VOLUME XII
ISBN No.: 978-93-94004-01-6
Physical Science

Estd. 1957

NALLAMUTHU GOUNDER MAHALINGAM COLLEGE

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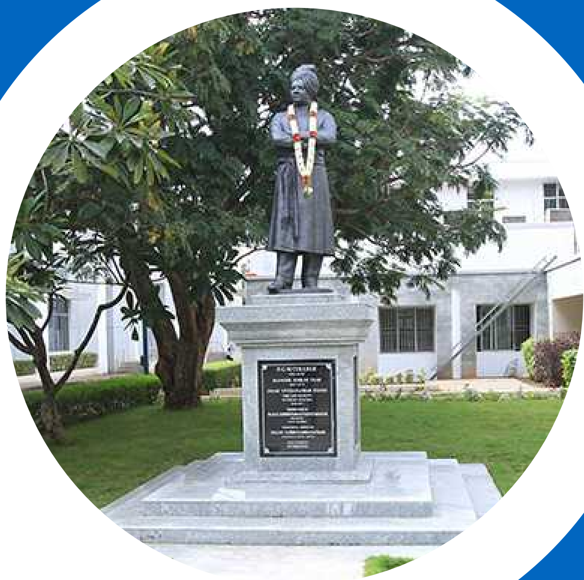

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27th October 2021

Jointly Organized by

Department of Biological Science, Physical Science and Computational Science

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International Conference on Emerging Trends in Science and Technology (ETIST 2021)
Jointly Organized by Department of Biological Science, Physical Science and Computational Science
Nallamuthu Gounder Mahalingam College, Affiliated to Bharathiar University, Tamilnadu, India.
Published by NGMC - November 2021

CONTRA *αω-CONTINUOUS FUNCTIONS IN TOPOLOGICAL SPACES

Dr. K.Baby [1] – M.Amsaveni[2] –C.Varshana[3]

ABSTRACT: In this paper, we introduce new class of functions namely contra *αω-continuous function, almost contra *αω-continuous function. Also relations between contra *αω continuous function, almost contra *αω continuous function with other existing contra continuous functions are compared. Finally the properties of the defined functions are examined.

Keywords:contra *αω-continuous function, almost contra *αω-continuous function, regular set connected function, ker (A).

1. INTRODUCTION

Devi, Balachandran and Maki introduced the concept of αg- closed sets in topological spaces. Dontchev introduced the concept of generalized semi pre- closed sets in topological spaces. Palaniappan and Rao introduced the concept of regular generalized closed sets in topological spaces. GovindappaNavalagi and Chandrashkarppa introduced the concept of generalized semi pre-regular-closed (gspr- closed) in topological spaces. Arya and Nour introduced the concept of generalized α regular closed sets in topological spaces.

Njastad introduced the concept of α- closed sets in topological spaces. The notion of ω – closed sets are introduced by Sundaram and Sheik John and recently Benchalli et.al studied ωα- closed set-in topological spaces. Ganambal introduced generalized pre closed sets in topological spaces. Parimala, Udhayakumar, Jeevitha and Biju introduced the concept of αω- closed set-in topological spaces.

Dontchev introduced the notion of contra continuous functions in 1996 .J.Dontchevet. al., introduced new class of functions called regular set connected functions. In 1968, M.K. Singalet. al., introduced the concept of almost continuous mapping.

2.PRELIMINARIES

Throughout this paper (X, τ) and (Y, σ) represent topological spaces. For a subset A of a spaces (X, τ), cl(A), int(A) denote the closure of A and the interior of A respectively.

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Definition-2.1

A subset A⊆ X is called

1. a semi-open set [18] if A ⊆ cl(int(A)) and a semi-closed if int(cl(A)) ⊆ A.
2. a α-open set [5]if A⊆int(cl(int(A))) and a α-closed set [5] if cl(int(cl(A))) ⊆ A.
3. s semi pre-open set (or) β-open set[1] if A ⊆ cl(int(cl(A))) and a semi pre-closed set (or) β-closed set if int(cl(int(A))) ⊆ A.
4. a pre-open set[8] if A ⊆ (int(cl(A)) and a pre-closed set if cl(int(A)) ⊆ A.
5. a regular open set[10] if A = int(cl(A)) and a regular closed set if cl(int(A)) = A.

Definition-2.2

A subset A of space (X, τ) is called

1. a generalized closed (briefly g-closed)[18] set if cl(A) ⊆ U and U is open in (X, τ), the complement of a g-closed set is called a g-open set.
2. a generalized semi pre-regular closed (briefly gspr-closed)[11] set if spcl(A) ⊆ U and U is regular open in (X, τ).
3. a generalized pre regular-closed (briefly gpr-closed)[11] set if pcl(A) ⊆ U whenever A ⊆ U and U is regular open in (X, τ).
4. a generalized semi pre-closed (briefly gsp-closed)[7] set if spcl(A) ⊆ U whenever A ⊆ U and U is open in (X, τ).
5. a regular generalized -closed (briefly rg-closed) [17]set if cl(A) ⊆ U whenever A ⊆ U and U is regular open in (X, τ).
6. a α generalized -closed (briefly αg-closed) set[5] if αcl(A) ⊆ U whenever A ⊆ U and U is open in (X, τ).
7. a generalized pre-closed (briefly gp-closed)[7] set if pcl(A) ⊆ U whenever A ⊆ U and U is open in (X, τ).
8. a generalized semi-closed (briefly gs-closed) set[7] if scl(A) ⊆ U whenever A ⊆ U and U is open in (X, τ).
9. a ω – closed set[25] if cl(A) ⊆ U whenever A ⊆ U and U is semi-open in (X, τ).
10. a αω – closed set[21] if ωcl(A) ⊆ U whenever A ⊆ U and U is α-open in (X, τ).

Definition-2.3

A function f : (X, τ)→(Y, σ) is called

1. g-continuous [3] if $f^{-1}(V)$ is g-open in (X, τ) for every open set V of (Y, σ).
2. rg-continuous [19] if $f^{-1}(V)$ is rg-open in (X, τ) for every open set V of (Y, σ).
3. gs-continuous [11] if $f^{-1}(V)$ is gs-open in (X, τ) for every open set V of (Y, σ).
4. αg-continuous [5] if $f^{-1}(V)$ is αg-open in (X, τ) for every open set V of (Y, σ).
5. gp-continuous [2] if $f^{-1}(V)$ is gp-open in (X, τ) for every open set V of (Y, σ).

6. gpr-continuous [2] if $f^{-1}(V)$ is gpr-open in (X, τ) for every open set V of (Y, σ).
7. gsp-continuous[11] if $f^{-1}(V)$ is gsp-open in (X, τ) for every open set V of (Y, σ).
8. gspr-continuous [11] if $f^{-1}(V)$ is gspr-open in (X, τ) for every open set V of (Y, σ).
9. αω-continuous [21] if $f^{-1}(V)$ is αω-open in (X, τ) for every open set V of (Y, σ).
10. Contra g- continuous [12] if $f^{-1}(V)$ is g-closed set in (X, τ) for every open set V of (Y, σ).
11. Contra gp- continuous [12] if $f^{-1}(V)$ is gp-closed set in (X, τ) for every open set V of (Y, σ).
12. Contra gpr-continuous [12] if $f^{-1}(V)$ is gpr-closed set in (X, τ) for every open set V of (Y, σ).
13. Contra gsp-continuous [12] if $f^{-1}(V)$ is gsp-closed set in (X, τ) for every open set V of (Y, σ).
14. Contra rg-continuous [12] if $f^{-1}(V)$ is rg-closed set in (X, τ) for every open set V of (Y, σ).
15. Contra αg-continuous [12] if $f^{-1}(V)$ is αg-closed set in (X, τ) for every open set V of (Y, σ).
16. Contra gs-continuous [12] if $f^{-1}(V)$ is gs-closed set in (X, τ) for every open set V of (Y, σ).
17. Almost contra continuous [23] if $f^{-1}(V)$ is closed in (X, τ) for every regular open set V of (Y, σ).

Definition- 2.4

A function f : (X, τ) → (Y, σ) is said to be regular set connected [6] if $f^{-1}(V)$ is clopen is (X, τ) for every regular open set V of (Y, σ).

Definition- 2.5 [2]

A function f : (X, τ)→(Y, σ) is called

1. *αω-open map if open set U in X, f(U) is *αω-open in Y.
2. *αω-close map if closed set U in X, f(U) is *αω-closed in Y.
3. Pre *αω- open if for every *αω- open U in X, f(U) is *αω- open in Y.
4. Pre *αω- closed if for every *αω- closed U in X, f(U) is *αω- closed in Y.

3. CONTRA *αω CONTINUOUS FUNCTION

Definition-3.1

A function f : (X, τ) → (Y, σ) is said to be contra *αω continuous if $f^{-1}(V)$ is *αω-closed set in (X, τ) for every open set V of (Y, σ).

Theorem-3.2 Every contra continuous is a contra *αω continuous but not conversely.

Proof: Let V be a open set in (Y, σ). Since f is contra continuous, $f^{-1}(V)$ is closed in (X, τ), but every closed set is *αω closed in (X, τ),[2] $f^{-1}(V)$ is *αω closed in (X, τ). Thus f is contra *αω continuous.

The converse of the above theorem need not to be true by the following example.

Example-3.3

Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=c, f(b)=b, f(c)=a. Let X = Y = {a, b, c}.

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

$(X, τ)^c$ = {ϕ, X, {b, c}, {c}}.

*αω closed set of (X, τ) = {ϕ, X, {c}, {b, c}, {a, c}}.

Hence every open set of (Y, σ) are*αω closed set of (X, τ) but f^{-1}{a, c} = {a, c} is not in $(X, \tau)^c$. Therefore f is contra *αω - continuous but not contra continuous.

Theorem-3.4 Every contra *αω continuous is contra g-continuous (contra gp-continuous)but not conversely

Proof: Let V be a open set in (Y, σ). Since f is contra *αω continuous, $f^{-1}(V)$ is *αω closed in (X, τ), but every *αω closed set g-closed (gp-closed)in (X, τ)[2], $f^{-1}(V)$ is g-closed(gp-closed) in (X, τ). Thus f is contra g-continuous (contra gp-continuous).

The converse of the above theorem need not to be true by the following examples.

Example-3.5

Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=a, f(b)=b, f(c)=c. Let X = Y = {a, b, c}.

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

*αω closed set of (X, τ) = {ϕ, X, {a}, {b, c}}.

g-closed set of (X, τ) = {ϕ, X, {a}, {b}, {c}, {a, b}, {b, c}, {a, c}}. Hence every open set of (Y, σ) are g-closed in (X, τ) but f^{-1}{b}={b} is not *αω closed in (X, τ). Therefore f is contra g continuous but not contra *αω continuous.

Example-3.6

Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=a, f(b)=b, f(c)=c. Let X = Y = {a, b, c}.

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

*αω closed set of (X, τ) = {ϕ, X, {c}, {b, c}, {a, c}}, gp-closed set of (X, τ) = {ϕ, X, {a}, {b}, {c}, {a, b}, {b, c}, {a, c}}. Hence every open set of (Y, σ) are gp-closed in (X, τ) but f^{-1}{a}={a} is not *αω closed in (X, τ). Therefore f is contra gp continuous but not contra *αω continuous.

Theorem-3.7 Every contra *αω continuous is contra gpr-continuous (contra gsp-continuous, contra rg-continuous, contra αg-continuous) but not conversely.

Proof: Let V be a open set in (Y, σ). Since f is contra *αω continuous, $f^{-1}(V)$ is *αω closed in (X, τ), but every *αω closed set is gpr-closed(gsp-closed, rg-closed, αg-closed)[2] in (X, τ), $f^{-1}(V)$ is gpr-closed(gsp-closed, rg-closed, αg-closed) in (X, τ). Thus f is contra gpr-continuous(contra gsp-continuous, contra rg-continuous, contra αg-continuous).

The converse of the above theorem need not to be true are given by the following examples.

Example-3.8

Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=a, f(b)=b, f(c)=c. Let X = Y = {a, b, c}.

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

*αω closed set of (X, τ) = {ϕ, X, {c}, {b, c}, {a, c}}.

gpr-closed set of (X, τ) = {ϕ, X, {c}, {a, b}, {b, c}, {a, c}}.

Hence every open set of (Y, σ) are gpr-closed in (X, τ) but f^{-1}{a, b} = {a, b} is not *αω closed in (X, τ). Therefore f is contra gpr continuous but not contra *αω continuous.

Example-3.9

Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=a, f(b)=b, f(c)=c. Let X = Y = {a, b, c}.

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

*αω closed set of (X, τ) = {ϕ, X, {c}, {b, c}, {a, c}}, gsp-closed set of (X, τ) = {ϕ, X, {a}, {b}, {c}, {b, c}, {a, c}}. Hence every open set of (Y, σ) are gsp-closed in (X, τ) but f^{-1}{a} = {a} is not *αω closed in (X, τ). Therefore f is contra gsp continuous but not contra *αω continuous.

Example-3.10

Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=a, f(b)=b, f(c)=c. Let X = Y = {a, b, c}.

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

*αω closed set of (X, τ) = {ϕ, X, {b}, {c}, {b, c}, {a, c}, {a, b}}.

rg-closed set of (X, τ) = {ϕ, X, {a}, {b}, {c}, {a, b}, {b, c}, {a, c}}. Hence every open set of (Y, σ) are rg-closed in (X, τ) but f^{-1}{a, b} = {a, b} is not *αω closed in (X, τ). Therefore f is contra rg continuous but not contra *αω continuous.

Example-3.11

Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=a, f(b)=b, f(c)=c. Let X = Y = {a, b, c}.

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

*αω closed set of (X, τ) = {ϕ, X, {a}, {b, c}}, αg-closed set of (X, τ) = {ϕ, X, {a}, {b}, {c}, {a, b}, {b, c}, {a, c}}. Hence every open set of (Y, σ) are αg-closed in (X, τ) but f^{-1}{a, b} = {a, b} is not *αω closed in (X, τ). Therefore f is contra αg continuous but not contra *αω continuous.

Theorem-3.12 Every contra *αω continuous is contra gs-continuous but not conversely.

Proof: Let V be a open set in (Y, σ). Since f is contra *αω continuous, f^{-1}(V) is *αω closed in (X, τ),[2] but every *αω closed set is gs-closed in (X, τ), f^{-1}(V) is gs-closed in (X, τ). Thus f is contra gs-continuous.

The converse of the above theorem need not to be true by the following example.

Example-3.13

Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=a, f(b)=b, f(c)=c. Let X = Y = {a, b, c}.

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

*αω closed set of (X, τ) = {ϕ, X, {c}, {b, c}, {a, c}}, gs-closed set of (X, τ) = {ϕ, X, {a}, {b}, {c}, {b, c}, {a, c}}. Hence every open set of (Y, σ) are gs-closed in (X, τ) but f^{-1}{a} = {a} is not *αω closed in (X, τ). Therefore, f is contra gs-continuous but not contra *αω continuous.

Theorem-3.14 Suppose *αωO(X, τ) is closed under arbitrary unions. Then the following are equivalent for a function f: (X, τ) → (Y, σ)

(i) fis contra *αω continuous.

(ii) for every closed subset F of Y, $f^{-1}(F)$ ϵ *αωO(X, τ).

(iii) for each x ϵ X and each F ϵ C(Y, f(x)), there exist a set U ϵ *αωO(X, x) such that f(U) ⊆F.

Proof:(i) ⇒ (ii) Let f is contra *αω continuous. Then $f^{-1}(V)$ is *αω closed in X for every open set V of Y. (ie) $f^{-1}(F)$ is *αω open in X for every closed set F of Y. Hence $f^{-1}(F)$ ϵ *αωO(X).

(ii) ⇒ (i) follows from the definition.

(ii) ⇒ (iii) For every closed subsets F of Y, $f^{-1}(F)$ϵ*αωO(X)[by (i)]. Then for each x ϵ X and each F ϵ C(Y, f(x)), there exist a set U ϵ *αωO(X, x) such that f(U) ⊆ F.

(iii) ⇒ (ii) For every x ϵ X, F ϵ C(Y, f(x)), there exist a set U_xϵ *αωO(X, x) such that f(U_x) ⊆F. Let F be a closed set of Y and x ϵ $f^{-1}(F)$. Then f(x)ϵF, there exist U ϵ *αωO(X, x) such that f(U) ⊆F which implies $f^{-1}(F)$=U{U_x: x ϵ $f^{-1}(F)$}.Hence $f^{-1}(F)$ is *αω open.

Theorem-3.15 If f : X→ Y is contra *αω continuous closed injection and A is open subset of X, then the restriction (f/A) : (X, τ) → (Y, σ) is contra *αω continuous.

Proof: Let V be any closed set in Y. since f : (X, τ) → (Y, σ) is contra *αω continuous, $f^{-1}(V)$ is *αω open in X. $(f/A)^{-1}(V)$ = $f^{-1}(V)$∩U is contra *αω open in X. Hence f($(f/A)^{-1}(V)$) is *αω open in U.

Lemma-3.16[6]The following properties hold for subsets A, B of a space X

i. x ϵ ker (A) if and only if U∩A = ϕ for any F ϵ C (X, x).

ii. A ⊂ ker(A) and A= ker(A) if A open in x

iii. If A⊂B then ker (A) ⊂ker (B)

Theorem- 3.17 Suppose that *αωC(X) is closed under arbitrary intersection. Then the following are equivalent for a function f:X→Y.

i. f is contra *αω continuous.

ii. The inverse image of every closed set of Yis *αω open.

iii. For each x ϵ X and each closed set B in Y with f(x) ϵ B, these exist a*αω open set A in X such that x ϵ A an f(A)⊂B.

iv. f (*αω-cl (A))⊂ker f(A) for every subset A of X.

v. *αω-cl ($f^{-1}(B)$) ⊆ f ′(ker(B)) for every subset B of Y.

Proof: From the definition of contra *αω continuous (i) ⇒ (ii) and (ii) ⇒ (i) follows.

(i) ⇒(iii) Let x ϵ X and B be a closed set in Y with f(x) ϵ B. By (i), if follows that f^{-1}(Y- B) = X – f^{-1} (B) is *αω closed and so $f^{-1}(B)$is * αω open.

(ii)⇒(iv) Let A be any subset of X. Let y ∉ ker f (A). Then there exist a closed set F containing y such that f(A) ∩ F=ϕ. We have A∩f^{-1}(f) = ϕ, Hence *αω-cl(A) ∩ f^{-1}(F)=ϕ. Thus f (*αω-cl(A)) ⊂ F=ϕ and y ∉ f (*αω-cl(A)) and hence f(*αω-cl(A)) ⊆ ker f (A).
(iv) ⇒(v) Let B be any subset of Y. By (iv), f(*αω-cl f^{-1}(B)) ⊂ker B and *αω-cl f^{-1}(B) ⊂ f^{-1} (ker B).
(v)⇒(i) Let B be any open set of Y. By (v), *αω-cl (f^{-1}(B)) ⊂ f^{-1} (ker B)=f^{-1} (B),*αω-cl (f^{-1}(B)) = f^{-1} (B). We obtain f^{-1} (B) is *αω- closed in X. Hence f is contra *αω continuous.

Definition -3.18

A space(X, τ) is *αω locally indiscrete if every *αω -open subset of X is closed.

Theorem -3.19 If a function f : (X, τ)→(Y, σ) is *αω continuous and the space (X, τ) is *αω locally indiscrete, then f is contra continuous.
Proof: Let V be a open set in (Y, σ). Since f is *αω continuous, f^{-1}(V) is *αω -open in X. Since X is locally *αω indiscrete, f^{-1}(V) is closed in X. Hence f is contra continuous.

4. Almost Contra *αω Continuous Function in Topological Spaces

Definition-4.1
A function f : (X, τ) → (Y, σ) is said to be almost contra *αω continuous if f^{-1}(V) is *αω closed in X for each regular open set V of Y.

Theorem-4.2 Every contra *αω continuous function is almost contra *αω continuous but not conversely.
Proof: Let V be a regular open set of (Y, σ). Since f is *αω contra continuous, f^{-1}(V) is *αω closed in (X, τ) for each regular open set V of Y. Thus f is a almost contra *αω continuous.

The converse of the above theorem need not to be true by the following example.

Example-4.3
Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=a, f(b)=b, f(c)=c. Let X = Y = {a, b, c}.
(X, τ) = {ϕ, X, {a}, {b}, {a, b}} and (Y, σ) = {ϕ, X, {a}}.
Regular open set of (X, τ) = {ϕ, X, {a}, {b}}, *αω closed set of (X, τ) = {ϕ, X, {c}, {b, c}, {a, c}}.
Hence every open set of (Y, σ) are regular open in (X, τ) but f^{-1}{a} = {a} is not *αω closed in (X, τ).
Therefore f is almost contra *αω continuous but not contra *αω continuous.

Theorem : 4.4 Let f : X→Y, g : Y→ Z be two functions. If is almost contra *αω continuous and g is regular set connected, then $g_o f$: X→Z is almost contra *αω continuous and almost *αω continuous.
Proof: Let V ϵ RO(Z) Since g is regular set connected g^{-1}(V) clopen in Y. Since f is almost contra *αω continuous. $f^{-1}[g^{-1}(V)] = (g_o f)^{-1}(V)$ is *αω open and *αω closed. Therefore ($g_o f$) is almost contra *αω continuous and almost *αω continuous.

Theorem : 4.5 Let f : X→Y, g:Y→Z be two functions. If f is contra *αω continuous and g is regular set connected, then $g_o f$: X→Z is *αω continuous and almost *αω continuous.

Proof: Let V∊ RO(Z) Since g is regular set connected. $g^{-1}(V)$ is clopen in Y. Since f is contra *αω continuous. $f^{-1}[g^{-1}(V)] = (g_o f)^{-1}(V)$ is *αω closed in X. Therefore, $(g_o f)$ is *αω continuous and almost *αω continuous.

Theorem: 4.6 Every regular set connected function is almost contra *αω continuous but not conversely.

Proof: Let V be any regular open in (X, τ). Since f : (X, τ)→(Y, σ) is regular set connected, $f^{-1}(V)$ is clopen in X and hence*αω clopen. That is $f^{-1}(V)$ is *αω open and *αω closed. Therefore f is almost contra *αω continuous.

The converse of the above theorem need not to be true by the following example.

Example-4.7

Let the mapping f : (X, τ)→(Y, σ) be defined as f(a)=a, f(b)=b, f(c)=c. Let X = Y = {a, b, c}.
(X, τ) = {ϕ, X, {a}, {b}, {a, b}} and (Y, σ) = {ϕ, X, {a}}.
Regular open set of (X, τ) = {ϕ, X, {a}, {b}}, Regular closed set of (X, τ) = {ϕ, X, {b, c}, {a, c}}.
Hence every open set of (Y, σ) are regular open in (X, τ) but not regular closed set in (X, τ). Here $f^{-1}\{a\}$ = {a}. Therefore f is almost contra *αω continuous but not regular set connected continuous function.

Theorem-4.8 If f : X→ Y is an almost contra *αω continuous closed injection and A is open subset of X, then the restriction (f/A) : X → Y is almost contra *αω continuous.

Proof: Let V be a regular closed set in Y. since f is almost contra *αω continuous, $f^{-1}(V)$∊*αωO(X). Since A is open, it follows that $(f(A)^{-1}(V)) = A \cap f^{-1}(V)$ ∊ *αωO(X). Therefore (f/A) : X → Y is almost contra *αω continuous.

Theorem-4.9 If f : X → Y is a surjective pre *αω open(pre *αω closed) and g : Y→ Z is a function such that $g_o f$ is almost contra *αω continuous, then g is almost contra *αω continuous.

Proof: Let V be any regular open set in Z. since $g_o f$ is almost contra *αω continuous, $f^{-1}(g^{-1}(V))=(gof)^{-1}(V)$ is *αω open(*αω closed). Since f is surjective pre *αω open(pre *αω closed), $f(f^{-1}(g^{-1}(V))) = g^{-1}(V)$ is *αω-open(*αω -closed). Therefore g is almost contra *αω continuous.\

Theorem -4.10 If f : X→Y and g:Y→Z are *αω continuous and Y is locally indiscrete, then $g_o f$: X→Z is *αω continuous.

Proof: Let A be a closed set in Z. since g is *αω continuous, $g^{-1}(A)$ is *αω closed in Y and hence open. Since f is *αω continuous, $(g_o f)^{-1}(A)=f^{-1}(g^{-1}(A))$ is *αω open in X. Hence $g_o f$ is contra *αω continuous.

5. CONCLUSION

In this paper, we studied the basic definition and preliminariesof topology and we introduced the concept of contra *αω continuous function and their properties were discussed. We also introduced the concept of almost contra *αω continuous and derived their relationship with contra *αω- continuous and other existing functions.

ACKNOWLEDGEMENT

We are thankful to our colleagues who provided expertise that greatly assisted the research. We are also grateful to the librarian for all necessary materials which improved the manuscript significantly. We are also immensely grateful to Dr.M.Vigneshwaran for his comments on the manuscript,that improved the version of the manuscript.

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