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Contra μ-β-Generalized α-Continuous Mappings in Generalized Topological Spaces

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ABSTRACT
In this paper, we have introduced contra μ-β-generalized α-continuous maps and also introduced almost contra μ-β-generalized α-continuous maps in generalized topological spaces by using μ-β-generalized α-closed sets (briefly μ-βGαCS). Also we have introduced some of their basic properties.

Keywords: *Generalized topology, generalized topological spaces, μ-α-closed sets, μ-β-generalized α-closed sets, μ-α-continuous, μ-β-generalized α-continuous, contra μ-α-continuous, almost contra μ-β-generalized α-continuous.*

1. INTRODUCTION
In 1970, Levin [6] introduced the idea of continuous function. He also introduced the concepts of semi-open sets and semi-continuity [5] in a topological space. Mashhour [7] introduced and studied α-continuous function in topological spaces. The notation of μ-β-generalized α-closed sets (briefly μ-βGαCS) was defined and investigated by Kowsalya. M and Jayanthi. D[4]. Jayanthi. D [2, 3] also introduced contra continuity and almost contra continuity on generalized topological spaces. In this paper, we have introduced contra μ-β-generalized α-continuous maps.

2. PRELIMINARIES
Let us recall the following definitions which are used in sequel.

Definition 2.1: [1] Let X be a nonempty set. A collection μ of subsets of X is a generalized topology (or briefly GT) on X if it satisfies the following:

1. Ø, X∈ μ and
2. If $\{M_i : i\in I\} \subseteq \mu$, then $\cup_{i\in I} M_i \in \mu$.

If μ is a GT on X, then (X, μ) is called a generalized topological space (or briefly GTS) and the elements of μ are called μ-open sets and their complement are called μ-closed sets.

Definition 2.2: [1] Let (X, μ) be a GTS and let A⊆ X. Then the μ-closure of A, denoted by $c_\mu(A)$, is the intersection of all μ-closed sets containing A.

Definition 2.3: [1] Let (X, μ) be a GTS and let A⊆ X. Then the μ-interior of A, denoted by $i_\mu(A)$, is the union of all μ-open sets contained in A.

Definition 2.4: [1] Let (X, μ) be a GTS. A subset A of X is said to be

i. μ-semi-closed set if $i_\mu(c_\mu(A)) \subseteq A$
ii. μ-pre-closed set if $c_\mu(i_\mu(A)) \subseteq A$
iii. μ-α-closed set if $c_\mu(i_\mu(c_\mu(A))) \subseteq A$
iv. μ-β-closed set if $i_\mu(c_\mu(i_\mu(A))) \subseteq A$
v. μ-regular-closed set if $A = c_\mu(i_\mu(A))$

Definition 2.5: [7] Let (X, μ_1) and (Y, μ_2) be GTSs. Then a mapping f: $(X, \mu_1) \rightarrow (Y, \mu_2)$ is called

i. μ-Continuous mapping if $f^{-1}(A)$ is μ-closed in (X, μ_1) for each μ-closed in (Y, μ_2).
ii. μ-Semi-continuous mapping if $f^{-1}(A)$ is μ-semi-closed in (X, μ_1) for every μ-closed in (Y, μ_2).
iii. μ-pre-continuous mapping if $f^{-1}(A)$ is μ-pre-closed in (X, μ_1) for every μ-closed in (Y, μ_2).
iv. μ-α-continuous mapping if $f^{-1}(A)$ is μ-α-closed in (X, μ_1) for every μ-closed in (Y, μ_2).
v. μ-β-continuous mapping if $f^{-1}(A)$ is μ-β-closed in (X, μ_1) for every μ-closed in (Y, μ_2).

Definition 2.6: [9] Let (X, μ_1) and (Y, μ_2) be GTSs. Then a mapping f: (X, μ_1) → (Y, μ_2) is called

i. contra μ-Continuous mapping if f^{-1} (A) is μ-closed in (X, μ_1) for every μ-open in (Y, μ_2).
ii. contra μ-semi continuous mappings if f^{-1} (A) is μ-semi closed in (X, μ_1) for every μ-open in (Y, μ_2).
iii. contra μ-pre-continuous mappings if f^{-1} (A) is μ-pre closed in (X, μ_1) for every μ-regular closed set A of (Y, μ_2).
iv. contra μ-α-continuous mapping if f^{-1}(A) is μ-α-closed in (X, μ_1) for every μ-open in (Y, μ_2).
v. contra μ-β-continuous mapping if f^{-1} (A) is μ-β-closed in (X, μ_1) for every μ-open in (Y, μ_2).

Definition 2.7: [3] Let (X, μ_1) and (Y, μ_2) be GTSs. Then a mapping f: (X, μ_1) → (Y, μ_2) is called

i. almost contra μ-Continuous mapping if f^{-1} (A) is μ-closed in (X, μ_1) for every μ-regular open in (Y, μ_2).
ii. almost contra μ-semi continuous mappings if f^{-1} (A) is μ-semi closed in (X, μ_1) for every μ-regular open in(Y, μ_2).
iii. almost contra μ-pre-continuous mappings if f^{-1} (A) is μ-pre closed in (X, μ_1) for every μ-regular open in (Y, μ_2).
iv. almost contra μ-α-continuous mapping if f^{-1}(A) is μ-α-closed in (X, μ_1) for every μ-regular open in (Y, μ_2).
v. Almost contra μ-β-continuous mapping if f^{-1} (A) is μ-β-closed in (X, μ_1) for every μ-regular open in (Y, μ_2).

3. CONTRA μ-β-GENERALIZED α - CONTINUOUS MAPPINGS

In this chapter we have introduced contra μ-β-generalized α-continuous mapping in generalized topological spaces and studied their properties.

Definition 3.1: A mapping f: (X, μ_1) → (Y, μ_2) is called a contra μ-β-generalized α-continuous mapping if f^{-1} (A) is a μ-β-generalized α-closed set in (X, μ_1) for each μ-open set A in (Y, μ_2).

Example 3.2: Let X = Y= {a, b, c} with μ_1 = {Ø, {a}, {b}, {a, b}, X} and μ_2= {Ø, {c}, Y}. Let f: (X, μ_1) → (Y, μ_2) be a mapping defined by f(a) = a, f(b) = b, f(c) = c. Now,

μ-βO(X) = {Ø, {a}, {b}, {a, b}, {b, c}, {a, c}, X}.

Let A = {c}, then A is a μ-open set in (Y, μ_2). Then f^{-1}({c}) is a μ-β-generalized α-closed set in (X, μ_1). Hence f is a contra μ-β-generalized α-continuous mapping.

Theorem 3.3: Every contra μ-continuous mapping is a contra μ-β-generalized α-continuous mapping but not conversely in general.

Proof: Let f: (X, μ_1) → (Y, μ_2) be a contra μ-continuous mapping. Let A be any μ-open set in (Y, μ_2). Since f is a contra μ-continuous mapping, f^{-1}(A) is a μ-closed set in (X, μ_1). Since every μ-closed set is a μ-β-generalized α-closed set, f^{-1}(A) is a μ-β-generalized α-closed set in (X, μ_1). Hence f is a contra μ-β-generalized α-continuous mapping.

Example 5.1.4: Let X = Y = {a, b, c, d} with μ_1 = {Ø, {a}, {c}, {a, c}, X} and μ_2 = {Ø, {d}, Y}. Let f: (X, μ_1) → (Y, μ_2) be a mapping defined by f(a) = a, f(b) = b, f(c) = c, f(d) = d. Now,

μ-βO(X) = {Ø, {a}, {c}, {a, b}, {a, c}, {a, d}, {b, c}, {c, d}, {a, b, c}, {b, c, d}, {a, c, d}, {a, b, d}, X}.

Let A = {d}, then A is a μ-open set in (Y, μ_2). Then f^{-1} ({d}) is a μ-β-generalized α-closed set, but not μ-closed as $c_\mu(f^{-1}(A)) = c_\mu(\{d\}) = \{b, d\} \neq f^{-1}(A)$ in (X, μ_1). Hence f is a contra μ-β-generalized α-continuous mapping, but not a contra μ-continuous mapping.

Theorem 3.5: Every contra μ-α-continuous mapping is a contra μ-β-generalized α-continuous mapping in general.

Proof: Let f: (X, μ_1) → (Y, μ_2) be a μ-α-contra continuous mapping. Let A be any μ-open set in (Y, μ_2). Since f is a μ-α-contra continuous mapping, f^{-1} (A) is a μ-α-closed set in (X, μ_1). Since every μ-α-closed set is a μ-β-generalized α-closed set, f^{-1} (A) is a μ-β-generalized α-closed set in (X, μ_1). Hence f is a contra μ-β-generalized α-continuous mapping.

Remark 3.6: A contra μ-pre-continuous mapping is not a contra μ-β-generalized α- continuous mapping in general.

Example 3.7: Let X =Y = {a, b, c} with μ_1 = {Ø, {a, b}, X} and μ_2 = {Ø, {a}, Y}. Let f: (X, μ_1) → (Y, μ_2) be a mapping defined by f(a) = a, f(b) = b, f(c) = c. Now,

μ-$\beta O(X) = \{\emptyset, \{a\}, \{b\}, \{a, b\}, \{b, c\}, \{a, c\}, X\}$.

Let A= {a}, then A is a μ-open set in (Y, μ_2). Then $f^{-1}(\{a\})$ is a μ-pre closed set as $c_\mu(i_\mu(f^{-1}(A))) = c_\mu(i_\mu(\{a\})) = \emptyset \subseteq f^{-1}(A)$, but not a μ-β-generalized α-closed set as $\alpha c_\mu(f^{-1}(A)) = X \nsubseteq U = \{a, b\}$ in (X, μ_1). Hence f is a contra μ-pre-continuous mapping, but not a contra μ-β-generalized α-continuous mapping.

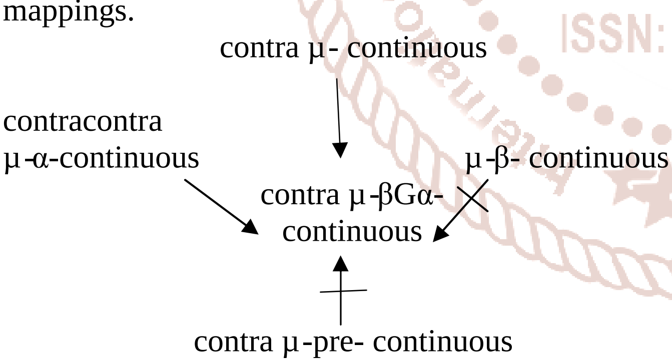
Remark 3.8: A contra μ-β-continuous mapping is not a contra μ-β-generalized α-continuous mapping in general.

Example 3.9: Let X = Y= {a, b, c} with $\mu_1 = \{\emptyset, \{a, b\}, X\}$ and $\mu_2 = \{\emptyset, \{a\}, Y\}$. Let $f: (X, \mu_1) \to (Y, \mu_2)$ be a mapping defined by f(a) = a, f(b) = b, f(c) = c. Now,

μ-$\beta O(X) = \{\emptyset, \{a\}, \{b\}, \{a, b\}, \{b, c\}, \{a, c\}, X\}$.

Let A= {a}, then A is a μ-open set in (Y, μ_2). Then $f^{-1}(\{a\})$ is a μ-β-closed set as $i_\mu(c_\mu(i_\mu(f^{-1}(A)))) = i_\mu(c_\mu(i_\mu(\{a\}))) = \emptyset \subseteq f^{-1}(A)$, but not μ-β-generalized α-closed set $\alpha c_\mu(f^{-1}(A)) = X \nsubseteq U = \{a, b\}$ in (X, μ_1). Hence f is a contra μ-β-continuous mapping, but not a contra μ-β-generalized α-continuous mapping.

In the following diagram, we have provided the relation between various types of contra μ-continuous mappings.



Theorem 3.10: A mapping $f: (X, \mu_1) \to (Y, \mu_2)$ is a contra μ-β-generalized α-continuous mapping if and only if the inverse image of every μ-closed set in (Y, μ_2) is a μ-β-generalized α-open set in (X, μ_1).

Proof: Necessity: Let F be a μ-closed set in (Y, μ_2).Then Y-F is a μ-open in (Y, μ_2). Then $f^{-1}(Y\text{-}F)$ is a μ-β-generalized α-closed set in (X, μ_1), by hypothesis. Since $f^{-1}(Y\text{-}F) = X - f^{-1}(F)$. Hence $f^{-1}(F)$ is a μ-β-generalized α-open set in (X, μ_1).

Sufficiency: Let F be a μ-open set in (Y, μ_2). Then Y-F is a μ-closed in (Y, μ_2). By hypothesis, $f^{-1}(Y\text{-}F)$ is a μ-β-generalized α-open set in (X, μ_1). Since $f^{-1}(Y\text{-}F) = X - f^{-1}(F)$ is a μ-β-generalized α-open set in (X, μ_1). Therefore $f^{-1}(F)$ is a μ-β-generalized α-closed set in (X, μ_1). Hence f is a contra μ-β-generalized α-continuous mapping.

Theorem 3.11: Let $f: (X, \mu_1) \to (Y, \mu_2)$ be a mapping and let $f^{-1}(V)$ be a μ-open set in (X, μ_2) for every closed V set in (Y, μ_2). Then f is a contra μ-β-generalized α-continuous mapping.

Proof: Let V be a μ-closed set in (Y, μ_2). Then $f^{-1}(V)$ be a μ-open set in (X, μ_1), by hypothesis. Since every μ-open set is μ-β-generalized α-open set in X. Hence $f^{-1}(V)$ is a μ-β-generalized α-open set in (X, μ_1). Hence f is a contra μ-β-generalized α-continuous mapping.

Theorem 3.12: If $f: (X, \mu_1) \to (Y, \mu_2)$ is a contra μ-β-generalized α-continuous mapping and $g: (Y, \mu_2) \to (Z, \mu_3)$ is a μ-continuous mapping then $g \circ f: (X, \mu_1) \to (Z, \mu_3)$ is a contra μ-β-generalized α-continuous mapping.

Proof: Let V be any μ-open set in (Z, μ_3). Then $g^{-1}(V)$ is a μ-open set in (Y, μ_2), since g is a μ-continuous mapping. Since f is a contra μ-β-generalized α-continuous mapping, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is a μ-β-generalized α-closed set in (X, μ_1). Therefore $g \circ f$ is a contra μ-β-generalized α-continuous mapping.

Theorem 3.13: If $f: (X, \mu_1) \to (Y, \mu_2)$ is a contra μ-continuous mapping and $g: (Y, \mu_2) \to (Z, \mu_3)$ is a contra μ-continuous mapping then $g \circ f: (X, \mu_1) \to (Z, \mu_3)$ is a μ-β-generalized α-continuous mapping.

Proof: Let V be any μ-open set in (Z, μ_3). Since g is a contra μ-continuous mapping, $g^{-1}(V)$ is a μ-closed set in (Y, μ_2). Since f is a contra μ-continuous mapping, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is a μ-open set in (X, μ_1). Since every μ-open set is a μ-β-generalized α-open set, $(g \circ f)^{-1}(V)$ is a μ-β-generalized α-open set in (X, μ_1). Therefore $g \circ f$ is a μ-β-generalized α-continuous mapping.

Theorem 3.14: If $f: (X, \mu_1) \to (Y, \mu_2)$ is a contra μ-α-continuous mapping and $g: (Y, \mu_2) \to (Z, \mu_3)$ is a contra μ-continuous mapping then $g \circ f: (X, \mu_1) \to (Z, \mu_3)$ is a μ-β-generalized α-continuous mapping.

Proof: Let V be any μ-closed set in (Z, μ_3). Since g is a μ-contra continuous mapping, $g^{-1}(V)$ is a μ-open set in (Y, μ_2). Since f is a μ-α-contra continuous mapping, $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is a μ-α-closed set in (X, μ_1). Since every μ-α-closed set is a μ-β-generalized α-closed set, $(g \circ f)^{-1}(V)$ is a μ-β-generalized α-closed set in (X, μ_1). Therefore $g \circ f$ is a μ-β-generalized α-continuous mapping.

Theorem 3.15: If f: $(X, \mu_1) \rightarrow (Y, \mu_2)$ is a μ-continuous mapping and g: $(Y, \mu_2) \rightarrow (Z, \mu_3)$ is a contra μ-continuous mapping then $g \circ f$: $(X, \mu_1) \rightarrow (Z, \mu_3)$ is a contra μ-β-generalized α-continuous mapping.

Proof: Let V be any μ-open set in (Z, μ_3). Since g is a contra μ-continuous mapping, $g^{-1}(V)$ is a μ-closed set in (Y, μ_2). Since f is μ-continuous $(g \circ f)^{-1}(V) = f^{-1}(g^{-1}(V))$ is a μ-closed set in (X, μ_1). Since every μ-closed set is a μ-β-generalized α-closed set, $(g \circ f)^{-1}(V)$ is a μ-β-generalized α-closed set. Therefore $g \circ f$ is a contra μ-β-generalized α-continuous mapping.

4. ALMOST CONTRA μ-β-GENERALIZED α-CONTINUOUS MAPPINGS

In this section we have introduced almost contra μ-β-generalized α-continuous mapping in generalized topological spaces and studied some of their basic properties.

Definition 4.1: A mapping f: $(X, \mu_1) \rightarrow (Y, \mu_2)$ is called an almost contra μ-β-generalized α-continuous mapping if $f^{-1}(A)$ is a μ-β-generalized α-closed set in (X, μ_1) for each μ-regular open set A in (Y, μ_2).

Example 4.2: Let X = Y= {a, b, c} with μ_1 = {Ø, {a}, {b}, {a, b}, X} and μ_2= {Ø, {c}, {a, b}, Y}. Let f: $(X, \mu_1) \rightarrow (Y, \mu_2)$ be a mapping defined by f(a) = a, f(b) = b, f(c) = c. Now,

μ-βO(X) = {Ø, {a}, {b}, {a, b}, {b, c}, {a, c}, X}.

Let A = {c}, then A is a μ-regular open set in (Y, μ_2). Then f^{-1}({c}) is a μ-β-generalized α-closed set in (X, μ_1). Hence f is an almost contra μ-β-generalized α-continuous mapping.

Theorem 4.3: Every almost contra μ-continuous mapping is an almost contra μ-β-generalized α-continuous mapping but not conversely.

Proof: Let f: $(X, \mu_1) \rightarrow (Y, \mu_2)$ be an almost contra μ-continuous mapping. Let A be any μ-regular open set in (Y, μ_2). Since f is almost contra μ-continuous mapping, $f^{-1}(A)$ is a μ-closed set in (X, μ_1). Since every μ-closed set is a μ-β-generalized α-closed set, $f^{-1}(A)$ is a μ-β-generalized α-closed set in (X, μ_1). Hence f is an almost contra μ-β-generalized α-continuous mapping.

Example 4.4: Let X = Y = {a, b, c, d} with μ_1 = {Ø, {a}, {c}, {a, c}, X} and μ_2 = {Ø, {d}, {a, b, c}, Y}. Let f: $(X, \mu_1) \rightarrow (Y, \mu_2)$ be a mapping defined by f(a) = a, f(b) = b, f(c) = c, f(d) = d. Now,

μ-βO(X) = {Ø, {a}, {c}, {a, b}, {a, c}, {a, d}, {b, c}, {c, d}, {a, b, c}, {b, c, d}, {a, c, d}, {a, b, d}, X}.

Let A = {d}, then A is a μ-regular open set in (Y, μ_2). Then f^{-1}({d}) is a μ-β-generalized α-closed set, but not μ-closed as $c_\mu(f^{-1}(A)) = c_\mu(\{d\}) = \{b, d\} \neq f^{-1}(A)$ in (X, μ_1). Hence f is an almost contra μ-β-generalized α-continuous mapping, but not almost contra μ-continuous mapping.

Theorem 4.5: Every almost contra μ-α-continuous mapping is an almost contra μ-β-generalized α-continuous mapping in general.

Proof: Let f: $(X, \mu_1) \rightarrow (Y, \mu_2)$ be an almost contra μ-α-continuous mapping. Let A be any μ-regular open set in (Y, μ_2). Since f is an almost contra μ-α-continuous mapping, $f^{-1}(A)$ is a μ-α-closed set in (X, μ_1). Since every μ-α-closed set is a μ-β-generalized α-closed set, $f^{-1}(A)$ is μ-β-generalized α-closed set in (X, μ_1). Hence f is an almost contra μ-β-generalized α-continuous mapping.

Remark 4.6: An almost contra μ-pre-continuous mapping is not an almost contra μ-β-generalized α-continuous mapping in general.

Example 4.7: Let X =Y = {a, b, c} with μ_1 = {Ø, {a, b}, X} and μ_2 = {Ø, {a}, {b, c}, Y}. Let f: $(X, \mu_1) \rightarrow (Y, \mu_2)$ be a mapping defined by f(a) = a, f(b) = b, f(c) = c. Now,

μ-βO(X) = {Ø, {a}, {b}, {a, b}, {b, c}, {a, c}, X}.

Let A= {a}, then A is a μ-regular open set in (Y, μ_2). Then f^{-1}({a}) is a μ-pre closed as $c_\mu(i_\mu(f^{-1}(A))) = c_\mu(i_\mu(\{a\})) = Ø \subseteq f^{-1}(A)$, but not μ-β-generalized α-closed set as $\alpha c_\mu(f^{-1}(A)) = X \not\subseteq U = \{a, b\}$ in (X, μ_1). Hence f is an almost contra μ-pre-continuous mapping, but not an almost contra μ-β-generalized α-continuous mapping.

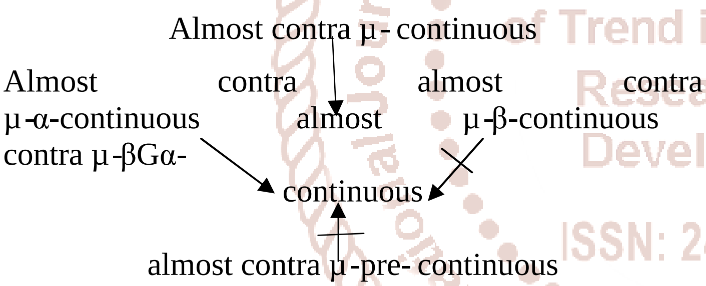
Remark 4.8: An almost contra μ-β-continuous mapping is not an almost contra μ-β-generalized α-continuous mapping in general.

Example 4.9: Let X = Y= {a, b, c} with μ_1 = {Ø, {a, b}, X} and μ_2 = {Ø, {a}, {b, c} Y}. Let f: (X, μ_1) → (Y, μ_2) be a mapping defined by f(a) = a, f(b) = b, f(c) = c. Now,

μ-βO(X) = {Ø, {a}, {b}, {a, b}, {b, c}, {a, c}, X}.

Let A= {a}, then A is a μ-regular open set in (Y, μ_2). Then f^{-1}({a}) is a μ-β-closed set as $i_\mu(c_\mu(i_\mu(f^{-1}(A))))$ = $i_\mu(c_\mu(i_\mu(\{a\})))$= Ø ⊆ f^{-1}(A), but not a μ-β-generalized α-closed set as $\alpha c_\mu(f^{-1}(A))$ = X ⊈ U = {a, b} in (X, μ_1). Hence f is an almost contra μ-β-continuous mapping, but not almost contra μ-β-generalized α-continuous mapping.

In the following diagram, we have provided the relation between various types of almost contra μ-continuous mappings.



Theorem 4.10: A mapping f: (X, μ_1) → (Y, μ_2) is an almost contra μ-β-generalized α-continuous mapping if and only if the inverse image of every μ-regular closed set in (Y, μ_2) is a μ-β-generalized α-open set in (X, μ_1).

Proof:

Necessity: Let F be a μ-regular closed set in (Y, μ_2). Then Y-F is a μ-regular open in (Y, μ_2). Since f is an almost contra μ-β-generalized α-continuous, f^{-1}(Y-F) is μ-β-generalized α-closed set in (X, μ_1). Since f^{-1}(Y-F) = X - f^{-1}(F). Hence f^{-1}(F) is μ-β-generalized α-open set in (X, μ_1).

Sufficiency: Let F be a μ-regular open set in (Y, μ_2). Then Y-F is a μ-regular closed in (Y, μ_2). By hypothesis, f^{-1}(Y-F) is a μ-β-generalized α-open set in (X, μ_1). Since f^{-1}(Y-F) = X - f^{-1}(F) is a μ-β-generalized α-open set, f^{-1}(F) is a μ-β-generalized α-closed set in (X, μ_1). Hence f is an almost contra μ-β-generalized α-continuous mapping.

Theorem 4.11: If f: (X, μ_1) → (Y, μ_2) is a μ-continuous mapping and g: (Y, μ_2) → (Z, μ_3) is an almost contra μ-continuous mapping then g ∘ f: (X, μ_1) → (Z, μ_3) is an almost contra μ-β-generalized α-continuous mapping.

Proof: Let V be any μ-regular open set in (Z, μ_3). Since g is an almost contra μ-continuous mapping, g^{-1}(V) is a μ-closed set in (Y, μ_2). Since f is a μ-continuous mapping, $(g \circ f)^{-1}$(V) = $f^{-1}(g^{-1}(V))$ is a μ-closed in (X, μ_1).Since every μ-closed set is a μ-β-generalized α-closed set, $(g \circ f)^{-1}$ (V) is a μ-β-generalized α-closed set in (X, μ_1). Therefore g ∘ f is an almost contra μ-β-generalized α-continuous mapping.

Theorem 4.12: If f: (X, μ_1) → (Y, μ_2) is a μ-α-continuous mapping and g: (Y, μ_2) → (Z, μ_3) is an almost contra μ-continuous mapping then g ∘ f: (X, μ_1) → (Z, μ_3) is a contra μ-β-generalized α-continuous mapping.

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