International Journal of Research in Advent Technology, Vol.7, No.4, April 2019
E-ISSN: 2321-9637
Available online at www.ijrat.org

(1, 2) * - α^* - Compact Spaces in Bitopological Spaces

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Abstract- In this paper, (1 ,2)*- α^* - isolated point,(1 ,2)*- α^* -compact spaces , (1,2)*- α^* - countably compact spaces and sequentially (1, 2) * - α^* - compact spaces in bitopological spaces are introduced and its properties are investigated.

Keywords-(1 ,2)*- α^* - isolated point ,(1, 2) * - α^* - compact spaces , (1 ,2)*- α^* - countably compact spaces and sequentially (1, 2) * - α^* - compact spaces.

1. INTRODUCTION

The study about a class of compact space called as S-closed space using semi open cover was first initiated by DI Maio and Noiri [4] .The notion of locally S-closed space was investigated by Noiri[7].The class of compact space namely GO-compact space and GO-connected space using g-open cover was introduced by Balachandran, Sundaram and Maki[1].Pauline Mary Helen, Ponnuthai Selvarani, Veronica Vijayan , Punitha Tharani[8] studied about g^{**} compact space and g^{**} compact space modulo I space Mohana and Arockiarani [6] introduced a class of (1, 2)*- π gα**-compact spaces and (1, 2)*- π gα**-connected spaces using (1, 2)*- π gα**-open sets in bitopological spaces.

In this paper, we introduce a new class of (1,2)*- α^* -compact space using (1,2)*- α^* open sets and investigate their properties. Further, we study (1,2)*- T_{α^*} $-$space , (1,2)*- ${}_gT_{\alpha^*}$ -space and their properties.

2. PRELIMINARIES

Throughout this paper, X and Y denote the bitopological spaces (X,τ_1,τ_2) and (Y,σ_1,σ_2) respectively, on which no separation axioms are assumed.

Definition 2.1.[5] A subset S of a bitopological space X is said to be $\tau_{1,2}$ -open if S=A∪B where $\tau_1 \in$ A and $\tau_2 \in$ B .A subset S of X is said to be (i) $\tau_{1,2}$ -closed if the complement of S is $\tau_{1,2}$ -open. (ii) $\tau_{1,2}$ -clopen if S is both $\tau_{1,2}$ -open and $\tau_{1,2}$ -closed.

Definition 2.2.[5] Let S be a subset of the bitopological space X. Then the $\tau_{1,2}$ - interior of S denoted by $\tau_{1,2}$ - int(S) is defined by ∪{G: G⊆S and G is $\tau_{1,2}$ - open} and $\tau_{1,2}$ - closure of S denoted by $\tau_{1,2}$ -cl(S) is defined by∩{F: S⊆F and F is $\tau_{1,2}$ - closed}.

Definition 2.3. A subset A of a bitopological space X is said to be

i)(1,2)*-regular open [5] if A= $\tau_{1,2} - \text{int}(\tau_{1,2} - \text{cl(A)})$.

ii)(1,2)*-α-open[5]if $A \subseteq \tau_{1,2} - \text{int}(\tau_{1,2} - \text{cl}(\tau_{1,2} - \text{int(A)}))$.

iii) $(1,2)^* - \alpha^* - \text{closed}$[2] if $\tau_{1,2} - \text{cl(A)} \subseteq U$ whenever $A \subseteq U$ and U is $(1,2)^* - \alpha -$open set in X.

Definition 2.4. A map $f : X \to Y$ is called

- **(i)** (1, 2)*-α*-continuous [3] if $f^{-1}(V)$ is (1, 2)*-α*-closed in X for every σ_{12} closed set V of Y.
- (ii) (1, 2)*-α*-irresolute[3] if $f^{-1}(V)$ is (1, 2)*-α*-closed in X for every (1,2)*-α*-closed V of Y.

Definition 2.5. [8]A map $f : X \to Y$ is called g**-resolute if f(V) is g**-open in Y whenever U is g**-open in X.

3. (1,2) * - α^* - COMPACT SPACES

Definition 3.1. A collection {A i : i ∈ I} of (1, 2)*-α*-open sets in a bitopological space X is called a (1, 2)*-α*-open cover of a subset B if B ⊆ ∪{A i : i ∈ I}.

Definition 3.2. A bitopological space X is called (1, 2)*-α*-compact, if every (1, 2)*-α*-open covering of X contains a finite subcollection that also covers X.A subset A of X is said to be (1, 2)*-α*-compact if every (1, 2)*-α*-open covering of A contains a finite subcollection that also covers A.

Definition 3.3. A subset B of a bitopological space X is said to be (1, 2)*-α*-compact relative to X, if for

every collection {A_i : i $\in$ I} of (1, 2)*-α*-open subsets of X such that B $\subseteq \cup${A_i : i $\in$ I} then,
there exists a finite subset I_0 of I such that B $\subseteq \cup${A_i : i $\in I_0$}.

Definition 3.4. A subset B of a bitopological space X is said to be (1, 2)*-α*-compact if B is (1, 2)*-α*-compact as the subset of X.

Remark 3.5. Any topological space having only finitely many points is necessarily (1, 2)*-α*-compact and (1, 2)*-compact.

Theorem 3.6. A (1, 2)*-α*-closed subset of (1, 2)*-α*-compact space is (1, 2)*-α*-compact.

Proof. Let A be a (1, 2)*-α*-closed subset of (1, 2)*-α*-compact space (X, τ_1, τ_2) and $\{U_\alpha\}_{\alpha\in\Delta}$ be a (1,2)*-α*-open cover for A.Then, $\{\{U_\alpha\}_{\alpha\in\Delta}, (X-A)\}$ is a (1, 2)*-α*-open cover for X.Since X is (1, 2)*-α*-compact,there exists $\alpha_1, \alpha_2, ... \alpha_n \in \Delta$ such that .Therefore,which proves A is (1, 2)*-α*-compact.

Theorem 3. 7. A (1, 2)*-α*-closed subset of (1, 2)*-α*-compact space is (1, 2)*-α*-compact relative to X.

Proof. Let A be a (1, 2)*-α*-closed subset of a (1, 2)*-α*-compact space X. Then A^c is (1, 2)*-α*-open in X. Let S be a cover of A by (1, 2)*-α*-open sets in X. Then, {S, A^c} is a (1, 2)*-α*-open cover of X. Since X is (1, 2)*-α*-compact, it has a finite subcover, say {G_1, G_2, ….Gn}. If this subcover contains A^c, we discard it. Otherwise leave the subcover as it is. Thus we have obtained a finite (1, 2)*-α*-open subcover of A and so A is (1, 2)*-α*-compact relative to X.

Theorem 3. 8.

(i) If f : X→Y is (1, 2)*-α*-continuous image of a (1, 2)*-α*-compact space, then (1, 2)*-compact.

(ii) If a map f : X→Y is (1, 2)*-α*-irresolute and a subset B is (1, 2)*-α*-compact relative to X, then the image f(B) is (1, 2)*-α*-compact relative to Y.

Proof.

(i) Let f : X→Y be a (1, 2)*-α*-continuous map from a (1, 2)*-α*-compact space X onto a bitopological space Y. Let {A i :i $\in$ I} be an open cover of Y. Then {f^{-1} (A_i): i $\in$ I} is a (1, 2)*-α*-open cover of X. Since X is (1, 2)*-α*-compact, it has a finite subcover, say {$f^{-1}(A_1)$, $f^{-1}(A_2)$,……. $f^{-1}(A_n)$}. Since f is onto, { A_1, A_2,……. A_n} is a $\sigma_{1,2}$-open cover of Y and so Y is (1, 2)*-compact.

(ii) Let {A_i :i $\in$ I} be any collection of (1, 2)*-α*-open subsets of Y such that f(B) $\subseteq \cup${A_i : i $\in$ I}. Then, B $\subseteq \cup${ $f^{-1}(A_i)$: i $\in$ I}. By using assumptions ,there exists a finite subset I_0 of I suchthat B $\subseteq \cup${ $f^{-1}(A_i)$:i $\in$ I}. Therefore, we have f(B) $\subseteq \cup${A_i : i $\in I_0$} which shows that f(B) is (1, 2)*-α*-compact relative to Y.

Definition 3.9. A map $f : X \to Y$ is called (1, 2)*-α* -resolute if f(V) is (1,2)*-α*-open in Y whenever U is (1,2)*-α*-open in X.

Definition: 3.10 A map $f : X \to Y$ is called strongly-(1, 2)*-α*-continuous if $f^{-1}(V)$ is τ_{12}-closed (τ_{12}-open) in X for every (1,2)*-α*-closed ((1,2)*-α*-open) set V of Y.

Definition 3.11. A topological space (X, τ_1, τ_2) is said to be a (1, 2)*-α*- T_1-space if for every pair of distinct points x,y in X ,there exists disjoint (1, 2)*-α*- open sets U and V in X such that $x \in U, y \notin U$ and $x \notin V, y \in V$.

Definition 3.12. A topological space (X, τ_1, τ_2) is said to be a (1, 2)*-α*- T_2-space if for every pair of distinct points x,y in X ,there exists disjoint (1, 2)*-α*- open sets U and V in X such that $x \in U$ and $y \in V$.

Definition: 3.13. A collection ζ of subsets of X is said to have finite intersection property if for every subcollection $\{C_1, C_2, ... C_n\}$ of ζ the intersection $C_1 \cap C_2 \cap ..... \cap C_n$ is non-empty.

Theorem: 3. 14. If a map f : X→Y is strongly-(1, 2)*-α*-continuous from a (1, 2)*-compact space X onto a bitopological space Y, then Y is (1, 2)*-α*-compact.

Proof: Let {A $_i$: i $\in$ I} be a (1, 2)*-α*-open cover of Y. Then {f^{-1} (A i): i $\in$ I} is a τ_{12}-open cover of X. As f is strongly-(1, 2)*-α*-continuous. Since X is (1, 2)*-compact, it has a finite subcover, say {f^{-1} (A_1), f^{-1} (A_2),……. f^{-1} (A_n)}. Since f is onto, { A_1, A_2,……. A_n} is a finite (1, 2)*-α*-open cover of Y and so Y is (1, 2)*-α*-compact.

Theorem: 3.15. Let (X, τ_1, τ_2) and (Y, σ_1, σ_2) be two topological spaces and $f : (X, \tau_1, \tau_2) \to (Y, \sigma_1, \sigma_2)$ be a function .Then

1. f is (1, 2)*-α*-irresolute and A is a (1, 2)*-α*-compact subset of X $\Rightarrow$ f(A) is a (1, 2)*-α*-compact subset of Y.
2. f is one to one ,(1, 2)*-α*-resolute and B is a (1, 2)*-α*-compact subset of Y $\Rightarrow$ $f^{-1}(B)$ is a (1, 2)*-α*-compact subset of X.

Proof: (1) and (2) Obvious from the definitions.

Theorem: 3.16 A topological space $\left(X,\tau_1,\tau_2\right)$ is (1, 2)*-α*-compact if and only if for every collection ζ of (1, 2)*-α*-closed sets in X having finite intersection property, $\cap_{c\in C} C$ of all elements of ζ is non-empty.

Proof: Let $\left(X,\tau_1,\tau_2\right)$ is (1, 2)*-α*-compact and ζ be a collection of (1, 2)*-α*-closed sets with finite intersection property. Suppose $\cap_{c\in C} C=\varphi$,then $\cap_{c\in C}\left(X-C\right)=X$ .Therefore , $\left\{X-C\right\}_{c\in C}$ is a (1, 2)*-α*-open cover for X.Then there exists $C_1,C_2,.....C_n\in\zeta$ such that $\bigcup_{i=1}^{n}\left(X-C_i\right)=X.$ Therefore, $\bigcap_{i=1}^{n}C_i=\varphi$ which is a contradiction. Therefore, $\bigcap_{c\in C} C\neq\varphi.$ Conversely, assume the hypothesis given in the statement. To prove X is (1, 2)*-α*-compact. Let $\left\{U_\alpha\right\}_{\alpha\in\Delta}$ be a (1,2)*-α*-open cover for X. Then $\bigcup_{\alpha\in\Delta}U_\alpha=X\Rightarrow\bigcap_{\alpha\in\Delta}\left(X-U_\alpha\right)=\varphi.$ By the hypothesis, there exists $\alpha_1,\alpha_2,......\alpha_n$ such that $\bigcap_{i=1}^{n}X-U_{\alpha_i}=\varphi$.Therefore, $\bigcup_{i=1}^{n}U_{\alpha_I}=X.$ Therefore, X is (1, 2)*-α*-compact.

Corollary 3.17: Let $\left(X,\tau_1,\tau_2\right)$ be a (1,2)*-α*-compact space and let $C_1\supseteq C_2\supseteq.....\supseteq C_n\supseteq C_{n+1}\supseteq........$ be a nested sequence of non-empty (1, 2)*-α*-closed sets in X. Then $\bigcap_{c\in Z^+} C_n$ is non-empty.

Proof: Obviously $\left\{C_n\right\}_{n\in Z^+}$ has finite intersection property. Therefore by Theorem 3.15, $\bigcap_{c\in Z^+} C_n$ is non-empty.

Theorem 3.18. Let $f:\left(X,\tau_1,\tau_2\right)\rightarrow\left(Y,\sigma_1,\sigma_2\right)$ be a function ,then

1) f is (1, 2)*-α*-continuous, onto and X is (1, 2)*-α*-compact $\Rightarrow$ Y is compact.
2) f is continuous, onto and X is (1, 2)*-α*-compact $\Rightarrow$ Y is compact.
3) f is (1, 2)*-α*-irresolute, onto and X is (1, 2)*-α*-compact $\Rightarrow$ Y is (1, 2)*-α*-compact.
4) f is strongly (1, 2)*-α*-irresolute, onto and X is (1, 2)*-α*-compact $\Rightarrow$ Y is (1, 2)*-α*-compact.
5) f is (1, 2)*-α*-open, bijection and Y is (1, 2)*-α*-compact $\Rightarrow$ X is compact.
6) f is open, bijection and Y is (1, 2)*-α*-compact $\Rightarrow$ X is compact.
7) f is (1, 2)*-α*-resolute, bijection and Y is (1, 2)*-α*-compact $\Rightarrow$ X is (1, 2)*-α*-compact.

Proof: (1):Let $\left\{U_\alpha\right\}_{\alpha\in\Delta}$ be an open cover for Y. Then $\left\{f^{-1}\left(U_\alpha\right)\right\}_{\alpha\in\Delta}$ is a (1, 2)*-α*-open cover for X. Since X is (1, 2)*-α*-compact, there exists $\alpha_1,\alpha_2,......\alpha_n$ such that $X\subseteq\bigcup_{i=1}^{n}f^{-1}\left(U_{\alpha_i}\right)$. Therefore, Y is compact. Proof for (2) to (7) are similar above.

4. (1, 2)*-α*-COUNTABLY COMPACT SPACE

Definition: 4.1. A subset A of a topological space $\left(X,\tau_1,\tau_2\right)$ is said to be (1, 2)*-α*-countably compact space if every countable (1, 2)*-α*-open covering of A has a finite subcover.

Remark 4.2. Every (1, 2)*-α*- compact space is (1, 2)*-α*- countably compact space.

Definition: 4.3: Let $\left(X,\tau_1,\tau_2\right)$ be a topological space and $x\in X.$ Every (1, 2)*-α*-open set containing x is said to be a (1, 2)*-α*-neighbourhood of x.

Definition: 4.4: Let A be a subset of a topological space $\left(X,\tau_1,\tau_2\right)$ .A point $x\in X$ said to be (1, 2)*-α*-limit point of A if every (1, 2)*-α*- neighbourhood of x contains a point of A other than x.

Theorem 4.5: In a (1, 2)*-α*-countably compact topological space every infinite subset has a (1, 2)*-α*-limit point.

Proof : Let $\left(X,\tau_1,\tau_2\right)$be (1, 2)*-α*- countably compact .Suppose that there exists an infinite subset which has no (1, 2)*-α*-limit point. Let $B=\left\{a_n/n\in N\right\}$ be a countable subset of A. Since B has no (1, 2)*-α*-limit point of B, there exists a (1, 2)*-α*- neighbourhood U_n of a_n such that $B\cap U_n=\left\{a_n\right\}$.Now $\left\{U_n\right\}$is a (1, 2)*-α*- open cover for B. Since B^c is (1, 2)*-α*- open, $\left\{B^c,\left\{U_n\right\}_{n\in Z^+}\right\}$is a countable (1, 2)*-α*- open cover for X. But it has no finite subcover which is a contradiction, since X is (1, 2)*-α*- countably compact. Therefore every infinite subset of X has a (1, 2)*-α*- limit point.

Corollary 4.6: In a compact topological space every infinite subset has a limit point.
Proof follows from theorem 4.5,since every (1, 2)*-α*- compact is (1, 2)*-α*- countably compact.

Theorem 4.7:A (1, 2)*-α*-closed subset of (1, 2)*-α*-countably compact space is (1, 2)*-α*-countably compact. Proof is similar to theorem 3.6.

Definition: 4.8 In a topological space (X, τ_1, τ_2),a point $x \in X$ is said to be (1, 2)*-α*-isolated point of A if every (1, 2)*-α*-open set containing x contains no point of A other than x.

Theorem 4.9: Let X be a non-empty (1, 2)*-α*-compact (1, 2)*-α*-T_2 space. If has no (1, 2)*-α*-isolated points, then X is uncountable.

Proof: Let $x_i \in X$. Choose a point y of X different from x. This is possible since $\{x_i\}$is not a (1, 2)*-α*- isolated point. Since X is (1, 2)*-α*-T_2 ,there exists (1, 2)*-α*-open sets such that U_1 and V_1 such that $U_1 \cap V_1 = \varphi; x \in U_{1,} y \in V_1$. Therefore V_1 is (1, 2)*-α*-open and $x_1 \notin g^{**}cl(V_1)$.By repeating the same process with V_1 in the place of X and x_1 in the place of y we get a point $x \neq x_1$ and a (1, 2)*-α*-open V_2 set such that V_2 is (1, 2)*-α*-open and $x_2 \notin (1,2)^* - \alpha^* cl(V_2)$. In general ,given V_{n-1} which is (1, 2)*-α*-open and non-empty ,choose V_n to be a non-empty (1, 2)*-α*-open set such that $V_n \subseteq V_{n-1}$ and $x_n \notin (1,2)^* - \alpha^* cl(V_n)$. Hence we get a nested sequence of (1, 2)*-α*-closed sets such that $(1,2)^* - \alpha^* cl(V_n) \supseteq (1,2)^* - \alpha^* cl(V_{n+1}) \supseteq ....$
Since X is (1, 2)*-α*-compact, $\cap (1,2)^* - \alpha^* cl(V_n) \neq \varphi.$ .Therefore, there exists $x \in \cap (1,2)^* - \alpha^* cl(V_n)$. But $x \neq x_n$, for every n, since $x_n \notin (1,2)^* - \alpha^* cl(V_n)$ and $x \in (1,2)^* - \alpha^* cl(V_n)$. Define $f: Z_+ \to X$ such that $f(n) = x_n$ .Then $x \in X$ has no preimage. Therefore, f is not onto and hence X is uncountable.

Note 4.10: The converse of Theorem 4.5 is true in a (1, 2)*-α*-T_1 space.

Theorem 4.11:In a (1, 2)*-α*-T_1 space ,if every infinite subset has a (1, 2)*-α*-limit point, the X is (1, 2)*-α*-countably compact.

Proof: Let every infinite subset has a (1, 2)*-α* - limit point. To prove X is a (1, 2)*-α*-countably compact. If not there exists a countable (1, 2)*-α*-open cover $\{U_n\}$ such that it has no finite sub cover. Since $U_1 \neq X$, there exists $x_1 \notin U_1$;since $X \neq U_1 \cup U_2$,there exists $x_2 \notin U_1 \cup U_2$. Proceeding like this there exists $x_2 \notin U_1 \cup U_2 \cup .... \cup U_n$ for all n. $A = \{x_n\}$is an infinite set. If $x \in X$,then $x \in U_n$ for some n. But $x_k \notin U_n$ for all $k \geq n.$ $U_n - \{x_1, x_2, x_3......x_{n-1}\}$is a (1, 2)*-α*-open set (since X is (1, 2)*-α*-T_1) containing x which does not have a point of A other than x. Therefore, x is not a limit point of A which is a contradiction.

Theorem 4.12 A topological space(X, τ_1, τ_2) is (1, 2)*-α* - countably compact if and only if for every countable collection ζ of (1, 2)*-α* - closed sets in X having finite intersection property, of all elements of ζ is non- empty.

Proof: Similar to the proof of theorem 3.15.

Corollary 4.13. X is (1, 2)*-α* - countably compact if and only if every nested sequence of (1, 2)*-α* - closed non-empty sets $C_1 \supset C_2 \supset ....$ has a non-empty intersection.

Proof. Obviously $\{C_n\}_{n \in Z^+}$ has finite intersection property. Therefore, by theorem 4.10, $\underset{c \in Z^+}{\cap} C_n$ is non-empty.

5. SEQUENTIALLY (1, 2)*-α* -COMPACT SPACE

Definition: 5.1 A subset A of a topological space (X, τ_1, τ_2) is said to be sequentially (1, 2)*-α* -compact space if every sequence in A contains a subsequence which (1, 2)*-α*- converges to some point in A.

Theorem: 5.2 A finite subset A of a topological space (X, τ_1, τ_2) is sequentially (1, 2)*-α* -compact.

Proof: Let $\{x_n\}$be an arbitrary sequence in X .Since A is finite, at least one element of the sequence say x_0 must be repeated infinite number of times .So the constant subsequence $x_0, x_{0,.......}$ must (1, 2)*-α* -converges to x_0.

Theorem 5.3 Every sequentially (1, 2)*-α* -compact space is (1, 2)*-α* -countably compact.

Proof: Let (X, τ_1, τ_2)be sequentially (1, 2)*-α* -compact.Since X is not (1, 2)*-α* -countably compact .Then there exists countable (1, 2)*-α* -open cover $\{U_n\}_{n\in Z^+}$ which has no finite subcover. Then $X = \bigcup_{n\in Z^+} U_n$. Choose

$$x_1 \in U_1, x_2 \in U_2 - U_1, x_3 \in U_3 - \bigcup_{i=1,2} U_i, ..., x_3 \in U_n - \bigcup_{i=1}^{n-1} U_i.$$

This is possible since $\{U_n\}$ has no finite subcover. Now $\{x_n\}$is a sequence in X. Let $x \in X$ be arbitrary .Then $x \in U_k$ for some k. By our choice of $\{x_n\}$, $x_i \notin U_k$ for all greater than k. Hence there is no subsequence of $\{x_n\}$which can (1, 2)*-α* -converge to x. Since x is arbitrary, the sequence $\{x_n\}$has no convergent subsequence which is a contradiction. Therefore X is (1, 2)*-α* -countably compact.

Theorem 5.4: Let $f : (X, \tau_1, \tau_2) \to (Y, \sigma_1, \sigma_2)$be a function ,then

1) f is (1, 2)*-α*-resolute, bijection and Y is sequentially (1, 2)*-α*-compact$\Rightarrow X$ is sequentially (1, 2)*-α*-compact.
2) f is onto, (1, 2)*-α*-irresolute and X is sequentially (1, 2)*-α*-compact $\Rightarrow Y$ is sequentially (1, 2)*-α*-compact.
3) f is onto ,(1, 2)*-α*-irresolute and X is sequentially (1, 2)*-α*-compact $\Rightarrow Y$ is sequentially (1, 2)*-α*-compact.
4) f is onto, (1, 2)*-continuous and X is sequentially (1, 2)*-α*-compact $\Rightarrow Y$ is sequentially compact.
5) f is onto, strongly (1, 2)*-α*-continuous and X is sequentially (1, 2)*-α*-compact $\Rightarrow Y$ is sequentially (1, 2)*-α*-compact.

Proof:(1) Let $\{x_n\}$be a sequence in X. Then $\{f(x_n)\}$ is a sequence in Y. It has a (1, 2)*-α*-convergent subsequence $\{f(x_n)\}$ such that $f(x_{n_k}) \xrightarrow{(1,2)^*-\alpha^*} y_0$ in Y. Then there exists $x_0 \in X$ such that $f(x_0) = y_0$. Let U be a (1,2)*-α*-open set containing x_0.Then $f(U)$ is a (1,2)*-α*-open set containing y_0. Then there exists N such that $f(x_{n_k}) \in f(U)$ for all $k \geq N$ .Therefore $f^{-1} \circ f(x_{n_k}) \in f^{-1} \circ f(U)$. Therefore $x_{n_k} \in U$ for all $k \geq N$ .This proves that X is sequentially (1, 2)*-α*-compact. Proof for (2) to (5) is similar to the above.

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