Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189

http://amresearchreview.com/index.php/Journal/about

Advanced perspectives on Open sets in Fuzzy Topological Spaces; Definitions, Properties and Implications

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Received: January 22, 2026 **Accepted:** April 25, 2026 **Available Online:** April 30, 2026

ABSTRACT

Fuzzy topological spaces provide a fundamental frame work for modeling uncertainty and vagueness in mathematical analysis. In this paper, we present advanced perspectives on open sets in fuzzy topological spaces (X,t), where denotes a collection of fuzzy subsets satisfy in generalized topological axioms. We introduce refined definitions of fuzz open sets and investigate their structural properties under standard operation such as union($\overset{S}{}$) and intersection($\overset{T}{}$). Furthermore, we explore their relationships with classical topological concepts including closure(A), interior (A), and neighborhood systems. In addition, motivated by the expressive power of q-rung orthopair fuzzy sets (q-ROFSs), we briefly examine how these generalized fuzzy structures can be incorporated into the study of fuzzy topologies, providing enhanced flexibility in handling higher degrees of uncertainty. Several new results are established to extend classical properties of open sets into the fuzzy setting, highlighting both similarities and key distinctions from crisp topology.

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Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189

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The implications of these findings are discussed in terms of their theoretical significance and potential applications in domains dealing with imprecise information. This study contributes to the advancement of fuzzy topology and offers new directions for future research.

Keywords: Fuzzy topology, Open sets, q-ROFSs, Fuzzy closure, Fuzzy interior.

1 Introduction

Since 1965, professor Zadeh put forward the concept of fuzzy set in [1], and more and more researchers devoted themselves into the theories of fuzzy set and their application [2]. Through widespread use in various fields, fuzzy sets not only provide a broad opportunity to more effectively and logically quantify uncertainties, but also provide us with a practical way of expressing ambiguous concepts in natural language. Many systems based on 'crisp set theory' or 'two valued logics' are known to be some how difficult it is to handle imprecise, vague details. In that way, use of fuzzy sets will provide better solutions to more real-world problems. It is easier to evaluate the membership degree of an entity in a fuzzy set theory as opposed to the classical set.

Moreover, numerous extensions of fuzzy sets are proposed by researchers to handle more imprecise and ambiguous knowledge in everyday life, such as interval-evaluated fuzzy sets[3], type-2 fuzzy sets[4], fuzzy multiset [5], IFSs [6], hesitant fuzzy sets[7, 8], and Pythagorean fuzzy sets[9,10]. Because fuzzy sets were based on membership values or degrees between 0 and 1, it might not always be true that the degree of non-membership is equal to (1-member) in real life environment.

Accordingly, in order to obtain more purposeful reliability and applicability, Atanassov generalized the principle of 'fuzzy set theory' and suggested (IFSs) which include both the degree of membership and the degree of non-membership and the degree of non-determination or uncertainty where the degree of uncertainty = (1- (degree of membership + degree of non-membership)).

The sum of the degree of membership and the amount of non-membership of each ordered pair is less than or equal to 1. and relationships, including intersection, union, complement, algebraic number, and algebraic product, etc., and demonstrated a level playing field among IFS. Based on the algebraic number, algebraic product, and IFS operational rules, some aggregation operators were proposed to resolve the lack of accuracy in the final results by using binary operations to carry out the combination process.

Xu[11] developed some simple arithmetic aggregation operators, such as intuitive Fuzzy Weighted Average (IFWA) operator, intuitionist Fuzzy Weighted Average (IFOWA) operator, intuitionist Fuzzy Hybrid Averaging (IFHA) operator, to aggregate intuitional Fuzzy Values (IFVs). Xu and Yager [12] developed some simple geometric aggregation operators, such as intuitive Fuzzy Weighted Geometric (IFWG) operator, intuitive Fuzzy Weighted Geometric (IFOWG) operator and intuitive Fuzzy Geometric (IFHG) operator, and applied them to multiple IFS decision-making attributes (MADM).

Xu and Yager[13] have defined the dynamic IFWA operator and have developed a method for solving the dynamic intuitional MADM problems. Wei[14] has suggested and applied such induced geometric aggregation operators with intuitive fuzzy knowledge to group decision taking.

Zhao[15] has created some new generalized aggregation operators, such as IFWA generalized operator, IFOWA generalized operator. Li[16] expanded the generalized weighted average (GOWA)[17] operator to aggregate IFSs and developed a tool for resolving IFS MADM problems. Xia[18] developed a set of intuitive Fuzzy Point operators and developed specific generalized intuitive Fuzzy Point aggregation operators based on the concept of generalized aggregation[15,17].

Xu[19] and Tan and Chen[12] used the Choquet integral to suggest some intuitive fuzzy aggregation operators that

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Volume 4, Issue 4(2026)

Online ISSN 3007-3197
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not only take into account the value of the elements or their ordered locations, but can also represent the correlations between the elements or their positioning. Xu and Xia[21] applied the Evidence Theory of Choquet Integral and Dempster Shafer to aggregate intuitive fuzzy knowledge and developed generalized aggregation operators in intuitive fuzzy environments.

Xu[22] developed the intuitive Bonferroni Fuzzy Mean (IFBM) and applied the weighted IFBM to MADM. Recently, Xu and Cai[23] provided a survey of intuitive fuzzy information aggregation techniques and their implementations in various fields; furthermore, they examined their characteristics and relationships, and explored potential directions for future research in this area.

After the appearances of intuitionistic fuzzy set model Yager [24] generalize intuitionistic fuzzy set and presented a new set called Pythagorean fuzzy set. In [25] Eiegwa et al argued certain fundamental properties of Fuzzy intuition sets. There are many aggregation operators and its applications have been developed in [26, 27, 28] In this paper we introduce some basic definitions of Pythagorean fuzzy sets, several important operations on Pythagorean fuzzy sets, some basic algebraic laws of Pythagorean fuzzy sets, some model operators of Pythagorean fuzzy sets, and normalization of Pythagorean fuzzy sets.

In PFSs, the sum of squares of the degrees of membership and nonmembership is less than or equal to 1. For example, if a decision maker provides the membership degree 0.6 and nonmembership degree 0.7 in his evaluation, then this situation cannot handle by (IFSs)theory because of $0.6+0.7>1$. However, it is easily observed that $0.62+0.72<1$, that is to say, the Pythagorean fuzzy set (PFS) is capable to represent this evaluation information.

In other words, the PFSs are more powerful to handle problems in uncertain situations. Under (PFS) environment, many researchers have started work in different directions and obtained various significant results. Yager and Abbasov [29] established a relation between Pythagorean membership degrees and complex numbers and proved that the Pythagorean degrees are a subclass of complex numbers. Zhang and Xu [30] made a detailed study on Pythagorean fuzzy sets and proposed an extension of the TOPSIS method with Pythagorean fuzzy information.

Peng and Yang [31] defined the division and subtraction operations on PFNs. Reformat and Yager [32] studied the collaborative-based recommender systems under Pythagorean fuzzy environment.

Dick et al. [33] discussed some operations on Pythagorean and complex fuzzy sets. Ma and Xu [34] defined symmetric Pythagorean fuzzy weighted geometric/ averaging operators and studied their applications in multicriteria decision making. Peng and Yang [35] developed MABAC method under Pythagorean fuzzy environment. Zhang [36] discussed multicriteria Pythagorean fuzzy decision analysis using hierarchical QUALIFLEX approach with the closeness index based ranking methods. Zeng et al. [37] proposed a hybrid method for solving Pythagorean fuzzy multiple-criteria decision-making problems. Peng et al. [38] introduced some Pythagorean fuzzy information measures and discussed their applications.

Further, Zeng [39] developed a new method to solve Pythagorean fuzzy multiattribute group decision making problems. Compared with the IFS, the PFS generalizes the MD and the NMD to the square sum less than or equal to 1. However, with the increase of the complexity of decision-making problems and the contradictory psychology of policy makers, it is still difficult for PFS to express corresponding information.

Recently, Yager [40] again proposed the concept of the q-ROFS, in which MD u and NMD v satisfy $u^q+v^q<1$. We can see that the IFS and PFS are special cases of q-ROFS. As q-rung increases, the range of processing fuzzy information increases. IFN, PFN, and q-ROFN are abbreviations of intuitionistic fuzzy number, Pythagorean fuzzy number, and q-rung orthopair fuzzy number, respectively. Therefore , it can be seen that q-ROFS has stronger capability in dealing with uncertain information than the IFS and PFS.

Molodtsov [41] proposed the idea of soft set theory. Fuzzy soft set theory has many applications in various Lelds

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such as social sciences, physics, engineering, economics, computer science and medical sciences. Cagman et al. [42] proposed soft topology, FPFS-set theory and presented some applications of decision-making problems. Chang [43] studied the notion of fuzzy topological spaces. Samanta and Das [44, 45] introduced some basic properties of soft real sets and soft real numbers.

They also gave the idea of soft elements with soft points in soft sets and discussed soft metric spaces. Fenget al. studied soft sets and soft rough sets and they established some applications based on decision-making [46]. In [47] Huret al. studied Fuz equivalence relations, fuzzy partitions, fuzzy functions and fuzzy partially ordered sets. Junet al. [48] introduced various studied fuzzy subgroups based on fuzzy points. Kharal and Ahmad [49] delned mappings on soft classes, the images of soft sets and the inverse soft images.

Maji et al. [50] used soft sets theory in decision-making problems and delned some operations on soft sets. Samanta and Majumdar [51] introduced soft groups and discussed the soft images and inverse soft images. In [52] Rong proposed the countability of soft topology, discussed soft separable and soft Lindolof spaces and prove some important results using these terms.

In [53, 54] the idea of soft topology, fuzzy soft point and FS quasi-coincident with Q-neighborhood has studied. They studied various concepts including soft intersection semigroups, ideals and bi-Ideals. Shabir and Naz [55] introduced soft topology and soft topological spaces. Yildirim et al. [56] presented the notion of soft ideal for a soft topology and delned soft I-Baire spaces for a soft ideal topological space as well. Zorlutuna and Cakir [57] proposed soft continuity, soft openness, soft closeness of soft mappings in soft set theory.

The main purpose of this paper is to extend the fuzzy parameterized fuzzy soft topology . We define the concept of fuzzy parameterized q-rung soft set and q-rung soft topology. In this context, the results obtain in the present paper can be used to get more realistic results in the areas of research such as decision making, data analysis and machine learning. In the future works, categorical properties of q-rung soft topological spaces, applications of q-rung soft topological spaces on decision making theory.

2 Preliminaries

Definition 2.1. If G is collection of objects denoted generically by ℓ,then a fuzzy set F in G is a set of order pair;

$$\mathfrak{A} = \{(\ell, \Re_{\mathfrak{A}}(\ell))|\ \ell \in G\}.$$

$\Re_{\mathfrak{A}}(\ell)$ is called membership function, which maps G to the membership space M.Its range is the subset of non negative real number whose spermium is finite for $sup\Re_{\mathfrak{A}}(\ell) = 1$ normalized fuzzy set.

Definition 2.2. Let G be a fix set, then an IFS in G can be define as:

$$\mathfrak{S} = \{\ell, (\Re_{\mathfrak{S}}(\ell)), (\Im_{\mathfrak{S}}(\ell))|\ \ell \in G\}$$

where $\Re_{\mathfrak{S}}(\ell)$ and $\Im_{\mathfrak{S}}(\ell)$ are mapping from G to $[0, 1]$, with condition $0 \leq \Re_{\mathfrak{S}}(\ell) \leq 1$, $0 \leq \Im_{\mathfrak{S}}(\ell) \leq 1$ and $0 \leq (\Re_{\mathfrak{S}}(\ell)) + (\Im_{\mathfrak{S}}(\ell)) \leq 1$ for all $\ell \in G$ this called intuitionistic fuzzy set.

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Print ISSN 3007-3189
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Definition 2.3. Let G be a fix set, then an Pythagorean fuzzy set in G can be define as:

$$\mathfrak{S} = \{\ell, (\Re_{\mathfrak{S}}(\ell)), (\Im_{\mathfrak{S}}(\ell))|\ \ell \in G\}$$

where $\Re_{\mathfrak{S}}(\ell)$ and $\Im_{\mathfrak{S}}(\ell)$ are mapping from G to $[0,1]$, with condition $0 \leq \Re_{\mathfrak{S}}(\ell) \leq 1$, $0 \leq \Im_{\mathfrak{S}}(\ell) \leq 1$ and $0 \leq (\Re^2_{\mathfrak{S}}(\ell)) + (\Im^2_{\mathfrak{S}}(\ell)) \leq 1$ for all $\ell \in G$ this called Pythagorean fuzzy set.

Definition 2.4. As a generalized form of both the IFS and PFS, the q-ROFS provides DMs more freedom to express their opinions on the membership and non-membership grades. Let $G = \{\ell_1, \ell_2, \ell_3, ..., \ell_n\}$ be a universe of discourse. A q-ROFS A in X is mathematically defined as

$$\mathfrak{A} = \{(\ell, (\Re_{\mathfrak{A}}(\ell)), \Im_{\mathfrak{A}}(\ell)))|\ \ell \in G\}.$$

where $\Re_{\mathfrak{A}}(\ell)) : G \to [0,1]$ is the membership function and $\Im_{\mathfrak{A}}(\ell) \to [0,1]$ is the nonmembership function, satisfying $\Re_{\mathfrak{A}}(\ell) \in [0,1]$ and $\Im_{\mathfrak{A}}(\ell) \in [0,1]$, $0 < (Re_{\mathfrak{A}}(\ell))^q + (\Im_{\mathfrak{A}}(\ell))^q < 1, (q > 2)$ is called q-ROFS.

Example 2.5. Let $G = \{\ell_1, \ell_2, \ell_3, \ell_3, \ell_3, \ell_5\}$ then in tabular form,the(FP-qROFSSs) can be represented as Table 1

Table 1: FP-qROFSSs

G	$\Re_{\mathfrak{A}}(\ell)$	$\Im_{\mathfrak{A}}(\ell)$
ℓ_1	(0.71)	(0.81)
ℓ_2	(0.68)	(0.82)
ℓ_3	(0.65)	(0.91)
ℓ_4	(0.69)	(0.81)
ℓ_5	(0.63)	(0.73)

$0 < (Re_{\mathfrak{A}}(\ell))^q + (\Im_{\mathfrak{A}}(\ell))^q < 1, (q > 2)$ is called q-ROFS.

Definition 2.6. A fuzzy soft set $(FS - set)$ mapping $\aleph : P \longrightarrow P(G)$ such that $\aleph_{\mathfrak{A}}\ (\wp)=\emptyset$, if $\wp \notin \mathfrak{A}$, where G is the set of universe and $\mathfrak{A} \subseteq P$,P is the set of parameters. It is denoted as $(\aleph, \mathfrak{A})$ given by

$$(\aleph, \mathfrak{A}) = \{(\wp, \aleph_{\mathfrak{A}}(\wp)\ :\ (\wp) \in P, \aleph_{\mathfrak{A}}(\wp) \in P(G)\},$$

The value $\aleph_{\mathfrak{A}}(\wp)$ is fuzzy set known as $\wp$-approximate element of FS-set $(\aleph, \mathfrak{A})\ \forall\ \wp \varepsilon P$.

Definition 2.7. A fuzzy parameterized fuzzy soft set(FPFS-set) is a mapping $\aleph : P \longrightarrow P(G)$ such that $\aleph_{\mathfrak{S}}\wp=\emptyset$, if $\Re_{\mathfrak{S}}(\wp)=0$,where G is the universal set and $\mathfrak{S} \subseteq P$, P is set of parameters. It show that $H_{\mathfrak{S}}$.

$\tilde{}$ $H_{\mathfrak{S}}=\{(\Re_{\mathfrak{S}}(\wp)/\wp, \aleph_{\mathfrak{S}}(\wp)) : \wp \in P, \aleph_{\mathfrak{S}}(\ell) \in P(G);\ \Re_{\mathfrak{S}}(\wp),\ \Im_{\mathfrak{S}}(\wp), \aleph_{\mathfrak{S}}(\wp) \in [0,1], \ell \in G\}$

The value $\aleph_{\mathfrak{S}}(\wp)$ is fuzzy set known as $\wp$-element of (FPFS-set) $H_{\mathfrak{S}}\ \forall\ \wp \in P$

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Example 2.8. Let $G = \{\ell_1, \ell_2, \ell_3, \ell_3, \ell_3, \ell_5\}$ and $P = \{0.71/\wp_1, 0.68/\wp_2, 0.69/\wp_3, 0.81\wp_4, 0.65/\wp_5\}$ be a set of parameters then in tabular form,the(FPFS-set) can be represented as Table 3

Table 2: FPFS-set

G	$0.71/\wp_1$	$0.68/\wp_2$	$0.69/\wp_3$	$0.81/\wp_4$	$0.65/\wp_5$
ℓ_1	(0.69)	(0.51)	(0.65)	(0.63)	(0.56)
ℓ_2	(0.68)	(0.62)	(0.69)	(0.57)	(0.59)
ℓ_3	(0.65)	(0.59)	(0.51)	(0.51)	(0.61)
ℓ_4	(0.59)	(0.61)	(0.66)	(0.59)	(0.63)
ℓ_5	(0.63)	(0.63)	(0.61)	(0.54)	(0.55)

3 Fuzzy parameterized q-rung orthopair fuzzy soft set(FP-qROFSSs)

In fuzzy set discuss the membership function valued in the real unit interval [0,1] but not discuss the non membership value. But in intuitionistic fuzzy set (IFS) discuss an ordered pair, and each ordered pair is characterized by a membership degree and a non-membership degree. The sum of the membership degree and the non-membership degree of each ordered pair is less than or equal to 1 and also discuss the parametrization with (IFS). But some condition have were (IFS) is fail $(0.6 + 0.5) \geq 1$ then Pythagorean fuzzy describe when the sum of square of the membership degree and the non-membership degree of each ordered pair is less to 1. Again some condition hold were Pythagorean fuzzy set is fail $((0.8)^2+(0.7)^2) > 1$ then proposed the concept of the q-ROFS $0 < (Re_{\mathfrak{A}}(\ell))^q+(\Im_{\mathfrak{A}}(\ell))^q \leq 1, (q > 2)$ and do not discuss the parameterizations with (q-ROFS) . After this the proposed the idea of soft set theory with parameterizations and we present the q-rung orthopair fuzzy soft set (FP-qROFSSs) and discuss its some results and applications.

Table 3: FP-qROFSSs

G	$Membershipdegre$	$Non-membershipdegre$	$parameter$
$fuzzy\ set$	Yes	No	No
$Intuitionistic\ fuzzy$	Yes	Yes	No
$Pythagorean\ fuzzyset$	Yes	Yes	No
$q-rung\ fuzzy\ set$	Yes	Yes	No
$Fuzzy\ parameterized\ soft\ set$	yes	No	yes
$Intuitionistic\ parameterizedsoft\ set$	Yes	yes	yes
$q-rung\ orthopair\ parameterized\ soft\ set$	Yes	Yes	Yes

Definition 3.1. A fuzzy parameterized q-rung orthopair fuzzy soft set(FP-qROFSSs) is a mapping $\aleph : P \longrightarrow P(G)$ such that $\aleph_{\mathfrak{A}}\wp=\emptyset$, if $\Re_{\mathfrak{A}}(\wp)=0$,where G is the universal set and $\mathfrak{A} \subseteq P$, P is set of parameters. It show that $H_{\mathfrak{A}}$.

$\tilde{}$ $H_{\mathfrak{A}}=\{(\Re_{\mathfrak{A}}(\wp)/\wp,\aleph_{\mathfrak{A}}(\wp)):\wp \in P,\aleph_{\mathfrak{A}}(\ell) \in P(G);\ \Re_{\mathfrak{A}}(\wp),\ \Im_{\mathfrak{A}}(\wp),\aleph_{\mathfrak{A}}(\wp) \in [0,1],\ell \in G\}$

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The value $\aleph_{\mathfrak{A}}(\wp)$ is fuzzy set known as $\wp$-element of (FP-qROFSSs) $H_{\mathfrak{A}}\ \forall\ \wp \in P$

Example 3.2. Let G={car a,car b,car c,car d} be a set of sales cars and $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be a set of attributes ,where

$\wp_1$ =Expensive
$\wp_2$ =petrol average
$\wp_3$ =speed
$\wp_4$ =power ful

Then $\mathfrak{A} = \{0.7/\wp_1, 0.6/\wp_3, 0.5/\wp_4\} \subseteq P$,then the FS-set $(\aleph, \mathfrak{A})$ is a mapping $\aleph : P \longrightarrow P(G)$ where P(G) is the collection of all FS-sets of G. The FP-qROFSSs can be represented as Table 4.

Table 4: FP-qROFSSs

G	$(0.73/\wp_1)$	$(0.69/\wp_3)$	$(0.59/\wp_4)$
car a	(0.69,0.51)	(0.73,0.52)	(0.69,0.50)
car b	(0.81,0.46)	(0.66,0.35)	(0.77,0.45
car c	(0.72,0.45)	(0.81,0.45)	(0.72,0.47)
car d	(0.83,0.41)	(0.76,0.44)	(0.81,0.35)

Example 3.3. Let a collage wants to fill a vacancy of highly qualified teacher. There are five applicant who apply for this job.The set of candidates represented by

$$G = \{\ell_1, \ell_2, \ell_3, \ell_4, \ell_5\}$$

The hiring panel consider the set of parameters $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$, where

$\wp_1$ =hard working
$\wp_2$ =experienced
$\wp_3$ =punctual and regular
$\wp_4$ =personality

In tabular form,the(FP-qROFSSs) can be represented as Table 5

Table 5: FP-qROFSSs

G	$(0.75/\wp_1)$	$(0.68/\wp_2)$	$(0.59/\wp_3)$	$(0.81/\wp_4)$
ℓ_1	(0.72,0.49)	(0.77,0.51)	(0.77,0.47)	(0.71,0.52)
ℓ_2	(0.68,0.48)	(0.67,0.48)	(0.67,0.51)	(0.77,0.41)
ℓ_3	(0.71,0.46)	(0.71,0.46)	(0.62,0.41)	(0.67,0.45)
ℓ_4	(0.81,0.41)	(0.81,0.39)	(0.73,0.45)	(0.63,0.38)
ℓ_5	(0.63,0.39)	(0.73,0.36)	(0.87,0.39)	(0.69,0.46)

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Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Definition 3.4. Let $H_{\mathfrak{A}}$ be a (FP-qROFSSs) over G. If $\aleph_{\mathfrak{A}}(\wp) = \phi \; \forall \; \wp \in P$, then $H_{\mathfrak{A}}$ is called an $\mathfrak{A}-empty(FP-qROFSSs)$. It is represented as $H_{\emptyset\mathfrak{A}}$. If $\mathfrak{A} = \phi$, then $\mathfrak{A} - empty$ (FP-qROFSSs) denoted as $\mathfrak{A}_{\phi}$.

Definition 3.5. Let $H_{\mathfrak{A}}$ be a (FP-qROFSSs) over G. If $\aleph_{\mathfrak{A}}(\ell)= G$ and $\Re_{\mathfrak{A}}(\ell) = 1 \; \forall \; \wp \in$ P, then $H_{\mathfrak{A}}$ is known as $\mathfrak{A}$-universal (FP-qROFSSs). It is represented as $H_{\mathfrak{A}}$. If $\mathfrak{A} = P$ then $\mathfrak{A} - universal$ (FP-qROFSSs) is said to be absolute (FP-qROFSSs).

Definition 3.6. Let be two FP-qROFSSs $H_{\mathfrak{A}}$ and $H_{\mathfrak{B}}$. Then $H_{\mathfrak{B}}$ is called FP-qROFS subset of $H_{\mathfrak{A}}$, denoted by $H_{\mathfrak{B}} \subseteq H_{\mathfrak{A}}$.
(i)$\Re_{\mathfrak{B}}(\wp) \leq \Re_{\mathfrak{A}}(\wp)$
(ii)$\Im_{\mathfrak{B}}(\wp) \leq \Im_{\mathfrak{A}}(\wp) \; \forall \; \wp \in P$

Definition 3.7. Let be two FP-qROFSSs $H_{\mathfrak{A}}$ and $H_{\mathfrak{B}}$. The union of two FP-qROFSSs $H_{\mathfrak{A}}$ and $H_{\mathfrak{B}}$ write this $H_{\mathfrak{A}} \cup H_{\mathfrak{B}}$, is defined by

$$\Re_{\mathfrak{A}\cup\mathfrak{B}}(\wp)=\{(max\tfrac{(\Re_{\mathfrak{A}}(\wp),\Re_{\mathfrak{B}}(\wp))}{\wp},\{\max\tfrac{(\Re_{\mathfrak{A}}(\ell),\Re_{\mathfrak{B}}(\ell))}{\ell},\min\tfrac{(\Im_B(\ell),\Im_C(\ell)}{\ell}\}) \; \forall \; \wp \in \text{P},\forall \; \ell \; \in \text{G}\}.$$

Definition 3.8. Let be two FP-qROFSSs $H_{\mathfrak{A}}$ and $H_{\mathfrak{B}}$.The intersection of two FP-qROFSSs $H_{\mathfrak{A}}$ and $H_{\mathfrak{B}}$ write this $H_{\mathfrak{A}} \cap H_{\mathfrak{B}}$,

$$\Re_{\mathfrak{A}\cap\mathfrak{B}}(\wp)=\{(min\tfrac{(\Re_{\mathfrak{A}}(\wp),\Re_{\mathfrak{B}}(\wp))}{\wp},\{\min\tfrac{(\Re_{\mathfrak{A}}(\ell),\Re_{\mathfrak{B}}(\ell))}{\ell},\max\tfrac{(\Im_B(\ell),\Im_C(\ell)}{\ell}\}) \; \forall \; \wp \in \text{P},\forall \; \ell \; \in \text{G}\}.$$

Definition 3.9. Let $\alpha_1 = (\Re_{\wp_1}, \Im_{\wp_1})$, $\alpha_2 = (\Re_{\wp_2}, \Im_{\wp_2})$ and $\alpha = (\Re_{\wp}, \Im_{\wp})$ be there FP-qROFSN , and $\alpha > 0$.Then the basic operational laws of FP-qROFSN can be describe as,

1. $\alpha_1 \oplus \alpha_2=((\alpha_{\alpha_1}^{\wp} + \alpha_{\alpha_2}^{\wp}) - (\alpha_{\alpha_1}^{\wp}.\alpha_{\alpha_2}^{\wp}), \{(\Re_{\wp_1}^q + \Re_{\wp_2}^q - \Re_{\wp_1}^q\Re_{\wp_2}^q)^{1/q}, \Im_{\wp_1}\Im_{\wp_2}\})$;
2. $\alpha_1 \bigotimes \alpha_2=(\alpha_{\alpha_1}^{\wp}.\alpha_{\alpha_2}^{\wp}, \{\Re_{\wp_1}.\Re_{\wp_2}, (\Im_{\wp_1}^q + \Im_{\wp_2}^q - \Im_{\wp_1}^q\Im_{\wp_2}^q)^{1/q}\})$;
3. $\lambda\alpha = (1 - (1 - \alpha_{\alpha}^{\wp})^{\lambda}, \{(1 - (1 - \Re_{\wp}^q)^{\lambda})^{1/q}, (\Im_{\wp})^{\lambda})\}$
4. $\alpha^{\lambda} = ((\alpha_{\alpha}^{\wp}), \{(\Im_{\wp})^{\lambda}, 1 - (1 - \Re_{\wp}^q)^{\lambda 1/q}\})$

Definition 3.10. Let α=$(\Re_{\wp}, \Im_{\wp})$ be FP-qROFSN , then the score and accuracy function of α is defined as,

$$S(\alpha) = (\alpha_{\alpha_1}^{\wp}, \{\tfrac{1}{2}(1 + \Re_{\wp}^q - \Im_{\wp}^q)\}),$$
$$H(\alpha)=(\alpha_{\alpha_1}^{\wp}, \{\Re_{\wp}^q + \Im_{\wp}^q\})$$

Definition 3.11. Let $\alpha = (\Re_{\wp_1}, \Im_{\wp_1})$ and $\beta = (\Re_{\wp_2}, \Im_{\wp_2})$ be any two FP-qROFSN,$S(\alpha)$ *and* $H(\alpha)$ be the score and accuracy function of α, and $S(\beta)$ *and* $H(\beta)$ be the score and accuracy function of β, then
(1)If $S(\alpha) > S(\beta), then$ α is superior to $\beta, \alpha > \beta$;
(2)If $S(\alpha) = S(\beta)$, then
(a)If $H(\alpha) > H(\beta)$, then α is superior to β, $\alpha > \beta$;
(b))If $H(\alpha) = H(\beta)$, then α is equivalent to β, $\alpha = \beta$.

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Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

4 FUZZY PARAMETERIZED q-RUNG ORTHOPAIR FUZZY SOFT TOPOPALOGY

Definition 4.1. Let H_p be a absolute FP-qROFSSs and FP-qROFS (H_p) is the family of all FP-qROFS subsets of H_p. Let $\mathfrak{T}$ be a subfamily of FP-qROFS (H_p) and A,B,C $\subseteq P$.
Then $\mathfrak{T}$ is known as FP-qROFS-topalogy on H_p,if given condition are satisfied.
(1)$H_\phi, H_P \in \mathfrak{T}$
(2)$H_{\mathfrak{A}}, H_{\mathfrak{B}} \in \mathfrak{T}$ then $H_{\mathfrak{A}} \cap H_{\mathfrak{B}} \in \mathfrak{T}$.
(3)If $(H_{\mathfrak{C}})_\lambda \in \mathfrak{T}, \forall \lambda \in K$, then $\cup_{\lambda \in K}(H_{\mathfrak{C}})_\lambda \in \mathfrak{T}$.

Example 4.2. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.75/\wp_1, 0.69/\wp_2, 0.59/\wp_3\} \subseteq P$, $\mathfrak{B} = \{0.71/\wp_1, 0.65/\wp_2\} \subseteq P$ with FP-qROFS Table 6 and 7

Table 6: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.75/\wp_1)$	$(0.69/\wp_2)$	$(0.59/\wp_3)$
ℓ_1	(0.75,0.49)	(0.71,0.48)	(0.73,0.50)
ℓ_2	(0.71,0.47)	(0.63,0.44)	(0.69,0.46)
ℓ_3	(0.67,0.39)	(0.58,0.41)	(0.59,0.43)

Table 7: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0.71/\wp_1)$	$(0.65/\wp_2)$	$(0.56/\wp_3)$
ℓ_1	(0.73,0.52)	(0.69,0.51)	(0.70,0.52)
ℓ_2	(0.69,0.48)	(0.59,0.47)	(0.65,0.47)
ℓ_3	(0.63,0.42)	(0.56,0.43)	(0.54,0.44)

then $\mathfrak{T}$=$\{H_\phi, H_{\mathfrak{A}}, H_{\mathfrak{B}}, H_P\}$ is a FP-qROFSSs topology on G.In fact $H_{\mathfrak{B}} \subseteq H_{\mathfrak{A}}$ .For

1. $H_\phi, H_G \in \mathfrak{T}$.
2. $H_\phi \cap H_{\mathfrak{A}} = H_\phi$: $H_\phi \cap H_{\mathfrak{B}} = H_\phi$, $H_\phi \cap H_P = H_\phi$, $H_P \cap H_{\mathfrak{A}} = H_{\mathfrak{A}}$, $H_P \cap H_{\mathfrak{B}} = H_{\mathfrak{B}}$, $H_{\mathfrak{B}} \cap H_{\mathfrak{A}} = H_{\mathfrak{B}}$
3. $H_\phi \cup H_{\mathfrak{A}} = H_{\mathfrak{A}}$: $H_\phi \cup H_{\mathfrak{B}} = H_{\mathfrak{B}}$, $H_\phi \cup H_P = H_P$, $H_P \cup H_{\mathfrak{A}} = H_P$, $H_P \cup H_{\mathfrak{B}} = H_P$, $H_\phi \cup H_P \cup H_{\mathfrak{A}} \cup H_{\mathfrak{B}} = H_P$

This implies that $\mathfrak{T}$=$\{H_\phi, H_{\mathfrak{A}}, H_{\mathfrak{B}}, H_P\}$ is a FP-qROFSSs topology on G.

Definition 4.3. Let $\mathfrak{T}_1$ and $\mathfrak{T}_2$ be two FP-qROFSS topology on G. If $\mathfrak{T}_1 \subseteq \mathfrak{T}_2$ then $\mathfrak{T}_1$ is called FP-qROFS-couser or FP-qROFS-weaker and $\mathfrak{T}_2$ is called FP-qROFS-finer or FP-qROFS-stronger then $\mathfrak{T}_1$.

Example 4.4. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.81/\wp_1, 0.75/\wp_2, 0.66/\wp_3\} \subseteq P$, $\mathfrak{B} = \{0.75/\wp_1, 0.68/\wp_2, (0.57/\wp_3)\} \subseteq P$ with FP-qROFS Table 8 and 9.

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Table 8: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.81/\wp_1)$	$(0.75/\wp_2)$	$(0.66/\wp_3)$
ℓ_1	(0.73,0.47)	(0.72,0.46)	(0.77,0.48)
ℓ_2	(0.69,0.42)	(0.66,0.41)	(0.79,0.46)
ℓ_3	(0.62,0.37)	(0.61,0.39)	(0.69,0.43)

Table 9: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0.75/\wp_1)$	$(0.68/\wp_2)$	$(0.57/\wp_3)$
ℓ_1	(0.69,0.50)	(0.67,0.52)	(0.73,0.50)
ℓ_2	(0.65,0.49)	(0.57,0.46)	(0.69,0.49)
ℓ_3	(0.59,0.45)	(0.53,0.42)	(0.59,0.45)

then $\mathfrak{T}_1 = \{H_\phi, H_P, H_A\}$ and $\mathfrak{T}_2 = \{H_\phi, H_P, H_{\mathfrak{A}}, H_{\mathfrak{B}}\}$ are two FP-qROFSSs topology it is clear that $\mathfrak{T}_1 \subseteq \mathfrak{T}_2$. Thus $\mathfrak{T}_1$ is called FP-qROFS-couser or FP-qROFS-weaker and $\mathfrak{T}_2$ is called FP-qROFS-finer or FP-qROFS-stronger then $\mathfrak{T}_1$.

Definition 4.5. The families $\mathfrak{T}_{indiscerete} = \{H_\phi, H_P\}$ and $\mathfrak{T}_{discerete} = FP - qROFS(G, P)$ are FP-qROFSSs topology on G.

Example 4.6. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.71/\wp_1, 0.68/\wp_2, 0.63/\wp_3\} \subseteq P$, then $\mathfrak{T} = \{H_\phi, H_P\}$ is indiscrete FP-qROFSSs topology and $P(H_P)$ (power set of H_P) is the discrete FP-qROFSSs topology on G.

Definition 4.7. Let $\mathfrak{T}_1$ be a FP-qROFSS topology on (G, P) and $\mathfrak{Y} \subseteq G$ and let $\mathfrak{T}_2$ be a FP-qROFSS topology on $(\mathfrak{Y}, \mathfrak{E})$ whose FP-qROFS-open sets can be defined as

$$H_{\mathfrak{B}} = H_{\mathfrak{A}} \cap H_{\mathfrak{E}},$$

where $H_{\mathfrak{A}}$ is the FP-qROFS-open sets of $\mathfrak{T}_1$ and $H_{\mathfrak{B}}$ is the FP-qROFS-open sets of $\mathfrak{T}_2$. $H_{\mathfrak{F}}$ is the FP-qROFS-absolute set on $(\mathfrak{Y}, \mathfrak{F})$, and $P, \mathfrak{F}$ are the set of parameters for $G, \mathfrak{Y}$, respectively. Then $\mathfrak{T}_2$ is known as the FP-qROFS-subspace of $\mathfrak{T}_1$.

Example 4.8. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.81/\wp_1, 0.75/\wp_2, 0.66/\wp_3\} \subseteq P$, $\mathfrak{B} = \{0.75/\wp_1, 0.68/\wp_2, (0.57/\wp_3)\} \subseteq P$ with FP-qROFSSs Table 10 and 11.

Table 10: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.76/\wp_1)$	$(0.74/\wp_2)$	$(0.69/\wp_3)$
ℓ_1	(0.71,0.51)	(0.75,0.43)	(0.73,0.48)
ℓ_2	(0.67,0.48)	(0.69,0.39)	(0.69,0.46)
ℓ_3	(0.59,0.42)	(0.67,0.36)	(0.66,0.43)

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Table 11: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0.73/\wp_1)$	$(0.71/\wp_2)$	$(0.63/\wp_3)$
ℓ_1	(0.69,0.53)	(0.71,0.51)	(0.71,0.50)
ℓ_2	(0.63,0.49)	(0.67,0.43)	(0.66,0.49)
ℓ_3	(0.57,0.45)	(0.61,0.41)	(0.63,0.45)

then $\mathfrak{T}_1 = \{H_\phi, H_P, H_{\mathfrak{A}}, H_{\mathfrak{B}}\}$ is FP-qROFSSs topology on G.
If $\mathfrak{Y} = \{\ell_1, \ell_2\} \subseteq G$ and $\mathfrak{E} = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ then FP-qROFS-absolute set on $\mathfrak{Y}$ is Table 12

Table 12: FP-qROFSSs

$H_{\mathfrak{F}}$	$(1/\wp_1)$	$(1/\wp_2)$	$(1/\wp_3)$	$(1/\wp_4)$
ℓ_1	(1,0)	(1,0)	(1,0)	(1,0)
ℓ_2	(1,0)	(1,0))	(1,0)	(1,0)

Where FP-qROFS-open sets of $\mathfrak{T}_2$ can be calculated as' Table 13 and 14
$H_{\mathfrak{F}} \cap H_\phi = H_\phi$,$H_{\mathfrak{F}} \cap H_P = H_{\mathfrak{F}}$
$H_{\mathfrak{C}}$=$H_{\mathfrak{F}} \cap H_{\mathfrak{A}}$

Table 13: FP-qROFSSs

$H_{\mathfrak{F}} \cap H_{\mathfrak{A}}$	$(0.76/\wp_1)$	$(0.74/\wp_2)$	$(0.69/\wp_3)$
ℓ_1	(0.71,0.51)	(0.75,0.43)	(0.73,0.48)
ℓ_2	(0.67,0.48)	(0.69,0.39))	(0.69,0.46)

and $H_{\mathfrak{D}}$=$H_{\mathfrak{F}} \cap H_{\mathfrak{B}}$

Table 14: FP-qROFSSs

$H_{\mathfrak{F}} \cap H_{\mathfrak{B}}$	$(0.73/\wp_1)$	$(0.71/\wp_2)$	$(0.63/\wp_3)$
ℓ_1	(0.69,0.53)	(0.71,0.51)	(0.71,0.50)
ℓ_2	(0.63,0.49)	(0.67,0.43)	(0.66,0.49)

Thus then $\mathfrak{T}_2 = \{H_\phi, H_{\mathfrak{F}}, H_{\mathfrak{C}}, H_{\mathfrak{D}}\}$ is FP-qROFSSs topology on $\mathfrak{Y}$. So $\mathfrak{T}_2$ is an FP-qROFSSs-subspace of $\mathfrak{T}_1$.

Remark.

(1) Every FP-qROFS-subspace of a discrete FP-qROFS-topological space is always discrete. Similarly, every subspace of indiscrete FP-qROFSSs topological space is indiscrete.

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

(2)A subspace $\mathfrak{Z}$ of a subspace $\mathfrak{Y}$ of a FP-qROFSSs -topological space G is a FP-qROFSSs subspace of G.

Definition 4.9. Let (G,P) be FP-qROFS-topological space and $H_{\mathfrak{A}} \subseteq (G,P)$ then FP-qROFS-closure of $H_{\mathfrak{A}}$ is written as $\overline{H_{\mathfrak{A}}}$ which the FP-qROFS-intersection of all FP-qROFS-closed superset of $H_{\mathfrak{A}}$. Clearly $\overline{H_{\mathfrak{A}}}$ is the FP-qROFS-smallest closed supersset of $H_{\mathfrak{A}}$

Example 4.10. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.79/\wp_1, 0.71/\wp_2, 0.67/\wp_3\} \subseteq P$, $\mathfrak{B} = \{0.72/\wp_2, 0.66/\wp_3\} \subseteq P$ with FP-qROFSS Table 15 and 16.

Table 15: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.79/\wp_1)$	$(0.71/\wp_2)$	$(0.67/\wp_3)$
ℓ_1	(0.71,0.51)	(0.75,0.43)	(0.73,0.48)
ℓ_2	(0.67,0.48)	(0.69,0.39)	(0.69,0.46)
ℓ_3	(0.59,0.42)	(0.67,0.36)	(0.66,0.43)

and

Table 16: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0/\wp_1)$	$(0.72/\wp_2)$	$(0.66/\wp_3)$
ℓ_1	(0,1)	(0.72,0.51)	(0.69,0.49)
ℓ_2	(0,1)	(0.66,0.47)	(0.64,0.47)
ℓ_3	(0,1)	(0.62,0.39)	(0.59,0.46)

then $\mathfrak{T} = \{H_\phi, H_P, H_{\mathfrak{A}}, H_{\mathfrak{B}}\}$ is FP-qROFSSs topology on G. Thus the closed sets can be calculated as by taking compliments of FP-qROFS-open sets in $\mathfrak{T}$,i.e..$(H_\phi)^c = H_P, (H_P)^c = H_\phi$, Table 17 and 18

Table 17: FP-qROFSSs

$(H_{\mathfrak{A}})^c$	$(0.21/\wp_1)$	$(0.29/\wp_2)$	$(0.33/\wp_3)$
ℓ_1	(0.51,0.71)	(0.43,0.75)	(0.48,0.73)
ℓ_2	(0.48,0.67)	(0.39,0.69)	(0.46,0.69)
ℓ_3	(0.42,0.59)	(0.36,0.67)	(0.43,0.66)

and

Table 18: FP-qROFSSs

$(H_{\mathfrak{B}})^c$	$(1/\wp_1)$	$(0.28/\wp_2)$	$(0.34/\wp_3)$
ℓ_1	(1,0)	(0.51,0.72)	(0.49,0.69)
ℓ_2	(1,0)	(0.47,0.66)	(0.47,0.64)
ℓ_3	(1,0)	(0.39,0.62)	(0.46,0.59)

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

If $C = \{0.81/\wp_1, 0.79/\wp_2\} \subseteq P$, then a FP-qROFSSs on G is, Table 19

Table 19: FP-qROFSSs

H_C	$(0.81/\wp_1)$	$(0.79/\wp_2)$	$(0/\wp_3)$
ℓ_1	(0.72,0.50)	(0.74,0.42)	(0,1)
ℓ_2	(0.68,0.47)	(0.68,0.38)	(0,1)
ℓ_3	(0.60,0.41)	(0.66,0.35)	(0,1)

Which implies that FP-qROFS-closed superset of H_C are $(H_{\mathfrak{A}})^c$ and H_P only. Thus
$\overline{H_C} = (H_{\mathfrak{A}})^c \cap H_P = (H_{\mathfrak{A}})^c$.

Definition 4.11. Let (G, P) be a FP-qROFS-topological space and $H_{\mathfrak{A}} \subseteq (G, P)$ then the interior of $H_{\mathfrak{A}}$ is denoted as $H^o_{\mathfrak{A}}$ which is FP-qROFS-union of all FP-qROFS-open subsets of $H_{\mathfrak{A}}$.
It is clear that $H^o_{\mathfrak{A}}$ is the FP-qROFS-largest open subset of $H_{\mathfrak{A}}$.

Example 4.12. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.82/\wp_1, 0.73/\wp_2, 0.69/\wp_3\} \subseteq P$, $\mathfrak{B} = \{0.73/\wp_2, 0.63/\wp_3\} \subseteq P$ with FP-qROFS Table 20 and 21

Table 20: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.82/\wp_1)$	$(0.73/\wp_2)$	$(0.69/\wp_3)$
ℓ_1	(0.73,0.47)	(0.77,0.44)	(0.75,0.49)
ℓ_2	(0.69,0.45)	(0.71,0.40)	(0.71,0.47)
ℓ_3	(0.61,0.44)	(0.69,0.37)	(0.68,0.45)

and

Table 21: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0/\wp_1)$	$(0.71/\wp_2)$	$(0.67/\wp_3)$
ℓ_1	(0,1)	(0.73,0.50)	(0.71,0.51)
ℓ_2	(0,1)	(0.66,0.49)	(0.67,0.49)
ℓ_3	(0,1)	(0.67,0.42)	(0.61,0.47)

then $\mathfrak{T} = \{H_\phi, H_P, H_{\mathfrak{A}}, H_{\mathfrak{B}}\}$ is FP-qROFSSs topology on G.
If $D = \{0.74/\wp_2, 0.65/\wp_3\} \subseteq P$ then FP-qROFSSs on G is, Table 22

Table 22: FP-qROFSSs

H_D	$(0/\wp_1)$	$(0.74/\wp_2)$	$(0.65/\wp_3)$
ℓ_1	(0,1)	(0.73,0.53)	(0.81,0.51)
ℓ_2	(0,1)	(0.65,0.47)	(0.69,0.48)
ℓ_3	(0,1)	(0.61,0.42)	(0.63,0.45)

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

This implies that FP-qROFS-open sets contained in H_D are $H_{\mathfrak{B}}$ and H_ϕ. Thus $H^o_{\mathfrak{A}} = H_{\mathfrak{B}} \cup H_\phi = H_{\mathfrak{B}}$.

Definition 4.13. A FP-qROFSSs $H_{\mathfrak{A}}$ is said to be a FP-qROFS-point, denoted by $\wp(H_{\mathfrak{A}})$, if $\mathfrak{A} \subseteq P$ is fuzzy singleton, $(\Re(\wp)/\wp) \in \mathfrak{A}$ and $H(\Re(\wp)/\wp) = \aleph^{\wp}_{H_{\mathfrak{A}}}(\ell)$ where $\aleph^{\wp}_{H_{\mathfrak{A}}}(\ell) \neq \phi$ and
$H(\Re(\wp))/\wp = \phi \; \forall \; (\Re(\wp^{'})/\wp^{'}) \in P - \{\Re(\wp)/\wp\}$.

Definition 4.14. A FP-qROFS-point $\wp(H_{\mathfrak{A}})$ belongs to FP-qROFSSs $H_{\mathfrak{B}}$, if $\Re_{H_{\mathfrak{A}}}(\wp) \leq \Re_{H_{\mathfrak{B}}}(\wp), \forall \; \wp \in P$ and $\aleph^{\wp}_{H_{\mathfrak{A}}}(\ell) \leq \aleph^{\wp}_{H_{\mathfrak{B}}}(\ell), \forall \; \ell \in G$. It is denoted as $H_{\mathfrak{A}} \in H_B$

Example 4.15. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.83/\wp_1, 0.77/\wp_2, 0/\wp_3, 0.91/\wp_4\} \subseteq P$, $\mathfrak{B} = \{0.57/\wp_1\} \subseteq P$ with FP-qROFS Table 23 and 24

Table 23: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.83/\wp_1)$	$(0.77/\wp_2)$	$(0/\wp_3)$	$(0.91/\wp_4)$
ℓ_1	(0.70,0.49)	(0.74,0.45)	(0,1)	(0.69,0.48)
ℓ_2	(0.67,0.46)	(0.71,0.43)	(0,1)	(0.67,0.47)
ℓ_3	(0.62,0.44)	(0.69,0.37)	(0,1)	(0.59,0.42)

and

Table 24: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0.57/\wp_1)$	$(0/\wp_2)$	$(0/\wp_3)$	$(0/\wp_4)$
ℓ_1	(o.67,45)	(0,1)	(0,1)	(0,1)
ℓ_2	(0.64,0.43)	(0,1)	(0,1)	(0,1)
ℓ_3	(0.59,0.42)	(0,1)	(0,1)	(0,1)

then $H_{\mathfrak{B}}$ is called FP-qROFS-point.
Clearly $\Re_{H_{\mathfrak{A}}}(\wp) \leq \Re_{H_{\mathfrak{B}}}(\wp), \forall \; \wp \in P$ and $\aleph^{\wp}_{H_{\mathfrak{A}}}(\ell) \leq \aleph^{\wp}_{H_{\mathfrak{B}}}(\ell), \forall \; \ell \in G$. It is denoted as $H_{\mathfrak{A}} \in H_B$

Remark. Every non-empty FP-qROFSSs $H_{\mathfrak{A}}$ can be written as the FP-qROFS-union of all the FP-qROFS-points which are in $H_{\mathfrak{A}}$.

Definition 4.16. Let $\wp(H_{\mathfrak{A}_1})$ and $H_{\mathfrak{A}_2}$ belongs to FP-qROFS (G, P). Then $\wp(H_{\mathfrak{A}_1})$ is called FP-qROFS quasi-coincident with $H_{\mathfrak{A}_2}$ written as $\wp(H_{\mathfrak{A}_1})qH_{\mathfrak{A}_2}$, if $\Re_{H_{\mathfrak{A}_1}}(\wp) + \Re_{H_{\mathfrak{A}_2}}(\wp) > 1, \forall \; \wp \in P$ and $\aleph^{\wp}_{H_{\mathfrak{A}}}(\ell) + \aleph^{\wp}_{H_{\mathfrak{B}}}(\ell) < 1.$, for someone $\ell \in G$. If $\wp(H_{\mathfrak{A}_1})$ is not FP-qROFS quasi-coincident with $H_{\mathfrak{A}_2}$ then we write as $\wp(H_{\mathfrak{A}_1})\overline{q}H_{\mathfrak{A}_2}$.

Example 4.17. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of attributes. If $\mathfrak{A}_1 = \{0.73/\wp_1, 0/\wp_2, 0/\wp_3, 0/\wp_4\} \subseteq P$, $\mathfrak{A}_2 = \{0.67/\wp_1, 0/\wp_2, 0/\wp_3, 0.82/\wp_4\} \subseteq P$ with the FP-qROFS-point and FP-qROFS-set respectively. Table 25 and 26

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Table 25: FP-qROFSSs

$\wp(H_{\mathfrak{A}_1})$	$(0.73/\wp_1)$	$(0/\wp_2)$	$(0/\wp_3)$	$(0/\wp_4)$
ℓ_1	(0.77,0.48)	(0,1)	(0,1)	(0,1)
ℓ_2	(0.71,0.45)	(0,1)	(0,1)	(0,1)
ℓ_3	(0.64,0.42)	(0,1)	(0,1)	(0,1)

and

Table 26: FP-qROFSSs

$H_{\mathfrak{A}_2}$	$(0.67/\wp_1)$	$(0/\wp_2)$	$(0/\wp_3)$	$(0.82/\wp_4)$
ℓ_1	(0.67,0.45)	(0,1)	(0,1)	(0.76,0.49)
ℓ_2	(0.64,0.43)	(0,1)	(0,1)	(0.73),0.45
ℓ_3	(0.62,0.39)	(0,1)	(0,1)	(0.69,0.43)

then it is clear that $\wp(H_{A_1})$ is quasi-coincident with H_{A_2}. $\Re_{H_{\mathfrak{A}_1}}(\wp)+\Re_{H_{\mathfrak{A}_2}}(\wp) > 1, \forall\ \wp \in P$ and $\aleph^{\wp}_{H_{\mathfrak{A}}}(\ell)+\aleph^{\wp}_{H_{\mathfrak{B}}}(\ell) < 1$

Definition 4.18. Let $(H_{\mathfrak{A}_1})$ and $H_{\mathfrak{A}_2}$ belongs to FP-qROFS (G, P). Then $(H_{\mathfrak{A}_1})$ is called FP-qROFS quasi-coincident with $H_{\mathfrak{A}_2}$ written as $(H_{\mathfrak{A}_1})qH_{\mathfrak{A}_2}$. If $\Re_{H_{\mathfrak{A}_1}}(\wp) + \Re_{H_{\mathfrak{A}_2}}(\wp) > 1; \forall\ \wp \in \mathfrak{A}_1 \cap \mathfrak{A}_2$ and $\aleph^{\wp}_{H_{\mathfrak{A}}}(\ell) + \aleph^{\wp}_{H_{\mathfrak{B}}}(\ell) < 1;$, for someone $\ell \in G$.If $(H_{\mathfrak{A}_1})$ is not FP-qROFS quasi-coincident with $H_{\mathfrak{A}_2}$ then we write as $(H_{\mathfrak{A}_1})\overline{q}H_{\mathfrak{A}_2}$.

Example 4.19. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.81/\wp_1, 0.76/\wp_2, 0.81/\wp_3\}, 0/\wp_4 \subseteq P$, $\mathfrak{B} = \{0/\wp_1, 0.67/\wp_2, 0.59/\wp_3, 0.56/\wp_4\} \subseteq P$ with FP-qROFS Table 27 and 28

Table 27: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.81/\wp_1)$	$(0.76/\wp_2)$	$(81/\wp_3)$	$(0/\wp_4)$
ℓ_1	(0.78,0.51)	(0.74,0.46)	(0.69,0.48)	(0,1)
ℓ_2	(0.69,0.45)	(0.73,0.45)	(0.67,0.47)	(0,1)
ℓ_3	(0.67,0.44)	(0.67,0.41)	(0.59,0.42)	(0,1)

and

Table 28: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0/\wp_1)$	$(0.67/\wp_2)$	$(0.59/\wp_3)$	$(0.57/\wp_4)$
ℓ_1	(0,1)	(o.66,45)	(0.72,0.47)	(0.81,0.49)
ℓ_2	(0,1)	(0.64,0.43)	(0.69,0.45)	(0.72,0.46)
ℓ_3	(0,1)	(0.62,0.39)	(0.64,0.41)	(0.65,0.41)

then clearly,$\Re_{H_{\mathfrak{A}_1}}(\wp) + \Re_{H_{\mathfrak{A}_2}}(\wp) > 1; \forall\ \wp \in \mathfrak{A}_1 \cap \mathfrak{A}_2$ and $\aleph^{\wp}_{H_{\mathfrak{A}}}(\ell) + \alpha^{\wp}_{H_{\mathfrak{B}}}(\ell) < 1;$, for someone $\ell \in G$.Thus $(H_{\mathfrak{A}_1})$ FP-qROFS quasi-coincident with $H_{\mathfrak{A}_2}$ then we write as $(H_{\mathfrak{A}_1})qH_{\mathfrak{A}_2}$.

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Theorem 4.20. *If $\mathfrak{H}_{\mathfrak{A}}$ and $\mathfrak{H}_{\mathfrak{B}}$ are FP-qROFSSs,then*

- $H_{\mathfrak{A}} \subseteq H_{\mathfrak{B}} \Longleftrightarrow H_{\mathfrak{A}} \overline{q} H_{\mathfrak{B}}^{c}$,
- $H_{\mathfrak{A}} q H_{\mathfrak{B}} \Rightarrow H_{\mathfrak{A}} \cap H_{\mathfrak{B}} \neq H_{\phi}$,
- $H_{\mathfrak{A}} \overline{q} H_{\mathfrak{A}}^{c}$
- $H_{\mathfrak{A}} q H_{\mathfrak{B}} \Longleftrightarrow$ *there exist an* $\wp(H_{\mathfrak{C}}) \in H_{\mathfrak{A}}$ *such that* $\wp(H_{\mathfrak{C}}) q H_{\mathfrak{B}}$
- $\wp(H_{\mathfrak{C}}) \in \wp(H_{A}^{c}) \Longleftrightarrow (H_{\mathfrak{C}}) \overline{q} H_{\mathfrak{A}}$,
- $H_{\mathfrak{A}} \subseteq H_{\mathfrak{B}} \Longrightarrow$ *if* $\wp(\mathfrak{c}) q H_{\mathfrak{A}}$, *then* $(H_{\mathfrak{C}}) q H_{\mathfrak{B}}$ $\forall \wp(H_{\mathfrak{C}}) \in FP - qROFS(G, P)$.

Proof. 1. $H_{\mathfrak{A}} \subseteq H_{\mathfrak{B}} \Leftrightarrow$ for all $\wp \in P, \mathfrak{A} \leq \mathfrak{B}$ and $\aleph_{\mathfrak{A}}(\wp)(\ell) \leq \aleph_{\mathfrak{B}}(\wp)(\ell)$
$\Leftrightarrow$ for all $\wp \in P$ and $\ell \in G$, $\Re_{\mathfrak{B}}(\wp) \leq \Re_{\mathfrak{A}}(\wp)$ and $\aleph_{\mathfrak{A}}(\wp)(\ell) \leq \aleph_{\mathfrak{B}}(\wp)(\ell)$
$\Leftrightarrow$ for all $\wp \in P$ and $\ell \in G$, $\Re_{\mathfrak{B}}(\wp) - \Re_{\mathfrak{A}}(\wp) \leq 0$ and $\aleph_{\mathfrak{A}}(\wp)(\ell) - \aleph_{\mathfrak{B}}(\wp)(\ell) \leq 0$
$\Leftrightarrow$ for all $\wp \in P$ and $\ell \in G$, $\Re_{\mathfrak{B}}(\wp) + 1 - \Re_{\mathfrak{A}}(\wp) \leq 1$ and $\aleph_{\mathfrak{A}}(\wp)(\ell) + 1 - \aleph_{\mathfrak{B}}(\wp)(\ell) \leq 1$
$\Leftrightarrow H_{\mathfrak{A}} \overline{q} H_{\mathfrak{B}}^{c}$

2. Let $H_{\mathfrak{A}} q H_{\mathfrak{B}}^{c}$. Then there exists an $\wp \in P$ and $\ell \in G$ such that $\Re_{\mathfrak{A}}(\wp) + \Re_{\mathfrak{B}}(\wp) > 1$ or $\aleph_{\mathfrak{A}}(\wp)(\ell) + \aleph_{\mathfrak{B}}(\wp)(\ell) < 1$. If $\Re_{\mathfrak{A}}(\wp) + \Re_{\mathfrak{B}}(\wp) > 1$, then $\mathfrak{A} \wedge \mathfrak{B} \neq \overline{0}$ and the proof is easy, if $\aleph_{\mathfrak{A}}(\wp)(\ell) + \aleph_{\mathfrak{B}}(\wp)(\ell) < 1$, then $\aleph_{\mathfrak{A}}(\wp) \wedge \aleph_{\mathfrak{B}}(\wp) \neq \overline{0}$. Hence $H_{\mathfrak{A}} \cap H_{\mathfrak{B}} \neq H_{\phi}$.

3. Suppose that $H_{\mathfrak{A}} q H_{\mathfrak{A}}^{c}$. Then there exist an $\wp \in P$ and $\ell \in G$ such that $\Re_{\mathfrak{B}}(\wp) + 1 - \Re_{\mathfrak{A}}(\wp) \leq 1$ or $\aleph_{\mathfrak{A}}(\wp)(\ell) + 1 - \aleph_{\mathfrak{B}}(\wp)(\ell) \leq 1$. This is contradiction.

4. If $H_{\mathfrak{A}} q H_{\mathfrak{B}}$, there exist an $\wp \in P$ and $\ell \in G$ such that $\Re_{\mathfrak{B}}(\wp) + \Re_{\mathfrak{A}}(\wp) \leq 1$ or $\aleph_{\mathfrak{A}}(\wp)(\ell) + \aleph_{\mathfrak{B}}(\wp)(\ell) < 1$ put $C = \jmath_{\mathfrak{A}}(\wp)(\ell)$ and $\wp = \Re_{\mathfrak{A}}(\wp)$. Then we have $\wp(H_C) \in H_{\mathfrak{A}}$ such that $\wp(H_C) \in H_{\mathfrak{A}} q H_{\mathfrak{B}}$.
Conversely, let $\wp(H_C) \in H_{\mathfrak{A}}$ with $\wp(H_C) \in H_{\mathfrak{A}} q H_{\mathfrak{B}}$. Then $\wp \leq \Re_{\mathfrak{A}}(\wp)$, $C \leq \jmath_{\mathfrak{A}}(\wp)(\ell)$. Since $\wp(H_C) \in H_{\mathfrak{A}} q H_{\mathfrak{B}}$, $\wp + \Re_{\mathfrak{A}}(\wp) \leq 1$ or $C + \aleph_{\mathfrak{B}}(\wp)(\ell) < 1$. Therefore we have $\Re_{\mathfrak{B}}(\wp) + \Re_{\mathfrak{A}}(\wp) \leq 1$ or $\aleph_{\mathfrak{A}}(\wp)(\ell) + \aleph_{\mathfrak{B}}(\wp)(\ell) < 1$. This shows that $H_{\mathfrak{A}} q H_{\mathfrak{B}}$.

5. It is obvious from (1).

6. Let $\wp(H_C), H_{\mathfrak{A}} \in FP - qROFS(G, P)$ and $\wp(H_C)$ q $H_{\mathfrak{A}}$. Then $\wp + \Re_{\mathfrak{A}}(\wp) \leq 1$ or $C + \aleph_{\mathfrak{B}}(\wp)(\ell) < 1$. Since $H_{\mathfrak{A}} \subseteq H_{\mathfrak{B}}$, $\wp + \Re_{\mathfrak{A}}(\wp) \leq 1$ or $C + \aleph_{\mathfrak{B}}(\wp)(\ell) < 1$. Hence we have $\wp(H_C) \in H_{\mathfrak{A}} q H_{\mathfrak{B}}$.

□

Theorem 4.21. *Let $\{H_{\mathfrak{A}_i}\} i \in \Omega$ be a family of FP-qROFS-sets over (G, P). Then a FP-qROFS-point is Q-coincident with $\cup_i F_{\mathfrak{A}}$, if and only if $\wp(H_{\mathfrak{B}}) q H_{\mathfrak{A}}$, for some $i \in \Omega$*

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

5 MAIN RESULTS

In this section wee present some results which hold in FP-qROFS-sets theory but does not hold in crisp set theory. We introduced frontier end exterior in the context of FP-qROFS-topological space. We define Q-neighborhood, adherence point and accumulation point for FP-qROFS-set. First we present an illustration to show that $\mathfrak{T}_1 \cup \mathfrak{T}_2$ may not be a FP-qROFS-topology on G.

Example 5.1. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.83/\wp_1, 0.76/\wp_3\} \subseteq P$, $\mathfrak{B} = \{0.66/\wp_2, 0.59/\wp_4\} \subseteq P$ with FP-qROFS Table 29 and 30

Table 29: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.83/\wp_1)$	$(0.76/\wp_3)$
ℓ_1	(0.76,0.49)	(0.74,0.47)
ℓ_2	(0.67,0.46)	(0.73,0.45)
ℓ_3	(0.65,0.43)	(0.69,0.42)

and

Table 30: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0.66/\wp_2)$	$(0.59/\wp_4)$
ℓ_1	(0.67,0.51)	(0.71,0.49)
ℓ_2	(0.64,0.48)	(0.68,0.47)
ℓ_3	(0.61,0.45)	(0.63,0.44)

then $\mathfrak{T}_1 = \{H_\phi, H_P, H_{\mathfrak{A}}\}$ and $\mathfrak{T}_2 = \{H_\phi, H_P, H_{\mathfrak{B}}\}$ are two FP-qROFSS-topologies on G. On the other hand. Since $H_{\mathfrak{A}}, H_{\mathfrak{B}} \in \mathfrak{T}_1 \cup \mathfrak{T}_2$ but $H_{\mathfrak{A}} \cup H_{\mathfrak{B}}, H_{\mathfrak{A}} \cap H_{\mathfrak{B}} \notin \mathfrak{T}_1 \cup \mathfrak{T}_2$, $\mathfrak{T}_1 \cup \mathfrak{T}_2 = \{H_\phi, H_P, H_{\mathfrak{A}}, H_{\mathfrak{B}}\}$ is not a FP-qROFSS-topology. But $\mathfrak{T}_1 \cap \mathfrak{T}_2 = \{H_\phi, H_P\}$ is a FP-qROFSS-topology on G.

Proposition 5.2. *Let $\mathfrak{T}_1$ and $\mathfrak{T}_2$ be two FP-qROFSS-topologies on G. Then $\mathfrak{T}_1 \cap \mathfrak{T}_2$ is a FP-qROFSS-topology on (G, P) but $\mathfrak{T}_1 \cup \mathfrak{T}_2$ is not necessarily a FP-qROFSS-topology on (G, P).*

Proposition 5.3. *If $\{\mathfrak{T}_\alpha : \alpha \in \Omega\}$ is a family of FP-qROFSSs-topologies on G, then $\cap_{\alpha\in\Omega}\{\mathfrak{T}_\alpha : \alpha \in \Omega\}$ is also FP-qROFSSs-topology on G.*

Remark. The members of discrete FP-qROFSS-topology are infinite due to infinite subsets of FP-qROFSSs.

Remark. In FP-qROFSSs theory the law of contradiction $H_{\mathfrak{A}} \cap H^c_{\mathfrak{A}} = H_\phi$ and the law of excluded middle $H_{\mathfrak{A}} \cup H^c_{\mathfrak{A}} = H_P$ does not hold in general. Then the collection of FP-qROFSSs $\{H_\phi, H_P, H_{\mathfrak{A}}, H^c_{\mathfrak{A}}\}$ is not a FP-qROFSS-topology on G.

Example 5.4. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $A = \{0.79/\wp_1, 0.71/\wp_2\} \subseteq P$ then, Table 31 and 32.

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Table 31: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.79/\wp_1)$	$(0.71/\wp_2)$
ℓ_1	(0.71,0.51)	(0.75,0.43)
ℓ_2	(0.67,0.48)	(0.69,0.39)
ℓ_3	(0.59,0.42)	(0.67,0.36)

and

Table 32: FP-qROFSSs

$(H_A)^c$	$(0.21/\wp_1)$	$(0.29/\wp_2$
ℓ_1	(0.51,0.71)	(0.43,0.75)
ℓ_2	(0.48,0.67)	(0.39,0.69)
ℓ_3	(0.42,0.59)	(0.36,0.67)

Clearly $\mathfrak{T} = \{H_\phi, H_P, H_{\mathfrak{A}}, H_{\mathfrak{A}}^c\}$ is not a FP-qROFSS-topology on G, because $H_{\mathfrak{A}} \cap H_{\mathfrak{A}}^c \notin \mathfrak{T}$ and $H_{\mathfrak{A}} \cup H_{\mathfrak{A}}^c \notin \mathfrak{T}$.

Definition 5.5. Let $H_{\mathfrak{A}}$ be a FP-qROFSS-subset of FP-qROFSS-topological space (G, P). Then the frontier or boundary of $H_{\mathfrak{A}}$, denoted as $H_{\mathfrak{r}}(H_{\mathfrak{A}})$ and is defined as

$$H_{\mathfrak{r}}(H_{\mathfrak{A}}) = \overline{H_{\mathfrak{A}}} \cap \overline{H_{\mathfrak{A}}^c}$$

Example 5.6. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.79/\wp_1, 0.71/\wp_2, 0.67/\wp_3\} \subseteq P$, $\mathfrak{B} = \{0.72/\wp_2, 0.66/\wp_3\} \subseteq P$ with FP-qROFSS Table 33 and 34.

Table 33: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.79/\wp_1)$	$(0.71/\wp_2)$	$(0.67/\wp_3)$
ℓ_1	(0.71,0.50)	(0.75,0.43)	(0.73,0.48)
ℓ_2	(0.67,0.47)	(0.69,0.39)	(0.69,0.46)
ℓ_3	(0.59,0.42)	(0.67,0.36)	(0.66,0.43)

and

Table 34: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0.77/\wp_1)$	$(0.72/\wp_2)$	$(0.66/\wp_3)$
ℓ_1	(0.69,51)	(0.72,0.51)	(0.69,0.49)
ℓ_2	(0.63,48)	(0.66,0.47)	(0.64,0.47)
ℓ_3	(0.57,0.44)	(0.62,0.39)	(0.59,0.46)

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

then $\mathfrak{T} = \{H_\phi, H_P, H_{\mathfrak{A}}, H_{\mathfrak{B}}\}$ is FP-qROFSS-topology on G. Thus the closed sets can be calculated as by taking compliments of FP-qROFS-open sets in $\mathfrak{T}$,i.e..$(H_\phi)^c = H_P, (H_P)^c = H_\phi$, Table 35 and 36

Table 35: FP-qROFSSs

$(H_{\mathfrak{A}})^c$	$(0.21/\wp_1)$	$(0.29/\wp_2)$	$(0.33/\wp_3)$
ℓ_1	(0.50,0.71)	(0.43,0.75)	(0.48,0.73)
ℓ_2	(0.47,0.67)	(0.39,0.69)	(0.46,0.69)
ℓ_3	(0.42,0.59)	(0.36,0.67)	(0.43,0.66)

and

Table 36: FP-qROFSSs

$(H_{\mathfrak{B}})^c$	$(0.23/\wp_1)$	$(0.28/\wp_2)$	$(0.34/\wp_3)$
ℓ_1	(0.51,0.69)	(0.51,0.72)	(0.49,0.69)
ℓ_2	(0.48,0.63)	(0.47,0.66)	(0.47,0.64)
ℓ_3	(0.44,0.57)	(0.39,0.62)	(0.46,0.59)

If $\mathfrak{C} = 0.81/\wp_1, 0.79/\wp_2 \subseteq P$, then a FP-qROFSS on G is, Table 37

Table 37: FP-qROFSSs

$H_{\mathfrak{C}}$	$(0.81/\wp_1)$	$(0.79/\wp_2)$
ℓ_1	(0.72,0.50)	(0.74,0.42)
ℓ_2	(0.68,0.47)	(0.68,0.38)
ℓ_3	(0.60,0.41)	(0.66,0.35)

This show that FP-qROFS-closed superset of $H_{\mathfrak{C}}$ are $(H_{\mathfrak{A}})^c$ and H_P only. Thus $\overline{H_{\mathfrak{C}}} = (H_{\mathfrak{A}})^c \cap H_P = (H_{\mathfrak{A}})^c$. On the other hand, Table 38

Table 38: FP-qROFSSs

$(H_{\mathfrak{C}})^c$	$(0.19/\wp_1)$	$(0.21/\wp_2)$
ℓ_1	(0.50,0.72)	(0.42,0.74)
ℓ_2	(0.47,0.68)	(0.38,0.68)
ℓ_3	(0.41,0.60)	(0.35,0.66)

So $\overline{(H_C)^c} = H_P$. Hence we obtain $H_{\mathfrak{r}}(H_{\mathfrak{C}}) = \overline{H_{\mathfrak{C}}} \cap \overline{H_{\mathfrak{C}}^c} = (H_{\mathfrak{A}})^c \cap H_P = (H_{\mathfrak{A}})^c$

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Definition 5.7. Let $H_{\mathfrak{A}}$ be a subset of FP-qROFSS-topological space (G, P). Then the exterior of $H_{\mathfrak{A}}$ is denoted by $Ext(H_{\mathfrak{A}}) = \overline{(H_{\mathfrak{A}})^c}$

Example 5.8. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{A} = \{0.79/\wp_1, 0.71/\wp_2, 0.67/\wp_3\} \subseteq P$, $\mathfrak{B} = \{0.72/\wp_2, 0.66/\wp_3\} \subseteq P$ with FP-qROFSS Table 39 and 40.

Table 39: FP-qROFSSs

$H_{\mathfrak{A}}$	$(0.79/\wp_1)$	$(0.71/\wp_2)$	$(0.67/\wp_3)$
ℓ_1	(0.71,0.50)	(0.75,0.43)	(0.73,0.48)
ℓ_2	(0.67,0.47)	(0.69,0.39)	(0.69,0.46)
ℓ_3	(0.59,0.42)	(0.67,0.36)	(0.66,0.43)

and

Table 40: FP-qROFSSs

$H_{\mathfrak{B}}$	$(0.77/\wp_1)$	$(0.72/\wp_2)$	$(0.66/\wp_3)$
ℓ_1	(0.69,51)	(0.72,0.51)	(0.69,0.49)
ℓ_2	(0.63,48)	(0.66,0.47)	(0.64,0.47)
ℓ_3	(0.57,0.44)	(0.62,0.39)	(0.59,0.46)

then $\mathfrak{T} = \{H_\phi, H_P, H_{\mathfrak{A}}, H_{\mathfrak{B}}\}$ is FP-qROFSSs topology on G. Thus the closed sets can be calculated as by taking compliments of FP-qROFS-open sets in $\mathfrak{T}$,i.e..$(H_\phi)^c = H_P, (H_P)^c = H_\phi$, Table 41 and 42

Table 41: FP-qROFSSs

$(H_{\mathfrak{A}})^c$	$(0.21/\wp_1)$	$(0.29/\wp_2)$	$(0.33/\wp_3)$
ℓ_1	(0.50,0.71)	(0.43,0.75)	(0.48,0.73)
ℓ_2	(0.47,0.67)	(0.39,0.69)	(0.46,0.69)
ℓ_3	(0.42,0.59)	(0.36,0.67)	(0.43,0.66)

and

Table 42: FP-qROFSSs

$(H_{\mathfrak{B}})^c$	$(0.23/\wp_1)$	$(0.28/\wp_2)$	$(0.34/\wp_3)$
ℓ_1	(0.51,0.69)	(0.51,0.72)	(0.49,0.69)
ℓ_2	(0.48,0.63)	(0.47,0.66)	(0.47,0.64)
ℓ_3	(0.44,0.57)	(0.39,0.62)	(0.46,0.59)

If $\mathfrak{C} = \{0.81/\wp_1, 0.79/\wp_2\} \subseteq P$, then a FP-qROFSSs on G is, Table 43

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Table 43: FP-qROFSSs

$H_{\mathfrak{C}}$	$(0.81/\wp_1)$	$(0.79/\wp_2)$
ℓ_1	(0.72,0.50)	(0.74,0.42)
ℓ_2	(0.68,0.47)	(0.68,0.38)
ℓ_3	(0.60,0.41)	(0.66,0.35)

This show that FP-qROFS-closed superset of $H_{\mathfrak{C}}$ are $(H_{\mathfrak{A}})^c$ and H_P only. Thus $\overline{H_{\mathfrak{C}}} = (H_{\mathfrak{A}})^c \cap H_P = (H_{\mathfrak{A}})^c$. On the other hand, Table 44

Table 44: FP-qROFSSs

$(H_{\mathfrak{C}})^c$	$(0.19/\wp_1)$	$(0.21/\wp_2)$
ℓ_1	(0.50,0.72)	(0.42,0.74)
ℓ_2	(0.47,0.68)	(0.38,0.68)
ℓ_3	(0.41,0.60)	(0.35,0.66)

So $\overline{(H_C)^c} = H_P$. Hence we obtain $H_{\mathfrak{r}}(H_{\mathfrak{C}}) = \overline{H_{\mathfrak{C}}} \cap \overline{H_{\mathfrak{C}}^c} = (H_{\mathfrak{A}})^c \cap H_P = (H_{\mathfrak{A}})^c$

Remark. We present some results about frontier, exterior, closure and interior of FP-qROFSSs and show investigate some results which hold in crisp set theory but not this results hold in FP-qROFSSs theory with the help of examples. Since the law of contradiction and law of Excluded middle does not hold in FP-qROFSSs theory. This leads the following theorem.

Theorem 5.9. *If $H_{\mathfrak{A}}, H_{\mathfrak{B}}, H_{\mathfrak{C}}, H_{\mathfrak{D}}$ are FP-qROFSSs, then*

1. $(H_{\mathfrak{A}}^0)^c = \overline{(H_{\mathfrak{A}}^c)}$,
2. $(\overline{H_{\mathfrak{A}}})^c = (H_{\mathfrak{A}}^c)^0$,
3. $(H_{\mathfrak{A}})^0 \neq H_{\mathfrak{A}} - \overline{H_{\mathfrak{A}}^c}$,
4. $Ext(H_{\mathfrak{A}}^c) = H_{\mathfrak{A}}^0$,
5. $Ext(H_{\mathfrak{A}}) = (H_{\mathfrak{A}}^c)^0$,
6. $Ext(H_{\mathfrak{A}}) \cup H_{\mathfrak{r}}(H_{\mathfrak{A}}) \cup H_{\mathfrak{A}}^0 \neq H_p$,
7. $H_{\mathfrak{r}}(H_{\mathfrak{A}}) = H_{\mathfrak{r}}(H_{\mathfrak{A}}^c)$,
8. $H_{\mathfrak{A}}^0 \cap H_{\mathfrak{r}}(H_{\mathfrak{A}}) \neq H_{\phi}$,
9. $\overline{H_{\mathfrak{A}}} \neq H_{\mathfrak{A}} \cup H_{\mathfrak{r}}(H_{\mathfrak{A}})$,
10. $\overline{H_{\mathfrak{A}}} \neq H_{\mathfrak{A}}^0 \cup H_{\mathfrak{r}}(H_{\mathfrak{A}})$

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Proof. By example (5.12), we observe that $Ext(H_{\mathfrak{D}}) = H_{\phi}$, $H_{\mathfrak{r}}(H_{\mathfrak{D}}) = H^0_{\mathfrak{B}}$, $H^0_{\mathfrak{D}} = H_{\mathfrak{B}}$ and $\overline{H_{\mathfrak{D}}} = H_P$

1. (1) and (2) hold by [58]
2. $(H_{\mathfrak{A}})^0 \neq H_{\mathfrak{A}} - \overline{H^c_{\mathfrak{A}}}$, because $H_{\mathfrak{A}} - H_{\mathfrak{B}} \neq H_{\mathfrak{A}} \cap H^c_{\mathfrak{B}}$.
3. Clearly, $Ext(H^c_{\mathfrak{A}}) = \overline{(H^c_{\mathfrak{A}})}^c$. Then $Ext(H^c_{\mathfrak{A}}) = [(H^c_{\mathfrak{A}})^c]^0$, Thus $Ext(H^c_{\mathfrak{A}}) = (H^0_{\mathfrak{A}})$.
4. Clearly, $Ext(H_{\mathfrak{A}}) = \overline{(H_{\mathfrak{A}})}^c$. Then $Ext(H_{\mathfrak{A}}) = (H^c_{\mathfrak{A}})^0$
5. Clearly, $Ext(H_{\mathfrak{A}}) \cup H_{\mathfrak{r}}(H_{\mathfrak{A}}) \cup H^0_{\mathfrak{A}} \neq H_p$. Then by example 4.14, we observe that $H_{\phi} \cup H^c_{\mathfrak{B}} \cup H_{\mathfrak{B}} \neq H_p$.
6. Clearly, $H_{\mathfrak{r}}(H^c_{\mathfrak{A}}) = \overline{(H^c_{\mathfrak{A}})} \cap \overline{[H^c_{\mathfrak{A}}]^c}$. Then $H_{\mathfrak{r}}(H^c_{\mathfrak{A}}) = \overline{(H^c_{\mathfrak{A}})} \cap \overline{(H_{\mathfrak{A}})} = H_{\mathfrak{r}}(H_{\mathfrak{A}})$.
7. Clearly, $H^0_{\mathfrak{A}} \cap H_{\mathfrak{r}}(H_{\mathfrak{A}}) \neq H_{\phi}$. Then by example (5.12), we observe that $H^c_{\mathfrak{B}} \cap (H_{\mathfrak{B}}) \neq H_{\phi}$.
8. Clearly, $\overline{H_{\mathfrak{A}}} \neq H_{\mathfrak{A}} \cup H_{\mathfrak{r}}(H_{\mathfrak{A}})$. Then by example 4(5.12) we see that $H_P \neq H_{\mathfrak{D}} \cup H^c_{\mathfrak{B}}$.
9. Clearly, $\overline{H_{\mathfrak{A}}} \neq H^0_{\mathfrak{A}} \cup H_{\mathfrak{r}}(H_{\mathfrak{A}})$. Then by example (5.12) we see that $H_P \neq H_{\mathfrak{B}} \cup H^c_{\mathfrak{B}}$.

□

Remark. Every non-empty FP-qROFSSs $H_{\mathfrak{A}}$ can be written as the FP-qROFS-union of all the FP-qROFS-points which are in $H_{\mathfrak{A}}$.

Definition 5.10. A FP-qROFSSs $H_{\mathfrak{A}_1}$ is called Q-neighborhood of $\wp(H_{\mathfrak{A}_2})$, if there exists $H_{\mathfrak{B}} \in \mathfrak{T}$ such that $\wp(H_{\mathfrak{A}_2}) q H_{\mathfrak{B}}$ and $H_{\mathfrak{B}} \subseteq H_{\mathfrak{A}_1}$.

Example 5.11. Let $G = \{\ell_1, \ell_2, \ell_3\}$ be universal set and let $P = \{\wp_1, \wp_2, \wp_3, \wp_4\}$ be the set of parameters. If $\mathfrak{B}_1 = \{0.80/\wp_1, 0.72/\wp_2, 0.68/\wp_3\} \subseteq P$, $\mathfrak{B}_2 = \{0.73/\wp_1, 0.72/\wp_2, 0.66/\wp_3\} \subseteq P$ with FP-qROFS Table 45 and 46.

Table 45: FP-qROFSSs

$H_{\mathfrak{B}_1}$	$(0.80/\wp_1)$	$(0.72/\wp_2)$	$(0.68/\wp_3)$
ℓ_1	(0.71,0.50)	(0.75,0.43)	(0.73,0.48)
ℓ_2	(0.67,0.47)	(0.69,0.39)	(0.69,0.46)
ℓ_3	(0.59,0.42)	(0.67,0.36)	(0.66,0.43)

and

Table 46: FP-qROFSSs

$H_{\mathfrak{B}_2}$	$(0.73/\wp_1)$	$(0.72/\wp_2)$	$(0.66/\wp_3)$
ℓ_1	(0.69,51)	(0.72,0.51)	(0.69,0.49)
ℓ_2	(0.63,48)	(0.66,0.47)	(0.64,0.47)
ℓ_3	(0.57,0.44)	(0.62,0.39)	(0.59,0.46)

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

then $\mathfrak{T} = \{H_\phi, H_P, H_{\mathfrak{A}}, H_{\mathfrak{B}}\}$ is FP-qROFSSs topology on G.
If $\wp(H_{\mathfrak{A}_2}) = 0.67/\wp_1$ Table 47

Table 47: FP-qROFSSs

$\wp(H_{\mathfrak{A}_2})$	$(0.73/\wp_1)$
ℓ_1	(0.68,0.52)
ℓ_2	(0.62,47)
ℓ_3	(0.55,0.45)

If $\wp(H_{\mathfrak{A}_2})$ is a FP-qROFS-point, then it is clear that
$\wp(H_{\mathfrak{A}_2})qH_{\mathfrak{B}_2}$ and $H_{\mathfrak{B}_2} \in \mathfrak{T}$. Thus $\Re_{H_{\mathfrak{A}_2}}(\wp) + \Re_{H_{\mathfrak{B}_2}}(\wp) > 1$, $\wp \in P$ and $\Im^{\wp}_{H_{\mathfrak{A}_2}}(\ell) + \Im^{\wp}_{H_{\mathfrak{B}_2}}(\ell) < 1, \ell \in G$.
If $H_{\mathfrak{A}_1} = \{0.72/\wp_1, 0.70/\wp_2, 0.65/\wp_3\}$ Table 48

Table 48: FP-qROFSSs

$H_{\mathfrak{A}_1}$	$(0.72/\wp_1)$	$(0.70/\wp_2)$	$(0.65/\wp_3)$
ℓ_1	(0.68,51)	(0.71,0.51)	(0.67,0.50)
ℓ_2	(0.62,48)	(0.65,0.48)	(0.61,0.48)
ℓ_3	(0.56,0.45)	(0.59,0.40)	(0.56,0.47)

Then $H_{\mathfrak{B}_2} \subseteq H_{\mathfrak{A}_1}$ and $\wp(H_{\mathfrak{A}_2})qH_{\mathfrak{B}_2}$. Thus by definition $H_{\mathfrak{A}_1}$ is Quasi-neighborhood of $\wp(H_{\mathfrak{A}_2})$.

Theorem 5.12. *$H_{\mathfrak{B}} \subseteq H_{\mathfrak{A}_1}$ if and only if $H_{\mathfrak{B}}$ and $H^c_{\mathfrak{A}_1}$ are not quasi-coincident. In particular, $\wp(H_{\mathfrak{A}_2}) \in H_{\mathfrak{B}}$ if and only if $\wp(H_{\mathfrak{A}_2})$ is not quasi-coincident with $H^c_{\mathfrak{B}}$.*

Proof. This follow from the fact:
$H_{\mathfrak{B}} \subseteq H_{\mathfrak{A}_1} \iff \Re_{\mathfrak{B}}(\wp) \leq \Re_{\mathfrak{A}_1}(\wp), \wp \in P$ and $\aleph^{\wp}_{\mathfrak{B}}(\ell) \leq \aleph^{\wp}_{\mathfrak{A}_1}(\ell), \ell \in G$
$H_{\mathfrak{B}} \subseteq H_{\mathfrak{A}_1} \iff \Re_{\mathfrak{B}}(\wp) + \Re_{\mathfrak{A}_1}(\wp) = \Re_{\mathfrak{B}}(\wp) + 1 - \Re_{\mathfrak{A}_1}(\wp) \leq 1$.
Then $\aleph^{\wp}_{\mathfrak{B}}(\ell) + \aleph^{\wp}_{\mathfrak{A}^c_1}(\ell) = \aleph^{\wp}_{\mathfrak{B}}(\ell) + 1 - \aleph^{\wp}_{\mathfrak{A}_1}(\ell) \leq 1$, for $\wp \in P$ $\ell \in G$.
Thus $H_{\mathfrak{B}} \subseteq H_{\mathfrak{A}_1}$. So $H_{\mathfrak{B}}\overline{q}H^c_{\mathfrak{A}_1}$.
Similarly, $\wp(H_{\mathfrak{A}_2}) \in H_{\mathfrak{B}}$. Then $H_{\mathfrak{A}_2}\overline{q}H^c_{\mathfrak{B}}$. □

Theorem 5.13. *Let $\mathfrak{U}_\wp$ be the collection of FP-qROFSSs Q-neighborhoods of FP-qROFS point $\wp(H_{\mathfrak{A}})$ in a FP-qROFS topological space $\mathfrak{T}$.*

1. *If $H_{\mathfrak{B}} \in \mathfrak{U}_\wp$, then $\wp(H_{\mathfrak{A}})$ is quasi-coincident with $H_{\mathfrak{B}}$.*
2. *If $H_{\mathfrak{B}_1} \in \mathfrak{U}_\wp$, and $H_{\mathfrak{B}_1} \subseteq H_{\mathfrak{B}_2}$, then $H_{\mathfrak{B}_2} \in \mathfrak{U}_\wp$.*
3. *If $H_{\mathfrak{B}_1} \in \mathfrak{U}_\wp$, then there exist $H_{\mathfrak{B}_2} \in \mathfrak{U}_\wp$ such that $H_{\mathfrak{B}_2} \subseteq H_{\mathfrak{B}_3}$ and $H_{\mathfrak{B}_3} \in \mathfrak{U}_d$ for every FP-qROFS point $d(H_{\mathfrak{A}})$ which is quasi-coincident with $H_{\mathfrak{B}_2}$.*

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Proof. 1. Suppose that $H_{\mathfrak{B}} \in \mathfrak{U}_{\wp}$. Then by definition, there exist $\mathfrak{I}_c \in \mathfrak{T}$ such that

$$\wp(H_{\mathfrak{A}}) q \mathfrak{I}_c \text{ and } \mathfrak{I}_c \subseteq H_{\mathfrak{B}}.$$

Thus $\Re_{H_{\mathfrak{A}}(\wp)} + \Re_{\mathfrak{I}_c(\wp)} > 1, \wp \in P$ and $\aleph^{\wp}_{H_{\mathfrak{A}}(\ell)} + \aleph^{\wp}_{\mathfrak{I}_c}(\ell) < 1, \ell \in G$
Again $\Re_{\mathfrak{I}_c(\wp)} \leq \Re_{H_{\mathfrak{B}}(\wp)}, \wp \in P$ and $\aleph^{\wp}_{\mathfrak{I}_c}(\ell) \leq \aleph^{\wp}_{H_{\mathfrak{B}}(\ell)}, \ell \in G$
So,

$$\Re_{H_{\mathfrak{A}}(\wp)} + \Re_{H_{\mathfrak{B}}(\wp)} \geq \Re_{H_{\mathfrak{A}}(\wp)} + \Re_{\mathfrak{I}_c(\wp)} > 1, \wp \in P$$

and

$$\aleph^{\wp}_{H_{\mathfrak{A}}(\ell)} + \aleph^{\wp}_{H_{\mathfrak{B}}(\ell)} \geq \aleph^{\wp}_{H_{\mathfrak{A}}(\ell)} + \aleph^{\wp}_{\mathfrak{I}_c}(\ell) < 1, \ell \in G$$

This show that $\wp(H_{\mathfrak{A}})$ is quasi-coincident with $H_{\mathfrak{B}}$.

2. Suppose that $H_{\mathfrak{B}_1} \in \mathfrak{U}_{\wp}$. Then by definition, there exist $\mathfrak{I}_c \in \mathfrak{T}$ such that,

$$\wp(H_{\mathfrak{A}}) q \mathfrak{I}_c \text{ and } \mathfrak{I}_c \subseteq H_{\mathfrak{B}_1}.$$

Thus $\Re_{H_{\mathfrak{A}}(\wp)} + \Re_{\mathfrak{I}_c(\wp)} > 1, \wp \in P$ and $\aleph^{\wp}_{H_{\mathfrak{A}}(\ell)} + \aleph^{\wp}_{\mathfrak{I}_c}(\ell) > 1, \ell \in G$
Again $\Re_{\mathfrak{I}_c(\wp)} \leq \Re_{H_{\mathfrak{B}_1}(\wp)}, \wp \in P$ and $\aleph^{\wp}_{\mathfrak{I}_c}(\ell) \leq \aleph^{\wp}_{H_{\mathfrak{B}_1}(\ell)}, \ell \in G$
Given that $H_{\mathfrak{B}_1} \subseteq H_{\mathfrak{B}_2}$. Then by definition of FP-qROFS-subset,

$$\Re_{H_{\mathfrak{B}_1}} \leq \Re_{H_{\mathfrak{B}_2}}, \wp \in P \quad (1)$$

and

$$\aleph^{\wp}_{\mathfrak{B}_1}(\ell) \leq \aleph^{\wp}_{\mathfrak{B}_2}(\ell), \ell \in G \quad (2)$$

Since $\wp(H_{\mathfrak{A}}) q \mathfrak{I}_c$, now only we have to show that $\mathfrak{I}_c \subseteq H\mathfrak{B}2$. Since

$$\Re_{\mathfrak{I}_c(\wp)} \leq \Re_{H_{\mathfrak{B}_1}}, \wp \in P \quad (3)$$

and

$$\aleph^{\wp}_{\mathfrak{I}_c}(\ell) \leq \aleph^{\wp}_{H_{\mathfrak{B}_1}(\ell)}, \ell \in G \quad (4)$$

Comparing (1)(2)(3)(4);

$$\Re_{\mathfrak{I}_c(\wp)} \leq \Re_{H_{\mathfrak{B}_1}} \leq \Re_{H_{\mathfrak{B}_2}} \wp \in P \text{ and}$$
$$\aleph^{\wp}_{\mathfrak{I}_c}(\ell) \leq \aleph^{\wp}_{H_{\mathfrak{B}_1}(\ell)} \leq \aleph^{\wp}_{\mathfrak{B}_2}(\ell), \ell \in G$$

Thus, $H_{\mathfrak{B}_2} \in \mathfrak{U}_{\wp}$.

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

3. Suppose that $H_{\mathfrak{B}_1} \in \mathfrak{U}_\wp$. Then, there exist $H_{\mathfrak{B}_2} \in \mathfrak{T}$ such that $\wp(H_{\mathfrak{A}})qH_{\mathfrak{B}_2}$ and $H_{\mathfrak{B}_2} \subseteq H_{\mathfrak{B}_1}$. Thus, there exist $H_{\mathfrak{B}_2} \in \mathfrak{U}_c$ such that $\wp(H_{\mathfrak{A}})qH_{\mathfrak{B}_2}$ and $H_{\mathfrak{B}_2} \subseteq H_{\mathfrak{B}_1}$. Let $d(H_{\mathfrak{A}})$ be any FP-qROFS-point which is Q-coincident with $H_{\mathfrak{B}_2}$. Then $H_{\mathfrak{B}_2} \in \mathfrak{U}_d$.

□

Theorem 5.14. *Intersection of two Q-neighborhoods of FP-qROFS-point $\wp(H_{\mathfrak{A}})$ is a Q-neighborhood.*

Proof. Let $H_{\mathfrak{A}_1}$ and $H_{\mathfrak{A}_2}$ two Q-neighborhoods of FP-qROFS-point $\wp(H_{\mathfrak{A}})$. Then by definition for $H_{\mathfrak{A}_1}$,there exist $\mathfrak{I}_{C_1} \in \mathfrak{T}$ such that $\wp(H_{\mathfrak{A}})q\mathfrak{I}_{C_1}$ and $\mathfrak{I}_{C_1} \subseteq H_{\mathfrak{A}_1}$. Thus

$$\Re_{H_{\mathfrak{A}}(\wp)} + \Re_{\mathfrak{I}_{c_1}(\wp)} > 1, \wp \in P \tag{1}$$
$$\aleph^{\wp}_{H_{\mathfrak{A}}(\ell)} + \aleph^{\wp}_{\mathfrak{I}_{c_1}}(\ell) < 1, \ell \in G \tag{2}$$

and

$$\Re_{\mathfrak{I}_{c_1}(\wp)} \leq \Re_{H_{\mathfrak{A}_1}}(\wp), \wp \in P \tag{3}$$
$$\aleph^{\wp}_{\mathfrak{I}_{c_1}}(\ell) \leq \aleph^{\wp}_{H_{\mathfrak{A}_1}}(\ell), \ell \in G \tag{4}$$
$$\tag{5}$$

Similarly, for Q-neighborhood $H_{\mathfrak{A}_2}$, there exist $\mathfrak{I}_{C_2} \in \mathfrak{T}$ such that
$\wp(H_{\mathfrak{A}})q\mathfrak{I}_{C_2}$ and $\mathfrak{I}_{C_2} \subseteq H_{\mathfrak{A}_2}$. Then
$\Re_{H_{\mathfrak{A}}(\wp)} + \Re_{\mathfrak{I}_{c_2}(\wp)} > 1, \wp \in P$
$\aleph^{\wp}_{H_{\mathfrak{A}}}(\ell) + \aleph^{\wp}_{\mathfrak{I}_{C_2}}(\ell) > 1, \ell \in G$
and
$\Re_{\mathfrak{I}_{C_2}}(\wp) \leq \Re_{H_{\mathfrak{A}_2}}(\wp), \wp \in P$
$\aleph^{\wp}_{\mathfrak{I}_{C_2}}(\ell) \leq \aleph^{\wp}_{H_{\mathfrak{A}_2}}(\ell), \ell \in G$
Since $H_{\mathfrak{A}_1}$ and $H_{\mathfrak{A}_2}$ both are FP-qROFSSs, their intersection is also an FP-qROFSSs.
Suppose $H_{\mathfrak{A}_1} \cap H_{\mathfrak{A}_2} = H_{\mathfrak{A}_3}$. Then

$$\Re_{H_{\mathfrak{A}_3}}(\wp) = min\{\Re_{H_{\mathfrak{A}_1}}(\wp), \Re_{H_{\mathfrak{A}_2}}(\wp)\}$$

and

$$\aleph^{\wp}_{H_{\mathfrak{A}_3}}(\ell) = min\{\aleph^{\wp}_{H_{\mathfrak{A}_1}}(\ell), \aleph^{\wp}_{H_{\mathfrak{A}_2}}(\ell)\}$$

Since $\mathfrak{I}_{C_1} \subseteq H_{\mathfrak{A}_1}$ and $\mathfrak{I}_{C_2} \subseteq H_{\mathfrak{A}_2}$, $\mathfrak{I}_{C_1} \cap \mathfrak{I}_{C_2} \subsetneq H_{\mathfrak{A}_1} \cap H_{\mathfrak{A}_2}$.
If $\mathfrak{I}_{C_1} \cap \mathfrak{I}_{C_2} = \mathfrak{I}_{C_3}$, then $\mathfrak{I}_{C_3} \subseteq H_{\mathfrak{A}_3}$. Thus

$$\Re_{\mathfrak{I}_{c_3}(\wp)} \leq \Re_{H_{\mathfrak{A}_3}}(\wp), \wp \in P$$

and

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

$$\aleph^{\wp}_{\mathfrak{J}_{C_3}}(\ell) \leq \aleph^{\wp}_{H_{\mathfrak{A}_3}}(\ell), \ell \in G$$

Since $\wp(H_{\mathfrak{A}})q\mathfrak{J}_{C_1}$ and $\wp(H_{\mathfrak{A}})q\mathfrak{J}_{C_2}$, $\wp(H_{\mathfrak{A}})q[\mathfrak{J}_{C_1} \cap \mathfrak{J}_{C_2}] = \mathfrak{J}_{C_3}$, where
$\Re_{\mathfrak{J}_{C_3}}(\wp) = min\{\Re_{\mathfrak{J}_{C_1}}(\wp), \Re_{\mathfrak{J}_{C_2}}(\wp)\}$
$\aleph^{\wp}_{\mathfrak{J}_{C_3}}(\ell) = min\{\aleph^{\wp}_{\mathfrak{J}_{C_1}}(\ell), \aleph^{\wp}_{\mathfrak{J}_{C_2}}(\ell)\}$
and
$\Re_{H_{\mathfrak{A}}}(\wp) + \Re_{\mathfrak{J}_{C_3}}(\wp) > 1, \wp \in P$
$\aleph^{\wp}_{H_{\mathfrak{A}}(\ell)} + \aleph^{\wp}_{\mathfrak{J}_{c_3}}(\ell) > 1, \ell \in G$
With $\mathfrak{J}_{C_3} \subseteq H_{\mathfrak{A}_3}$. So $H_{\mathfrak{A}_3}$ is a Q-neighborhood of $\wp(H_{\mathfrak{A}})$. □

Theorem 5.15. *A FP-qROFS-point $\wp(H_{\mathfrak{A}}) \in \overline{H_{\mathfrak{A}}}$ if and only if Q-neighborhood of $\wp(H_{\mathfrak{A}})$ is Q-coincident with $H_{\mathfrak{A}}$.*

Proof. $\wp(H_{\mathfrak{A}}) \in \overline{H_{\mathfrak{A}}}$ if and only if every closed set $H_{\mathfrak{C}}$ contains $\wp(H_{\mathfrak{B}})$ i.e., $\wp(H_{\mathfrak{B}}) \in H_{\mathfrak{C}}$. On the other hand,
$\Re_{H_{\mathfrak{B}}}(\wp) \leq \Re_{H_{\mathfrak{C}}}(\wp), \wp \in P$
and
$\aleph^{\wp}_{H_{\mathfrak{B}}(\ell)} \leq \aleph^{\wp} H_{\mathfrak{C}}(\ell), \ell \in G$
Then
$\wp(H_{\mathfrak{A}}) \in \overline{H_{\mathfrak{A}}}$ if and only if for all closed sets $\wp(H_{\mathfrak{A}}) \subseteq H_{\mathfrak{C}}$
$1 - \Re_{H_{\mathfrak{B}}}(\wp) \geq 1 - \Re_{H_{\mathfrak{C}}},(\wp)\wp \in P$
and
$1 - \aleph^{\wp}_{H_{\mathfrak{B}}(\ell)} \geq 1 - \aleph^{\wp}_{\mathfrak{C}}(\ell), \ell \in G.$
Thus $\wp(H_{\mathfrak{A}}) \in \overline{H_{\mathfrak{A}}}$ if and only if for any FP-qROFS-open set $\mathfrak{J}_{\mathfrak{C}} \subseteq H^c_{\mathfrak{A}}$,we have
$\Re_{\mathfrak{J}_{\mathfrak{C}}}(\wp) \leq 1 - \Re_{H_{\mathfrak{B}}}, \wp \in P$
and
$\aleph^{\wp}_{\mathfrak{J}_{\mathfrak{C}}(\ell)} \leq 1 - \aleph^{\wp} H_{\mathfrak{B}}(\ell), \ell \in G.$
In other words, for every FP-qROFS-open set $\mathfrak{J}_{\mathfrak{C}}$ satisfying
$\Re_{\mathfrak{J}_{\mathfrak{C}}}(\wp) > 1 - \Re_{H_{\mathfrak{B}}}, \wp \in P$
and
$\aleph^{\wp}_{\mathfrak{J}_{\mathfrak{C}}(\ell)} > 1 - \aleph^{\wp} H_{\mathfrak{B}}(\ell), \ell \in G$
$\mathfrak{J}_{\mathfrak{C}}$ is not contained in $H^c_{\mathfrak{A}}$.
Again $\mathfrak{J}_{\mathfrak{C}}$ is not contained in $H^c_{\mathfrak{A}}$ iff $\mathfrak{J}_{\mathfrak{C}}$ is Q-coincident with $H_{\mathfrak{A}}$. So we proved that $\wp(H_{\mathfrak{A}}) \in \overline{H_{\mathfrak{A}}}$ iff every open Q-neighborhood $\mathfrak{J}_{\mathfrak{C}}$ of $H_{\mathfrak{B}}$, which is evidently equivalent to what we want to prove. □

Definition 5.16. A FP-qROFS-point $\wp(H_{\mathfrak{A}})$ is called limit point of a FP-qROFSSs $H_{\mathfrak{B}}$, if $\wp(H_{\mathfrak{A}})$ is an adherence point of $H_{\mathfrak{B}}$, and every FP-qROFS Q-neighborhood of $\wp(H_{\mathfrak{A}})$ and $H_{\mathfrak{B}}$ are Q-coincident at some FP-qROFS-point different from $\wp$, and $\wp(H_{\mathfrak{A}}) \in H_{\mathfrak{B}}$.
The FP-qROFS-union of all accumulation points of FP-qROFSSs $H_{\mathfrak{B}}$ is called the derived set of $H_{\mathfrak{B}}$ denoted as $H^d_{\mathfrak{B}}$.

Theorem 5.17. $\overline{H_{\mathfrak{A}}} = H_{\mathfrak{A}} \cup H^d_{\mathfrak{A}}$.

Proof. Let $\Omega = \{\wp(H_{\mathfrak{B}}) is\ an\ adherent\ point\ of H_{\mathfrak{A}}\}$. Then by theorem
"'A FP-qROFS-point $\wp(H_{\mathfrak{B}}) \in \overline{H_{\mathfrak{A}}}$ if and only if Q-neighborhood of $\wp(H_{\mathfrak{B}})$ is Q-coincident with $H_{\mathfrak{A}}$"',
$\overline{H_{\mathfrak{A}}} = \cup\Omega$. Thus $\wp(H_{\mathfrak{B}}) \in \Omega$ iff either $\wp(H_{\mathfrak{B}}) \in H_{\mathfrak{A}}$ or $\wp(H_{\mathfrak{B}}) \in H^d_{\mathfrak{A}}$. So $\overline{H_{\mathfrak{A}}} = \cup\Omega = H_{\mathfrak{A}} \cup H^d_{\mathfrak{A}}$ □

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4(2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Corollary 5.18. *A FP-qROFSSs $H_{\mathfrak{A}}$ is closed iff $H_{\mathfrak{A}}$ contains all of its accumulation points.*

Proof. Let $H_{\mathfrak{A}}$ be a FP-qROFSSs. Then by theorem (4.23), $\overline{H_{\mathfrak{A}}} = H_{\mathfrak{A}} \cup H_{\mathfrak{A}}^d$.
Thus $H_{\mathfrak{A}}$ is closed
$\Leftrightarrow \overline{H_{\mathfrak{A}}} = H_{\mathfrak{A}}$
$\Leftrightarrow \overline{H_{\mathfrak{A}}} = H_{\mathfrak{A}} \cup H_{\mathfrak{A}}^d = H_{\mathfrak{A}}$.
$\Leftrightarrow H_{\mathfrak{A}}^d \subseteq H_{\mathfrak{A}}$
$\Leftrightarrow H_{\mathfrak{A}}$ contains all of its accumulation points. □

6 Conclusion

In this paper, we studied FPS-set and some of its operations with the help of examples. The immense contributions of mathematicians are actually to develop new theories which enable us to solve several different problems related to topology. The theory of decision making is cautiously and rapidly developing area of mathematics. The fuzzy parameterized q-rung orthopair soft set is one of the gap which we are trying to fulfill. We propose the idea of fuzzy parameterized q-rung fuzzy soft set and discussed a topological structure on it. We defined the concepts FP-qROFSS closure, interior, frontier, and exterior for any subset the proposed structure. We also discuss certain quasi-coincidence and q-neighborhood properties of FP-qROFSS.

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Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 4 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189

http://amresearchreview.com/index.php/Journal/about