# Study on Anti Topological Ordered Spaces

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**Abstract:** In the exploration of topological spaces across various contexts, the cornerstone concepts revolve around open sets, closed sets, as well as the notions of interior and exterior of a set. Equivalently fundamental are the foundational principles encountered when delving into the realm of Anti-topological spaces (ATS). The landscape of mathematical inquiry delves into the intricate definitions and properties of anti-open sets, anti-closed sets, anti-interiors, anti-exteriors, as well as b-anti-open sets, b-anti-closed sets, anti-b-interiors, and anti-b-closures, among a rich array of others. Scholars worldwide have not only encountered but also delved deep into these foundational ideas. This article introduces, studies, and analyzes fundamental properties of concepts like Anti-g-closed, Anti-g-open, Anti-ig-closed, Anti-dg-closed, and Anti-bg-closed specifically within the context of "Anti-topological ordered spaces (ATOS)".

**Keywords:** Anti-g-closed (Anti-g-c), Anti-g-open(Anti-g-o), Anti-ig-closed(Anti-ig-c), Anti-dg-closed(Anti-dg-c) and Anti-bg-closed(Anti-bg-c).

## 1. Introduction

In 2021, Şahin et al. introduced the concept of ATS, a significant milestone in mathematical exploration. This ground breaking work inspired further investigation, including Witczak's comprehensive study. Within this work, Witczak delved into anti-interior and anti-closure for sets, analyzing their properties in depth. The study also explored anti-dense sets and anti-nowhere-dense sets, shedding light on their essential characteristics. Additionally, the concept of anti-continuity was examined, contributing to the evolving discourse in this field.

Over the years, researchers have extensively explored open and closed sets [1, 2, 3, 4, 9, 13, 14, 16, 17] across various mathematical contexts. Witczak [29] expanded on this research thread by introducing concepts like anti-semi-open sets, pseudo-anti-open sets, and anti-genuine sets. Recently, Khaklary and Ray [11] contributed to this body of work by introducing and investigating a diverse array of open sets in the context of anti-topological spaces. These included anti-p-oss, anti-p-css, r-oss, r-css, α-oss, α-css, & more, thus enriching our understanding of topological structures with anti-properties.

This article contributes to the advancement of the field by unveiling innovative concepts within Anti-Topological spaces. Specifically, we introduce the novel notions of Anti-g-open sets and Anti-g-closed sets, enriching our understanding of these spaces. Additionally, we explore the realms of ATOS by defining Anti-ig-c, Anti-dg-c, and Anti-bg-c sets, offering fresh perspectives & insights into the intricacies of these ordered spaces.

## 2. preliminaries

**Definition 2.1[38]**: In the background of a non-empty set X and its associated clan $\tau$ of subsets, we can define an Anti-topological space (X, $\tau$), where $\tau$ is referred to as the Anti-topology. In this framework, $\tau$ must fulfil any of the subsequent criteria {i, ii, iii} to qualify as an Anti-topology.

(i) $\emptyset, X \notin \tau$

(ii) For each n which is finite with $s_1, s_2, s_3, \dots, s_n \in \tau, \bigcap_{i=1}^{n} s_i \notin \tau$.

(iii) For each set $s_1, s_2, s_3, \dots, s_n \in \tau, \bigcup_{i \in I} s_i \notin \tau$, in which I is a reference set.

Anti-Closed sets can be understood as the complements of Anti-Open sets within the context of an anti-topological space. These Anti-oss represent the counterpart of traditional o-ss in the context of ATS.

**Remark 2.2[38]:** In a space devoid of topology. It is satisfied that beneath are met.

(i) $X$ and the empty set are not Anti-o.

(ii) It is not Anti-o to join the Anti-oss.

(iii) It is not Anti-o when the Anti-oss intersect.

**Definition 2.3[38]:** The collection comprising all Anti-Open portions of a set 'A' is its Anti-Interior in an ATS (X, $\tau$). Declared otherwise, Anti-int(A) refers to the combine to all sets B, where B is a portion of A and B is Anti-Open.

**Definition 2.4[38]:** The meeting of all Anti-Closed the extra sets of a set 'A' are referred to as the Anti-Closure of the set A that occurs in Anti-topological space (X, $\tau$). To say it another way, Anti-cl(A) is the meet of all sets G, where G is Anti-Closed and an extra set of A.

**Lemma 2.5[38]:** Suppose that A ⋐ B, B ∈ τ, and (X, τ) is an ATS. After that, A ∉ τ.

**Proof:** If "A ⋐ B then A = A ⋒ B" and "A ⋒ B ∉ $\tau$" .

**Lemma 2.6[38]:** Let X be a dimension that isn't empty. Let U be an assortment of X portions that, if merged arbitrarily, are anti-closed. When there are finite intersections, it is then anti-closed.

**Proof:** Pretend as "A and B" are both independent parts of 'X' which means "A, B ∈ $U$ & A ⋒ B ∈ $U$". Finally, acknowledge that "A ⋓ (A ⋒ B) = A". Due to agreements prohibit closure, A ∉ $U$. This is incoherent. Keep in mind that under finite unions, assuming Anti-closure was sufficient. A few characteristics of Anti-css can be examined.

**Lemma 2.7[38]:** Infer that A, B ∈ $\tau_{Cl}$ while (X, τ) is an ATS. Believe "A ≠ B". Next, "A ⋒ B ∉ $\tau_{Cl}$".

**Proof:** If A, B ∈ $\tau_{Cl}$ indicates that −A, −B ∈ $\tau$. Let A ⋒ B ∈ $\tau_{Cl}$. At that, −(A ⋒ B) ∈ $\tau$. Fortunately −A ⋓ −B ∈ $\tau$, and this is in disagreement.

**Lemma 2.8[38]:** Infer that $\{A_i\}_{i\in J}$ ⋐ $\tau_{Cl}$ as well as (X, $\tau$) is an ATS. Later that, $\bigcup_{i\in J} A_i \notin \tau_{Cl}$.

**Proof**: Let $\bigcup_{i\in J} A_i \in \tau_{Cl}$. As a result, (by reason of De Morgan's rules) $\bigcap_{i\in J}(-A_i) \in \tau$. Consequently, $-\bigcup_{i\in J} A_i \in \tau$. Fortunately $A_i \in \tau$ applies to all $i \in J$, consequently their meeting should be exceeding τ. This is incoherent.

**Definition 2.9[38]**: If A is an Anti-PreOpen set if and solely if $A$ ⋐ ($AntiCl(A)$) and (X, $\tau$) is an ATS and $A$ ⋐ $X$.

**Definition 2.10[38]**: If (X, τ) is an ATS and accepting "$A$ ⋐ $X$" & A is an anti-SemiOpen set, then A are likely to be such if $A$ ⋐ ($Ant$(A)).

**Definition 2.11[15]**: If $A$ ⋐ $AntiInt(AntiCl(AntiInt(A)))$ and (X, τ) is an ATS with $A$ ⋐ $X$, then A is Anti-AlphaOpen.

**Definition 2.12[15]**: A is considered Anti-RegularOpen if and only if $A = AntiInt(AntiCl(A))$, where $A$ ⋐ $X$ and (X, τ) is an ATS.

**Definition 2.13[15]:** A is designated as Anti-BetaOpen if $A$ ⋐ ($Ant$($AntiCl$(A))). This is assuming that (X, τ) is an ATS and $A$ ⋐ $X$.

**Definition 2.14[15]:** If portion A of an ATS (X, τ) is Anti-RegularOpen in X, or equivalently, if *A = AntiCl(AntiInt(A))*, then $A^c$ is Anti-RegularClosed in X.

**Definition 2.15[15]:** Anti-AlphaClosed is a portion A of an ATS (X, τ) if *AntiCl(AntiInt(AntiCl(A))) ⋐ A.*

**Definition 2.16[15]:** If *AntiInt*($Ant$(A)) ⋐ $A$, then a portion A of an ATS (X, τ) is considered anti-semiclosed.

**Definition 2.17[15]:** If $AntiCl\big(AntiInt(A)\big)$ ⋐ $A$, then a portion A of an ATS (X, τ) is "AntiPreClosed".

**Definition 2.18[15]**: If A is "AntiBetaClosed" if $AntiInt\Big(AntiCl\big(AntiInt(A)\big)\Big)$ ⋐ $A$ and X is an anti-topological space and $A$ ⋐ $X$.

**Definition 2.19[15]:** If a portion of an ATS ($X$, τ) is both anti-o & anti-closed, it is referred to as anti-clopen.

## 3. Anti-g-closed sets

**Definition 3.1:** If A ⋐ O and O is Anti-open, then A is Anti-g-c iff Anti-cl(A) ⋐ O.

**Theorem 3.2:** If Anti-cl(A)-A fails to include any not void Anti-closed sets, iff A is Anti-g-c.

**Proof:** Suppose that F represents an Anti-closed subset of Anti-cl(A)-A. Since A is anti-g-c, we get Anti-cl(A) ⋐ C(F) or F ⋐ C(Anti-cl(A)). Thus, A ⋐ C(F). F ⋐ Anti-cl(A) ⋒ C(Anti-cl(A)) = ∅ ⟹ F = ∅. Contrariwise, pretend that A ⋐ O & O is Anti-o. Anti-cl(A) ⋒ C(O) is a non-void Anti-c portion of Anti-cl(A)-A if cl(A) does not include O.

**Theorem 3.3:** Given two sets of anti-g-css, A ⋒ B is also Anti-g-c.

**Proof:** If "A ⋒ B ⋐ O & O is Anti-open", Anti-cl(A) ⋐ O and Anti-cl(B) ⋐ O. Anti-cl(A) ⋒ Anti-cl(B) ⋐ O ⋒ O = O ⟹ Anti-cl(A) ⋒ Anti-cl(B) ⋐ O (1)

W.k.t Anti-cl(A ⋒ B) ⋐ Anti-cl(A) ⋒ Anti-cl(B) (2)
From (1) & (2), we get "Anti-cl(A ⋒ B) ⋐ Anti-cl(A) ⋒ Anti- cl(B) ⋐ O".
Anti-cl(A ⋒ B) ⋐ O
Therefore Anti-cl(A ⋒ B) ⋐ O whenever A ⋒ B ⋐ O & O is Anti-open.
Hence A ⋒ B is Anti-g-c.

**Theorem 3.4:** Assume that B is an Anti-g-cs with respect to A & A is an Anti-g-c portion of X. In X, B is resulting in Anti-g-c.

**Proof:** Let B ⋐ O & O be Anti-o in X. Then "B ⋐ A ⋒ O" & hence $Anti-cl_A(B)$ = A ⋒ O. Thus, it concludes that A ⋒ Anti-cl(B) ⋐ A ⋒ O and A ⋐ O ⋓ C(Anti-cl(B)). Because A is Anti-g-c in X, we get Anti-cl(A) ⋐ O ⋓ C(Anti-cl(B)). Which means Anti-cl(B) ⋐ Anti-cl(A) ⋐ O ⋓ C(cl(B)) ⟹ Anti-cl(B) ⋐ O.

**Theorem 3.5:** If A is Anti-g-c & A ⋐ B ⋐ Anti-cl(A), then B is Anti-g-c.

**Proof:** Anti-cl(B)-B ⋐ Anti-cl(A)-A & because Anti-cl(A)-A lacks a known theorem, neither does Anti-cl(B)-B have any non-empty Anti-closed subsets.

**Theorem 3.6:** Presume that A is anti-g-closed in X & let "A ⋐ Y ⋐ X". In regard to Y, A is consequently Anti-g-c.

**Proof:** Let A ⋐ Y ⋒ O & O be Anti-open in X. Then A ⋐ O & Consequently, "Anti-cl(A) ⋐ O. Y ⋒ Anti-cl(A) ⋐ Y ⋒ O" is the consequent relationship.

## 4. Anti-g-open

**Definition 4.1:** A is anti-generalized open if C(A) is anti-g-c.

**Theorem4.2:** If A is Anti-g-o, iff F ⋐ Anti-intA when F is Anti-c & F ⋐ A.

The easy proof is left to the reader.

**Theorem 4.3:** The set A ⋓ B is Anti-g-open if A and B are distinct.

**Proof:** Set F to be an anti-c portion of A ⋓ B. F ⋒ Anti-cl(A) ⋐ A & consequently, by established theory F ⋒ Anti-cl(A) ⋐ Anti-int(A). Ily, F ⋒ Anti-cl(B) ⋐ Anti-int(B). Now F = F ⋒ (A ⋓ B) ⋐ (F ⋒ Anti-cl(A)) ⋒ (F ⋒ Anti-cl(B)) ⋐ Anti-intA ⋓ Anti-intB ⋐ Anti-int(A ⋓ B). Hence F ⋐ Anti-int(A ⋓ B) & by established theory A ⋓ B is Anti-g-open. Since F ⋐ Anti-int(A ⋓ B), A ⋓ B is Anti-g-o by theorem.

**Corollary 4.4:** Let A and B be Anti-g-css with separated C(A) and C(B). Next A ⋒ B is Anti-g-c.

The demonstration derives immediately from theorem by proving that C(A ⋒ B) is Anti-g-o.

**Theorem 4.5:** A set A is Anti-g-o in (X, $\tau$) iff O =X every time O is Anti-o & Anti-intA ⋓ C(A) ⋐ O.

**Proof:** Suppose that O is Anti-open & Anti-intA ⋐ O. Now C(O) ⋐ Anti-cl(C(A)) ⋒ A = Anti-cl(C(A)) – C(A). Because C(O) is Anti-c and C(A) is Anti-g-c, by established theory it follows that C(O) = ∅ or X = O. Conversely presume that F is an Anti-cs and F ⋐ A. From established theory, it works to establish that F ⋐ Anti-intA. Now Anti-intA ⋓ C(A) ⋐ Anti-intA ⋓ C(F) and hence Anti-intA ⋓ C(F) =X. It means consequently that F ⋐ Anti-intA.

**Theorem 4.6:** If "A ⋐ B ⋐ X" whereby A is Anti-g-o with regard to B & B is Anti-g-o with regard to X, then A is Anti-g-o corresponding to X.

**Proof:** Let F be an Anti-cs and presume that F ⋐ A. Consequently, F ⋐ $\mathrm{Anti}-\mathrm{int}_{\mathrm{B}}\mathrm{A}$ since F is anti-closed with respect to B. Thus there's an Anti-open set O to ensure F ⋐ O ⋒ B ⋐ A. But F ⋐ $O^*$ ⋐ B for some Anti-oss $O^*$ since B is Anti-g-o in X. Thus F ⋐ $O^*$ ⋒ O ⋐ B ⋒ O ⋐ A. It emerges thus that F ⋐ Anti-intA. Using theorem A is Anti-g-o in X.

**Theorem 4.7:** If Anti-intA ⋐ B ⋐ A & A is Anti-g-o, then B is Anti-g-o.

**Proof:** C(A) ⋐ C(B) ⋐ Anti-cl(C(A)) and since C(A) is Anti-g-c, it argues that C(B) is Anti-g-c by argument hence B is Anti-g-o.

## 5. Anti-ig, dg and bg css in ATOS

**Definition 5.1:** "If (X, $\leq$) is a partially ordered set and (X, $\tau$) is an anti-topological space, the triplet (X, $\tau, \leq$) happens to be anti-topological ordered space".

**Definition 5.2:** The notation [x, →] will represent {y ∈ X/x ≤ y} for each x ∈ X. If A = Anti-i(A), where Anti-i(A) = $\bigcup_{x \in A}[x, \rightarrow]$, then portion A of an ATOS $(X, \tau, \leq)$ is anti-increasing.

**Definition 5.3:** The notation [←, x] will represent {y ∈ X/y ≤ x} for each x ∈ X. If A = Anti-d(A), where Anti-d(A) = $\bigcup_{x\in A}[\leftarrow, x]$, then portion A of an ATOS $(X, \tau, \leq)$ is anti-decreasing.

"The complement of an Anti-decreasing (resp.an Anti-increasing) set is an Anti-increasing (resp. a Anti-decreasing) set. C(A) denotes the complement of A in X.

Anti-icl(A) = ⋒ {F/F is an Anti-increasing closed subset of X containing A}

Anti-dcl(A) = ⋒ {F/F is a Anti-decreasing closed subset of X containing A}

Anti-bcl(A) = ⋒ {F/F is a closed subset of X containing A with F = i(F) = d(F)}

Anti-IO(X) (resp. Anti-DO(X), Anti-BO(X)) denotes the collection of all Anti-increasing (resp. Anti-decreasing, both Anti-increasing and Anti-decreasing) open subsets of an Anti-topological ordered space $(X, \tau, \leq)$. For a subset A of a space $(X, \tau, \leq)$, Anti-icl(A) (resp. Anti-dcl(A), Anti-bcl(A)) denote the Anti-increasing (resp. Anti-decreasing, both Anti-increasing and Anti-decreasing) closure of A".

**Definition 5.4:** If Anti-icl($A$) ⋐ $U$ every time "$A$ ⋐ $U$", where $U$ is Anti-O then $A$ is an Anti-ig-cs.

**Definition 5.5:** If Anti-dcl($A$) ⋐ $U$ every time "$A$ ⋐ $U$", where $U$ is Anti-O then $A$ is an Anti-dg-cs.

**Definition 5.6:** If Anti-bcl($A$) ⋐ $U$ every time "$A$ ⋐ $U$", where $U$ is Anti-O then $A$ is an Anti-bg-cs

**Theorem 5.7:** Every Anti-bclosed set is an Anti-iclosed set.

**Proof:** W.k.t "Every balanced set is an increasing set". Afterward every Anti-bclosed set is an Anti-iclosed.

**Example 5.8:** Let $X$ = {1, 2, 3, 4, 5}, $\tau$ = {{1}, {4}, {2, 3}, {3, 5}} be an Anti-topology for $X$ and ≤ = {(1, 1), (2, 2), (3, 3), (2, 3), (3, 4)}. Let P = {1, 4, 5}. P is Anti-iclosed set rather than a Anti-bclosed set.

**Theorem 5.9:** Every Anti-bclosed set is an Anti-dclosed set.

**Proof:** W.k.t "Every balanced set is a decreasing set". Afterward every Anti-bclosed set is a Anti-dclosed.

**Example 5.10:** Consider ex 5.8. Let P = {1, 2, 3, 5}. P is Anti-dclosed set rather than a Anti-bclosed set.

**Theorem 5.11:** The concepts of anti-iclosedness and anti-dclosedness exist separately. The following examples will show this.

**Example 5.12:** Consider ex 5.8. Let P = {1, 4, 5}. P is Anti-iclosed set rather than a Anti-dclosed set. Let Q = {1, 2, 3, 5}. Q is Anti-dclosed set rather than a Anti-iclosed set.

**Theorem 5.13:** Each set that's anti-bg-closed is also anti-ig-closed.

**Proof:** W.k.t "Every balanced set is an increasing set". Afterward every Anti-bg-cs is an Anti-ig-cs.

**Example 5.14:** Consider ex 5.8. Let P = {4}. P is Anti-igclosed set rather than an Anti-bgclosed set.

**Theorem 5.15:** Every Anti-bg-cs is an Anti-dg-cs.

**Proof:** W.k.t "Every balanced set is a decreasing set". Afterward every Anti-bg-cs is an Anti-dg-cs.

**Example 5.16:** Consider ex 5.8. Let P = {2}. P is Anti-dgclosed set rather than a Anti-bgclosed set.

**Theorem 5.17:** Anti-dg and Anti-ig closedness are two different concepts. The following examples will show this.

**Example 5.18:** Consider ex 5.8. Let P = {4}. P is Anti-igclosed set rather than a Anti-dgclosed set. Let Q = {2}. Q is Anti-dgclosed set rather than a Anti-igclosed set.

**Theorem 5.19:** "If there isn't a non-empty Anti-closed set in Anti-icl(A)-A iff set A is Anti-ig-closed.

**Proof:** Suppose F is an Anti-c portion of Anti-icl(A)-A. If A ⋐ C(F) & since A is Anti-ig-c, we get Anti-icl(A) ⋐ C(F) or F ⋐ C(Anti-icl(A)). Thus F ⋐ Anti-icl(A) ⋒ C(Anti-icl(A)) = ∅ ⟹ F = ∅.

Conversely suppose that A ⋐ O & that O is anti-open. If Anti-icl(A) does not contained O, then Anti-icl(A)-A has a not void Anti-c portion called anti-icl(A) ⋒ C(O)".

**Theorem 5.20:** "A ⋒ B" is anti-ig-c if A, B are both anti-ig-c.

**Proof:** If A ⋒ B ⋐ O & O is Anti-open, Anti-icl(A) ⋐ O and Anti-icl(B) ⋐ O. Anti-icl(A) ⋒ Anti-icl(B) ⋐ O ⋒ O = O ⟹ Anti-icl(A) ⋒ Anti-icl(B) ⋐ O (1)

W.k.t "Anti-icl(A ⋒ B) ⋐ Anti-icl(A) ⋒ Anti-icl(B)" (2)

From (1) and (2), we have "Anti-icl(A ⋒ B) ⋐ Anti-icl(A) ⋒ Anti- icl(B) ⋐ O

Anti-icl(A ⋒ B) ⋐ O"
Therefore Anti-icl(A ⋒ B) ⋐ O whenever A ⋒ B ⋐ O and O is Anti-open.
Hence A ⋒ B is Anti-ig-closed.

**Theorem 5.21:** If B is an anti-ig-closed set with respect to A and A is an anti-ig-c portion of X, next B is also anti-ig-c in X.

**Proof:** Let B ⋐ O & O be Anti-o in X ⟹ "B ⋐ A ⋒ O" & hence $Anti - icl_A(B)$ = A ⋒ O. That means that A ⋒ Anti-icl(B) A ⋒ O and A ⋐ O ⋓ C(Anti-icl(B)). X is Anti-ig-closed for A, therefore Anti-icl(A) ⋐ O ⋓ C(Anti-icl(B)). Anti-icl(B) ⋐ Anti-icl(A) ⋐ O ⋓ C(Anti-icl(B)) and Anti-icl(B) ⋐ O.

**Theorem 5.22:** If A is Anti-ig-c and A ⋐ B ⋐ Anti-icl(A), then B is Anti-ig-c.
**Proof:** Anti-icl(B)-B ⋐ Anti-icl(A)-A & void Anti-c portions exist in Anti-icl(A)-A or Anti-icl(B)-B, thus use the known theorem.

**Theorem 5.23:** Given "A ⋐ Y ⋐ X", A is anti-ig-c in X. Anti-ig-closed A is related to Y.

**Proof:** Let A ⋐ Y ⋒ O & presume that O is Anti-o in X. Then "A ⋐ O & Anti-icl(A) ⋐ O". That means Y ⋒ Anti-icl(A) ⋐ Y ⋒ O.

**Conclusion:**
In this article, we have introduced the notion of Anti-g-css and Anti-g-css in connection with ATS and Anti-ig-closed, Anti-dg-closed and Anti-bg-css in ATOS and then explored their fundamental properties. Furthermore, we have defined the Anti-g*-c & Anti-g*-open of a set, delving into an in-depth analysis of their associated properties. From the above discussion, we have found that classes of anti-g-oss and anti-g-css in anti-topological spaces are finer than classes of anti-oss & anti-css, respectively. Also, the deviations from standard topological expectations signify the unique characteristics of the anti-topological space under consideration.

As we move forward, our future research endeavors will aim to investigate novel concepts and ideas related to anti-topological spaces. We anticipate that the insights presented in this article will contribute to the advancement of various facets within the field of anti-topological spaces, aiding researchers in their exploration and development of this intriguing domain.

**References:**

[1] Azad, K. K. (1981). On fuzzy semicontinuity, fuzzy almost continuity and fuzzy weakly continuity. Journal of mathematical analysis and applications, 82(1), 14-32. https://doi.org/10.1016/0022-247X(81)90222-5.

[2] Alabdulsada, L. M. H. (2019). On B-Open Sets. European Journal of Pure and Applied Mathematics, 12(2), 358–369. https://doi.org/10.29020/nybg.ejpam.v12i2.3401.

[3] Al-Odhari, A. M. "On infra topological spaces." International Journal of Mathematical Archive 6.11 (2015): 179-184.

[4] Benchalli, S. S., & Karnel, J. J. (2010). On fuzzy b-open sets in fuzzy topological spaces. Journal of Computer and Mathematical Sciences, 1(2), 103-273.

[5] Császár, Akos. "Generalized topology, generized continuity." Acta mathematica hungarica 96.4 (2002): 351-357.

[6] Császár, Ákos. "Weak structures." Acta Mathematica Hungarica 131 (2011).

[7] Das, Birojit, Apu Kumar Saha, and Baby Bhattacharya. "On Infi-topological spaces." Journal of fuzzy mathematics 25.2 (2017): 437-448.

[8] Ebenanjar, P. E., Immaculate, H. J., & Wilfred, C. B. (2018, December). On neutrosophic b-open sets in neutrosophic topological space. In Journal of Physics: Conference Series (Vol. 1139, No. 1, p. 012062). IOP Publishing. https://doi.org/10.1088/1742-6596/1139/1/012062.

[9] G. Sravani and G. Srinivasarao "Investigation on rg-Closed Type Sets in TOS", European Chemical Bulletin 2023,12(7), 8421– 8428.

[10] G. SRINIVASARAO, et al. "g-Closed type sets and g*-Closed type sets in Topological Ordered Spaces", 5(6)2014, 1276-1285.

[11] G. Srinivasarao., D. Madhusudanrao, and N. Srinivasarao "Applications of ig, dg, bg-Closed type sets in topological ordered spaces", 8(1) (2015), 12-22.

[12] G. Srinivasarao, D. Madhusudanarao, and N. Srinivasarao. "Separation Axioms using ig*, dg*, bg*-closed Type Sets in Topological Ordered Spaces", International Journal of Advances in Engineering & Technology 7.6 (2015): 1840-1850.

[13] Iswarya, P., & Bageerathi, K. (2016). On neutrosophic semi-open sets in neutrosophic topological spaces. International Journal of Math. Trends and Tech., 37(3), 214-223. https://doi.org/10.14445/22315373/IJMTTV-37P529.

[14] Jamunarani, R., P. Jeyanthi, and T. Noiri. "On generalized weak structures." Journal of Algorithms and Computation 47.1 (2016): 21-26.

[15] Khaklary, J. K., & Ray, G. C. (2023). A new class of NeutroOpen, NeutroClosed, AntiOpen and AntiClosed sets in NeutroTopological and AntiTopological spaces. International Journal of Neutrosophic Science (IJNS), 20(2). https://doi.org/10.54216/IJNS.200206.

[16] Khaklary, Jeevan Krishna, and Tomasz Witczak. "Introduction to anti-bitopological spaces." Neutrosophic Sets and Systems 55.1 (2023): 32.

[17] Levine, N. (1963). Semi-open sets and semi-continuity in topological spaces. The American mathematical monthly, 70 (1), 36 - 41. https://doi.org/10.1080/00029890.1963.11990039.

[18] Mashhour, A. S. (1982). On precontinuous and weak precontinuous mappings. In Proc. Math. Phys. Soc. Egypt. (Vol. 53, pp. 47-53). https://doi.org/10.1080/00029890.1963.11990039.

[19] Mashhour, A. S. "On supratopological spaces." Indian J. Pure Appl. Math. 14 (1983): 502-510.

[20] Rao, V. V., & Rao, Y. S. (2017). Neutrosophic Pre-open sets and Pre-closed sets in Neutrosophic Topology. International Journal of Chem Tech Research, 10(10), 449-458.

[21] Shahna, A. S. B. (1991). On fuzzy strong semicontinuity and fuzzy precontinuity. Fuzzy sets and systems, 44(2), 303-308. https://doi.org/10.1016/0165-0114(91)90013-G.

[22] Şahin, M., Kargın, A., & Yücel, M. (2021). Neutro-topological space and anti-topological space. NeutroAlgebra Theory, 1, 16.

[23] Şahin, Memet, Abdullah Kargın, and Murat Yücel. "Neutro-topological space and anti-topological space." NeutroAlgebra Theory 1 (2021): 16.

[24] Smarandache, F. n-valued Refined Neutrosophic Set and Logic and its Applications in Physics. Progress in Physics, 143-146.

[25] Smarandache, Florentin. Structure, NeutroStructure, and AntiStructure in Science. Infinite Study, 2021.

[26] Smarandache, Florentin. NeutroAlgebra is a generalization of partial algebra. Infinite Study, 2020.

[27] Smarandache F., Introduction to NeutroAlgebraic Structures and AntiAlgebraic Structures (revisited)., Neutrosophic Sets and Systems, vol. 31, pp. 1-16, 2020. DOI: 10.5281/zenodo.3638232.

[28] Smarandache, Florentin. Generalizations and alternatives of classical algebraic structures to neutroalgebraic structures and antialgebraic structures. Infinite Study, 2020.

[29] S. Warner, Topological rings, vol. 178 of North-Holland Mathematics Studies, NorthHolland Publishing Co., Amsterdam, 1993.

[30] P. Bhatacharya and B. K. Lahiri, Semi-generalized closed sets in topology, Indian J. Math, 29(3) (1987), 375-382.

[31] Pervin, William J. "Connectedness in bitopological spaces." Indag. Math 29 (1967): 369-372.

[32] Khaklary, Jeevan Krishna, and Tomasz Witczak. "Introduction to anti-bitopological spaces." Neutrosophic Sets and Systems 55.1 (2023): 32.

[33] Puiwong, Jenjira, Chokchai Viriyapong, and Jeeranunt Khampakdee. "Weak separation axioms in bi-weak structure spaces." Burapha Science Journal (2017): 110-117.

[34] Witczak, T. (2022). Some remarks on anti-topological spaces. arXiv preprint arXiv:2202.10013, Asia Mathematika, 6(1), 23-34. https://doi.org/10.48550/arXiv.2202.10013.

[35] Witczak, Tomasz. "Interior and closure in anti-minimal and anti-biminimal spaces in the frame of anti-topology." Neutrosophic Sets and Systems 56.1 (2023): 29.
[36] Witczak, Tomasz. "Interior and closure in anti-minimal and anti-biminimal spaces in the frame of anti-topology." Neutrosophic Sets and Systems 56.1 (2023): 29.
[37] Witczak, Tomasz. "Some remarks on anti-topological spaces." arXiv preprint arXiv:2202.10013 (2022).
[38] Witczak, Tomasz. "On dense, rare and nowhere dense sets in anti-topological spaces." Neutrosophic Algebraic Structures and Their Applications (2022): 42.