**Netrosophic chaotic b-closed set in neut rosophic chaotic topological space**

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**Abstract:** This article focuses on devising the novel idea of framing a b-open set in neutrosophic chaotic topological space. We further devote this article to the study of the properties posed by this newly developed set suitable examples are provided as and when required.

**Keywords:** neutrosophic chaotic set**,** neutrosophic chaotic topological space, neutrosophic chaotic open sets, neutrosophic chaotic b-closed set.

**1. Introduction**

Fuzzy sets which allows the elements to have a degrees of membership in the set and it was introduced by Zadeh [12] in 1965. The degrees of membership lies in the real unit interval [0, 1]. Intuitionstic fuzzy set (IFS) allows both membership and non membership to the elements and this was introduced by Atnassov [1] in 1983. By introducing one more component in IFS set neutrosophic set was introduced by Smarandache [9] in 1998. Neutrosophic set has three components truth membership function, indeterminacy membership function and falsity membership function respectively. This neutrosophic set helps to handle the indeterminate and inconsistent information effectively. In 2016 concept of neutrosophic semi-open sets in neutrosohic topological space by introduced P.Ishwarya and K.Bageerathi[4]. In 2017 V.Venkateswara Rao and Y. Srinivasa Rao[11] introduced the concept of neutrosophic pre-open sets and neutrosophic pre-closed in neutrosophic topological spaces. In 2018 P. Evanzalin Ebenanjar et al[3] introduced the concept of neutrosophic b-open sets in neutrosophic topological space The concept of chaotic function in general metric space was introduced by R.L.Devaney[2]. It has many applications in trafficforecasting, animation, computer graphics, medical field, image processing, etc. T.Thrivikraman and P.B. Vinod Kumar[10] defined chaos and fractals in general topological spaces. The concept of the fuzzy chaotic set was introduced by R.Malathi and M.K. Uma[5] in 2018. In [6] we introduced the concept of neutrosophic chaotic continuous functions. In this we extend the neutrosophic b-closed set in neutosophic chaotic topological space.

2. Preliminaries

**2.1 Definition[9]** Let X be a universe. A Neutrosophic set A on X can be defined as follows:

Where and

Here, is the degree of membership, is the degree of inderminancy and is the degree of non-membership.

**2.2 Deﬁnition [9]** Let X be a non empty set, A = <x,AT,AI,AF> and B = <x,BT,BI,BF> be neutrosophic sets on X, and let {Ai : i∈ J} be an arbitrary family of neutrosophic sets in X, where Ai = <x,AT, AI, AF>

1. A B if and only if AT BT, AI BI and AF BF



1. A = B if and only if A B and B A.



1. = <x,AF,1-AI,AT>
2. A∩B=<x,ATBT,AIBI,AFBF>



1. A∪B=<x,ATBT,AIBI,AFBF>



1. ∪Ai = <x,AiT,AiI,AiF>



1. ∩Ai = <x,AiT,AiI,AiF>



1. A − B = A .



1. 0N = <x,0,1,1>; 1N = <x,1,0,0>.

**2.3 Deﬁnition [8]** A neutrosophic topology (NT for short) on a nonempty set X is a family τ of neutrosophic set in X satisfying the following axioms:

(i) 0N, 1N ∈ τ.

(ii) G1G2 ∈ τ for any G1,G2∈ τ.

(iii) Gi∈ τ for any arbitrary family {Gi :i∈J} ⊆ τ.

In this case the pair (X, τ) is called a neutrosophic topological space (NTS for short) and any neutrosophic set in τ is called a neutrosophic open set(NOS for short) in X. The complement A of a neutrosophic open set A is called a neutrosophic closed set (NCS for short) in X.

**2.4 Deﬁnition [8]** Let (X, τ) be a neutrosophic topological space and A = <X,AT,AI,AF> be a set in X. Then the closure and interior of A are deﬁned by

Ncl(A) = {K : K is a neutrosophic closed set in X and A K},



Nint(A) = {G : G is a neutrosophic open set in X and G A}.



**2.5 Deﬁnition[7]** Let X be a nonempty set and f : X → X be any mapping. Let be any neutrosophic set in X. The neutrosophic orbit Of() of under the mapping f is defined as OfT() = {,f1(),f2(),...fn()}, OfI() = {,f1(),f2(),...fn()} , OfF() = {,f1(),f2(),...fn()} for ∈ X and n ∈ Z+.

**2.6 Definition[7]** Let X be a nonempty set and let f : X→ X be any mapping. The neutrosophic orbit set of under the mapping f is defined as NOf() = <,OfT(),OfI(),OfF()> for ∈ X, where OfT()= {f1()f2()...fn()}, OfI()= {f1()f2()...fn()}, OfF()= {f1()f2()...fn()}.

**2.7 Definition[6]** Let X be a nonempty set and let f : X → X be any mapping. Then a neutrosophic set of X is called neutrosophic periodic set with respect to f if fn(𝛶) = 𝛶, for some n ∈ Z+. smallest of these n is called neutrosophic periodic of X.

**2.8 Definition [6]** Let (X, T) be a neutrosophic topological space. Let f : X → X be any mapping. The neutrosophic periodic set with respect to f which is in neutrosophic topology τ is called neutrosophic periodic open set with respect to f. Its complement is called a neutrosophic periodic closed set with respect to f.

**2.9 Notation** P = {neutrosophic periodic open sets with respect to f }.

**2.10 Definition [6]** Let (X, τ) be a neutrosophic topological space and 𝜆 ∈ NF(X) (Where NF(X) is a collection of all nonempty neutrosophic compact subsets of X). Let f : X → X be any mapping. Then f is neutrosophic chaotic with respect to 𝜆 if

(i) cl NOf (𝜆) = 1,

(ii) P is neutrosophic dense.

**2.11 Example** Let X = {a, b, c}. Define = {0, 1, 𝜇1, 𝜇2, 𝜇3, 𝜇4} where 𝜇1, 𝜇2, 𝜇3, 𝜇4 : X → [0,1] are defined as 𝜇1 (a) =<a,0.4,0.3,0.6>, 𝜇1 (b) =<b,0.8,0.7,0.2>, 𝜇1 (c) = <c,0.4,0.3,0.6>, 𝜇2 (a) = <a,0.4,0.3,0.6>, 𝜇2(b) =<b, 0.8,0.2,0.2>, 𝜇2 (c) = <c,0.5,0.2,0.5> 𝜇3 (a)=<a,0.8,0.2,0.2>, 𝜇3 (b)=<b,0.8,0.7,0.2>, 𝜇3 (c)=<c,0.6,0.2,0.4>, 𝜇4 (a)=<a,0.9,0.2,0.1>, 𝜇4 (b)=<a,0.8,0.7,0.2>, 𝜇4 (c)=<a,0.9,0.2,0.1>,

Let 𝜆: X → I be defined as 𝜆 (a) =<a,0.3,0.2,0.7> (b) = <b,0.6,0.5,0.4> 𝜆(c) =<c, 0.3,0.2,0.7>. Define f : X → X as f(a) = b, f(b) = c, f(c) = a. The neutrosophic orbit set of 𝜆 under the mapping f is defined as NOf (𝜆) = 𝜆 f(𝜆) f2(𝜆) … NOf (𝜆)(a) = <a,0.3,0.2,0.7>, NOf (𝜆)(b) = <b,0.6,0.5,0.4>, NOf (𝜆)(c) =<c, 0.3,0.2,0.7>. Therefore cl(NOf (𝜆)) = 1. Here P(a) = <a,0.4,0.3,0.6>, P(b) =<b, 0.8,0.7,0.2> ,P(c) = <c,0.4,0.3,0.6> and cl (P) is neutrosophic dense. Hence f is neutrosophic chaotic with respect to 𝜆.

**2.12 Notation** (i) NC (𝜆) = {f: X → X **/** f is neutrosophic chaotic with respect to 𝜆}.

(ii) NCH(𝜆) = {𝜆∈ NF(X) **/** NC(𝜆) ≠ 𝜙}.

**2.13 Definition** A neutrosophic topological space (X, τ) is called a neutrosophic chaos space if NCH (𝜆) ≠ 𝜙. If (X, τ) is neutrosophic chaos space then the element of the NCH(X) are called chaotic sets in X.

**3. Netrosophic chaotic b-closed set in neutrosophic chaotic topological space**

**3.1 Definition:** Let (X, τ) be a neutrosophic chaos space. Let be the collection of neutrosophic chaotic sets in X satisfying the following conditions:

1. 0NC,1NC
2. If A1, A2 ,then A1A2
3. If {Aj:jJ}, then

Then is called the neutrosophic chaotic topological space in X. The triple (X, τ,) is called a neutrosophic chaotic topological space. The element of are called neutrosophic chaotic open sets. The complement of neutrosophic chaotic open set is called neutrosophic chaotic closed set.

**3.2 Example:** Let X = {a, b, c}. Define = {0, 1, 𝜇1, 𝜇2, 𝜇3, 𝜇4} where 𝜇1, 𝜇2, 𝜇3, 𝜇4 : X → [0,1] are such that 𝜇1 (a) =<a,0.4,0.3,0.6>, 𝜇1 (b) =<b,0.8,0.7,0.2>, 𝜇1 (c) = <c,0.4,0.3,0.6>, 𝜇2 (a) = <a,0.4,0.3,0.6>, 𝜇2(b) =<b, 0.8,0.2,0.2>, 𝜇2 (c) = <c,0.5,0.2,0.5> 𝜇3 (a)=<a,0.8,0.2,0.2>, 𝜇3 (b)=<b,0.8,0.7,0.2>, 𝜇3 (c)=<c,0.6,0.2,0.4>, 𝜇4 (a)=<a,0.9,0.2,0.1>, 𝜇4 (b)=<a,0.8,0.7,0.2>, 𝜇4 (c)=<a,0.9,0.2,0.1>,

Let 𝜇1, 𝜇2, 𝜇3}.Clearly (X,T,) is called neutrosophic chaotic topological space.

**3.3 Definition:** Let(X,T,) be neutrosophic chaotic topological space and A=<x, TA,IA,FA> be neutrosophic chaotic set in X. then the neutrosophic chaotic interior and neutrosophic chaotic closure are defined by

1. intNC(A)=
2. clNC(A)=

Note that for any neutrosophic chaotic set A in (X,T,) , we have clNC(Ac)=(intNC(A))c and intNC(Ac)=(clNC (A))c.

It can be also shown that clNC(A) is NCCS and intNC(A) is NVOS in X.

1. A is NCCS in X if and only if clNC(A)=A.
2. A is NCOS in X if and only if intNC(A)=A.

**3.4 Proposition:** Let A be any neutrosophic chaotic set in X. Then

1. intNC(1NC-A) = 1NC-(clNC(A)) and
2. clNC(1NC-A) = 1NC-(intNC(A))

Proof: (i) By definition clNC(A) =

1NC-(clNC(A)) = 1NC-

=

=

= intNC(1NC-A)

(ii) The proof is similar to (i).

**3.5 Proposition:** Let(X, τ,) beneutrosophic chaotic topological space and A, B be neutrosophic chaotic sets in X. Then the following properties hold:

1. intNC(A) A
2. A clNC(A)
3. A B intNC(A) intNC(B)
4. A B clNC(A) clNC(B)
5. intNC(intNC(A))=intNC(A)
6. clNC(clNC(A))=clNC(A)
7. intNC(A B) = intNC(A) intNC(B)
8. clNC(A B) = clNC(A) clNC(B)
9. intNC(1NC) = 1NC
10. clNC(0NC) = 0NC

Proof:

(a),(c) and (i) are obvious, (e) follows from (a)

g) From intNC(AB) (A) and intNC(AB) (B) we obtain intNC(A B) intNC(A) intNC(B). On the other hand, from the facts intNC(A) A and intNC(B) B intNC(A) intNC(B) A B and intNC(A) intNC(B) we see that intNC(A) intNC(B) intNC(AB), for which we obtain the required result.

(a)-(j) They can be easily deduced from (a)-(i).

**3.6 Definition.** Let A be a neutrosophic chaotic set of a neutrosophic chaotic topological space. Then A is said to be neutrosophic chaotic pre open [NCPO]set of X if there exists a neutrosophic chaotic open set NCO such that NCOANCO(clNC(A)).

**3.7 Definition:** A neutrosophic chaotic set A=<x, TA,IA,FA> in neutrosophic chaotic topological space (X, τ,) is said to be

1. A neutrosophic chaotic pre- open set if AintNC(clNC(A)) and neutrosophic chaotic pre-closed set if clNC(intNC(A))A.
2. A neutrosophic chaotic α-open set if AintNC(clNC(Nint(A))) and neutrosophic chaotic α-closed set if clNC(intNC(clNC(A)))A.
3. neutrosophic chaotic semi-open set AclNC(intNC(A)) and neutrosophic chaotic semi-closed set if intNC(clNC(A))A.
4. neutrosophic chaotic b-open set if AintNC(clNC(A))clNC(intNC(A)) and neutrosophic chaotic b-closed set intNC(clNC(A))clNC(intNC(A))A.
5. a neutrosophic chaotic -open set, if AclNC(intNC(clNC(A))) and neutrosophic chaotic -closed set if intNC(clNC(intNC(A)))A.
6. neutrosophic chaotic regular open set if A =intNC(clNC(A)) and neutrosophic chaotic regular closed set, if A = clNC(intNC(A)).

**3.8 Definition** Let (X, τ,) be a neutrosophic chaotic topological space and A=<x, TA,IA,FA> be a NCS in X. The neutrosophic chaotic b interior of A and denoted by bintNC(A) is defined to be the union of all neutrosophic chaotic b-open sets of X which are contained in A. The intersection of all neutrosophic chaotic b-closed sets containing A is called the neutrosophic b-closure of A and is denoted by bclNC(A).

1. bintNC(A) =
2. bclNC(A) =

**3.9 Theorem** In a neutrosophic chaotic topological space X

1. An arbitrary union of neutrosophic chaotic b-open sets is a neutrosophic chaotic b-open set.
2. An arbitrary intersection of neutrosophic chaotic b-cosed sets is a neutrosophic chaotic b-closed set.

Proof: (i) Let {} be a collection of neutrosophic chaotic b-cosed sets. Then for each , Now . Thus is a neutrosophic chaotic b-open set.

(ii) Similarly by taking complements.

**3.10 Theorem.**

1. Every neutrosophic chaotic open set in the neutrosophic chaotic topological space in X is neutrosophic chaotic pre-open set in X.
2. Every neutrosophic chaotic pre-open set in the neutrosophic chaotic topological spaces (X, τ,) is neutrosophic chaotic b-open set in (X, τ,).
3. Every neutrosophic chaotic semi-open set in the neutrosophic chaotic topological spaces (X, τ,) is neutrosophic chaotic b-open set in (X, τ,).
4. Every neutrosophic chaotic -open set in the neutrosophic chaotic topological spaces (X, τ,) is neutrosophic chaotic b-open set in (X, τ,).
5. Every neutrosophic chaotic regular-open set in the neutrosophic chaotic topological spaces (X, τ,) is neutrosophic chaotic b-open set in (X, τ,).
6. Every neutrosophic chaotic -open set in the neutrosophic chaotic topological spaces (X, τ,) is neutrosophic chaotic b-open set in (X, τ,).

Proof: (i) Let A be NCO set in NCTS. Then A=intNC(A).Clearly AclNC(A) taking interior on both sides we get intNC(A)intNC(clNC(A)). Since A=intNC(A), AintNC(clNC(A)). A is a neutrosophic chaotic pre-open set in X.

(ii) Let A be neutrosophic chaotic pre-open set in a NCTS. Then AintNC(clNC(A)) which implies AintNC(clNC(A))intNC(A) intNC (clNC(A))clNC(intNC A). Hence A is a neutrosophic chaotic b-closed sets.

(iii) Let A be neutrosophic chaotic semi-open set in a NCTS. Then AclNC(intNC(A)) which implies AclNC(intNC(A))intNC(A) clNC(intNC(A))intNC(clNC(A)). Hence A is a neutrosophic chaotic b-closed sets.

(iv) (v) and (vi) Proof is obvious from above Definition.

**3.11 Remark.** From above the following implication and none of these implications is reversible as shown by examples given below



**3.12 Example**  Let X={x} and 𝜇1, 𝜇2, A be neutrosophic chaotic sets defined as follows

𝜇1 (x) =<x,0.5,0.4,0.3>, 𝜇2 (x) = <x,0.4,0.5,0.6> . Let 𝜇1, 𝜇2} be neutrosophic chaotic topology on X. A={<x,0.1, 0.3, 0.8>} Then the set A is neutrosophic chaotic open set but not neutrosophic chaotic regular open set. Since A = clNC(intNC(A))0NC.

**3.13 Example.** Let X={x} and 𝜇1, 𝜇2, A be neutrosophic chaotic sets defined as follows

𝜇1 (x) =<x,0.3,0.2,0.8>, 𝜇2 (x) = <x,0.4,0.3,0.7>. Let 𝜇1, 𝜇2} be neutrosophic chaotic topology on X. A={<x,0.2, 0.6, 0.4>}. Then the set A is neutrosophic chaotic b- open set AclNC(intNC(A))intNC(clNC(A)) 1Nc. but not neutrosophic chaotic semi- open set. Since A⊈ clNC(intNC(A))⊈0NC.

**3.14 Example.** Let X={x} and 𝜇1, 𝜇2, 𝜇3, 𝜇4, A be neutrosophic chaotic sets defined as follows

𝜇1 (x) =<x,0.5,0.6,0.5>, 𝜇2 (x) = <x,0.4,0.7,0.8> , 𝜇3 (x) = <x,0.5,0.4,0.5> and

𝜇4 (x) = <x,0.4,0.6,0.8>

Let 𝜇1, 𝜇2} be neutrosophic chaotic topology on X.

A={<x,0.5, 0.3, 0.2>}. Then the set A is neutrosophic chaotic b- open set but not neutrosophic pre- open set. Since A⊈intNC(N clNC (A))⊈<0.5, 0.4, 0.5>

**3.15 Theorem:** Let A be a neutrosophic chaotic set in neutrosopic chaotic topological space .then

1. sclNC(A) = A∪ intNC (clNC(A)) and

sintNC(A) = A∩ clNC (intNC (A))

1. pclNC(A) = A ∪ clNC (intNC (A)) and

pintNC(A) =A ∩ intNC (clNC(A)).

Proof: (i) sclNC(A) intNC (clNC(sclNC(A)) intNC (clNC(A)).

A sclNC(A) = sclNC(A) A intNC (clNC(A)).

So A intNC (clNC(A)) sclNC(A) -----------------(1)

Also A sclNC(A)

intNC (clNC(A)) intNC (clNC(sclNC(A)) sclNC(A).

A intNC (clNC(A)) sclNC(A)A sclNC(A)----- -------------(2)

From (1) and (2), sclNC(A) = A∪ intNC (clNC(A)).

sintNC(A) = A clNC (intNC(A)) can be proved by taking the complement of sclNC(A) = A∪ intNC (clNC(A)). This proves (i).

The proof for (ii) is analogous.

**3.16 Theorem:** Let A be a neutrosophic chaotic set in neutrosopic chaotic topological space .then

1. bclNC(A) = sclNC(A) pclNC(A)
2. bintNC(A) = sintNC(A) pintNC(A)

Proof: Since bclNC(A) is a neutrosophic chaotic b-closed set.

We have bclNC(A) intNC(clNC(bclNC(A)) clNC(intNC(bclNC(A)) intNC(clNC(A)) clNC(intNC(A)) and also bclNC(A) AintNC(clNC(A)) clNC(intNC(A))= sclNC(A) pclNC(A). The reverse inclusion is clear. Therefore bintNC(A) = sintNC(A) pintNC(A).

Analogously (ii) can be proved.

**3.17 Theorem:** Let A be a neutrosophic chaotic set in neutrosopic chaotic topological space. Then

(i) sclNC(sintNC(A)) = sintNC(A) ∪ intNC(clNC(intNC(A)))

(ii) sintNC(sclNC(A)) = sclNC(A) clNC(intNC(clNC(A)))

Proof: We have sclNC(sintNC(A)) = sintNC(A) ∪ intNC(clNC(sintNC(A))) = sintNC(A) ∪ intNC (clNC[A clNC (intNC(A)]) sintNC(A) intNC [clNC(A) clNC (clNC (intNC(A)))] = sintNC(A) ∪ intNC [clNC (intNC (A))]

To establish the opposite inclusion we observe that,

sclNC (sintNC (A)) = sintNC(A) intNC(clNC(sintNC(A)) sintNC(A) ∪ intNC(clNC(intNC (A))).

Therefore we have sclNC(sintNC(A)) = sintNC(A) ∪ intNC(clNC(intNC(A))).

This proves (i).

The proof for (ii) is analogous.

**3.18 Theorem**  Let A be a neutrosophic chaotic set in neutrosopic chaotic topological space. Then

(i) pclNC(pintNC(A)) = pintNC(A) ∪ clNC(intNC(A))

(ii) pintNC(pclNC(A)) = pclNC(A) intNC(clNC(A))

Proof: We have pclNC(pintNC(A)) = pintNC(A) ∪ clNC(intNC(pintNC(A))) = pintNC (A) ∪ clNC(intNC [A intNC(clNC (A))] = pintNC(A) ∪ clNC[intNC(A) intNC(intNC(clNC(A)))] = pintNC(A) ∪ clNC (intNC(A))

To establish the opposite inclusion we observe that,

pclNC(pintNC(A)) = pintNC(A) ∪ intNC(clNC(pintNC(A)) pintNC(A) ∪ intNC(clNC(intNC(A))).

Therefore we have pclNC(pintNC(A)) = pintNC(A) ∪ clNC(intNC(A))

This proves (i).

Analogously (ii) can be proved.

**3.19 Theorem**  Let (X, τ,) be a neutrosopic chaotic topological space. If A is a neutrosophic chaotic open set and B is a neutrosophic chaotic b- open set in X. Then AB is a neutrosophic chaotic b- open set in X.

Proof: Let A be a neutrosophic chaotic open set and B is a neutrosophic chaotic b- open set.

Now, M= AB = intNC(A) bintNC(A)bintNC(A) bintNC(A)= bintNC(A B)= bintNC(M)

(i.e) M bintNC(M). But bintNC(M) M. Hence, M= bintNC(M). (i.e) M= AB is a neutrosophic chaotic b- open set.

**3.20 Theorem**  Let (X, τ,) be a neutrosopic chaotic topological space. If A is a neutrosophic chaotic - open set and B is a neutrosophic chaotic b- open set in X. Then AB is a neutrosophic chaotic b- open set in X.

Proof: Let A be a neutrosophic chaotic - open set and B is a neutrosophic chaotic b- open set.

Now, M= AB = intNC(A) bintNC(A)bintNC(A) bintNC(A)= bintNC(A B)= bintNC(M)

(i.e) M bintNC(M). But bintNC(M) M. Hence, M= bintNC(M). (i.e) M= AB is a neutrosophic chaotic b- open set.

**3.21 Theorem** If A be a subset of a space (X, τ,), then bintNC(bclNC(A))= bclNC(bintNC(A)).

Proof: LetA be a subset of a space (X, τ,), Now, bintNC(bclNC(A))=sintNC(bclNC(A)) pintNC(bclNC(A)) = bclNC(sintNC(A)) pintNC(bclNC(A)) = sclNC(sintNC(A)) pintNC(pclNC(A))--(1)

And bclNC(bintNC(A))=bclNC(sintNC (A) pintNC(A)) = bclNC(sintNC(A)) bclNC(pintNC(A)) = sclNC(sintNC(A)) pintNC(pclNC(A))-----(2)

Hence from (1) and (2) we get bintNC(bclNC(A))= bclNC(bintNC(A)).

Hence the theorem.

**4. Conclusion**

With the induction of the above definitions in neutrosophic chaotic topological spaces. We can extend its scope by generalizing this new concept. This would open new avenues of research in the existing neutrosophic topological setting.

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