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On Strongly Rβgc*-Continuous Mappings in Topological Spaces

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ABSTRACT

The Aim of this paper is to introduce a new type of mappings called strongly Regular β-generalized c*-continuous mappings and study their basic properties. Also, we establish the relationship between strongly Regular β-generalized c*-continuous mappings and other near continuous mappings in topological spaces.

Keywords : Strongly βgc*-closed sets, Strongly βgc*-open sets, Strongly βgc*-continuous mappings, Strongly Rβgc*-continuous mappings.

I. INTRODUCTION

In 1963, Norman Levine introduced semi-open sets in topological spaces. Also in 1970, he introduced the concept of generalized closed sets. N. Levine introduced the concept of semi-continuous function in 1963. In 1980, Jain introduced totally continuous functions. In 1995, T.M. Nour introduced the concept of totally semi-continuous functions as a generalization of totally continuous functions. In 2011, S.S. Benchalli et.al introduced the concept of semi-totally continuous functions in topological spaces. In this paper we introduce Strongly Regular β-generalized c*-continuous mappings in topological spaces and study their basic properties.

Section 2 deals with the preliminary concepts. In section 3, Strongly Regular β-generalized c*-continuous mappings are introduced and their basic properties are studied.

II. PRELIMINARIES

Throughout this paper X denotes a topological space on which no separation axiom is assumed. For any subset A of X, cl(A) denotes the closure of A, int(A) denotes the interior of A. Further X\A denotes the complement of A in X. The following definitions are very useful in the subsequent sections.

Definition: 2.1 A subset A of a topological space X is called

i. a semi-open set [9] if A⊆cl(int(A)) and a semi-closed set if int(cl(A))⊆A.
ii. a regular-open set [18] if A=int(cl(A)) and a regular-closed set if A=cl(int(A)).

iii. a π-open set [19] if A is the finite union of regular-open sets and the complement of π-open set is said to be π-closed.

iv. a β-open set [1] (semi-pre open set[2]) if A⊆cl(int(cl(A))) and a β-closed set (semi-pre closed set) if int(cl(int(A)))⊆A.

Definition: 2.2 A subset A of a topological space X is said to be a clopen set if A is both open and closed in X.

Definition: 2.3 [10] A subset A of a topological space X is said to be a c^*-open (semi-clopen) set if int(cl(A))⊆A⊆cl(int(A)).

Definition: 2.4 [16] A subset A of a topological space X is called a π-generalized β-closed (briefly, πgβ-closed) set if βcl(A)⊆H whenever A⊆H and H is π-open in X. The complement of the πgβ-closed set is said to be πgβ-open.

Definition: 2.5 [13] A subset A of a topological space X is called a generalized semi pre regular-closed (briefly, gspr-closed) set if spcl(A)⊆H whenever A⊆H and H is regular-open in X. The complement of the gspr-closed set is said to be gspr-open.

Definition: 2.6 [10] A subset A of a topological space X is said to be a generalized c^*-closed set (briefly, gc^*-closed set) if cl(A)⊆H whenever A⊆H and H is c^*-open. The complement of the gc^*-closed set is gc^*-open [11].

Definition: 2.7 [12] A subset A of a topological space X is said to be strongly β-generalized c^*-closed (briefly, strongly βgc^*-closed) if βcl(A)⊆H whenever A⊆H and H is gc^*-open in X. The complement of the strongly βgc^*-closed set is said to be strongly βgc^*-open.

Definition: 2.8 A function $f : X \rightarrow Y$ is called

i. Semi-continuous [9] if the inverse image of every open subset of Y is semi-open in X.
ii. Totally continuous [7] if the inverse image of every open subset of Y is clopen in X.
iii. Strongly continuous [8] if the inverse image of every subset of Y is clopen in X.
iv. Totally semi-continuous [15] if the inverse image of every open subset of Y is semi- clopen in X.
v. Strongly semi-continuous [15] if the inverse image of every subset of Y is semi- clopen in X.
vi. Semi-totally continuous [3] if the inverse image of every semi- open subset of Y is clopen in X.
vii. Semi-totally semi-continuous [6] if the inverse image of every semi-open subset of Y is semi-clopen in X.
viii. S-continuous [14] if the inverse image of every semi-open subset of Y is open in X.
ix. Almost-continuous [17] if the inverse image of every regular-open subset of Y is open in X.
x. Regular set connected [4] if the inverse image of every regular-open subset of Y is clopen in X.
xi. Π-generalized β-continuous [16] (briefly, πgβ-continuous) if the inverse image every closed set in Y is πgβ-closed in X.
xii. Generalized semipre regular-continuous [13] (briefly, gspr-continuous) if the inverse image of every closed

set in Y is gspr-closed in X.

Definition: 2.9 [5] A space X is said to be locally indiscrete if every closed set is regular closed in X.

III. STRONGLY REGULAR β-GENERALIZED C*-CONTINUOUS MAPPINGS

In this section, we introduce strongly Regular β-generalized c*-continuous mappings and study their relation with near continuous mappings.

Definition: 3.1 A mapping $f:X\to Y$ is said to be strongly Regular βgc*-continuous (briefly, strongly Rβgc*-continuous) if the inverse image of every regular-closed set in Y is strongly βgc*-closed in X.

Example: 3.2 Let X={a,b,c,d} with topology τ={∅, {a}, {c}, {d}, {a,c}, {a,d}, {c,d}, {a,c,d}, X} and Y={1,2,3,4} with topology σ={∅, {1}, {2}, {3}, {1,2}, {1,3}, {2,3}, {3,4}, {1,2,3}, {2,3,4}, {1,3,4}, Y}. Define $f : X \to Y$ by f(a)=2, f(b)=4, f(c)=3, f(d)=1. Then the inverse image of every regular-closed set in Y is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.3 Every continuous mapping is strongly Rβgc*-continuous.
Proof: Assume that $f:X\to Y$ is continuous. Let V be a regular-closed set in Y. Then V is closed in Y. Since f is continuous, $f^{-1}(V)$ is closed in X. Therefore, by Proposition 3.3 [12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.4 Every semi-continuous mapping is strongly Rβgc*-continuous.
Proof: Assume that $f:X\to Y$ is semi-continuous. Let V be a regular-closed set in Y. Then V is closed in Y. Since f is semi-continuous, $f^{-1}(V)$ is semi-closed in X. Therefore, by Proposition 3.7[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.5 Every totally continuous mapping is strongly Rβgc*-continuous.
Proof: Assume that $f:X\to Y$ is totally continuous. Let V be a regular-closed set in Y. Then V is closed in Y. Since f is totally continuous, $f^{-1}(V)$ is clopen in X. This implies, $f^{-1}(V)$ is closed in X. Therefore, by Proposition 3.3[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.6 Every totally semi-continuous mapping is strongly Rβgc*-continuous.
Proof: Assume that $f:X\to Y$ is totally semi-continuous. Let V be a regular-closed set in Y. Then V is closed in Y. Since f is totally semi-continuous, $f^{-1}(V)$ is semi-clopen in X. This implies, $f^{-1}(V)$ is semi-closed in X. Therefore, by Proposition 3.7[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.7 Every strongly semi- continuous mapping is strongly Rβgc*-continuous.

Proof: Assume that f:X→Y is strongly semi-continuous. Let V be a regular-closed set in Y. Then V is closed in Y. Since f is strongly semi-continuous, $f^{-1}(V)$ is semi-clopen in X. This implies, $f^{-1}(V)$ is semi-closed in X Therefore, by Proposition 3.7[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.8 Every strongly continuous mapping is strongly Rβgc*-continuous.
Proof: Assume that f:X→Y is strongly continuous. Let V be a regular-closed set in Y. Then V is closed in Y. Since f is strongly continuous, $f^{-1}(V)$ is clopen in X. This implies, $f^{-1}(V)$ is closed in X. Therefore, by Proposition 3.3[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.9 Every semi-totally continuous mapping is strongly Rβgc*-continuous.
Proof: Assume that f:X→Y is semi-totally continuous. Let V be a regular-closed set in Y. Then V is semi-closed in Y. Since f is semi- totally continuous, $f^{-1}(V)$ is clopen in X. This implies, $f^{-1}(V)$ is closed in X Therefore, by Proposition 3.3[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.10 Every semi-totally semi-continuous mapping is strongly Rβgc*-continuous.
Proof: Assume that f:X→Y is semi-totally semi- continuous. Let V be a regular-closed set in Y. Then V is semi-closed in Y. Since f is semi-totally semi-continuous, $f^{-1}(V)$ is semi-clopen in X. This implies, $f^{-1}(V)$ is semi-closed in X. Therefore, by Proposition 3.7[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.11 Every s-continuous mapping is strongly Rβgc*-continuous.
Proof: Assume that f:X→Y is s-continuous. Let V be a regular- closed set in Y. Then V is semi-closed in Y. Since f is s-continuous, $f^{-1}(V)$ is closed in X. Therefore, by Proposition 3.3[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.12 Every almost-continuous mapping is strongly Rβgc*-continuous.
Proof: Assume that f:X→Y is almost-continuous. Let V be a regular-closed set in Y. Then $f^{-1}(V)$ is closed in X. Therefore, by Proposition 3.3[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

Proposition: 3.13 Every Regular set-connected mapping is strongly Rβgc*-continuous.
Proof: Assume that f:X→Y is Regular set-connected. Let V be a regular-closed set in Y. Then $f^{-1}(V)$ is clopen in X. This implies, $f^{-1}(V)$ is closed in X Therefore, by Proposition 3.3[12], $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.
The Converse of the above Propositions need not be true as shown in the following example.

Example:3.14 Let X={a,b,c,d,e} with topology τ={∅,{a,b},{c,d},{a,b,c,d},X} and Y={1,2,3,4,5} with topology σ={∅,{1},{2},{1,2},{1,2,3}, {1,2,3,4},{1,2,3,5},Y}. Define f:X→Y by f(a)=1, f(b)=2, f(c)=3, f(d)=4, f(e)=5. Then f is strongly Rβgc*-continuous. But f is not continuous (semi-continuous, totally semi-continuous, totally continuous, semi-totally continuous, semi-totally semi-continuous, strongly continuous, strongly semi-continuous, s-continuous, almost-continuous, regular set-connected), since $f^{-1}(\{1\})$={a}.

Proposition: 3.15 Every strongly βgc*-continuous mapping is strongly Rβgc*-continuous.

Proof: Assume that f:X→Y is strongly βgc*-continuous. Let V be a regular-closed set in Y. Then V is closed in Y. Since f is strongly βgc*-continuous, $f^{-1}(V)$ is strongly βgc*-closed in X. Hence f is strongly Rβgc*-continuous.

The Converse of the above Proposition need not be true as shown in the following example.

Example: 3.16 Let X={a,b,c,d,e} with topology τ={∅,{a,b},{c,d},{a,b,c,d},X} and Y={1,2,3,4,5} with topology σ={∅,{1},{2},{1,2},{1,2,3}, {1,2,3,4},{1,2,3,5},Y}. Define g:X→Y by g(a)=g(b)=g(c)=g(d)=5, g(e)=4. Then g is strongly Rβgc*-continuous. But g^{-1}({5})={a,b,c,d} which is not a strongly βgc*-closed set in X. Therefore, g is not strongly βgc*-continuous.

Proposition: 3.17 Let X be a topological space and Y be a locally indiscrete space. Then every strongly Rβgc*-continuous mapping f:X→Y is πgβ-continuous.

Proof: Assume that f:X→Y is strongly Rβgc*-continuous. Let V be a closed set in Y. Then V is regular-closed in Y, since Y is locally indiscrete. Since f is strongly Rβgc*-continuous, $f^{-1}(V)$ is strongly βgc*-closed in X. Therefore, by Proposition 3.12 [12], $f^{-1}(V)$ is πgβ-closed in X. Hence f is πgβ-continuous.

Proposition: 3.18 Let X be a topological space and Y be a locally indiscrete space. Then every strongly Rβgc*-continuous mapping f:X→Y is gspr-continuous.

Proof: Assume that f:X→Y is strongly Rβgc*-continuous. Let V be a closed set in Y. Then V is regular-closed in Y, since Y is locally indiscrete. Since f is strongly Rβgc*-continuous, $f^{-1}(V)$ is strongly βgc*-closed in X. Therefore, by Proposition 3.13 [12], $f^{-1}(V)$ is gspr-closed in X. Hence f is gspr-continuous.

Proposition: 3.19 The mapping f:X→Y is strongly Rβgc*-continuous if and only if the inverse image of every regular-open set in Y is strongly βgc*-open in X.

Proof: Assume that f:X→Y is strongly Rβgc*-continuous. Let U be a regular-open set in Y. Then Y\U is regular-closed in Y. This implies, f^{-1}(Y\U) is strongly βgc*-closed in X. Since f^{-1}(Y\U)=X\$f^{-1}$(U), we have X\$f^{-1}$(U) is strongly βgc*-closed in X. This implies, f^{-1}(U) is strongly βgc*-open in X. Conversely, assume that f^{-1}(U) is strongly βgc*-open in X for every regular-open set U in Y. Let V be a regular-closed set in Y. Then Y\V is regular-open in Y. Therefore, f^{-1}(Y\V) is strongly βgc*-open in X. That is, X\$f^{-1}$(V) is strongly βgc*-open in X. This implies, f^{-1}(V) is strongly βgc*-closed in X. Therefore, f is strongly Rβgc*-continuous.

Remark: 3.20 Composition of two strongly Regular βgc*-continuous mappings need not be strongly Regular βgc*-continuous. For example, let X={a,b,c,d}, Y={1,2,3,4}, Z={p,q,r,s,t}. Then, clearly τ={∅,{a},{b},{a,b},{a,c}, {a,b,c},X} is a topology on X, σ={∅, {1}, {2}, {3}, {1,2}, {1,3}, {2,3}, {3,4}, {1,2,3}, {2,3,4}, {1,3,4},Y} is a topology on Y and η={∅,{p}, {s},{t},{p,s},{p,t},{s,t}, {p,s,t},Z} is a topology on Z. Define f : X → Y by f(a)= f(d)=1, f(b)= f(c)=2 and g : Y → Z by g(1)=p, g(2)=g(3)= g(4)=t. Then f and g are strongly Rβgc*-continuous. Consider the regular-closed set {p,q,r} in Z. Then $(g \circ f)^{-1}$({p,q,r})= $f^{-1}(g^{-1}$({p,q,r}))=f^{-1}({1})={a,d}, which is not a strongly βgc*-closed set in X. Therefore, g∘f is not strongly Rβgc*-continuous.

Proposition: 3.21 If f:X→Y is strongly βgc*-continuous and g:Y→Z is continuous, then g∘f:X→Z is strongly Rβgc*-continuous.

Proof: Assume that f:X→Y is strongly βgc*-continuous and g:Y→Z is continuous. Let V be a regular-closed set in Z. Then $g^{-1}(V)$ is closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g\circ f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly Rβgc*-continuous.

Proposition: 3.22 If f:X→Y is strongly βgc*-continuous and g:Y→Z is totally continuous, then g∘f:X→Z is strongly Rβgc*-continuous.

Proof: Assume that f:X→Y is strongly βgc*-continuous and g:Y→Z is totally-continuous. Let V be a regular-closed set in Z. Then $g^{-1}(V)$ is clopen in Y. This implies, $g^{-1}(V)$ is closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g\circ f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly Rβgc*-continuous.

Proposition: 3.23 If f:X→Y is strongly βgc*-continuous and g:Y→Z is strongly continuous, then g∘f:X→Z is strongly Rβgc*-continuous.

Proof: Assume that f:X→Y is strongly βgc*-continuous and g:Y→Z is strongly continuous. Let V be a regular-closed set in Z. Then $g^{-1}(V)$ is clopen in Y. This implies, $g^{-1}(V)$ is closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g\circ f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly Rβgc*-continuous.

Proposition: 3.24 If f:X→Y is strongly βgc*-continuous and g:Y→Z is semi-totally continuous, then g∘f:X→Z is strongly Rβgc*-continuous.

Proof: Assume that f:X→Y is strongly βgc*-continuous and g:Y→Z is semi-totally continuous. Let V be a regular-closed set in Z. Then $g^{-1}(V)$ is clopen in Y. This implies, $g^{-1}(V)$ is closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g\circ f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly Rβgc*-continuous.

Proposition: 3.25 If f:X→Y is strongly Rβgc*-continuous and g:Y→Z is totally continuous, then g∘f:X→Z is strongly Rβgc*-continuous.

Proof: Assume that f:X→Y is strongly Rβgc*-continuous and g:Y→Z is totally-continuous. Let V be a regular-closed set in Z. Then $g^{-1}(V)$ is clopen in Y. This implies, $g^{-1}(V)$ is regular-closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g\circ f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly Rβgc*-continuous.

Proposition: 3.26 If f:X→Y is strongly Rβgc*-continuous and g:Y→Z is strongly continuous, then g∘f:X→Z is strongly Rβgc*-continuous.

Proof: Assume that f:X→Y is strongly Rβgc*-continuous and g:Y→Z is strongly continuous. Let V be a regular-closed set in Z. Then $g^{-1}(V)$ is clopen in Y. This implies, $g^{-1}(V)$ is regular-closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g\circ f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly Rβgc*-continuous.

Proposition: 3.27 If f:X→Y is strongly Rβgc*-continuous and g:Y→Z is semi-totally continuous, then g∘f:X→Z is strongly Rβgc*-continuous.

Proof: Assume that f:X→Y is strongly Rβgc*-continuous and g:Y→Z is semi-totally continuous. Let V be a regular-closed set in Z. Then $g^{-1}(V)$ is clopen in Y. This implies, $g^{-1}(V)$ is regular-closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g∘f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly Rβgc*-continuous.

Proposition: 3.28 If f:X→Y is strongly Rβgc*-continuous and g:Y→Z is totally continuous, then g∘f:X→Z is strongly βgc*-continuous.

Proof: Assume that f:X→Y is strongly Rβgc*-continuous and g:Y→Z is totally-continuous. Let V be a closed set in Z. Then $g^{-1}(V)$ is clopen in Y. This implies, $g^{-1}(V)$ is regular-closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g∘f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly βgc*-continuous.

Proposition: 3.29 If f:X→Y is strongly Rβgc*-continuous and g:Y→Z is strongly continuous, then g∘f:X→Z is strongly βgc*-continuous.

Proof: Assume that f:X→Y is strongly Rβgc*-continuous and g:Y→Z is strongly continuous. Let V be a closed set in Z. Then $g^{-1}(V)$ is clopen in Y. This implies, $g^{-1}(V)$ is regular-closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g∘f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly βgc*-continuous.

Proposition: 3.30 If f:X→Y is strongly Rβgc*-continuous and g:Y→Z is semi-totally continuous, then g∘f:X→Z is strongly βgc*-continuous.

Proof: Assume that f:X→Y is strongly Rβgc*-continuous and g:Y→Z is semi-totally continuous. Let V be a closed set in Z. This implies, V is semi-closed in Z. Therefore, $g^{-1}(V)$ is clopen in Y. This implies, $g^{-1}(V)$ is regular-closed in Y. Therefore, $f^{-1}(g^{-1}(V))$ is strongly βgc*-closed in X. That is, $(g∘f)^{-1}(V)$ is strongly βgc*-closed in X. Hence g∘f is strongly βgc*-continuous.

IV. CONCLUSION

In this paper we have introduced strongly Regular β-generalized c*-continuous mappings in topological spaces and studied some of their basic properties. Also, we have discussed the relation of strongly Regular β-generalized c*-continuous mappings with near continuous mappings in topological spaces.

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This is to certify that **S. Malathi** has presented a research paper entitled ***'On Strongly Rβgc*-Continuous Mappings in Topological Spaces'*** in the ICAMS-2021 held during 4^{th}, 5^{th}, 6^{th} October 2021, Department of Mathematics, K. D. K. College of Engineering, Great Nag Road, Nandanvan, Nagpur, Maharashtra, India

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IJSRSET Team wishes all the best for bright future

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