VOLUME-7, ISSUE-8, AUGUST-2018 • PRINT ISSN No 2277 - 8160

Original Research Paper

Science

A NOTE ON FUZZY SOFT σ - BAIRE SPACES

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ABSTRACT In this paper we investigate several characterizations of fuzzy soft σ - Baire spaces and study the conditions under which a fuzzy soft topological space becomes a fuzzy soft σ - Baire space.

KEYWORDS : Fuzzy soft σ -nowhere dense set, fuzzy soft σ- first category space, fuzzy soft σ- second category space. fuzzy soft σ - Baire spaces.

INTRODUCTION

The concept of fuzzy sets and fuzzy soft set operations was first introduced by L.A ZADEH in his classical paper [20] in the year 1965. This concept provides a natural foundation for treating mathematically the fuzzy soft phenomena which exist pervasively in our heal world and for new branches of fuzzy soft mathematics . Thereafter the paper of C.L.CHANG [2] tremendous growth of the numerous fuzzy soft topological concepts. Since then much attention has been paid to generalize the attention the basic concepts of general topology in fuzzy setting and this a modern theory of fuzzy soft topology has been developed.

The concept of Baire space have been studied extensively in classical topology in [3-5, 15]. In 2013 the concept of Baire space in fuzzy setting was introduced and studied by G.Thangaraj and S.Anjamose [19].

Molodtsov [14] initiated the theory of soft sets as a new mathematical tool for dealing with uncertainties which traditional mathematical tools cannot handle. he has shown several applications of this theory in solving any practical problems in economics, engineering, social science, medical social, etc. later other authors like Maji et al. [6,12,13] have further studied the theory of soft sets and used this theory to solve some decision making problems. Next, the concept of fuzzy soft set is introduced and studied [7-9,10,11] a more generalized concept, which is a combination of fuzzy set and studied its properties since then much attention has been paid to generalize the basic concepts of fuzzy topology in soft setting and this a modern theory of fuzzy soft topology has been developed.

2. PRELIMINARIES

Definition 2.1[10]: The fuzzy soft set $F_\phi \in FS(U, E)$ is said to be null fuzzy soft set and it is denoted by ϕ, if for all $e \in E$, $F(e)$ is the null fuzzy soft set $\bar{0}$ of U, where $\bar{0}(x) = 0$ for all $x \in U$.

Definition 2.2 [10]: Let $F_E \in FS(U, E)$ and $F_E(e) = \bar{1}$ for all $e \in E$, where $\bar{1}(x) = 1$ for all $x \in U$. Then F_E is called absolute fuzzy soft set. It is denoted by $\bar{E}$.

Definition 2.3[10]: A fuzzy soft set F_A is said to be a fuzzy soft subset of a fuzzy soft set G_B over a common universe U if $A \subseteq B$ and $F_A(e) \subseteq G_B(e)$ for all $e \in A$, i. e., if $\mu^e_{F_A}(x) \leq \mu^e_{G_B}(x)$ for all $x \in U$ and for all $e \in E$ and denoted by $F_A \subseteq G_B$.

Definition 2.4[10]: Two fuzzy soft sets F_A and G_B over a common universe U are said to be fuzzy soft equal if F_A is a fuzzy soft subset of G_B and G_B is a fuzzy soft subset of F_A .

Definition 2.5[10]: The union of two fuzzy soft sets F_A and G_B over the common universe U is the fuzzy soft set H_C, defined by $H_C(e) = \mu^e_{H_C} = \mu^e_{F_A} \cup \mu^e_{G_B}$ for all $e \in E$, where $C = A \cup B$. Here we write $H_C = F_A \tilde{\vee} G_B$.

Definition 2.6[10]: Let F_A and G_B be two fuzzy soft set, then the intersection of F_A and G_B is a fuzzy soft set H_C, defined by $H_C(e) = \mu^e_{H_C} = \mu^e_{F_A} \cap \mu^e_{G_B}$ for all $e \subset E$, where $C = A \cap B$. Here we write $H_C = F_A \tilde{\wedge} G_B$.

Definition 2.7[1]: Let $F_A \in FS(U, E)$ be a fuzzy soft set. Then the complement of F_A, denoted by F^C_A , defined by

$$F^C_A(e) = \begin{Bmatrix} \bar{1} - \mu^e_{F_A}, & \text{if } e \in A \\ \bar{1}, & \text{if } e \notin A. \end{Bmatrix}$$

Definition 2.8[18]: Let ψ be the collection of fuzzy soft sets over U. Then ψ is called a fuzzy soft topology on U if ψ satisfies the following axioms:

(i) ϕ, $\bar{E}$ belong to ψ.

(ii) The union of any number of fuzzy soft sets in ψ belongs to ψ.

(iii) The intersection of any two fuzzy soft sets ψ belongs to ψ.

The triplet (U, E,) is called a fuzzy soft topological space over U. The members of are called fuzzy soft open sets in U and complements of them are called fuzzy soft closed sets in U.

Definition 2.9[17]: The union of all fuzzy soft open subsets of F_A over (U, E) is called the

Definition 2.9[17]: The union of all fuzzy soft open subsets of F_A over (U, E) is called the interior of F_A and is denoted by $int^{fs}(F_A)$.

Proposition 2.1[17]: $int^{fs}(F_A \tilde{\wedge} G_B) = \text{int}\ (\ ) \tilde{\wedge}\ int^{fs}(G_B)$.

Definition 2.10 [17]: Let $F_A \in FS(U, E)$ be a fuzzy soft set. Then the intersection of all closed sets, each containing F_A , is called the closure of F_A and is denoted by $cl^{fs}(F_A)$.

Remarks 2.1 [17]:

(1) For any fuzzy soft set F_A in a fuzzy soft topological space (U, E, ψ), it is easy to see that $(cl^{fs}(F_A))^c = int^{fs}(F^C_A)$ and $(int^{fs}(F_A))^c = cl^{fs}(F^C_A)$.

(2) For any fuzzy soft F_A subset of a fuzzy soft topological space (U, E, ψ,), we define the fuzzy soft subspace topology ψ_{F_A} on F_A by $K_D \in \psi_{F_A}$ if $K_D = F_A \tilde{\wedge} G_B$ For some $G_B \in \psi$.

(3) For any fuzzy soft H_C in F_A fuzzy soft subspace of a fuzzy soft topological space, we denote to the interior and closure of H_C in F_A by $int^{fs}_{F_A}(H_C)$ and $cl^{fs}_{F_A}(H_C)$, respectively.

3. FUZZY SOFT σ -BAIRE SPACES

Definition 3.1[16] : Let (U, E, ψ) be a fuzzy soft topological space. Then (U, E, ψ) is called a Fuzzy soft σ- Baire space if $\text{int}^{fs}(\vee_{i=1}^{\infty}(F_{A_i})) = 0$, where F_{A_i}' s are fuzzy soft σ - nowhere dense sets in (U, E, ψ).

Example 3.1: Let U = { C_1 , C_2 , C_3 } be the set of three flats and E = { e_1, e_2, e_3}, where e_1, e_2, e_3 stand for costly, modern, security services. Then we consider

$$F_E = \begin{bmatrix} .6 & .5 & .7 \\ .6 & .4 & .6 \\ .5 & .3 & .4 \end{bmatrix}, G_E = \begin{bmatrix} .6 & .8 & .7 \\ .4 & .7 & .7 \\ .3 & .6 & .5 \end{bmatrix}, H_E = \begin{bmatrix} .6 & .5 & .8 \\ .5 & .3 & .7 \\ .4 & .2 & .6 \end{bmatrix}$$

$T^1_E = F_E \wedge G_E$, $T^2_E = F_E \wedge H_E$, $T^3_E = G_E \wedge H_E$, $T^4_E = F_E \vee G_E$, $T^5_E = F_E \vee H_E$, $T^6_E = G_E \vee H_E$, $T^7_E = F_E \wedge (G_E \vee H_E)$, $T^8_E = \ \vee (G_E \wedge H_E)$, $T^9_E = G_E \wedge (F_E \vee H_E)$, $T^{10}_E = G_E \vee (F_E \wedge H_E)$, $T^{11}_E = H_E \wedge (F_E \vee H_E)$, $T^{12}_E = H_E \vee (F_E \wedge \ )$, $T^{13}_E = F_E \vee G_E \vee H_E$ and $T^{14}_E = F_E \wedge G_E \wedge H_E$.

Now, consider the fuzzy soft sets $\alpha = (1 - F_E) \vee (1 - T^8_E) \vee (1 - T^{13}_E) = \begin{bmatrix} .4 & .5 & .3 \\ .4 & .6 & .4 \\ .5 & .7 & .6 \end{bmatrix}$,

$\beta = (1 - G_E) \vee (1 - T^5_E) \vee (1 - T^{10}_E) = \begin{bmatrix} .4 & .5 & .3 \\ .6 & .6 & .3 \\ .7 & .7 & .5 \end{bmatrix}$ and $\vartheta = (1 - H_E) \vee (1 - T^1_E) \vee (1 - T^4_E) \vee (1 - T^6_E) = \begin{bmatrix} .4 & .5 & .3 \\ .6 & .7 & .4 \\ .7 & .8 & .6 \end{bmatrix}$ in (U, E, ψ). Then α, β and ϑ are fuzzy soft F_σ - sets in (U, E, ψ) and $int^{fs}(\alpha) = 0$, $int^{fs}(\beta) = 0$ and $int^{fs}(\vartheta) = 0$. Then α, β and ϑ are fuzzy soft σ - nowhere dense sets in (U, E, ψ). Moreover, $(1 - T^2_E) \vee (1 - T^3_E) \vee (1 - T^7_E) \vee (1 - T^9_E) \vee (1 - T^{11}_E) \vee (1 - T^{12}_E) \vee (1 - T^{14}_E) = \vartheta$ and also $int^{fs}(\alpha \vee \beta \vee \vartheta) = int^{fs}(\vartheta) = 0$ and therefore ($U, E,$) is a fuzzy soft σ - Baire Space.

Theorem 3.1[16]: Let (U, E , ψ) be a fuzzy soft topological space. Then the following are equivalent:

(1) (U, E , ψ) is a fuzzy soft σ - Baire space.

(2) $\text{int}^{fs}(F_A) = 0$ for every fuzzy soft σ -first category set F_A in (U, E , ψ).

(3) $cl^{fs}(G_B) = 1$ for every fuzzy soft σ - residual set G_B in (U, E , ψ).

Theorem 3.2[16]: If is a fuzzy soft dense and fuzzy G_δ - set in a fuzzy soft topological space (U, E , ψ), then $1 - F_A$ is a fuzzy soft first category *set* in (U, E , ψ).

Theorem 3.3[16]: In a fuzzy soft topological space (U, E , ψ), a fuzzy soft set F_A is a fuzzy soft σ - nowhere dense set in (U, E , ψ) if and only if $1 - F_A$ is a fuzzy soft dense and fuzzy soft

G_δ - set in (U, E , ψ).

Proposition 3.1: If the fuzzy soft topological space (U, E , ψ) is a fuzzy soft σ - Baire space, then cl^{fs} [$\wedge_{i=1}^{\infty}$ (F_{A_i})] =1, where the fuzzy soft sets (F_{A_i})'s (i = 1to ∞) are fuzzy soft dense and fuzzy soft G_δ -sets in (U, E , ψ).

Proof. Let (F_{A_i})'s (i=1to ∞) be fuzzy soft dense and fuzzy soft G_δ - sets in (U,E, ψ). By theorem 3.3, $(1- F_{A_i})$'s are fuzzy soft σ - nowhere dense sets in (U,E, ψ). Then the fuzzy soft set F_A $=\vee_{i=1}^{\infty}(1- F_{A_i})$ is a fuzzy soft σ - first category set in (U,E, ψ). Now int^{fs} (F_A) = int^{fs} ($\vee_{i=1}^{\infty}(1- F_{A_i}$)) = int^{fs} (1– [$\wedge_{i=1}^{\infty}$ (F_{A_i})]) =1– cl^{fs} [$\wedge_{i=1}^{\infty}(F_{A_i})$]. Since (U, E, ψ) is a fuzzy soft σ - Baire space , by theorem 3.1, we have int^{fs} (F_A) = 0. Then 1– cl^{fs} [$\wedge_{i=1}^{\infty}$ (F_{A_i})] = 0. This implies that cl^{fs} [$\wedge_{i=1}^{\infty}$ $(F_{A_i}$)] =1.

Proposition 3.2: If the fuzzy soft topological space (U,E, ψ) is a fuzzy soft σ - Baire space , then int^{fs} ($\vee_{i=1}^{\infty}(1–F_{A_i})$)=0 , where the fuzzy soft sets $(1– F_{A_i})$'s (i=1 to ∞) are fuzzy soft first category sets formed from the fuzzy soft dense and fuzzy soft G_δ - sets F_{A_i} in (U,E, ψ).

Proof. Let the fuzzy soft topological space (U,E, ψ) is a fuzzy soft σ - Baire space and the fuzzy soft sets $(F_{A_i}$)'s (i=1 to ∞) be fuzzy soft dense and fuzzy soft G_δ - sets in (U,E, ψ). By proposition 3.1, cl^{fs} [$\wedge_{i=1}^{\infty}(F_{A_i}$)]=1. Then 1–cl^{fs} [$\wedge_{i=1}^{\infty}(F_{A_i}$)]=0.This implies that int^{fs} ($\vee_{i=1}^{\infty}(1– F_{A_i})$) = 0. Also by theorem 3.2, (1– F_{A_i})'s are fuzzy soft first category sets in (U,E, ψ). Hence int^{fs} ($\vee_{i=1}^{\infty}$ (1– F_{A_i})) = 0. where the fuzzy soft sets $(1– F_{A_i})$'s (i = 1 to ∞) are fuzzy soft first category sets formed from the fuzzy soft dense and fuzzy soft G_δ- sets F_{A_i} in (U,E, ψ).

Theorem 3.4[16]: Let (U,E ,ψ) be a fuzzy soft topological space. Then the following are equivalent:

(1) (U,E, ψ) is a fuzzy soft Baire space.

(2) int^{fs} (F_A)=0 for every fuzzy soft first category set F_A in (U,E, ψ).

(3) cl^{fs} (G_B)=1 for every fuzzy soft residual set G_B in (U,E, ψ).

Proposition 3.3: If the fuzzy soft first category sets are formed from the fuzzy soft dense and fuzzy soft G_δ - sets in a fuzzy soft σ -Baire space (U,E, ψ), then (U,E, ψ) is a fuzzy soft

Proof. Let the fuzzy soft topological space (U,E, ψ) be a fuzzy soft σ - Baire space. By proposition 3.2, int^{fs} ($\vee_{i=1}^{\infty}(1–F_{A_i}$))=0,where the fuzzy soft sets $(1–F_{A_i}$)'s (i=1 to ∞) are fuzzy soft first category sets formed from the fuzzy soft dense and fuzzy soft G_δ - sets F_{A_i} in (U,E, ψ). Now $\vee_{i=1}^{\infty}$[$int^{fs}(1–F_{A_i})$] ≤ int^{fs} ($\vee_{i=1}^{\infty}$ [1–F_{A_i}]) , Then we have $\vee_{i=1}^{\infty}$[$int^{fs}(1–F_{A_i})$] = 0. This implies that int^{fs} $(1–F_{A_i})$= 0, where $(1–F_{A_i})$ is a fuzzy soft first category set in (U, E , ψ). By theorem 3.4,(U, E, ψ) is a fuzzy soft Baire space.

Definition 3.2 [16] : A fuzzy soft topological space (U, E , ψ) is called fuzzy soft σ- first category if the fuzzy soft set 1_X is a fuzzy soft σ-first category set in (U, E , ψ). That is, 1_X= $\vee_{i=1}^{\infty}(F_{A_i})$, where $(F_{A_i}$)'s are fuzzy soft σ - nowhere dense sets in (U, E , ψ) otherwise, (U, E , ψ) will be called a fuzzy soft σ - second category space.

Proposition 3.4: If the fuzzy soft topological space (U, E , ψ) is a fuzzy σ - first category space, then (U, E , ψ) is not a fuzzy soft σ - Baire space.

Proof. Let the fuzzy soft topological space (U, E , ψ) is a fuzzy soft σ - first category space. Then $\vee_{i=1}^{\infty}$ (F_{A_i}) = 1_X , where (F_{A_i})'s are fuzzy σ - nowhere dense sets in (U, E , ψ). Now int^{fs} ($\vee_{i=1}^{\infty}$ (F_{A_i})) = int^{fs} (1_X)=1 ≠0. Hence by definition, (U, E , ψ) is not a fuzzy σ - Baire space.

Proposition 3.5: If $\wedge_{i=1}^{\infty}$ (F_{A_i}) ≠ 0, where the fuzzy soft sets (F_{A_i})'s are fuzzy soft dense and fuzzy soft G_δ- sets in a fuzzy soft topological space (U, E , ψ), then (U, E , ψ) is a fuzz soft σ -second category space.

Proof. Let (F_{A_i})'s (i=1 to ∞) are fuzzy soft dense and fuzzy soft G_δ- sets in (U, E , ψ). By theorem 3.3, $(1–F_{A_i})$'s are fuzzy soft σ - nowhere dense sets in (U, E , ψ). Now $\wedge_{i=1}^{\infty}$ $(F_{A_i}$) ≠0 implies that 1– $\wedge_{i=1}^{\infty}$ (F_{A_i}) ≠1. Then $\vee_{i=1}^{\infty}(1–F_{A_i})$≠1. Hence (U, E , ψ) is not a fuzzy soft σ - first category space and therefore (U, E , ψ) is a σ - second category space.

Proposition 3.6: If is a fuzzy soft σ - first category set in (U, E , ψ), then there is a fuzzy soft F_σ -set G_B in (U, E , ψ) such that F_A ≤ G_B.

Proof. Let be a fuzzy soft σ - first category set in (U, E , ψ). Then $F_A = \vee_{i=1}^{\infty}(F_{A_i}$) where F_{A_i}'s are fuzzy soft σ - nowhere dense sets in (U, E , ψ). Now [1– cl^{fs} (F_{A_i})]'s are fuzzy soft open sets in (U, E , ψ). Then G_B = $\wedge_{i=1}^{\infty}$ (1– cl^{fs} (F_{A_i})) is a fuzzy soft G_δ- set in (U, E , ψ) and 1– G_B =1– [$\wedge_{i=1}^{\infty}$ (1– cl^{fs} (F_{A_i}))]= $\vee_{i=1}^{\infty}(cl^{fs}$ (F_{A_i})). Now $F_A = \vee_{i=1}^{\infty}(F_{A_i})$ ≤ $\vee_{i=1}^{\infty}(cl^{fs}$ (F_{A_i})) =1 – G_B. That is, F_A ≤ 1– G_B and 1– G_B is a fuzzy soft F_σ - set in (U, E , ψ). Let H_C = 1– G_B. Hence , if F_A is a fuzzy soft σ- first category set in (U, E , ψ), then there is a fuzzy soft F_σ - set H_C in (U, E , ψ) such that F_A ≤ H_C .

Proposition 3.7: If F_A is a fuzzy soft σ- residual set in a fuzzy soft topological space (U, E , ψ) Such that H_A ≤ F_A, where H_A is a fuzzy soft dense and fuzzy soft G_δ - set in (U, E , ψ), then (U, E , ψ) is a fuzzy soft σ - Baire space.

Proof. Lets F_A be a fuzzy soft σ - residual set in a fuzzy soft topological space (U, E , ψ). Then 1– F_A is a fuzzy soft σ -first category set in (U, E , ψ). Now by proposition 3.6, there is a fuzzy soft F_σ -set G_B in (U, E , ψ). such that 1– F_A ≤ G_B. This implies that 1– G_B ≤ F_A Let H_A = 1– G_B.Then H_A is a fuzzy soft G_δ - set in (U, E , ψ) and H_A ≤ F_A implies that cl^{fs} (H_A) cl^{fs} (F_A). if cl^{fs} (H_A)=1, than we have cl^{fs} (F_A) = 1. Hence , by theorem 3.4, (U, E , ψ) is a fuzzy soft σ - Baire space.

Proposition 3.8: If the fuzzy soft topological space (U, E , ψ) is a fuzzy soft σ - Baire space and if $\vee_{i=1}^{\infty}(F_{A_i})$ = 1 , then there exists atleast one F_σ- set F_{A_i} such that int^{fs} (F_{A_i})≠ 0.

Proof. Suppose that int^{fs} (F_{A_i}) = 0, for i=1 to ∞, where (F_{A_i})'s for fuzzy soft σ - nowhere dense sets in (U, E , ψ).Then $\vee_{i=1}^{\infty}(F_{A_i})$ = 1. implies that int^{fs} [$\vee_{i=1}^{\infty}(F_{A_i})$] = int^{fs}[1] = 1≠ 0, a contradiction to (U, E , ψ) being a fuzzy soft σ - Baire space. Hence int^{fs} (F_{A_i}) ≠ 0, for atleast one F_σ - set F_{A_i} in (U, E , ψ).

Proposition 3.9: If the fuzzy soft topological space (U, E , ψ) is a fuzzy soft σ - Baire space , then no non-zero a fuzzy soft open set is a fuzzy soft σ - first category set in (U, E , ψ).

Proof. Let F_A be a non-zero fuzzy soft open set in a fuzzy soft σ - Baire space (U, E , ψ). suppose that F_A $=\vee_{i=1}^{\infty}$ (F_{A_i}) where the fuzzy soft sets (F_{A_i})'s are fuzzy soft σ - nowhere dense sets in (U, E , ψ). Then int^{fs} (F_A) = int^{fs}($\vee_{i=1}^{\infty}(F_{A_i})$). Since (U, E , ψ) is a fuzzy soft σ- Baire space, int^{fs} ($\vee_{i=1}^{\infty}(F_{A_i})$) = 0. This implies that int^{fs} (F_A) = 0. Then we will have F_A=0, which is a contradiction, since F_A ∈ T implies that int^{fs} (F_A) = F_A ≠0. Hence no non - zero fuzzy soft open set is a fuzzy soft σ -first category set in (U, E , ψ).

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