#s*gα-closed sets in Topological Spaces

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Abstract: **This paper deals with a new class of sets namely #s*gα-closed sets in topological spaces and derive the properties of #s*gα-closed sets. Also we find the relationship between #s*gα-closedsets and the other existing sets. Moreover with the help of these sets, we introduce three new spaces, $_{\#s*g\alpha}T_b$ spaces, αgT_b spaces, sT_b** spaces.**

Keywords - **#s*gα-closed sets, $_{\#s*g\alpha}T_b$ spaces, αgT_b spaces, sT_b** spaces.**

I.INTRODUCTION

Levine and A.S.Mashhour [19] introduced semi-continuous maps and α-continuous maps respectively.P.Battacharaya and B.K.Lahiri [6] introduced semi generalized closed sets,H.Maki,R.Devi and K.Balachandran [20] introduced α-generalized closed sets and generalized α-closed sets respectively.R.Devi et.al [9] introduced αg-continuous,gs-continuous,αg-irresolute and gs-irresolutemaps.R.Devi,H.Maki and K.Balachandran [11] introduced semi-generalized-homeomorphism in topological spaces.Recently M.K.R.S.Veerakumar [31]introduced g*-closed sets and M.Vigneshwaran [34] introduced *gα-closed sets in topological spaces.K.Ayswarya [4] introduced s *gα-closed sets in topological spaces.In this paper, we introduce a new class of sets namely #s*gα-closed sets in topological spaces and derive its properties.Also we find the relationship between #s*gα-closed sets and other existing sets.Moreover, with the help of these sets, we introduce three new spaces $_{\#s*g\alpha}T_b$space, sT_b**space, αgT_bspaceand their properties. Also we introduce #s*gα-continuous maps, #s*gα-irresolute maps and discuss their properties.

II.PRELIMINARIES

Throughout this dissertation (x, τ), (y, σ) and (z, η) represents topological spaces on which no separation axiom are assumed unless otherwise mentioned. For a subset A of space x, τ, cl(A) and int(A) denote the closure and interior of A in X respectively. The power set of X is denoted by P(X).
Let us recall the following definitions

Definition 2.1

A subset A of a topological space (x, τ) is called
(1) a pre-open set**[1]** if A⊆int(cl(A)) and a pre-closed set if cl(int(A)).
(2) a semi-open set**[8]** if A⊆cl(int(A)) and a semi-closed set if int(cl(A))⊆A.
(3) a α-open set**[11]** if A⊆int(cl(int(A))) and a α-closed set[20] if cl(int(cl(A)))⊆A.
(4) a semi pre-open set**[1]**(=β-open[1]) if A⊆cl(int(cl(A))) and a semi pre-closed set**[2]**(β-closed**[1]**) if int(cl(int(A)))⊆A.
(5) a regular-open set**[25]** if A=int(cl(A)) and a regular-closed set if cl(int(A))=A.

The class of all closed(respectively semi pre-closed, α-closed) subsets of a space (X, τ) is denoted by C(X, τ)(respectively SpC(X ,τ),αC(X, τ).The intersection of all semi-closed (respectively pre-closed, semi pre-closed and α-closed)sets containing a subset A of x, τ is called the semi-closure(respectively pre closure, semi pre-closure and α-closure) of A is denoted by scl(A)(respectively pcl(A),spcl(A) and α-cl(A)).

Definition 2.2

A subset A of a topological space (x, τ) is called
(1) a generalized closed set (briefly g-closed **[7]** if cl(A)⊆U whenever A⊆U and U is open in(x, τ).
(2) a semi-generalized closed set (briefly sg-closed) **[3]** if scl(A)⊆U whenever A⊆U and U is semi-open in(x, τ).
(3) a generalized semi-closed set (briefly gs closed) **[4]** if scl(A)⊆U whenever A⊆U and U is open in(x, τ).
(4) a generalized α- closed set (briefly gα-closed) **[10]** if αcl(A)⊆U whenever A⊆U and U is α-open in(x, τ).
(5) a α-generalized closed set (briefly αg-closed) **[9]** if α cl(A)⊆U whenever A⊆U and U is open in(x, τ).
(6)a generalized semi pre-closed set (briefly gsp-closed)**[5]** if spcl(A)⊆U whenever A⊆U and U is open in(x, τ).
(7) a generalized pre semi-closed set (briefly ps-closed) **[12]** if spcl(A)⊆U whenever A⊆U and U is g-open in(x ,τ).
(8) a g*-closed set **[18]** if cl(A)⊆U whenever A⊆U and U is g-open in(x ,τ).
(9) a *g-closed set **[17]** if cl(A)⊆U whenever A⊆U and U is ĝ-open in(x, τ).

(10) a $g^{\#}$-closed set **[15]** if cl(A)⊆U whenever A⊆U and U is αg-open in(x, τ).

(11) a $g^{\#}$s-closed set **[19]** if scl(A)⊆U whenever A⊆U and U is αg-open in (x, τ).

(12) a $g^{\#}$α-closed set **[13]** if αcl(A)⊆U whenever A⊆U and U is g-open in (x, τ).

(13) a *gα-closed set **[21]** if cl(A)⊆U whenever A⊆U and U is gα-open in (x, τ).

(14) a s*gα-closed set **[2]** if scl(A)⊆U whenever A⊆U and U is *gα-open in (x, τ).

(15) a (gsp)*-closed set **[6]** if cl(A)⊆U whenever A⊆U and U is gsp-open in(x, τ).

(16) a (gs)*-closed set **[14]** if cl(A)⊆U whenever A⊆U and U is gs-open in (x, τ).

(17) a ĝ-closed set **[20]** if cl(A)⊆U whenever A⊆U and U is semi-open in (x, τ).

(18) a $^{\#}$g-closed set **[16]** if cl(A)⊆U whenever A⊆U and U is *gα-open in (x, τ).

(19) a gα-closed set **[10]** ifα cl(A)⊆U whenever A⊆U and U is α-open in (x, τ).

The class of all g-closed sets (gsp-closed sets) of space x, τ is denoted by GC(x, τ), (GSPC(x, τ)).

III. BASIC PROPERTIES OF $^{\#}$s*gα-CLOSEDSETS

Definition3.1: A subset A of (X, τ) is called a $^{\#}$s*gα-closed set if cl (A) ⊆U whenever A⊆U and U is s*gα-open in (X, τ).

The class of $^{\#}$s*gα-closed subsets of (X,τ) is denoted by $^{\#}$s*gα C(X,τ).

***Theorem 3.2*:**Every closed set is $^{\#}$s*gα-closed set. But the converse need be not true.

Proof:Let A⊆U and U is s*gα-open. Since A is closed cl(A) = A⊆U, it implies cl(A) ⊆U. Therefore A is a $^{\#}$s*gα-closed set.

The following example supports that a $^{\#}$s*gα-closed set need not be a closed set.

Example 3.3: Let X={a,b,c} with τ={X, φ, {a, b}} and $τ^c$={X, φ, {c}}

$^{\#}$s*gα-closed sets are X, φ, {c}, {b, c}, {a, c}

Let A = {b, c} is $^{\#}$s*gα -closed set, but not a closed set in (X, τ).

Theorem3.4: Every $^{\#}$s*gα closed set is *gα-closed set. But the converse need not be true.

Proof: Let A⊆U and U is gα-open. Since every gα-open set is s*gα-open, U is s*gα-open. Since A is $^{\#}$s*gα-closed set, cl(A)⊆U. Therefore A is *gα-closed set.

The following example supports that a $^{\#}$s*gα-closed set need not be a *gα-closed set.

Example 3.5: Let X = {a, b, c, d} with τ={X, φ, {a}, {b, c}, {a, b, c}}, and $τ^c$={X, φ, {d}, {a, d}, {b, c, d}}

$^{\#}$s*gα -closed sets are X, φ, {d},{a, d},{b, c, d},{a, c, d},{a, b, d}

*gα-closed sets are X, φ, {d}, {c, d},{a, d},{b, d}, {b, c, d},{a, c, d},{a, b, d}

Let A = {c, d} is *gα-closed set, but not a $^{\#}$s*gα -closed set in (X, τ).

Theorem 3.6: Every $^{\#}$s*gα-closed set is s*gα-closed set. But the converse need not be true.

Proof: Let A⊆U and U is *gα-open. We know that every *gα-open set is s*gα-open then U is s *gα-open. Since A is $^{\#}$s*gα-closed set, cl(A)⊆U. We know that every closed set is a semi closed set. Hence scl(A)⊆cl(A)⊆U implies scl(A)⊆U. Therefore A is an s*gα-closed set.

The following example supports that an s*gα-closed set need not be a$^{\#}$s*gα-closed set.

Example 3.7: Let X = {a, b, c} with τ={X, φ, {a}} and $τ^c$={X, φ, {b, c}}

s*gα-closed sets are X, φ, {b}, {c}, {a, b}, {b, c}, {a, c}

$^{\#}$s*gα -closed sets are X, φ, {b, c}

Let A = {a, b} is s*gα-closed set, but not a $^{\#}$s*gα -closed set in (X, τ).

Theorem 3.8: Every $^{\#}$s*gα-closed set (a) $^{\#}$g-closed set (b)*g-closed set (c) g*-closed set (d) ĝ-closed set. But the converse need not be true.

Proof:(a)Let A⊆U and U is *g-open. We know that every *g-open set is s*gα-open then U is s*gα-open. Since A is $^{\#}$s*gα-closed set, cl(A)⊆U whenever A⊆U and U is s*gα-open. Therefore A is a $^{\#}$g-closed set.

(a) Let A⊆U and U is ĝ-open. We know that every ĝ-open set is s*gα-open then U is s*gα-open. Since A is $^{\#}$s*gα-closed set, cl(A)⊆U whenever A⊆U and U is s*gα-open. Therefore A is a *g-closed set.

(b) Let A⊆U and U is g-open. We know that every g-open set is s*gα-open then U is s*gα-open. Since A is $^{\#}$s*gα-closed set, cl(A)⊆U whenever A⊆U and U is s*gα-open. Therefore A is a g*-closed set.

(c) Let A⊆U and U is semi open. Since every semi-open set is s*gα-open set, then U is s*gα-open. Since A is $^{\#}$s*gα-closed set, cl(A)⊆U. Therefore A is a ĝ-closed set.

The following examples supports that converse need not be true.

Examples 3.9: (a)Let X={a, b, c} with τ={X, φ, {a}, {b, c}} and $τ^c$={X ,φ, {a}, {b, c}}

$^{\#}$g-closed sets are X, φ, {a}, {b}, {c}, {a, b},{b, c},{a, c}

$^{\#}$s*gα -closed sets are X, φ, {b, c}

Let A = {a, b} is $^{\#}$g-closed set, but not a $^{\#}$s*gα -closed set in (X, τ)

(b) Let X = {a, b, c} withτ={X, φ,{a}, {a, b}} and $τ^c$={ X, φ, {c}, {b, c}}

*g-closed sets are X, φ, {c}, {b, c}, {a, c}

$^{\#}$s*gα -closed sets are X, φ, {c}, {b, c}

Let A = {a, c} is *g- closed set but not $^{\#}$s*gα-closed set.

(c)Let X = {a, b, c} with τ={X, φ, {a}, {a, b}} and $τ^c$={X, φ, {b, c}, {c}}

g*-closed sets are x, φ, {c}, {b, c}, {a, c}

$^{\#}$s*gα-closed sets are X, φ, {c}, {b, c}

Let A= {a, c} is g*-closed set but not $^{\#}$s*gα-closed set.

(d)Let X= {a, b, c} withτ={X, φ, {a},{b, c}}and $τ^c$={X, φ, {a}, {b, c}}

ĝ- Closed sets are X, φ, {c}, {a}, {b}, {c}, {a, b},{b, c}, {a, c}}

$^{\#}$s*gα-closed sets are X, φ, {a}, {b, c}

Let A = {b} is ĝ-closed set but not #s*gα-closed set.

Theorem 3.10: Every #s*gα-closed set is g#s closed set.

Proof: Let A⊆U and U is αg-open. We know that every αg-open set is s*gα-open. Then U is αg-open. Since A is #s*gα closedset, cl (A)⊆U. We know that every closed set is semi-closed set, scl(A)⊆cl(A)⊆U implies scl(A)⊆U. Therefore A is g#s-closed set.

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

Example 3.11: Let X = {a, b, c} with τ={X, φ, {a}, {a, b}} and τ^c={X, φ, {c}, {b, c}, {a, c}}

g#s-closed sets are X, φ, {a}, {b}, {c}, {b, c}, {a, c}

#s*gα-closed sets are X, φ, {c}, {a, c}, {b, c}

Let A = {a} is g#s-closed set, but not a #s*gα-closed set in (X, τ).

Theorem 3.12: Every #s*gα-closed set is (a)g#α-closedset (b)#gα-closedset(c)gα-closedset(d)αg-closedset.

Proof:(a) Let A⊆U and U is g-open. We know that every g-open set is s*gα-openset. Then U is s*gα-open. Since A is #s*gα closed set cl(A)⊆U. We know that every closed set is α-closed set, αcl (A)⊆cl(A)⊆U implies αcl(A)⊆U. Therefore A is g#α-closed set.

(b) Let A⊆U and U is g#α-open. We know that every g#α-open set is s*gα-open then U is s*gα-open. Since A is #s*gα-closed set, cl(A)⊆U. We know that every closed set is α-closed set, αcl(A)⊆cl(A)⊆U implies αcl(A)⊆U. Therefore A is a #gα-closed set.

(c)Let A⊆U and U is α-open. We know that every α-open set is s*gα-open then U is s*gα-open. Since A is #s*gα-closed set, cl(A)⊆U . We know that every closed set is α-closed set, αcl(A)⊆cl(A)⊆U implies αcl(A)⊆U. Therefore A is a gα-closed set.

(d)Let A⊆U and U is open. Since every open set is s*gα-open set, then U is s*gα-open. Since A is #s*gα-closed set, cl(A)⊆U. We know that every closedset is α-closedset, αcl(A)⊆cl(A)⊆U implies αcl(A)⊆U. Therefore A is a αg-closed set.

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

Examples 3.13: (a)Let X = {a, b, c} with τ={X, φ, {a}, {a, b}} and τ^c={X, φ, {c}, {b, c}}

Here A = {b} is g#α-closed set but not a #s*gα -closed set in (X, τ).

(b) Let X = {a, b, c} with τ={X, φ,{a},{b, c} and τ^c={X, φ, {a}, {b, c}}

Here A={c} is #gα-closedset but not a #s*gα-closed set in (X, τ).

(c)Let X = {a, b, c} with τ={X, φ, {a}, {a, b}} and τ^c={X, φ, {c}, {b, c}}

Here A= {b} is gα-closed set but not a #s*gα-closed set in (X, τ).

(d)Let X = {a, b, c} with τ={X, φ,{a},{b, c}} and τ^c={X, φ, {a}, {b, c}}

Here A = {b} is αg-closed set but not a #s*gα -closed set in (X, τ).

Theorem 3.14: Every #s*gα-closed set is (a)gs-closed set (b)gsp-closed set

Proof: (a)Let A⊆U and U is open. We know that every open set is s*gα-open. Then U is s*gα-open. Since A is #s*gα-closed set, cl(A)⊆U. We know that every closed set is semi-closed set, scl(A)⊆cl(A)⊆U implies scl(A)⊆U. Therefore A is gs-closed set.

(b)Let A⊆U and U is open. We know that every open set is s*gα-open, then U is s*gα-open. Since A is #s*gα closed set, cl(A)⊆U. We know that every closed set is semipre-closed set, spcl(A)⊆scl(A)⊆cl(A)⊆U implies spcl(A)⊆U. Therefore A is gsp-closed set.

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

Examples3.15: (a)Let X = {a, b, c} with τ={X, φ, {a}, {a, b}} and τ^c={X , φ, {c}, {b, c}}

gs-closed sets are X, φ, {b}, {c}, {a, b}, {b, c}, {a, c}

#s*gα -closed sets are X, φ, {c}, {b, c}

Let A = {b} is gs-closed set, but not a #s*gα -closed set in (X, τ).

(b)Let X ={a, b, c} with τ={X, φ, {a}, {b}, {a, b}} and τ^c={X, φ, {c}, {b, c}{a, c}}

gsp-closed sets are X, φ, {a},{b},{c},{b, c},{a, c}

#s*gα-closed sets are X, φ, {c}, {a, c}, {b, c}

Let A= {a} is gsp-closed set, but not a #s*gα -closed set in (X, τ).

Theorem 3.16: Every (gsp)*-closed set is a #s*gα-closed set .But the converse need not be true.

Proof: Let A⊆U and U is s*gα-open. Since every s*gα-open set is gsp-open set, then U is gsp-open .Since A is (gsp)*-closed set, cl(A)⊆U. Therefore A is a #s*gα-closed set.

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

Example3.17: Let X = {a, b, c} with τ={X, φ, {a}, {a, b}}and τ^c={X, φ, {c}}

(gsp)*-closed sets are X, φ, {c}

#s*gα -closed sets are X, φ, {c}, {b, c}, {a, c}

Here A= {b, c} is #s*gα-closedset but not a (gsp)*-closed set in (X, τ).

Theorem 3.18: Every (gs)*-closed set is #s*gα-closed set. But converse need not be true.

Proof: Let A⊆U and U is s*gα-open. Since every s*gα-open set is gs-open set, then U is gs-open .since A is (gs)*-closed set, cl(A)⊆U. Therefore A is a #s*gα-closed set.

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

Example 3.19: Let X= {a, b, c, d} with τ={X, φ, {a}, {b, c},{a, b, c}} and τ^c={X, φ, d, {a}, {a, d}, {b, c, d}}

(gs)*-closed sets are X, φ, {d}, {a, d}, {b, c, d}

#s*gα-closed sets are X, φ, {d}, {a, d}, {a, c, d},{b, c, d},{a, b, d}

Here A= {a, c, d} is #s*gα -closed set but not a (gs)*-closed set in (X, τ).

Theorem 3.20:If A and B are #s*gα-closed sets then A∪B is also #s*gα-closedset.

Proof:Let A and B be #s*gα-closed sets .Let A∪B⊆U, then U is s*gα-open. Since A and B are #s*gα-closed sets cl(A)⊆U and cl(B)⊆U. This implies thatcl(A∪B) =cl(A)∪cl(B) implies cl(A∪B)⊆U. Therefore A∪B is #s*gα-closed set.

Remark3.21:The intersection of two #s*gα-closed sets is also a #s*gα-closed sets.

Theorem 3.22:If A is a #s*gα-closed set of (X, τ) such that A⊆B⊆cl(A) then B is also a#s*gα-closedset.

Proof:Let U be a s*gα-open set of (X, τ) such that B⊆U then A⊆U where U is s*gα-open. Since A is #s*gα-closed, cl(A)⊆U then cl(B)⊆U. Hence B is a #s*gα-closed set.

Theorem 3.23: If A is a #s*gα-closed set of (X, τ) then cl(A)\A does not contain any non-emptys*gα-closedset.

Proof:Let F be a s*gα-closedset of (X, τ) such that F⊆cl(A)\A then A⊆X\F.Since A is a #s*gα-closedset cl(A)⊆x\F this implies F⊆x\cl(A).Hence F⊆(A\cl(A))∩(cl(A)\A)=φ

Therefore F=φ and cl (A) does not contain any non-empty s*gα-closed set.

Theorem3.24:If a set A is #s*gα-closed set of (x, τ) then cl(A)–A contains no non empty closedset in (x, τ)

Proof:Suppose that A is #s*gα-closed set. Let F be a closed subset of cl(A)–A. Then $A\subseteq F^c$. But A is #s*gα-closed set, therefore $cl(A)\subseteq F^c$. Consequently, $F\subseteq (cl(A))^c$. We already have F⊆cl(A).Thus $F\subseteq cl(A)\cap (cl(A))^c$ and F is empty.

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

Example 3.25:Let X={a, b, c} with τ = {X, φ, {a}}.Then #s*gαC(X) = {X, φ, {b, c}} If A = {b}, then cl(A)–A = {c} does not contain any nonempty closed set. But A is not #s*gα-closed set in (x, τ).

Theorem3.26:A set A is #s*gα-closed set if and only if cl(A)–A contains no nonempty s*gα-closed set.

Proof: Necessity

Suppose that A is #s*gα-closed set. Let S be a s*gα-closed subset of cl(A)–A. Then $A\subseteq S^c$. Since A is #s*gα-closed, We have $cl(A)\subseteq S^c$. Consequently, $S\subseteq (cl(A))^c$. Hence $S\subseteq cl(A)\cap (cl(A))^c = \varphi$. Therefore S is empty.

Sufficiency

Suppose that cl(A)–A contains no nonempty s*gα –closed set. Let A⊆G and G be s*gα-open. If cl(A)⊄G, then $cl(A)\cap G^c \neq \varphi$. Since cl(A) is a closed set and G^c is a s*gα-closed set, $cl(A)\cap G^c$ is a nonempty s*gα-closed subset of cl(A)–A, this is a contradiction. Therefore cl(A)⊆G and hence A is #s*gα-closed set.

Theorem 3.27:Let A⊆Y⊆X and suppose that A is #s*gα-closed in (X, τ). Then A is#s*gα-closed relative to Y.

Proof: Let A⊆Y∩G, where G is s*gα-open in (X, τ). Then A⊆G and hence cl(A)⊆G. This implies that Y∩cl(A)⊆Y∩G. Thus A is #s*gα-closed relative to Y.

Theorem3.28:If A is a s*gα-open and #s*gα-closed in (X, τ), then A is closed in (X, τ).

Proof: Since A is s*gα-open and #s*gα-closed, cl(A)⊆A and hence A is closed in (x, τ).

Remark 3.29: #s*gα-closed set is independent of semi-closed set and α-closed set.

Let X = {a, b, c} with τ = {X, φ, {c}}
Semi-closed sets are X, φ, {b}, {c}, {b, c}
α-closed sets are X, φ, {b}, {c}, {b, c}
#s*gα-closed sets are X, φ, {b, c}

Here B = {b} is Semi-closed set and α-closed set but not a #s*gα-closed set.

Let X = {a, b, c} with τ = {X, φ, {a, b}}
Semi- closed sets are X, φ, {c}
α-closed sets are X, φ, {c}
#s*gα-closed sets are X, φ, {c}, {b, c}, {a, c}

Here B = {b, c} is #s*gα-closed set but not a Semi-closed set and α-closed set.

IV. APPLICATIONS OF #s*gα-CLOSEDSETS

Definition 4.1:A space (x, τ) is called a $_{\#s*g\alpha}T_b$-space if every #s*gα-closed set is closed.

Definition 4.2:A space (X, τ) is called a αgT_b space if every αg-closed set is #s*gα-closed set.

Definition 4.3:A space (X, τ) is called a sT_b**space if every #s*gα-closed set is *gα-closed set.

Theorem 4.4:If (x, τ) is a $_{\#s*g\alpha}T_b$ space then every singleton of X is either #s*gα-closed or open.

Proof: Let x∈X and suppose that {x} is not s*gα-closed set of (X, τ).Then X−{x} is not s*gα-open set. This implies that X is only s*gα-open set containing X−{x}.SoX−{x} is a #s*gα-closed set of (X, τ).Since (X, τ) is a $_{\#s*g\alpha}T_b$-space, X−{x} is closed set or equivalently {x} is open set in (X, τ).

Theorem 4.5:If (x, τ) is a αgT_b space then every singleton of X is either closed or #s*gα-open.

Proof:Let x∈X and suppose that {x} is not closed set of (X, τ).Then X−{x} is not open. This implies that X is only open set containing X−{x}.So X−{x} is a αg-closed set of (X, τ).Since (X, τ) is a αgT_b space, X−{x} is a #s*gα-closed set or equivalently {x} is #s*gα-open set.

CONCLUSION

In this paper, we introduce a new class of sets namely #s*gα-closed sets in topological spaces and derive the properties of #s*gα-closed sets. Also we find the relationship between #s*gα-closed sets and the other exisisting sets. Moreover with the help of these sets, we introduce three new spaces , $_{\#s*g\alpha}T_b$ spaces, αgT_b spaces, sT_b** spaces.

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