in X for each open set V of Y.

ii) contra precontinuous [9] if f -1(V) is preclosed set in X for each open set V of Y.
iii) contra semi-continuous [5] if f -1(V) is semi-closed set in X for each open set V of Y.
iv) contra α continuous [8] if f -1(V) is α-closed set in X for each open set V of Y.
v) contra pre semi-continuous [25] if f -1(V) is pre semi-closed set in X for each open set V of Y.
vi) contra gp-continuous if f -1(V) is gp-closed set in X for each open set V of Y.
vii) contra gpr-continuous if f -1(V) is gpr-closed set in X for each open set V of Y.
viii) contra gsp-continuous if f -1(V) is gsp-closed set in X for each open set V of Y.
ix) contra gp*-continuous [20] if f -1(V) is gp*-closed set in X for each open set V of Y.
x) contra g*p-continuous [16] if f -1(V) is g*p-closed set in X for each open set V of Y.

**Definition 2.7:** A function f : (X, τ) →(Y, σ) is called
i) perfectly continuous [15] if f -1(V) is clopen in X for every open set V of Y.
ii) almost continuous [21] if f -1(V) is open in X for each regular open set V of Y.
iii) almost αg*p-continuous [17] if f -1(V) is αg*p-open in X for each regular open set V of Y.
iv) almost contra g*p-continuous [16] if f -1(V) is g*p-closed in X for each regular open set V of Y.
v) preclosed [13] if f (U) is preclosed in Y for each closed set U of X.
vi) contra preclosed [2] if f (U) is preclosed in Y for each open set U of X.

**Definition 2.8:** Let A be a subset of a space (X , τ ) .
(i) The set ∩{U ϵ τ / A ⊂ U} is called the kernel of A and is denoted by ker (A) .
(ii) The set ∩{F ϵ X / A ⊂ F , F is preclosed} is called the preclosure of A and is denoted by pc1(A)

**Lemma 2.9:** The following properties hold for subsets A, B of a space X:
(1) x ϵ ker(A) if and only if A ∩ F ≠ϕ for any F ϵ C(X , x) .
(2) A ⊂ ker(A) and A = ker (A) if A is open in X.
(3) If A ⊂B , then ker (A) ⊂ ker(B) .
**Definition 2.10[18]:** A function f : (X, τ) →(Y, σ) is called contra αg*p-continuous if $f^{-1}(V)$ is αg*p-closed set in X for every open set V in Y.

**.3. Strongly αg*p-irresolute functions.**

**Definition:3.1**
A function f: X→Y is said to be strongly αg*p -irresolute if $f^{-1}(V)$ is open in X for every αg*p -open set V of Y.

**Definition:3.2**

A function f: X→Y is said to be strongly α- irresolute if $f^{-1}(V)$ is open in X for every α- open set V of Y.

**Theorem:3.3**

If f: X→Y is a strongly αg*p -irresolute ,then f is strongly α-irresolute.

**Proof:**Let V be α- open set in Y and hence V is αg*p -open in Y. Since f is strongly αg*p -irresolute, then $f^{-1}(V)$ is open in X. Therefore $f^{-1}(V)$ is open in X for every α- open set V in Y. Hence f is strongly α- irresolute.

**Theorem:3.4**

If f: X→Y is a continuous and Y is a αg*p -$T_{1/2}$-space , then f is strongly αg*p -irresolute.

**Proof:**Let V be αg*p -open in Y. Since Y is αg*p -$T_{1/2}$-space, V is α-open in Y and hence open in Y. Since f is continuous, $f^{-1}(V)$ is open in X. Thus,$f^{-1}(V)$ is open in X for every αg*p -open set V in Y. Hence f is strongly αg*p - irresolute.

**Theorem:3.5**

If f: X→Y is a αg*p -irresolute, X is a αg*p -$T_{1/2}$-space , then f is strongly αg*p -irresolute.

**Proof:**Let V be αg*p -open in Y. Since f is αg*p -irresolute, $f^{-1}(V)$ is αg*p -open in X. Since X is a αg*p -$T_{1/2}$-space, $f^{-1}(V)$ is α- open in X and hence open in X. Thus, $f^{-1}(V)$ is open in X for every αg*p -open set V in Y. Hence f is strongly αg*p -irresolute.

**Theorem:3.6**

Let f: X→Y and g:Y→Z be any functions. Then

(i) g o f: X→Z is αg*p -irresolute if f is αg*p -continuous and g is strongly αg*p -irresolute.
(ii) g o f: X→Z is strongly αg*p -irresolute if f is strongly αg*p -irresolute and g is αg*p –irresolute.

**Proof:**
(i)Let V be a αg*p -open set in Z. Since g is strongly αg*p -irresolute, $g^{-1}(V)$ is open in Y. Since f is αg*p -continuous, $f^{-1}(g^{-1}(V))$ is αg*p -open in X.
⟹ $(g \circ f)^{-1}(V)$ is αg*p -open in X for every αg*p -open set V in Z.
⟹ (g o f) is αg*p -irresolute.

(ii) Let V be a αg*p -open set in Z. Since g is αg*p -irresolute, $g^{-1}(V)$ is αg*p -open in Y. Since f is strongly αg*p -irresolute, $f^{-1}(g^{-1}(V))$ is open in X.
⟹$(g \circ f)^{-1}(V)$ is open in X for every αg*p -open set V in Z.
⟹( g o f) is strongly αg*p -irresolute.

**Theorem:3.7**

The following are equivalent for a function f: X→Y:
(i) f is strongly αg*p -irresolute.
(ii) For each x∈ X and each αg*p -open set V of Y containing f(x), there exists an open set U in X containing x such that f(U)⊂V.
(iii) $f^{-1}(V) \subset int(f^{-1}(V))$ for each αg*p -open set V of Y.
(iv) $f^{-1}(F)$ is closed in X for every αg*p -closed set F of Y.

**Proof:** (i)⟹(ii):

Let x ∈X and V be a αg*p -open set in Y containing f(x). By hypothesis,$f^{-1}(V)$ is open in X and contains x.

Set $U=f^{-1}(V)$. Then U is open in X and f(U)⊂V.

(ii)⟹(iii):

Let V be a αg*p -open set in Y and $x \in f^{-1}(V)$.

By assumption, there exists an open set U in X containing x , such that f(U)⊂V.

Then x∈U⊂int(U)

⊂int $(f^{-1}(V))$.
Then $f^{-1}(V) \subset int(f^{-1}(V))$

(iii) ⟹(iv):

Let F be a αg*p -closed set in Y. Set V= Y – F. Then V is αg*p -open in Y.

By (iii), $f^{-1}(V) \subset int(f^{-1}(V))$.

Hence $f^{-1}(F)$ is closed in X.

(iv)⟹ (i):

Let V be αg*p -open set in Y. Let F = Y – V. That is F is αg*p -closed set in Y. Then $f^{-1}(F)$ is closed in X,(by (iv)). Then $f^{-1}(V)$ is open in X. Hence f is strongly αg*p -irresolute.

**Theorem:3.8**

A function f: X→Y is strongly αg*p -irresolute if A is open in X, then f/A: A→Y is strongly αg*p -irresolute.

**Proof:**Let V be a αg*p -open set in Y. By hypothesis, $f^{-1}(V)$ is open in X. But $(f/A)^{-1}(V) = A \cap f^{-1}(V)$ is open in A and hence f/A is strongly αg*p -irresolute.

**Theorem:3.9**

Let f: X→Y be a function and $\{A_i: i\in\Lambda\}$ be a cover of X by open sets of (X,τ). Then f is strongly αg*p -irresolute if $f/A_i$ : $(A_i,\tau/A_i) \rightarrow (Y,\sigma)$ is strongly αg*p -irresolute for each i ∈Λ.

**Proof:**Let V be a αg*p -open set in Y. By hypothesis, $(f/A_i)^{-1}(V)$ is open in $A_i$. Since $A_i$ is open in X, $(f/A_i)^{-1}(V)$ is open in X for every i∈ Λ.

$f^{-1}(V) = X\cap f^{-1}(V)$

$=\cup\{A_i \cap f^{-1}(V): i \in \Lambda\}$

$=\cup\{(f/A_i)^{-1}(V): i\in \Lambda\}$ is open in X.

Hence f is strongly αg*p -irresolute.

**Theorem:3.10**

Let f: X→Y be a strongly αg*p -irresolute surjective function. If X is compact, then Y is αG*PO-compact.

**Proof:**Let $\{A_i: i \in\Lambda\}$ be a cover of sgα -open sets of Y. Since f is strongly sgα -irresolute and X is compact, we get $X \subset\cup\{f^{-1}(A_i): i \in\Lambda\}$.Since f is surjective, $Y = f(X) \subset\cup\{A_i: i\in\Lambda\}$.Hence Y is αG*PO-compact.

**Theorem:3.11**

If f:X → Y is strongly αg*p -irresolute and a subset B of X is compact relative to X, then f(B) is αG*PO-compact relative to Y.

**Proof:** Obvious.

**Definition: 3.12**

A function f: X→Y is said to be

(i)a strongly α- αg*p -irresolute function if $f^{-1}(V)$ is α- open in X for every αg*p -open set V in Y.
(ii) a strongly β- αg*p -irresolute function if $f^{-1}(V)$ is β-open in X for every αg*p -open set V in Y.

**Theorem:3.13**

(i) If f: X→Y is strongly α- αg*p -irresolute , then f is strongly αg*p -irresolute.

(ii) If f: X→Y is strongly α- αg*p -irresolute , then f is strongly β- αg*p -irresolute.

**Proof:** (i)Let f be a strongly α- αg*p -irresolute function and let V be a αg*p -open set in Y. Then $f^{-1}(V)$ is α- open in X and hence open in X.

$\Rightarrow f^{-1}(V)$ is open in X for every αg*p -open set V in Y.

Hence f is strongly α- αg*p -irresolute.

(ii) Let f be a strongly α- αg*p -irresolute function and let V be a αg*p -open set in Y. Then

$f^{-1}(V)$ is α-open in X and hence open in X.

$\Rightarrow f^{-1}(V)$ is open in X for every αg*p -open set V in Y.
$\Rightarrow f^{-1}(V)$ is β-open in X for every αg*p -open set V in Y.

Hence f is strongly β- αg*p -irresolute.

**Remark: 3.14**

Converse of the above need not be true as seen in the following examples.

**Example: 3.15**

(i)Let X= Y = {a,b,c} , τ= {φ, X,{a},{b},{a,b},{a,c}} and σ ={φ, Y,{a},{b},{a,b}}.

Let f:X→Y be an identity map. Here for every αg*p -open set V in Y, $f^{-1}(V)$ is open and β-open in X. Hence f is strongly αg*p -irresolute and strongly β- αg*p -irresolute.

But for every αg*p -open set V in Y, $f^{-1}(V)$ is not α- open in X. Thus, f is not strongly α- αg*p -irresolute .Hence strongly αg*p -irresolute function need not be strongly α- αg*p -irresolute function and strongly β- αg*p -irresolute function .

**Theorem:3.16**

If f:X→Y and g:Y→Z , then g o f: X→Z is

(i) strongly αg*p -irresolute if f is strongly α- αg*p -irresolute and g is αg*p -irresolute.
(ii) strongly β- αg*p –irresolute if f is strongly αg*p - irresolute and g is αg*p -irresolute.

**Proof:**Let V be an αg*p -open set in Z. Since g is αg*p -irresolute, $g^{-1}(V)$ is αg*p -open in Y. Since f is strongly α- αg*p -irresolute , $f^{-1}(g^{-1}(V))$ is α- open in X.

⟹$(g \circ f)^{-1}(V)$ is regular open in X and hence open in X.

Hence (g o f) is strongly αg*p -irresolute.

(i) Let V be an αg*p -open set in Z. Since g is αg*p -irresolute, $g^{-1}(V)$ is αg*p -open in Y. Since f is strongly αg*p -irresolute , $f^{-1}(g^{-1}(V))$ is open in X and hence β-open in X.

⟹$(g \circ f)^{-1}(V)$ is β- open in X for every αg*p –open set V in Z.

Hence (g o f) is strongly β- αg*p -irresolute.

**Theorem:3.17**

If f:X→Y and g:Y→Z , then g o f: X→Z is

(i) strongly α- αg*p -irresolute if f is regular irresolute and g is strongly α- αg*p -irresolute.
(ii) strongly α- αg*p -irresolute if f is α- continuous and g is strongly αg*p -irresolute.
(iii) strongly β- αg*p -irresolute if f is continuous and g is strongly αg*p -irresolute.

**Proof:**Let V be a αg*p -open set in Z. Since g is strongly α- αg*p -irresolute, $g^{-1}(V)$ is α- open in Y. Since f is α- irresolute , $f^{-1}(g^{-1}(V))$ is α- open in X.

⟹$(g \circ f)^{-1}(V)$ is α- open in X .

Hence (g o f) is strongly α- αg*p -irresolute.

(i) Let V be an αg*p -open set in Z. Since g is strongly αg*p -irresolute, $g^{-1}(V)$ is open in Y. Since f is α- continuous , $f^{-1}(g^{-1}(V))$ is α-open in X.

⟹$(g \circ f)^{-1}(V)$ is α- open in X .

Hence (g o f) is strongly α- αg*p -irresolute.

(ii) Let V be an αg*p -open set in Z. Since g is strongly αg*p -irresolute, $g^{-1}(V)$ is open in Y.

Since f is continuous , $f^{-1}(g^{-1}(V))$ is open in X.

$\Rightarrow$(g o f)$^{-1}$(V) is open in X and hence β-open in X.

Hence (g o f) is strongly β- αg*p -irresolute.

**Theorem :3.18**

The following are equivalent for a function f: X→Y:

(i) f is strongly α- αg*p -irresolute.

(ii) For each x ∈X and each αg*p -open set V of Y containing f(x), there exists a α- open set U in X containing x such that f(U) ⊂V.

(iii) $f^{-1}$(V)⊂ Cl(Int ($f^{-1}$(V))) for each αg*p -open set V of Y.

(iv) $f^{-1}$(F) is regular closed in X for every αg*p -closed set F of Y.

**Proof:** Similar to that of Theorem 3.7

**Theorem:3.19**

The following are equivalent for a function f: X→Y:

(i) f is strongly β- αg*p -irresolute.

(ii) For each x ∈X and each αg*p -open set V of Y containing f(x), there exists a β- open set U in X containing x such that f(U)⊂ V.

(iii) $f^{-1}$(V)⊂ Cl(Int ($f^{-1}$(V))) for each αg*p -open set V of Y.

(iv) $f^{-1}$(F) is β-closed in X for every αg*p -closed set F of Y.

**Proof:** Similar to that of Theorem 3.7.

**Lemma: 3.20**

If f: X→Y is strongly α- αg*p -irresolute and A is a α- open subset of X, then f/A : A→Y is strongly α- αg*p -irresolute.

**Proof:**

Let V be a αg*p -open in Y . By hypothesis, $f^{-1}$(V) is α- open in X. But $(f/A)^{-1}$(V) = A ∩$f^{-1}$(V) is regular open in A. Hence f/A is strongly α- αg*p -irresolute.

**Theorem:3.21**

Let f: X→Y and {$A_\lambda$: λ ∈Λ} be a cover of X by α- open set of (X,τ). Then f is a strongly α- αg*p -irresolute function if f/$A_\lambda$: $A_\lambda$→Y is strongly α- αg*p -irresolute for each λ∈ Λ.

**Proof:**Let V be any αg*p -open set in Y. By hypothesis, $(f/A_\lambda)^{-1}$(V) is α- open in $A_\lambda$. Since $A_\lambda$ is regular open in X, it follows that $(f/A_\lambda)^{-1}$(V) is αg*p -open in X for each λ∈ Λ.

$f^{-1}$(V) =X∩$f^{-1}$(V)
=∪{$A_\lambda$ ∩$f^{-1}$(V): λ ∈Λ}
=∪{$(f/A_\lambda)^{-1}$(V): λ∈ Λ} is regular open in X.

Hence f is strongly α- αg*p -irresolute.

**Lemma:3.22**

If f: X→Y is strongly β- αg*p -irresolute and A is a α-open subset of X, then f/A : A→Y is strongly β- αg*p -irresolute.

**Proof:**Let V be a αg*p -open in Y . By hypothesis, $f^{-1}(V)$ is β-open in X. But $(f/A)^{-1}(V) = A\cap f^{-1}(V)$ is β- open in A. Hence f/A is strongly β- αg*p -irresolute.

**Theorem:3.23**

Let f: X→Y and $\{A_\lambda: \lambda \in\Lambda\}$ be a cover of X by β- open sets of (X,τ). Then f is a strongly β- αg*p -irresolute function if $f/A_\lambda$: $A_\lambda$→Y is strongly β- αg*p -irresolute for each $\lambda \in\Lambda$.

**Proof:**Let V be any αg*p -open set in Y. By hypothesis, $(f/A_\lambda)^{-1}(V)$ is β- open in $A_\lambda$. Since $A_\lambda$ is β- open in X, it follows that $(f/A_\lambda)^{-1}(V)$ is β-open in X for each $\lambda \in\Lambda$.

$f^{-1}(V) = X\cap f^{-1}(V)$

$= \cup\{A_\lambda \cap f^{-1}(V): \lambda \in \Lambda\}$

$=\cup\{(f/A_\lambda)^{-1}(V): \lambda \in\Lambda\}$ is β- open in X.

Hence f is strongly β- αg*p -irresolute.

**Theorem:3.24**

If a function f: X→Y is strongly β-αg*p -irresolute , then $f^{-1}(B)$ is β-closed in X for any nowhere dense set B of Y.

**Proof:** Let B be any nowhere dense subset of Y. Then Y−B is regular in Y and hence αg*p -open in Y. By hypothesis, $f^{-1}(Y-B)$ is β-open in X. Hence $f^{-1}(B)$ is β-closed in X.

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