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The Collection of Various βws – Closed Sets in Topological Spaces

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Abstract:

This research presents an innovative class of Beta weakly semi-closed sets namely, The collection of various βws – closed sets in Topological spaces. Throughout this paper, βws-Semi closure sets, βws-Interior and βws – Neighbourhood sets were examined to get the fundamental facts in the Beta weakly semi-closed sets. In this paper, the notion of countable βws-semi-closed sets and βws-Interior in TS were explored and βws – Neighbourhood (βws-nbd) in TS were also studied to get results. Here, many characterizations were obtained along with some of their feature results.

Keywords: Beta weakly semi interior sets (βws-int), Beta weakly semi closure sets (βws- cl), Beta weakly semi neighbourhood sets (βws-nbd), Topological spaces(TS).

1. Introduction

The fundamental concepts of the collection of various βws – closed sets in topological spaces play crucial roles in general topology. Numerous researchers have investigated into exploring their fundamental properties, leading to inspirations for generalizing these concepts to innovative extents. R.S. Suriyaand, T. Shyla Issac Mary [1] introduced Alpha weakly semi closed-sets in topological spaces. Levine N [2] introduced and he was studied on Generalized CS in topology in 1970. V. Kavitha, V.E. Sasikala, [3] introduced and studied on the closed sets in Beta generalized CS in topological spaces. D.Sivaraj and V.E. Sasikala,[4] studied on A Study on soft α–open sets in 2016. V.E. Sasikala, D. Sivaraj et al., [5, 6] studied on soft semi weakly generalized closed set in soft topological spaces in the year 2019. Many researchers introduced the soft topological spaces, V.E. Sasikala et al.,[7] introduced and investigated Soft swg separation axioms in soft topological spaces in 2019. In 1986, D. Andrijevic [8] discussed the Semi-preopen sets. Balachandran [9] studied on Generalized - α - closed maps and Maki, H. and α - generalized closed maps" in 1998. Basavaraj M.Ittanagi & Veeresha A Sajjanar, [10] introduced and investigated On weakly semi CS in topological Spaces, in the year 2017. Caldas, M, Jafari, S, Noiri, T & Simoes, M, [11] have defined and studied on A new generalization of contra continuity via Levine's g-CS in 2007. G.B.Navalagi, [12] discussed the Semi pre neighbourhoods and properties of gspr -closed sets in topology in the year 2001. Indirani, K, Sathesh mohan, P & Rajendran, [14], explained Almost contra gr*-continuous function in topological Space, in the year 2014. Mariappa. K & Sekar.S, [15] discussed the details of regular generalized b-CS, in the year 2013. V.E. Sasikala and D. Sivaraj [16] introduced and studied on soft β–open sets, in 2017. Noiri, T., Popa, V. [17] presented a new class of between closed-sets and g-closed-sets in the year 2006. V.E. Sasikala, D. Sivaraj, R. Thirumalaisamy and J. Venkatesan[18-20] have defined and studied on soft regular star generalized star closed sets in soft topological spaces. This research aims to introduce the ideas extending βws – closure, βws-interior and βws – neighbourhood within TS, along with providing characterizations for these concepts

2. PRELIMNARIES

Assume we recall that the following definitions the before said are used by our sequel.

Definition: 2.1 [1] A ⊆ B of a TS (Ҳ, τ) it's called a semi – OS if B ⊆ clint ((B)) and also a semi- CS and int (cl (B)) ⊆ B.

Definition: 2.2 [6] A ⊆ P of a TS (Ҳ,τ) it's called a weakly CS (briefly, wg–C) if cl(int(P)) ⊆ Ģ whenever P ⊆ and Ģ open in Ҳ.

Definition: 2.3 [5] A ⊆ P of a TS (Ҳ,τ) it's called a regular generalized α - CS (briefly rgα-C) if αcl (P) ⊆ Ģ whenever P ⊆ Ģ and Ģ is regular α–OS in Ҳ.

3. BETA WEAKLY SEMI – INTERIOR:

Definition: 3.1 Let P be a subset of a TS in Ҳ**,** βws-interior of P be symbolized by βwsint (P) it was described as βwsint (P) = ∪{Q ⊆ P and Q be βws-OS in Ҳ} or ∪ {Q: Q⊆ P and Q is βwsO(Ҳ) or βwsint (P)} be a combination of all βws-OS with includes P.

Theorem: 3.2 If P and E are subsets of a TS in Ҳ, then

i) βws int (Ҳ) = Ҳ, βws int (ϕ) = ϕ, βws int (P) ⊆ P

ii) When E is a βws-OS included in P, that the E ⊆ βws int (P).

iii) Assume that P ⊆ E then βws int (P) ⊆ βws int (E), βwsint (P) = βwsint (βwsint (P)).

Proof:

i) For the aim of defining on βws- interior, βwsint (Ҳ) = ∪ (Q: Q ⊆ Ҳ and Q are βws –OS in Ҳ}. Since Ҳ be βws – open, βwsint (Ҳ) = Ҳ .By using Definition 3.1, βwsint (φ) = ∪ {Q: Q ⊆ φ and B is βws – OS in Ҳ}. But φ are the only βws – OS included in φ. Therefore βwsint (φ) = φ.

ii) If Ҳ∈βwsint – int (P). Then there exists an βws – OS Q ∍ Ҳ ∈ P. Thus βwsint (P) ⊆ P.

iii) Assume that E be any βws – OS such that E ⊆ P . Let Ҳ∈E, E an βws – OS included in P then Ҳ∈βwsint (P). Hence E ⊆ βwsint (P).

Let us assume Ҳ∈βwsint (P). There is a βws – OS Q ∍ Ҳ∈ Q ⊆ P. Considering P ⊆ E, Ҳ∈ Q ⊆ E. Hence, Ҳ∈βwsint (E). Therefore, βwsint (P) ⊆ βwsint (E).

Let P be any subset of Ҳ. By using Definition 3.1, if Q ⊆ P and Q∈ βwsO(Ҳ) then Q ⊆ βws-int (P). Since Q exists a βws-OS contained within βwsint (P), by (iii), Q ⊆ βwsint (P)). Hence βwsint (βwsint (P)) ⊆∪ {Q: Q ⊆ P and Q∈βws O(Ҳ)} = βwsint (P). Therefore βwsint (βwsint (P)) = βwsint (P).

Theorem: 3.3 Let P is a subset TS in Ҳ. If P be βws – OS then βwsint (P) = P.

Proof:

Assume P is the βws-OS of a TS in Ҳ. It is known that βwsint (P) ⊆ (P)⇒ (1). Similarly, P denotes a βws-OS that contains P in Theorem 3.2 (iii) P ⊆ βwsint (P) ⇒ (2). Therefore, βwsint (P) = P based on (1) and (2).

Theorem: 3.4 Assume that ℘ and Ω subsets of TS in Ҳ, and then βws int (℘) ∪ (βws int Ω)) ⊆ βws int (℘ ∪ Ω).

Proof:

If ℘ and Ω be any two subsets in Ҳ. We know that ℘ ⊆ ℘ ∪ Ω and Ω ⊆ ℘ ∪ . Since ℘ ⊆ ℘ ∪ Ω, βws – int (℘) ⊆ βws – int (℘ ∪ Ω). Since Ω⊆ ℘ ∪ Ω, βws – int (Ω) ⊆ βws – int (℘ ∪ Ω). This implies that [βws - int (℘) ∪ (βws – int (Ω))] ⊆ βws - int (℘ ∪ Ωs).

Remark: 3.5

For any two subsets P and Q of X. βws – int (P) ∪ βws – int (Q) ≠ βws – int (P ∪Q) given in that following explanation.

Example: 3.6

Let Ҳ = {ɱ, ƀ, ҏ}, τ = {Ҳ, φ, {ɱ}, {ҏ}, {ɱ, ҏ}}, βws O(Ҳ) = {Ҳ, φ, {ƀ, ҏ}, {ɱ, ҏ}, {ҏ}}. Let P = {ƀ, ҏ}, Q = {ɱ, ҏ}, P ∪ Q = {ɱ, ƀ, ҏ}. Now βws – int (P) = {ҏ}, βws – int (Q) = {ɱ} and [βws – int (P) ∪ βws – int (Q)] = {ҏ, ɱ} and βws – int ∂}, {ҏ, ∂}, {ɱ, ҏ}, {ɱ, ∂}, {ɱ, ҏ, ∂}} βws O(Ҳ) = { Ҳ, φ, {ƀ, ҏ, ∂}, {ɱ, ҏ, ∂}, {ɱ, ƀ, ∂}, {ҏ, ∂}, {ƀ, ∂}, {ɱ, ∂}}. Let P = {ƀ, ∂}, Q = {ƀ, ҏ, ∂}, int (P) = {ƀ}, βint (P) = {ƀ} this implies βwsint (P) = {ƀ, ҏ, ∂}, ∴,{ ƀ, ∂} ⊆ {ƀ, ҏ, ∂} Hence int (P) ⊆ βws- int (P) and β int (P) ⊆ βws –int (P).

4. Methods and Discussion

BETA WEAKLY SEMI – CLOSURE:

Definition: 4.1 Assume P is a subset of a TS in Ҳ**,** Beta weakly semi –closure on P be denoted by βwscl (P) also it is defined as βws cl (P) = ∩ {Q: P ⊆ Q, Q is βws-CS in Ҳ} or intersection on all βws –CS in Ҳ.

Theorem: 4.2 In that instance**,** P and E are elements of a TS in Ҳ and then

i) βws cl(Ҳ) = Ҳ, βws cl(φ) = φ,

ii) P ⊆ βws cl(P).

iii) If E has any βws – CS in Ҳ including P, as the result βws cl(P) ⊆ E.

iv) In that case P ⊆ E then βws cl(P) ⊆ βws cl(E),

v) βws cl(℘) = βws cl(βws cl(℘)).

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Proof:

i) According to the definition βws-closure, βws cl(Ⴟ) = ∩ among them βws – CS in Ⴟ including Ⴟ = Ⴟ ∩ {βws – CS including Ⴟ} = Ⴟ ∩ Ⴟ = Ⴟ. ∴, βws cl(Ⴟ) = Ⴟ. According to the definition about βws – closure, βws cl(φ) = ∩ among them βws – CS in Ⴟ containing φ =φ ∩ any βws – CS in Ⴟ which includes φ = φ∩ = φ. ∴, βws cl(φ) = φ.

ii) In accordance with explanation on βws – closure on P, It's clear which P ⊆ βws cl(P).

iii) Let E is part of βws – CS in Ⴟ including A. Considering that βws cl(P) is the intersection all βws – CS in Ⴟ which includes P. βws cl(P) exists in each and every βws – CS through Ⴟ which includes P. Therefore, particularly βws cl(P) ⊆ E.

iv) Suppose P and E are subsets of Ⴟ ∍ P ⊆ E. By the definition of βws – closure, βws cl(E) = ∩ {Q: Q is βws – CS in Ⴟ }. If E ⊆ Q,Q is βws – CS with Ⴟ then βws cl(E) ⊆ Q. Since Q ⊆ E ⊆ Q is βws – CS in Ⴟ, we have βws cl(P) ⊆ Q, βws cl(P) ⊆ ∩ {Q: is βws – CS in Ⴟ} = βws cl(E). ∴, βws cl(P) ⊆ βws cl(E).

v) Assume that ℘ is a brief subset of Ⴟ. According to a definition of βws – closure, βws cl(℘) = ∩ {Ꭷ : ℘ ⊆ Ꭷ, Ꭷ is βws – CS in Ⴟ}. If ℘ ⊆ , then βws cl(℘) ⊆ Ꭷ . Since Ꭷ be a βws – CS which includes βws cl (℘), from (iii) βws cl(βws cl(℘)) ⊆ Ꭷ .∴, βws cl(℘)) = ∩ {Ꭷ : ℘ ⊆ Ꭷ , Ꭷ is βws –CS in Ⴟ} = βws cl(℘). Hence βws cl(℘) = βws cl(βws cl(℘))).

THEOREM 4.3: Let us consider ϰ∈Ⴟ. Then, ϰ∈βws- clA iff V ∩ A ≠ϕ ∀ βws – OS V including the points ϰ.

Proof: Let assume that ϰ∈βws – cl A. To prove V ∩ A ≠ϕ ∀ βws – OS V including the ϰ. Suppose that ∃ βws – OS V which includes ϰ∍ V∩A = ϕ, and then A⊆ ϰ -V, because V ∩ A = ϕ. By theorem 4.2 (iv) ∊βws- cl A ⊆ ∊ βws- cl(Ⴟ -V). Given V is an βws –OS then Ⴟ -V is βws –C. Since Ⴟ -V is βws –C. Then βws- cl(Ⴟ -V) = Ⴟ -V. Thus βws – cl A ⊆ Ⴟ -V.∴, ϰ∉βws – cl A which is a contradiction to our assumption. ∴,V ∩ A = ϕ ∀ βws – OS V containing the point ϰ. Conversely, Assume that V ∩A≠ϕ ∀ βws – OS V containing the point ϰ. To prove ϰ∈βws –clA. Suppose ϰ∉βws – clA, ∃ an βws – C ⊆ F which includes A ∍ ϰ ∉F. ∴, ϰ∈Ⴟ –F. ∴, (Ⴟ –F) ∩ A = ϕ, because A⊆F. That's contradiction, because ϰ∈Ⴟ –F. ∴, ϰ∈βws – cl A.

THEOREM 4.4: If A and B are subsets of the space Ⴟ, then βws – cl(A ∩ B) ⊆ (βws – clA) ∩ (βws – clB).

Proof: Assume that A and B are any two subsets of Ⴟ. Since A ∩ B ⊆ A, from using theorem 4.2(iv), βws – cl (A ∩ B) ⊆ βws – clA. Also A ∩ B ⊆ B ⇒ βws – cl(A ∩ B) ⊆ βws – clB. Thus βws – cl (A ∩ B) ⊆ (βws – clA) ∩ (βws – clB).

Remark 4.5 :

In generally, (βws – clA) ∩ (βws – clB) ⊈ βws – cl (A ∩B) as the example below explains.

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Example: 4.6

Let Ӽ = {ϻ, ƃ, ꝑ, ∂}, τ = { Ӽ, ϕ, {ϻ}, {ꝑ}, {∂}, {ꝑ, ∂ }, { ϻ, ∂ }, { ϻ, ꝑ, ∂} following that using βws C(Ӽ, τ) ={Ӽ, ϕ, {ϻ}, {ƃ}, {ꝑ}, {ϻ, ƃ}, {ϻ, ꝑ}, {ƃ, ꝑ}}. Let A = {ϻ}, B = {ꝑ}, then A ∩ B ={ϕ}⇒ βws – cl(A ∩ B) = ϕ → (1). Also βws – cl A = {ϻ, ƃ}, βws – clB = {ϻ, ꝑ} then (βws – cl A) ∩ (βws – clB) = {ϻ} → 2, From 1 and 2, (βws – cl A) ∩ (βws – clB) ⊈ βws – cl (A∩ B).

5. BETA WEAKLY SEMI CLOSED NEIGHBORHOOD AND LIMIT POINTS:

βws – Neighborhood through is TS introduced by using Notion of βws – OS.

Definition: 5.1 If Ӽ is a TS with the ӽ∈ Ӽ. If subset N of Ӽ it is said βws – Neighborhood (briefly - βws – nbd) of ӽ if ∃ an βws – OSG that the ӽ∈ ɕ ⊆ N.

Definition: 5.2 Let subset N of a space Ӽ is known as βws – nbd of P ⊆ N if ∃ an βws – OSG which P ⊆ G ⊆ N. A group of all βws – Neighborhood of ӽ∈ Ӽ is known as βws – nbd of Ӽ and that will be represented by βws – N (Ӽ).

Theorem: 5.3 Each of open Neighborhood on ӽ∈Ӽ is an βws – Neighborhood of ӽ∈Ӽ.

Proof:

Assume that N be an open– Neighborhood N on ӽ∈Ӽ. To prove N is an βws – Neighborhood on ӽ. From definition 5.1, ∃ an OS ɕ ∋ ӽ∈ɕ ⊆ N. Now ɕ is an βws – O, since every OS is βws – O in Ӽ. ∴, N be an βws – Neighborhood of ӽ.

Theorem: 5.4 Let a subset N of a space Ӽ is βws – O, and N be a βws– Neighborhood everyone it's points.

Proof: Assume N be βws – O. If ӽ∈ N. To prove N is βws – Neighborhood of ӽ. Considering N is a βws – OS, ӽ∈N ⊆ N. From, definition 5.1, N is βws – Neighborhood of ӽ. Considering Ӽ represents an arbitrary N point, N is a βws – Neighborhood everyone it's points.

Theorem: 5.5 Let us consider Ӽ be a TS. Let F be a βws –C subset on Ӽ and ӽ∈ Ӽ – F , Also, there is a βws – Neighborhood N of ӽ ∋ N ∩ F = φ.

Proof: Assume F is a βws – C ⊆ Ӽ also ӽ∈Ӽ –F. Since Ӽ – F be βws – O, by using Theorem 3.3.6, Ӽ – F contains a βws – Neighborhood each one of its points. Then ∃ an βws – Neighborhood N on ӽ ∋ N ⊆ Ӽ - F. Hence N ∩F = φ.

Theorem: 5.6 Let us consider N be an βws – Neighborhood of a TS in Ӽ and of every ӽ∈ Ӽ and let the βws – N (ӽ) is a collection of every βws – Neighborhood of ӽ.

i) For each ӽ∈Ӽ, βws – N (ӽ) ≠ φ

ii) If N∈βws – N (ӽ), then ӽ∈N .

iii) If N ∈βws – N (ӽ) and N ⊆ M, then M∈βws - N (ӽ).

iv) If N ∈βws – N (ӽ) or M ∈βws – N (ӽ) then N ∪ M ∈ βws – N (ӽ).

v) If N ∈βws – N (ҳ), then ∃ M ∈βws – N (ҳ) ∍ M ⊆ N and M ∈βws – N (y) for all y∈M.

vi) If N ∈βws – N (ҳ) and M ∈βws – N (ҳ) then N ∩ M ∈βws – N (ҳ).

Proof:

i) Since Ҳ be an βws – OS, by using Theorem 5.7, it be an βws – nbd on every ҳ∈ Ҳ. Then ∃ the least of any βws – Neighborhood (known as Ҳ) for every ҳ ∈ Ҳ. Therefore, βws – N (ҳ) ≠ φ for each ҳ∈ Ҳ.

ii) If N ∈βws – N (ҳ), N be an βws – Neighborhood of ҳ, from definition 5.1, ҳ ∈ N .

iii) Let us assume N ∈βws – N (ҳ). Let N ⊆ M. ∴, there be a βws – OS Ģ ∍ ҳ ∈ Ģ⊆ N . Now ҳ ∈ Ģ ⊆ M, Since N ⊆ M. ∴, M is an βws – Neighborhood of ҳ. Hence M ∈βws – N (ҳ).

iv) Given N∈βws – N (ҳ) or M∈βws – N (ҳ).From Definition5.1, ∃ an βws –OS Ģ$_1$ and Ģ$_2$ ∍ ҳ ∈ Ģ$_1$ ⊆ N or ҳ∈Ģ$_2$ ⊆ M. Thus ҳ ∈ Ģ$_1$ ∪ Ģ$_2$ ⊆ N ∪ M. Assume Ģ$_1$ and Ģ$_2$ are βws – OS, Ģ$_1$ ∪ Ģ$_2$ is an βws – OS. Thus N ∪M ∈ βws – N (ҳ).

v) Let N∈βws– N (ҳ). ∴,∃ an βws – OS M ∍ ҳ ∈ M ⊆ N. Since M is a βws – OS, by using theorem 5.7, it is an βws – Neighborhood each one it's points. Hence M ∈βws – N (y) for each y∈ M.

vi) Given N ∈βws – N (ҳ) and M∈βws – N (ҳ). From using definition 5.1, ∃ an βws –OS Ģ$_1$ and Ģ$_2$ ∍ ҳ∈ Ģ$_1$ ⊆ N and ҳ∈ Ģ$_2$ ⊆ M. Thus ҳ ∈ Ģ$_1$ ∩ Ģ$_2$ ⊆ N ∩ M. ∴, Ģ$_1$ and Ģ$_2$ are βws – OS, by using 3.10, Ģ$_1$ ∩ Ģ$_2$ is an βws – OS. Thus N ∩ M is an βws- Neighborhood of ҳ. ∴, N ∩ M ∈βws – N (ҳ).

Definition: 5.7 Let Ҳ be a TS with P as a subset of Ҳ, point ҳ∈ Ҳ is known as Beta weakly semi – limit point of if each βws- Neighborhood on Ҳ has a P point that is different through Ҳ it has ((N – { Ҳ }) ∩ P) ≠ φ ∀ βws- Neighborhood N of ҳ.

Remark: 5.8

In generally, βws-neighborhood N of ҳ∈Ҳ can't be a neighborhood of ҳ in Ҳ as demonstrated by the following explanation.

Example: 5.9

Let Ҳ = {ɱ, ƀ, ꝑ, ꝺ}, τ = {Ҳ, ϕ, {ɱ }, {ƀ}, {ɱ, ƀ},{ɱ, ƀ, ꝑ}} be a topology on Ҳ. Therefore, βws O(Ҳ) = {Ҳ, ϕ, {ɱ }, {ƀ}, {ꝑ}, {ꝺ }, {ɱ, ƀ}, {ƀ, ꝑ}, {ꝑ, ꝺ }, {ɱ, ƀ, ꝑ }}. The set {ƀ, ꝑ, ꝺ } is a βws- nbd of the point ꝺ, ∴, βws –OS {ꝑ, ꝺ } ∍ {ꝺ } ⊆ {ꝑ, ꝺ } ⊆ {ƀ, ꝑ, ꝺ }.The set {ƀ, ꝑ, ꝺ } is not an neighborhood of the point ꝺ, ∴,OS Ģ$_1$ exists ∍ ꝑ∈ ⊆ Ģ{ ꝑ, ꝺ }.

Definition: 5.10 If P ⊂ Ҳ. Let the points ҳ∈Ҳ is known as βws – limit points of P if each βws – limit points on P if every βwg – CS which includes ҳ contains a points on P apart from Ҳ. The collection of all βwg – limit points of P is known as βws – derived set of P with be devoted by Dβws – (P). Some properties of the above concepts are as follows:

Theorem: 5.11 βwg – clP = P ∪ $D_{\beta wg}$ (P).

Proof:

Let $x \in \beta wg - clP$. Then either $x \in P$ or $x \notin P$. Let $x \notin P$ as well as if x is not an βwg – limit point on P. Then $\exists$ βwg – OS Q containing $x \ni Q \cap P = \varphi$. This means that is a βwg – CS containing P. So $\beta wg - cl\ P \subset Q$ and $x \notin Q^c$. Thus we get a contradiction.

This proves that either $x \in P$ or x is βwg – limit point of P, In other words $\beta wg - cl\ P \subset P \cup D\beta wg\ (P)$.

Again in order to prove that $P \cup D_{\beta wg}\ (P) \subset \beta wg - cl\ P$, we Need to prove that if $x \notin \beta wg - cl\ (P)$ then $x \notin P \cup D\beta wg\ (P)$. Now $x \notin \beta wg - cl\ (P) \Rightarrow x \in (\beta wg - cl(P))^c$ which is βwg - O. $\Rightarrow$ x is Neither a point on P Nor a βwg – limit point on P $\Rightarrow x \notin P \cup D\beta wg(P)$. Hence the result.

COROLLARY: 5.12 A subset P of X is βwg – C iff $D\beta wg\ (P) \subset P$.

Proof:

Let P be βwg – closed. Then $\beta wg - cl\ P = P \cup D\beta wg\ (P)$. This proves that $D\beta wg\ (P) \subset P$. Conversely, if $D\beta wg\ (P) \subset P$, then $\beta wg - cl\ P = P \cup D\beta wg\ (P) = P$. Hence P is βwg – closed.

5. Conclusion

We discovered fresh cases as well as the weaker and stronger βws-limits and βws-CS neighborhoods. The concepts of βws-neighborhood, βws-closure, βws-interior, and βws-limit points are introduced and examined in order to characterize the features of βws-CS.

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