ON FUZZY SUPRA P-SPACES

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Abstract

In this paper we introduced and studied the concepts of fuzzy supra P-spaces. Also we discuss several characterizations and properties of fuzzy supra P-spaces are introduced. Several examples are given to illustrate the concepts.

Keywords: *Fuzzy supra F_σ-set, Fuzzy supra G_δ-set, Fuzzy supra nowhere dense set, Fuzzy supra dense set.*

1. Introduction

In the year 1965, L. A.Zadeh [12] was first introduced the concept of fuzzy sets and fuzzy set operations in his classical paper. In 1968, the theory of fuzzy topological spaces was introduced and developed by C.L.Chang [3].

In 1983, Mashhour.A.S.et.al., [5] introduced and studied the concept of Supra topological spaces. In 1987, AbdEl-monsef et.at [1] introduced the concepts of fuzzy supra topological as a natural generalization of the notion of supra topological spaces.

In 1972, Mishra.A.K [6] introduced the concepts of P-spaces as a generalization of ω_α-additive spaces of Sikorski [10] and Cohen.L.W and Goffman.C [4]. The concept of P-spaces in fuzzy setting was introduced by Thangaraj.G and Balasubramanian.G [11].

In this paper introduced and studied the concepts of fuzzy supra P-spaces. Several examples are given to illustrate the concepts. It is established that fuzzy supra σ-boundary sets are fuzzy supra closed sets, fuzzy supra co-σ-boundary sets are fuzzy supra open sets in fuzzy supra P-spaces.

2. Preliminaries

Definition 2.1 [1].

A collection T^* of fuzzy sets in a set U is called fuzzy supra topology on U if the following conditions are satisfied:

1) **0** and **1** belongs to T^*.

2) $g_\chi \in T^*$ for each $\chi \in \Lambda$ implies $(\vee_{\chi \in \Lambda} g_\chi) \in T^*$.

The pair (U,T^*) is called a fuzzy supra topological space. The elements of T^* are called fuzzy supra open sets and the complement of a fuzzy supra open set is called fuzzy supra closed set.

Definition: 2.2 [9]

Let (U,T^*) be a fuzzy supra topological space and μ be a fuzzy set in U, then the fuzzy supra closure and fuzzy supra interior of μ defined respectively as

$cl^*(\mu) = \wedge \{ g / g$ is a fuzzy supra closed set in U and $\mu \leq g\}$

$int^*(\mu) = \vee \{ g / g$ is a fuzzy supra open set in U and $g \leq \mu\}$

Definition: 2.3 [9]

Let (U,T) be a fuzzy topological space and T^* be a fuzzy supra topology on U. We call T^* a fuzzy supra topology associated with T if $T \leq T^*$.

Remark: 2.4 [9]

1) The fuzzy supra closure of a fuzzy set μ in a fuzzy supra topological space is the smallest fuzzy supra closed set containing μ.

2) The fuzzy supra interior of a fuzzy set μ in a fuzzy supra topological space is the largest fuzzy supra open set contained in μ.

3) If (U,T^*) is an associated fuzzy supra topological space with the fuzzy topological space (U,T) and μ is any fuzzy set in U, then $int(\mu) \leq int^*(\mu) \leq \mu \leq cl^*(\mu) \leq cl(\mu)$

Lemma 2.5 [3]

For a fuzzy set μ in a fuzzy topological space U,

(i) $1 - int(\mu) = cl(1- \mu)$,

(ii) $1 - cl(\mu) = int(1 - \mu)$.

Definition 2.6 [7]

A fuzzy supra open set μ in fuzzy supra topological space (U,T^*) is called fuzzy supra F_σ-set in (U,T^*) if $\mu = \vee_{i=1}^{\infty} (\mu_i)$, where $1 - \mu_i \in T^*$ for $i \in I$,

Definition 2.7 [7]

A fuzzy supra open set μ in fuzzy supra topological space (U,T^*) is called fuzzy supra G_δ-set in (U,T^*) if $\mu = \wedge_{i=1}^{\infty}(\mu_i)$, where $\mu_i \in T^*$ for $i \in I$.

Definition 2.8 [7]

A fuzzy set μ in a fuzzy supra topological space (U,T^*) is called a fuzzy supra dense set if there exists no fuzzy supra closed set β in (U,T^*) such that $\mu<\beta<1$. That is, $cl^*(\mu)=1$, in (U,T^*).

Definition 2.9 [8]

A fuzzy set μ in fuzzy supra topological space (U,T^*) is called a fuzzy supra nowhere dense set if there exists no non-zero fuzzy supra open set δ in (U,T^*) such that $\delta < cl^*(\mu)$. That is, $int^*cl^*(\mu)=0$, in (U,T^*).

Definition 2.10 [8]

A fuzzy set μ in a fuzzy supra topological space (U,T^*) is called a fuzzy supra first category set if $\mu = \vee_{i=1}^{\infty}(\mu_i)$, where (μ_i)'s are fuzzy supra nowhere dense set in (U,T^*). Any other fuzzy set in (U,T^*) is said to be fuzzy supra second category space.

3. Fuzzy Supra P-Spaces

Definition 3.1

A fuzzy supra topological space (U,T^*) is called a fuzzy supra P-space if countable intersection of fuzzy supra open sets in (U,T^*) is fuzzy supra open. That is., every non- zero fuzzy supra $G_{\square}$-set in (U,T^*) is fuzzy supra open set in (U,T^*).

Example 3.1

Let U={x,y,z}.The fuzzy sets μ_1, μ_2 and μ_3□are defined on U as follows:

μ_1:U□[0,1] is defined as $\mu_1(x)=0.2$; $\mu_1(y)=0.3$; $\mu_1(z)=0.1$.

μ_2:U□[0,1] is defined as $\mu_2(x)=0.3$; $\mu_2(y)=0.4$; $\mu_2(z)=0.4$.

μ_3:U□[0,1] is defined as $\mu_3(x)=0.1$; $\mu_3(y)=0.2$; $\mu_3(z)=0.3$.

Then, T^*= {0, μ_1, μ_2, μ_3, (μ_1□μ_2), (μ_1□μ_3), (μ_2□μ_3), (μ_1□μ_2), (μ_1□μ_3), (μ_2□μ_3), [μ_1□(μ_2□μ_3)], [μ_1□(μ_2□μ_3)], (μ_1□μ_2□μ_3), (μ_1□μ_2□μ_3), 1} is a fuzzy supra topology on U. Now the fuzzy sets μ_1□μ_3= {μ_1□□μ_1□μ_2□□□μ_1□μ_2□□(μ_2□μ_3)} and μ_1□μ_2 = {μ_2□(μ_2□μ_3) □□[μ_1□(μ_2□μ_3)]□□[μ_1□(μ_2□μ_3)]} are fuzzy supra $G_{\square}$-sets in (U,T^*) and μ_1□μ_3, μ_1□μ_2 are fuzzy supra open sets in (U,T^*). Hence, (U,T^*) is a fuzzy supra P-space.

Example 3.2:

Let U={x,y,z}.The fuzzy sets μ_1, μ_2 and μ_3□are defined on U as follows:

μ_1:U□[0,1] is defined as $\mu_1(x)=0.3$; $\mu_1(y)=0.6$; $\mu_1(z)=0.2$.

μ_2:U□[0,1] is defined as $\mu_2(x)=0.5$; $\mu_2(y)=0.7$; $\mu_2(z)=0.4$.

μ_3:U□[0,1] is defined as $\mu_3(x)=0.7$; $\mu_3(y)=0.3$; $\mu_3(z)=0.4$.

Then, T^*= {0, μ_1, μ_2, μ_3, (μ_1□μ_2), (μ_1□μ_3), (μ_2□μ_3), (μ_1□μ_2), (μ_2□μ_3), (μ_1□μ_2□μ_3), 1} is a fuzzy supra topology on U. Now the fuzzy set λ = {μ_1□μ_2□μ_3□(μ_1□μ_2) □□(μ_1□μ_3)□□□□(μ_2□μ_3)□□□(μ_1□μ_2)□□(μ_2□μ_3)□□(μ_1□μ_2□μ_3)} is a fuzzy supra $G_{\square}$-set in (U,T^*). But λ is not a fuzzy supra open set in (U,T^*). Hence the fuzzy supra topological space (U,T^*) is not a fuzzy supra P-space.

Proposition 3.1.

If μ is a non-zero fuzzy supra F_σ–set in a fuzzy supra P- space (U,T^*), then μ is a fuzzy supra closed set in (U,T^*).

Proof.

Since μ is a non-zero fuzzy supra F_σ-set in (U,T^*), $\mu = \bigvee_{i=1}^{\infty}(\mu_i)$, where (μ_i)'s are fuzzy supra closed in (U,T^*). Then $1-\mu = 1-(\bigvee_{i=1}^{\infty}(\mu_i)) = \bigwedge_{i=1}^{\infty}(1-\mu_i)$. Now, (μ_i)'s are fuzzy supra closed set in (U,T^*), implies that (1□μ_i)'s are fuzzy supra open set in (U,T^*). Hence, we have $1-\mu = \bigwedge_{i=1}^{\infty}(1-\mu_i)$, where 1□$\mu_i$□$T^*$. Then 1□μ is a fuzzy supra G_δ-set in (U,T^*). Since (U,T^*) is a fuzzy supra P-space, 1□μ is fuzzy supra open in (U,T^*). Therefore μ is a fuzzy supra closed set in (U,T^*).

Proposition 3.2.

If the fuzzy supra topological space (U,T^*) is a fuzzy supra P-space, then $cl^*(\bigvee_{i=1}^{\infty}(\mu_i)) = \bigvee_{i=1}^{\infty} cl^*(\mu_i)$ where (μ_i)'s are non-zero fuzzy supra closed sets in (U,T^*).

Proof.

Let (μ_i)'s be non-zero fuzzy supra closed sets in a fuzzy supra P-space (U,T^*). Then $\mu = \bigvee_{i=1}^{\infty}(\mu_i)$, is a non–zero fuzzy supra F_σ–set in (U,T^*). Byproposition.3.1, μ is a fuzzy supra closed set in (U,T^*). Hence $cl^*(\mu)=\mu$, which implies that $cl^*\left(\bigvee_{i=1}^{\infty}(\mu_i)\right) = \bigvee_{i=1}^{\infty}(\mu_i) = \bigvee_{i=1}^{\infty} cl^*(\mu_i)$ [since (μ_i)'s are fuzzy supra closed, $cl^*(\mu)=(\mu)$]. Therefore $cl^*\left(\bigvee_{i=1}^{\infty}(\mu_i)\right) = \bigvee_{i=1}^{\infty} cl^*(\mu_i)$, where (μ_i)'s are fuzzy supra closed sets in

(U,T^*).

Proposition 3.3.

If (μ_i)'s are fuzzy supra regular closed sets in a fuzzy supra P-space (U,T^*), then $cl^*\left(\vee_{i=1}^{\infty}(\mu_i)\right)=\vee_{i=1}^{\infty}(\mu_i)$.

Proof.

Let (μ_i)'s be fuzzy supra regular closed sets in a fuzzy supra P-space (U,T^*). Then $(1-\mu_i)$'s are fuzzy supra open sets in (U,T^*). Let $\lambda=\wedge_{i=1}^{\infty}[1-\mu_i]$. Then λ is a non-zero fuzzy supra G_δ-set in (U,T^*). Since the fuzzy supra topological space (U,T^*) is a fuzzy supra P-space, $int^*(\lambda)=\lambda$, which implies that $\text{int}^*\left(\wedge_{i=1}^{\infty}[1-\mu_i]\right)=\wedge_{i=1}^{\infty}[1-\mu_i]$. Then, $1-cl^*\left(\vee_{i=1}^{\infty}(\mu_i)\right)=1-\vee_{i=1}^{\infty}(\mu_i)$. Hence, we have $cl^*\left(\vee_{i=1}^{\infty}(\mu_i)\right)=\vee_{i=1}^{\infty}(\mu_i)$.

Proposition 3.4.

If the fuzzy supra topological space (U,T^*) is a fuzzy supra P- space and if μ is a fuzzy supra first category set in (U,T^*), then μ is not a fuzzy supra dense set in (U,T^*).

Proof.

Assume the contrary. Suppose that μ is a fuzzy supra first category set in (U,T^*) such that $cl^*(\mu)=1$. Then, $\mu=\vee_{i=1}^{\infty}(\mu_i)$, where (μ_i)'s are fuzzy supra nowhere dense sets in (U,T^*). Now $1-cl^*(\mu_i)$ is a fuzzy supra open set in (U,T^*). Let $\lambda=\wedge_{i=1}^{\infty}\left[1-cl^*(\mu_i)\right]$. Then λ is a non-zero fuzzy supra G_δ-set in (U,T^*). Now we have $\wedge_{i=1}^{\infty}\left[1-cl^*(\mu_i)\right]=1-\vee_{i=1}^{\infty}cl^*(\mu_i)\leq 1-\vee_{i=1}^{\infty}(\mu_i)=1-\mu$. Hence $\lambda\leq 1\square\mu$. Then $int^*(\lambda)\leq int^*(1-\mu)=1-cl^*(\mu)=1-1=0$. That is, $int^*(\lambda)=0$. Since (U,T^*) is a fuzzy supra P-space, $\lambda=int^*(\lambda)$ which implies that $\lambda=0$, a contradiction to λ being a non-zero fuzzy supra G_δ-set in (U,T^*). Hence $cl^*(\mu)\neq 1$. Therefore μ is not a fuzzy supra dense set in (U,T^*).

Proposition 3.5.

If the fuzzy supra topological space (U,T^*) is a fuzzy supra P-space and if μ is a fuzzy supra first category set in (U,T^*), then μ is not a fuzzy supra nowhere dense set in (U,T^*).

Proof.

Let μ be a fuzzy supra first category set in a fuzzy supra P-space (U,T^*). Then, we have $\mu=\vee_{i=1}^{\infty}(\mu_i)$, where (μ_i)'s are fuzzy supra nowhere dense sets in (U,T^*). Now $\text{int}^*\text{cl}^*(\mu)=\text{int}^*\text{cl}^*\left(\vee_{i=1}^{\infty}(\mu_i)\right)\geq\text{int}^*\left(\vee_{i=1}^{\infty}cl^*(\mu_i)\right)$ and $\left[\vee_{i=1}^{\infty}cl^*(\mu_i)\right]$ is a fuzzy supra F_σ-set in (U,T^*). Since (U,T^*) is a fuzzy supra P-space, by Proposition.3.1, $\left[\vee_{i=1}^{\infty}cl^*(\mu_i)\right]$ is a non-zero fuzzy supra closed set in (U,T^*). Also interior of a fuzzy supra closed is a fuzzy supra regular open set, $\text{int}^*\left[\vee_{i=1}^{\infty}cl^*(\mu_i)\right]$ is a non-zero fuzzy supra regular open set in (U,T^*). Hence, we have $0\neq\text{int}^*\left[\vee_{i=1}^{\infty}cl^*(\mu_i)\right]\leq\text{int}^*cl^*(\mu)$ implies that $int^*cl^*(\mu)\neq 0$. Therefore, μ is not a fuzzy supra nowhere dense set in (U,T^*).

Proposition 3.6.

If μ is a fuzzy supra first category set in a fuzzy supra P-space (U,T^*) such that $\lambda\leq 1\square\mu$, where λ is a non-zero fuzzy supra dense and fuzzy supra G_δ-set in (U,T^*), then μ is a fuzzy supra nowhere dense set in (U, T^*).

Proof.

Let μ be a fuzzy supra first category set in (U,T^*). Then, $\mu=\vee_{i=1}^{\infty}(\mu_i)$, where (μ_i)'s are fuzzy supra nowhere dense sets in (U,T^*). Now, $1-cl^*(\mu_i)$ is a fuzzy supra open set in (U,T^*). Let $\lambda = \wedge_{i=1}^{\infty}[1-cl^*(\mu_i)]$. Then λ is a non-zero fuzzy supra G_δ-set in (U,T^*). Now, we have $\wedge_{i=1}^{\infty}\left[1-cl^*\left(\mu_i\right)\right]=1-\vee_{i=1}^{\infty}cl^*\left(\mu_i\right)\leq 1-\vee_{i=1}^{\infty}\left(\mu_i\right)=1-\mu.$ Hence, $\lambda\leq\left(1-\mu\right)$. Then we have $\mu \leq (1-\lambda)$. Now, $int^*cl^*(\mu) \leq int^*cl^*(1-\lambda)$, which implies that $int^*cl^*(\mu) \leq 1-cl^*int^*(\lambda)$. Since (U,T^*) is a fuzzy supra P-space, the fuzzy supra G_δ-set λ is fuzzy supra open set in (U,T^*) and $int^*(\lambda) = \lambda$. Therefore, $int^*cl^*(\mu) \leq 1-cl^*(\lambda)=1-1=0$ (since λ is fuzzy supra dense). Then, $int^*cl^*(\mu)=0$ and hence μ is a fuzzy supra nowhere dense set in (U,T^*).

Theorem 3.1.[8]

Let (U,T^*) be a fuzzy supra topological space. Then the following are equivalent:

(1) (U,T^*) is a fuzzy supra Baire space.

(2) $int^*(\lambda)=0$, for every fuzzy supra first category set λ in (U,T^*).

(3) $cl^*(\mu)=1$, for every fuzzy supra residual set μ in (U,T^*).

Proposition 3.7.

If μ is a fuzzy supra first category set in a fuzzy supra P-space (U,T^*) such that $\lambda \leq 1-\mu$, where λ is a non-zero fuzzy supra dense and fuzzy supra G_δ-set in (U,T^*), then (U,T^*) is a fuzzy supra Baire space.

Proof.

Let μ be a fuzzy supra first category set in (U,T^*). By Proposition.3.6, we have $int^*cl^*(\mu)=0$. Then $int^*(\mu) \leq int^*cl^*(\mu)$ implies that $int^*(\mu) = 0$ and hence by Theorem 3.1, (U,T^*) is a fuzzy supra Baire space.

Proposition 3.8.

If the fuzzy supra topological space (U,T^*) is a fuzzy supra P- space and if μ is a fuzzy supra dense and fuzzy supra first category set in (U,T^*), then there is no non-zero fuzzy supra G_δ-set λ in (U,T^*) such that $\lambda\leq 1-\mu$.

Proof.

Let μ be a fuzzy supra first category set in (U,T^*). By Proposition.3.6, we have a fuzzy supra G_δ-set λ in (U,T^*) such that $\lambda \leq 1-\mu$. Then, $int^*(\lambda) \leq int^*(1-\mu)$ implies that $int^*(\lambda) \leq 1-cl^*(\mu) = 1-1 = 0$ [since μ is fuzzy supra dense, $cl^*(\mu)=1$]. That is, $int^*(\mu)=0$. Since (U,T^*) is a fuzzy supra P-space, $int^*(\lambda)=\lambda$ and hence we have $\lambda=0$. Hence, if μ is a fuzzy supra dense and fuzzy supra first category set in (U,T^*), then there is no non-zero fuzzy supra G_δ-set λ in (U,T^*) such that $\lambda \leq 1-\mu$.

Definition 3.2.

A fuzzy set μ in a fuzzy supra topological space (U,T^*) is called a fuzzy supra σ-boundary set, if $\mu = \vee^{\infty}_{i=1}(\mu_i)$ where $\mu_i = cl^*(\mu_i) \wedge (1-\mu_i)$ and (μ_i)'s are fuzzy supra regular open sets in (U,T^*).

Proposition 3.9.

If μ is a fuzzy supra σ-boundary set in a fuzzy supra topological space (U,T^*), then μ is a fuzzy supra F_σ-set in (U,T^*).

Proof.

Let μ be a fuzzy supra σ-boundary set in a fuzzy supra topological space (U,T^*). Then $\mu = \vee^{\infty}_{i=1}(\mu_i)$, where $\mu_i = cl^*(\mu_i)\wedge (1-\mu_i)$ and (μ_i)'s are fuzzy supra regular open sets in (U,T^*). Since (μ_i) is a fuzzy supra regular open set in (U,T^*), $(1-\mu_i)$ is a fuzzy supra regular closed set in (U,T^*). This implies that $(1-\mu_i)$ is a fuzzy supra closed set in (U,T^*) and hence $cl^*(1-\mu_i) = 1-\mu_i$ in (U,T^*). Then $\mu_i = cl^*(\mu_i)$

$\wedge$ (1− μ_i) is a fuzzy supra closed set in (U,T*). Thus $\mu = \vee^{\infty}_{i=1}(\mu_i)$, where (μ_i)'s are fuzzy supra closed sets in (U,T*), implies that μ is a fuzzy supra F_σ-set in (U,T*).

Proposition 3.10.

If μ is a fuzzy supra σ-boundary set in a fuzzy supra P-space (U,T*), then μ is a fuzzy supra closed set in (U,T*).

Proof.

Let μ be a fuzzy supra σ-boundary set in (U,T*). Then, by Proposition 3.9, μ is a fuzzy supra F_σ-set in (U,T*) and 1-μ is a fuzzy supra G_δ-set in (U,T*). Since (U,T*) is a fuzzy supra P-space, the fuzzy supra G_δ-set, 1-μ is a fuzzy supra open set in (U,T*) and hence μ is a fuzzy supra closed set in (U,T*).

Definition 3.3.

A fuzzy set μ in a fuzzy supra topological space (U,T*) is called a fuzzy supra co-σ-boundary set if $\mu = \wedge_{i=1}^{\infty}(\mu_i)$, where μ_i = $int^*(1-\mu_i) \wedge (\mu_i)$ and (μ_i)'s are fuzzy supra regular open sets in (U,T*)

Proposition 3.11.

If μ is a fuzzy supra co-σ-boundary set in a fuzzy supra P-space (U,T*), then μ is a fuzzy supra open set in (U,T*).

Proof.

Let μ be a fuzzy supra co-$\sigma-$boundary set in (U,T*). Then, 1-μ is a fuzzy supra σ-boundary set in (U,T*). Since (U,T*) is a fuzzy supra P-space, by Proposition.3.10, 1-μ is a fuzzy supra closed set in (U,T*) and thus μ is a fuzzy supra open set in (U,T*).

4. Conclusion

In this paper, we introduced and studied the concepts of fuzzy supra P-spaces. Several characterizations and properties of these spaces are established. Suitable examples are given to illustrate the concepts. It is established that fuzzy supra σ-boundary sets are fuzzy supra closed sets and fuzzy supra F_σ-set, fuzzy supra co-σ-boundary sets are fuzzy supra open sets in fuzzy supra P-spaces.

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