ON #α-REGULAR GENERALIZED OPEN SETS AND #$\alpha - RG$ NEIGHBOURHOODS IN TOPOLOGICAL SPACES

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ABSTRACT

In this paper we introduce a new class of open sets called the class of #αrg -open and study their relationship with other open sets. Also we introduce of #αrg neighbourhood (shortly#αrg -nbhd) in topological spaces #αrg-closure.

Keywords: #αrg -open sets, #αrg –nbhd, #αrg-closure

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1. INTRODUCTION

Regular open sets and rw-open sets have been introduced and investigated by stone [18] and Benchalli and Wali [1] Maki [10] defined α-generalized closed sets in 1994. Dontchev, Gnanambal and Palaniappan and Rao [5, 7, 13] introduce gsp closed sets. Syed Ali Fatima [19] defined #rg-closed sets. In this paper we introduce new class of sets called: #αrg -open sets which is properly placed in between the class of #rg -open sets and the class of $\pmb{\alpha}$g-open sets.

Throughout this paper (X,τ) represents a on-empty topological space on which no separation axiom is assumed unless otherwise mentioned. For a subset A of a topological space X, cl(A) and int(A) denote the closure of A and the interior of A respectively (X,τ) will be replaced by X if there is no chance of confusion. X\A or A^c denotes the complement of A in X. Let us recall the following definitions.

Definition 1.1: A Subset A of a space X is called
(1) a preopen set [11] if A$\subseteq$ int(cl (A)) and a preclosed set if cl(int (A)) $\subseteq$A
(2) a semiopen set [8] if A$\subseteq$cl(int (A)) and a semiclosed set if int(cl (A) $\subseteq$A
(3) an α-open set [21] if A$\subseteq$int(cl(int(A))) and an α-closed set [ ]if cl(int(cl(A))) $\subseteq$A
(4) a regular open set [13] if A=int(cl (A))and a regular closed set if A=cl(int (A))
(5) a π-open set [1] if A is a finite union of regular open sets.
(6) regular semi open [15] if there is a regular open U such U$\subseteq$A$\subseteq$cl(U)

Definition 1.2: A subset A of a topological space (X,τ) is called.
(1) an *α-generalized* closed set (briefly *αg-closed*)[14] if αcl(A) $\subseteq$U whenever A$\subseteq$U and U is open in (X,τ) .
(2) a generalized pre closed set (briefly gp-closed) [14] if pcl(A)$\subseteq$U whenever A $\subseteq$U and U is open (X,τ)
(3) a generalized semi pre closed set (briefly gsp-closed) [14] if spcl(A)$\subseteq$U whenever A$\subseteq$U and U is a open (X,τ)
(4) a generalized α--closed (i.e., g α--closed) set [21] if αcl(A) $\subseteq$U whenever A$\subseteq$U and U is open set in X.
(5) #rg-closed (19) if cl(A) $\subseteq$U whenever A$\subseteq$U and U is rw-open.
(6) #αrg-closed ( ) if αcl(A) $\subseteq$U whenever A$\subseteq$U and U is rw-open,

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2. #𝛼-REGULAR GENERALIZED OPEN SETS

In this section we introduce the concept of $\#arg - open$ sets and characterize their properties.

Definition 2.1: A subset A of a space X is called $\#\alpha - regular$ generalized open (briefly $\#arg - open$) set if its complement is $\#arg - closed$. We denote the set of all $\#arg - open$ sets in X by $\#\alpha RGO(X)$

Remark 2.2: $\alpha cl(X \backslash A) = X \backslash \alpha int(A)$

Theorem 2.3: A subset A of X is $\#arg - open$ if and only if $F \subseteq \alpha int(A)$ whenever F is rw-closed and $F \subseteq A$.

Proof:

Necessity: Let A be $\#arg - open$. Let F be rw-closed and $F \subseteq A$ then $X \backslash A \subseteq X \backslash F$ Since X\A is $\#arg - closed$, $\alpha cl(x \backslash A) \subseteq X \backslash F$ by Remark 2.2 $X \backslash \alpha int(A) \subseteq X \backslash F$ that is $F \subseteq \alpha int(A)$.

Sufficiency: Suppose F is rw-closed and $F \subseteq A$ implies $F \subseteq \alpha int(A)$. Let X\A$\subseteq$U where U is rw-open. Then $X \backslash U \subseteq A$ and X\U is rw-closed. By hypothesis $X \backslash U \subseteq \alpha int(A)$. That is $X \backslash \alpha int(A) \subseteq U$ by Remark 2.2 $\alpha cl(x \backslash A) \subseteq U$. Hence X\A is $\#arg -$closed. Thus A is $\#arg -$ open.

Theorem 2.4: If $\alpha int(A) \subseteq B \subseteq A$ and A is $\#arg -$ open then B is $\#arg -$ open.

Proof: Let A be $\#arg -$ open set and $\alpha int(A) \subseteq B \subseteq A$. Now $\alpha int(A) \subseteq B \subseteq A$ implies $X \backslash A \subseteq X \backslash B \subseteq X \backslash \alpha int(A)$. That is $X \backslash A \subseteq X \backslash B \subseteq \alpha cl(x \backslash A)$. Since X\A is $\#arg - closed$ then A is $\#arg - open$. X\B is $\#arg - closed$ then B is $\#arg - open$.

Remark 2.5: For any $A \subseteq X, \alpha int(\alpha cl(A) \backslash A) = \phi$

Theorem 2.6: If $A \subseteq X$ is $\#arg - closed$ then $\alpha cl(A) \backslash A$ is $\#arg - open$.

Proof: Let A be $\#arg - closed$. Let F be rw-closed set such that $F \subseteq \alpha cl(A) \backslash A$. Then by theorem 3.2 [21] F= ϕ So, $F \subseteq \alpha int(\alpha cl(A) \backslash A)$. This shows that $\alpha cl(A) \backslash A$ is $\# arg - open$.

Theorem 2.7: If a subset A of a space X is $\# rg - open$ then it is $\# arg - open$ but not conversely.

Proof: Let A be $\#rg - open$ set in space X. Then X\A is $\#rg - closed$ set. By Theorem 3.2 [21] X\A is $\# arg - closed$. Therefore A is $\# arg - open$ set in X.

The converse of the theorem need not be true as seen from the following example.

Example 2.8: Let $X = \{a, b, c, d\}$ be with topology $\tau = \{X, \phi, \{a, b\}\}$ then the set A={a,b,c} is $\#arg - open$ but not $\#rg - open$ in X.

Corollary 2.9: Every regular open set is $\#arg - open$ but not conversely.

Proof: Follows from Fathima [20] and Theorem [2.7]

Corollary 2.10: Every $\pi - open$ sent is $\#arg - open$ but not conversely.

Proof: Follows from Fathima [20] and Theorem [2.7]

Theorem 2.11: If a subset A of a topological space (X,τ) is open that it is $\#arg - open$ but not conversely.

Proof: Let A be an open set in a space X. Then X\A is closed set. By Theorem 3.7 [21] X\A is $\#arg - closed$. Therefore A is $\#arg - open$ set in X. The converse of the theorem need not be true as seen from the following example.

Example 2.12: Let X ={a, b, c, d} be with topology $\tau = \{X, \phi, \{c\}, \{a, b\}, \{a, b, c\}\}$ then the set {b} is $\#arg - open$ but not open set in X.

Theorem 2.13: If a subset A of a topological Space (X,τ) is α −open then it is $\#arg - open$ but not conversely.

Proof: Let A be $\alpha - open$ set in X. Then X\A is $\alpha - closed$ set then by theorem 3.10 [21] X\A is $\#arg - closed$ set in X. Therefore A is $\#arg - open$ set in X.

The converse of the theorem need not be true as seen from the following example.

Example 2.14: Let X = {a, b, c, d} be with topology $\tau = \{X, \phi, \{c\}, \{a, b\}\{a, b, c\}\}$ then the set {a} is $\#arg - open$ but not $\alpha - open$ set in X.

Theorem 2.15: If a subset A of X is $\#arg - open$ then it is gp-open but not conversely.

Proof: Let A be $\#arg - open$ set in a space X. Then X\A is $\#arg - closed$ set in X then by theorem 3.12 [21] X\A is gp-closed set in X. Therefore A is gp-open in X.

The converse of the theorem need not be true as seen from the following example.

Example 2.16: Let X ={a,b,c,d} be with the topology $\tau = \{X, \phi, \{a, b\}\}$ then the set A={a,d} is gp-open but not $\#arg - open$ set in X.

Theorem 2.17: If a subset A of a space X is $\#arg - open$ then it is $\alpha g - open$.

Proof: Let A be $\#arg - open$ in X. Then X\A is $\#arg - closed$ set in X. Then By theorem 3.14 [21] X\A is $\alpha g - closed$ set in X. Therefore A is $\alpha g - open$ in X.

The converse of the theorem need not be true as seen from the following example.

Example 2.18: Let X ={a,b,c} be with the topology $\tau = \{X, \phi, \{c\}, \{a, b\}\}$ the set A={a,c} is $\alpha g - open$ but not $\#arg - open$ set in X.

Theorem 2.19: If a subset A of a space X is $\#arg - open$ then it is gsp-open.

Proof: Let A be $\#arg - open$ in X. Then X\A is $\#arg - closed$ set in X. Then by theorem 3.16 [21] X\A is gsp-closed set in X. Therefore A is gsp-open in X.

The converse of the theorem need not be true as seen from the following example.

Example 2.20: Let X ={a, b, c} be with the topology $\tau = \{X, \phi, \{c\}, \{a, b\}\}$ then the set A={a,c} is gsp-open but not $\#arg - open$

Theorem 2.21: If A and B are $\#arg - open$ set in a space X. The $A \cap B$ is also $\#arg - open$ set in X.

Proof: If A and B are $\#arg - open$ sets in a space X. Then X\A and X\B are $\#arg - closed$ sets in a space X. By theorem 3.20 [21] $(X\backslash A) \cup (X\backslash B)$ is also $\#arg - closed$ sets in X. Therefore $A \cap B$ is $\#arg - open$ set in X.

Theorem 2.22: The union of two $\#arg - open$ sets in X is not a $\#arg - open$ set in X.

Example 2.23: Let X = {a,b,c,d} be with topology $\tau = \{X, \phi, \{a\}, \{b\}, \{a, b\}\}$ then the set A={b,c} and B={b,d} are $\#arg - open$ set in X but $A \cup B = \{b. c, d\}$ is not $\#arg - open$ set in X.

Theorem 2.24: If a set A is $\#arg - open$ set in X then G=X whenever G is rw-open and $(\alpha\ int(A) \cup (X\backslash A)) \subseteq G$.

Proof: Suppose that A is $\#arg - open$ set in X. Let G be rw-open and $(\alpha int(A) \cup (X\backslash A)) \subseteq G$. This implies $G^c \subseteq (\alpha int(A) \cup A^c)^c = (\alpha int(A))^c \cap A$. That is $G^c \subseteq (\alpha int(A))^c \backslash A^c$. Thus $G^c \subseteq \alpha cl(A^c) \backslash A^c$ Now G^c is rw-closed and A^c is $\#arg - closed$, by theorem 3.23 [21] it follows that $G^c = \phi$. Hence G=X.

Theorem 2.25: Every Singleton point set in a space is either $\#arg - open$ or rw-closed.

Proof: Follows from theorem 3.27 [21]

3. #α-REGULAR GENERALIZED NEIGHBOURHOODS

Definition 3.1: Let X be a topological space and let x $\in$ X. A subset N of x is said to be #αrg − Neighbourhood (briefly #αrg − nbhd) of x if and only if there exists a #αrg − open set U such that x$\in$U$\subset$ N.

Definition 3.2: A subset N of space X is called a #αrg − neighbourhood (briefly #αrg − nbhd) of A$\subset$ X if and only if there exists a #αrg − open set U such that A$\subset$ U $\subset$ N.

Theorem 3.3: Every neighbourhood of N of x $\in$ X is a #αrg − Neighbourhood of X.

Proof: Let N be a neighbourhood of point $x \in X$ by definition of neighbourhood, there exists an open set U such that x$\in$U$\subset$ N. Since every open set is #αrg − open set, U is #αrg − open set such that $x \in$U$\subseteq$ N. This implies N is #αrg − Neighbourhood of X.

The converse of the above theorem need not be true as seen from the following example.

Example 3.4: Let X={a, b, c, d} be with topology $\tau = \{X. \phi, \{c\}, \{a,b\}, \{a,b,c\}\}$ Then #αRGO(X) {X,ϕ,{a},{b},{c},{a,b},{a,b,c}}. The set {b, d} is #αrg − nbhd of the point b, since the #αrg − open set {b} is such that b$\in \{b\} \subseteq \{b, d\}$. However the set {b, d} is not a nbhd of the point b. Since no open set U exists such that $b \in \{b\} \subseteq \{b, d\}$. However the set {b, d} is not a nbhd of the point b. Since no open set U exists such that b$\in U \subseteq \{b, d\}$.

Theorem 3.5: If a subset N of a space X is #αrg − open then N is #αrg − nbhd of each of its point.

Proof: Suppose N is #αrg − open let $x \in N$, For N is #αrg − open set such that $x \in N \subseteq N$ Since 'x' is an arbitrary point of N, it follows that N is a #αrg − nbhd of each of its points. The converse of the theorem is not true as seen from the following example.

Example 3.6: Let X={a, b, c, d} be with topology $\tau = \{X, \phi, \{c\}, \{a,b\}, \{a,b,c\}\}$ then #αRGO$(X) = \{X, \phi, \{a\}, \{b\}, \{c\}, \{a,b,c\}\}$ The set {b,c} is a #αrg − nbhd of the point b. Since the #αrg − open set {b} is such that b$\in \{b\} \subset \{b,c\}$. Also the set {b,c} is #αrg − nbhd of the point {c} since the #αrg − open set {c} is such that $c \in \{c\} \subseteq \{b,c\}$, That is {b,c} is a #αrg − nbhd of each of its points. However the set {b,c} is not #αrg − open set in X.

Theorem 3.7: If F is a #αrg − closed subset of X and $x \in F^c$ then there exists a #αrg − nbhd N of x such that N$\cap F = \phi$.

Proof: Let F be #αrg − closed subset of X and x$\in F^c$ then F^c is #αrg − open set of X. So by theorem 3.5 F^c contains a #αrg − nbhd of each of its points. Hence there exists a #αrg − nbhd.N of x such that $N \subseteq F^C$. Hence $N \cap F = \phi$

Definition 3.8: Let x be a point in a space X. The set of all #αrg − nbhd of x is called #αrg − nbhd system at X and is denoted by #αrg − N(X).

Theorem 3.9: Let X be a topological space and for each x$\in$ X. #αrg − N(x) be the collection of all #αrg − nbhds of x. Then we have the following results.
- (i) $Vx \in X$, #αrg − N(x) $\neq \phi$
- (ii) $N \in$ #αrg-N(x) $\Rightarrow$ x$\in$N
- (iii) $N \in$ #αrg-N(x), $N \subset M \Rightarrow M \in$ #αrg-N(x)
- (iv) $N \in$ #αrg-N(x), $M \in$ #αrg-N(x) $\Rightarrow$ N$\cap M \in$ #αrg-N(x)
- (v) $N \in$ #αrg-N(x)$\Rightarrow$there exists M$\in$ #αrg-N(x) such that M$\subset N$ and $M \in$ #αrg-N(y) For every y$\in M$.

Proof:
- (i) Since X is a #αrg − open set, it is #αrg − nbhd of every $x \in X$. Hence there exists atleast one #αrg − nbhd (namely X) for each $x \in X$. Hence #αrg − N(x) $\neq \phi$ for every $x \in X$.
- (ii) If $N \in$ #αrg-N(x), then N is a #αrg − nbhd of x. So by the definition of #α rg − nbhd, x$\in$ N.
- (iii) Let $N \in$ #αrg-N(x) and $N \subset M$. Then there is a #αrg-open set U such that x$\in$U$\subset N$ since $N \subset M$, x$\in$ U$\subset N$ and so M is #αrg − nbhd of x. Hence M$\in$#αrg − N(x).
- (iv) Let N$\in$ #αrg-N(x) and M$\in$#αrg-N(x). Then by definition of #αrg − nbhd there exists #αrg-open sets U_1 and U_2 such that x$\in U_1 \subset N$ and x$\in U_2 \subset M$. Hence x$\in$U$_1 \cap$U$_2 \subset N \cap M$. Since U$_1 \cap_2$ is #αrg − open set, N$\cap M$ is a #αrg − nbhd of x. Hence N$\cap$M$\in \alpha gr − N(x)$.

(v) If N∈ #$arg − N(x)$ then there exists a # $arg − open$ set M. Such that x∈ $M ⊂ N$. Since M is a #$arg −$ $open\ set,$ it is #$arg − nbhd$ of each of its points. Therefore M∈ #$arg − N(y)$ for every y∈ M.

4. #α-REGULAR GENERALIZED   CLOSURE AND THEIR PROPERTIES.

Definition 4.1: For a subset A of X # arg-cl(A)= ∩{F:A⊆ F, F is # $arg − closed\ in X$}

Definition 4.2: Let (X,τ) be a topological space and $τ_{\#arg}$={V⊆X, # $arg − cl(X\backslash V)$=X\V).

Remark 4.3: If A⊆ X is # $arg − closed$ then # $arg − cl(A) = A$. But the converse is not time, it is seen from the following example.

Example 4.4: Let X = {a,b,c,d} be with topology. $τ = \{X, φ, \{a\}, \{b\}, \{a, b\}\}$ Let A={b, c} then # arg-cl(A) =A but A is not # $arg − closed$.

Remark 4.5: # $arg − cl(φ) = φ$ and # $arg − cl(X) = X$.
   (i)   A ⊆# $arg − cl(A)$ for every subset A of X.
   (ii) Let A and B be subsets of X if A⊆ B then # arg-cl(A)⊆ #arg-cl(B).

Theorem 4.6: Suppose $τ_{\#arg}$ is a topology. If A is # arg-closed in (X,τ) then A is $α − closed\ in$ (X, $τ_{\#arg}$).

Proof: Suppose A is # arg-closed in (X,τ), # $arg − cl(A) = A$. This implies X\A∈ $τ_{\#arg}$. That is X\A is $α −$ $open\ in\ (X, τ_{\#arg})$. Hence A is $α − closed\ in\ (X, τ_{\#arg})$

Theorem 4.7: For any x∈ X, $x ∈$ # $arg − cl(A)$ if and only if V∩ $A ≠ φ$ for every # $arg − open\ set$ V containing x.

Proof:
Necessity: Let x∈ # $arg − cl(A)$. Suppose there exists a #$arg − open$ set V containing x such that V∩ $A = φ$. Since A⊆X\V, # $arg − cl(A)$ ⊆\V this implies that x∉ # $arg − cl(A)$a contradiction.

Sufficiency: Suppose x∉ # $arg − cl(A)$, then there exists a # $arg −$closed subset F containing A such that x∉F, Then x∈X\F and X\F is #$arg − open$. Also (X\F) ∩ $A = φ$ a contradiction.

Theorem 4.8: Let A and B be subsets of X then # arg-cl(A∩ $B)$ ⊆ # $arg − cl(A)$ ∩# $arg − cl(B)$.

Proof: Since A∩ B ⊆A and B, by Remark 4.5 # $arg − cl(A∩ B)$ ⊆ #$α\ rg$-cl(A) and # $arg − cl(A∩ B)$ ⊆ # arg-cl(B) thus # $arg − cl(A∩ B)$ ⊆ # arg-cl(A) ∩ # $arg − cl$ (B).

Remark 4.9: # $arg − cl$(A) ∩ # arg-cl(B)⊄# arg-cl(A∩ $B)$ it is seen from the following example.

Example 4.10: Let X ={a, b, c, d} be with topology $τ = \{X, φ, \{a\}, \{b\}, \{a, b\}, \{a, b, c\}\}$. Let A={a} and B={d} $A ∩ B = ∅$ # arg-cl(A)={a,d} and # arg-cl(B)={d} Then # arg-cl(A) ∩ # arg-cl(B) ={d}⊄# arg-cl($A ∩ B$)

Theorem 4.11: If A and B are # arg-closed sets then # arg-cl($A ∪ B$) = # arg-cl(A)∪ # arg-cl(B).

Proof: Let A and B be # arg-closed in X. Then $A ∪ B$ is also # arg-closed. Then # arg-cl($A ∪ B$)= $A ∪ B$= # arg-cl(A)∪ # arg-cl(B).

Definition 4.12: For any A⊆ X, # $arg − int(A)$ is defined as the union of all # arg-open set contained in A.

Theorem 4.13: (X\# $arg − int(A)$) = # arg-cl(x\A)

Proof: Let x∈ X\# $arg − int(A)$ then x ∉ #$arg − int(A)$ That is every #$arg − open$ set B containing x is such that B ⊄ A. This implies that every #$arg − open$ set B containing x intersects X\A. By theorem 4.6 x∈# arg-cl(X\A). Hence (X\# arg-int (A))⊆ # arg-cl(X\A). Conversely let x∈# arg-cl(X\A). Then every # arg-open set U containing x intersects X\A. That is every # arg-open set U containing x is such that U⊄A, implies x∈# arg-int(A). Hence # arg-cl(X\A)⊆(X\# arg-int (A)) Thus (X\# arg-int (A))=# arg-cl(X\A).

CONCLUSION

In this paper we study #αrg- open sets and their basic properties relationship with some generalized sets in topological space also we have discuss #αrg-neighbourhood and #αrg-closure and their properties..

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