Research Article

Fuzzy Simple Partially Ordered Γ- Semigroups

Srinivas Telikepalli[1], A. Gangadhara Rao[2], K.V.Naga Lakshmi[3], N.Srimannarayana[4]
[1]Dept. of Mathematics, QIS INSTITUTE OF TECHNOLOGY, Ongole 1,
[2]Dept. of Mathematics, V.S.R. & N.V.R. College, Tenali 2 ,
[3]Dept. of Mathematics, SRR & CVR Govt Degree College, Vijayawada, India 3,
[4]Department of Mathematics, Koneru Lakshmaiah Education Foundation, Vaddeswaram, A.P., India.

Article History: Received: 11 January 2021; Accepted: 27 February 2021; Published online: 5 April 2021

Abstract: In this paper, it is shown that $f_{(S\Gamma a]}$ and $f_{(a\Gamma S]}$ are respectively fuzzy left and fuzzy right ideals of S. S is a fuzzy left(right) simple po- Γ -semigroup⇔ $f_{(S\Gamma a]} = f_S = S$ $(f_{(a\Gamma S]} = f_S = S) \forall a \in S$.
It is proved that for any semi group S "TFAE"
(1) S is left(right) simple po- Γ -semigroup.
(2) S is a fuzzy left(right)simple **Γ**-semigroup.
The union of all proper fuzzy ideals of S is the only fuzzy maximal ideal of S ,where S is a **PO -Γ-Semigroup** with 'e', unity.

MATHEMATICAL SUBJECT CLASSIFICATION (2010): 20M12; 20M17;20N25.

Keywords: Fuzzy semisimple,globally idempotent,fuzzy globally idempotent,left simple po-Γ-semigroup ,fuzzy left simple po-Γ- semigroup, right simple po-Γ-semigroup ,fuzzy right simple po-Γ- semigroup, semisimple and idempotent.

1. INTRODUCTION:

CLIFFORD [2],[3] and LJAPIN [4] have thoroughly explored the algebraic theory of semigroups**.**Anjaneyulu [1] puts forth the ideal theory in general semigroups. The definitions of fuzzysimple**Γ** -semigroup, fuzzyleft simple**Γ** -semigroup, and fuzzyright simple**Γ** -semigroup are presented. In 1965, LAZADEH suggested the concept of a fuzzy subset of a set. A number of experiments on fuzzy sets then resulted in fuzzy logic, the theory of fuzzy sets, fuzzy algebra, etc.ROSENFELD was the founder of fuzzy abstract algebra. The fuzzytheory of semigroups was advanced by Kuroki and Xie.

2. PRELIMINARIES:

In the present paper "FLSPOΓS" denotes Fuzzy left simplepo- Γ-semigroup,
"LSPOΓS"**denotes left simple**po- Γ-semigroup,
"FRSPOΓS" denotes Fuzzy Right simplepo- Γ-semigroup,
"RSPOΓS"**denotes Right simple**po- Γ-semigroup,
"**TFAE**" denotes "The following are equal".
'S' denotes po- Γ -semigroup unless otherwise specified
DEFINITION***2.1:*** **S** is a **Γ**-semigroup with ordered relation'≤' is said to be **PO-Γ-Semigroup** if S is a poset suchthat m ≤ n⇒mγp ≤ nγp and pγm ≤ pγn∀m, n, p∈ S and γ ∈ Γ.
DEFINITION 2.2: **A function f: S→[0,1]is known as *fuzzysubset*of S.**
DEFINITION2.3: Let X(≠∅)⊆ S.We define$\boldsymbol{f_X}: \boldsymbol{S} \rightarrow [\mathbf{0}, \mathbf{1}]$by $\boldsymbol{f_X}(x) = \begin{cases} \mathbf{1} \, \boldsymbol{if} \, \boldsymbol{x} \in \boldsymbol{X} \\ \mathbf{0} \, \boldsymbol{if} \, \boldsymbol{x} \notin \boldsymbol{X} \end{cases}$Then $\boldsymbol{f_X}$ isa *fuzzy subset* ofS.
DEFINITION2.4: For p&q,two fuzzysubsets of S,***the inclusionrelation*** p⊆q is defined by $p(z) \leq q(z), \forall z \in S$ and $p \cup q, p \cap q$are defined by
$(p \cup q)(z) = max\{p(z), q(z)\} = p(z) \vee q(z),\ for\ all\ z \in S$,
$(p \cap q)(z) = min\{p(z), q(z)\} = p(z) \wedge q(z),\ for\ all\ z \in S$.
DEFINITION2.5:([13])For x∈**S,**f&g(two *fuzzysubset*s of S),the product**(**f Γ g)is statedas

$$(f\ \Gamma\ g)(x) = \begin{cases} V_{x \leq y\gamma z} f(y) \wedge g(z), & if\ x \leq y\gamma z \\ \mathbf{0} & \boldsymbol{otherwise} \end{cases}$$

DEFINITION2.6: For any subset P of S,**(P] defined as (P]**={ z∈S / z≤ p for some p∈P}. For P={k} we define(k]= ({k}] = {z∈S / z ≤k}.
DEFINITION2.7: A *fuzzy subset*' $\boldsymbol{\tau}$ ' of S is known as (A) fuzzy Γ-subsemigroup([14])of S if $\boldsymbol{\tau}(m\gamma p) \geq \boldsymbol{\tau}(m) \wedge \boldsymbol{\tau}(p), \forall m, p \in S\ and\ \gamma \in \Gamma$.**(B)** fuzzy Γ-subsemigroup([15]) of S⇔ $\boldsymbol{\tau}\Gamma\boldsymbol{\tau} \subseteq \boldsymbol{\tau}$ **. (C)***fuzzy po*-Γ-*subsemigroup*of S if (i)$\boldsymbol{u} \leq \boldsymbol{v}\ \boldsymbol{then}\ \boldsymbol{\tau}(\boldsymbol{u}) \geq \boldsymbol{\tau}(\boldsymbol{v})$
(ii)$\boldsymbol{\tau}(u\gamma v) \geq \boldsymbol{\tau}(\boldsymbol{u}) \wedge \boldsymbol{\tau}(\boldsymbol{v}), \forall \boldsymbol{u}, \boldsymbol{v} \in \boldsymbol{S}, \forall \gamma \in \Gamma$. ***(D)****fuzzy left ideal*[16]of S if
$(i)\boldsymbol{u} \leq \boldsymbol{v}\ \boldsymbol{then}\ \boldsymbol{\tau}(\boldsymbol{u}) \geq \boldsymbol{\tau}(\boldsymbol{v})$ (ii) $\boldsymbol{\tau}(u\gamma v) \geq \boldsymbol{\tau}(v), \forall \boldsymbol{u}, \boldsymbol{v} \in \boldsymbol{S}, \forall \gamma \in \Gamma$.
(E)*fuzzy left ideal*[16]ofS⇔**'τ'**satisfies that(i) $\boldsymbol{u} \leq \boldsymbol{v}\ \boldsymbol{then}\ \boldsymbol{\tau}(\boldsymbol{u}) \geq \boldsymbol{\tau}(\boldsymbol{v}), \forall \boldsymbol{u}, \boldsymbol{v} \in \boldsymbol{S}$ (ii) $s\ \Gamma\ \boldsymbol{\tau} \subseteq \boldsymbol{\tau}$.
(F)***fuzzy right ideal***[16]of S if(i)$\boldsymbol{u} \leq \boldsymbol{v}\ \boldsymbol{then}\ \boldsymbol{\tau}(\boldsymbol{u}) \geq \boldsymbol{\tau}(\boldsymbol{v})$ (ii)$\boldsymbol{\tau}(u\gamma v) \geq \boldsymbol{\tau}(\boldsymbol{u}), \forall \boldsymbol{u}, \boldsymbol{v} \in \boldsymbol{S}, \forall \gamma \in \Gamma$.

(G)fuzzy right ideal[16] of S ⇔'$\boldsymbol{\tau}$ 'satisfies that***(1)*** $\boldsymbol{u \leq v\ then\ \tau(u) \geq \tau(v)}$, $\forall\ \boldsymbol{u, v \in S}$**(2)**$\boldsymbol{\tau}\ \Gamma s \subseteq \boldsymbol{\tau}$.**(H)*fuzzy ideal***[16]of S if***(1)*** $\boldsymbol{u \leq v\ then\ \tau(u) \geq \tau(v)}$ **(2)**$\boldsymbol{\tau}(u\gamma v) \geq \boldsymbol{\tau}(v), \boldsymbol{\tau}(u\gamma v) \geq \boldsymbol{\tau}(u), \forall\ \boldsymbol{u, v \in S}, \forall \gamma \in \Gamma$.**(I)fuzzy ideal[16] of S iff τsatisfies that(i)** $\boldsymbol{u \leq v\ then}\ \tau(\boldsymbol{u}) \geq \tau(\boldsymbol{v})$, $\forall\ \boldsymbol{u, v \in S}$(ii) $\boldsymbol{\tau}\ \Gamma s \subseteq \boldsymbol{\tau}\ and\ s\Gamma\boldsymbol{\tau} \subseteq \boldsymbol{\tau}$.
(J)Idempotent if $\boldsymbol{\tau}2 = \boldsymbol{\tau}\Gamma\boldsymbol{\tau} = \tau$ **".**

3. FUZZY SIMPLE PARTIALLY ORDERED Γ-SEMIGROUPS

DEFINITION3.1: If S itself is the only left ideal of Sthen S is LSPO**ΓS**.
DEFINITION 3.2: PO- Γ- semigroupS is FLSPO**ΓS** ***if*** each fuzzyleft ideal of S isaconstant function.

DEFINITION3.3: 'f 'be a *fuzzysubset*of apo- Γ- semigroup S.

$$\boldsymbol{f_{(S\Gamma a]}(x)\ is\ defined\ as}$$
$$\boldsymbol{f_{(S\Gamma a]}(x)} = \begin{cases} 1 & if\ x \in (S\Gamma a] \\ 0 & otherwise \end{cases}$$

THEOREM3.4:$\boldsymbol{f_{(S\Gamma a]}}$ **is afuzzyleftideal of a PO-**Γ- Semigroup**S,**$\forall \boldsymbol{a} \in S$.
Proof:(i)Let $x, y \in S$ and $x \leq y$
If $y \in (S\Gamma a]$ since $x \leq y \Rightarrow x \in (S\Gamma a]$ then $f_{(S\Gamma a]}(x) = 1 = f_{(S\Gamma a]}(y)$
If $y \notin (S\Gamma a]$then$f_{(S\Gamma a]}(y) = 0 \leq f_{(S\Gamma a]}(x)$.
By summarizing the above $f_{(S\Gamma a]}(x) \geq f_{(S\Gamma a]}(y)$
(ii) If $y \notin (S\Gamma a]$then $f_{(S\Gamma a]}(y) = 0 \leq f_{(S\Gamma a]}(x\gamma y)$.
If $y \in (S\Gamma a]$ then $f_{(S\Gamma a]}(y) = 1$
Since $y \in (S\Gamma a]$ and(SΓa] is a leftideal of S
we have $x\gamma y \in (S\Gamma a], \forall\ x \in S$, γ∈Γ([8])⇒ $f_{(S\Gamma a]}(x\gamma y) = 1 = f_{(S\Gamma a]}(y)$
Therefore$f_{(S\Gamma a]}(x\gamma y) \geq f_{(S\Gamma a]}(y)$.
$Hence\ f_{(S\Gamma a]}$ is a fuzzyleftideal of S.
THEOREM 3.5: In a po- Γ- semigroup S, "TFAE".
(p) S is a LSPO**ΓS**
(q) S is a FLSPOΓS.
Proof:(p) ⇒ (q)
Assume (P) holds.
supposeT is anyfuzzy left ideal of S which implies that ∃ elements$x, y \in S$ and α,γ∈**Γ∋***b*=*xαaanda*=yγb.
By definition of T we have$T(a) = T(\ y\gamma b\ ) \geq T(\ b\ ) = T(\ x\alpha a\ ) \geq T(\ a\ )$
⇒ *T*(a) = *T*(b) $\forall a, b \in$ S and α,γ∈**Γ**⇒*T is a constant fuzzy ideal.*
Hence (q).
***(q)⇒(p)*:**
Assume (***q***) holds.
*Suppose A is po left ideal*of S.∴ $C_A$isa fuzzyleftideal of S(*from*[9]).
⇒ $C_A$is a *constant function*.
let$x, y \in S, \gamma \in \boldsymbol{\Gamma}$ since $A \neq \emptyset$, $C_A(x\gamma y) = 1 \Rightarrow x\gamma y \in A \Rightarrow S \subseteq A$
ThereforeA=S. Hence (p).
THEOREM 3.6:S *is* **FLSPOΓS⇔** $\boldsymbol{f_{(S\Gamma a]} = f_S = S\ \forall a \in S}$**,where S is *a*po-Γ-semigroup.**
***Proof*:**Suppose S is a **FLSPOΓS**. FromTh3.5 S is a LSPO**ΓS**. Then from[5], (S**Γ**a]=S. Therefore$f_{(S\Gamma a]} = f_S = S$.
Conversly assume that $f_{(S\Gamma a]} = f_S = S \Rightarrow f_{(S\Gamma a]}(x) = f_S(x)$
⇒ (S**Γ**a]=S. Then from[5]S *is*a LSPO**ΓS**. ∴FromTh.3.5 S isa FLSPO**ΓS.**
DEFINITION 3.7:A**PO-**Γ-semigroup S is known as a RSPO**ΓS**if S*itself is the only po right ideal of S.*
DEFINITION 3.8: *If each fuzzy right ideal of 'S' is a constant function* then S is termed as **FRSPOΓS.**

DEFINITION 3.9: *f be a fuzzy subset*of***apo-****Γ-semigroup* S.

$$\boldsymbol{f_{(a\Gamma S]}(x)\ is\ defined\ as}$$
$$\boldsymbol{f_{(a\Gamma S]}(x)} = \begin{cases} 1 & if\ x \in (a\boldsymbol{\Gamma}S] \\ 0 & otherwise \end{cases}$$

DEFINITION 3.10: If every fuzzy ideal of 'S' is a constant function then S is ***fuzzy simple po*-Γ*-semigroup.***

THEOREM3.11: $\boldsymbol{f_{(a\Gamma S]}}$**is afuzzy right ideal of a po-Γ-semigroupS for every**$\boldsymbol{a \in S}$**.**
***Proof*:** (p) Let $x, y \in S, \alpha, \beta \in \boldsymbol{\Gamma}$and $x \leq y$
If $y \in (a\boldsymbol{\Gamma}S]$ since $x \leq y \Rightarrow x \in (a\boldsymbol{\Gamma}S]$ then $f_{(a\Gamma S]}(x) = 1 = f_{(a\Gamma S]}(y)$
If $y \notin (a\boldsymbol{\Gamma}S]$then$f_{(a\Gamma S]}(y) = 0 \leq f_{(a\Gamma S]}(x)$.
By summarizing the above $f_{(a\Gamma S]}(x) \geq f_{(a\Gamma S]}(y)$

(q) If $x \notin (a\Gamma S]$then$f_{(a\Gamma S]}(x) = 0 \leq f_{(a\Gamma S]}(x\gamma y)$.
If $x \in (a\Gamma S]$ then $f_{(a\Gamma S]}(x) = 1$
Since $x \in (a\Gamma S]$ and(a**Γ**S] *is a* ***poright ideal***of S,
then $x\gamma y \in (a\Gamma S]$, $\forall y \in S, \forall \gamma \in \Gamma$(from theorem [5]).

$$\Rightarrow f_{(a\Gamma S]}(x\gamma y) = 1 = f_{(a\Gamma S]}(x)$$

$\therefore f_{(a\Gamma S]}(x\gamma y) \geq f_{(a\Gamma S]}(x)$.
From(p)and(q) $f_{(a\Gamma S]}$ is afuzzy right ideal of S.

THEOREM 3.12:In a po-Γ-semigroup S, "TFAE".
l) S is aRSPOΓS.
m) S is a FRSPOΓS.
Proof* :*(l) ⇒(m):
Assume S **is a RSPOΓS**.
*supposef isfuzzy right ideal*of S.Then**∃** elements$x, y \in S and\ \alpha, \beta \in$**Γ**such that a$\alpha$x=b and a=b$\beta$y(from [7]).
∵ f is afuzzy right ideal of S,$f(a) = f(b\beta y) \geq f(b) = f(a\alpha x) \geq f(a)$ ⇒*f(a) = f(b)*$\forall a, b \in S$⇒ f is a constant fuzzy ideal.
∴ S *is* **FRSPOΓS**.
***(m)⇒(l)*:**
*SupposeS is a***FRSPOΓS**.
*Assume A as any po right ideal*of S⇒ C_A*is a fuzzyrightidealof*S(from [9]).
⇒ $C_A$is a constant function.
Let $x, y \in S, \gamma \in \Gamma$ *Since* $A \neq \emptyset$, $C_A(x\gamma y) = 1 \Rightarrow x\gamma y \in A \Rightarrow S \subseteq A$
ThereforeA=S.
Hence S **is RSPOΓS**.

THEOREM3.13:S *is* **FRSPOΓS**⇔ $\boldsymbol{f_{(a\Gamma S]} = f_S = S\ \forall a \in S}$.
***Proof*:**Suppose that S is a **FRSPOΓS**. S isa **RSPOΓS**(From theorem 3.12). Then from [5], (aΓS]=S.
Therefore$f_{(a\Gamma S]} = f_S = S$.
Conversly assume that$f_{(a\Gamma S]} = f_S = S \Rightarrow f_{(a\Gamma S]}(x) = f_S(x)$
⇒ (a**Γ**S]=S.Then S is a **RSPOΓS**(from [5]). ThenS is a **FRSPOΓS**(from Theorem 3.12).

DEFINITION3.14:*fandg*areany two fuzzy subsets of S, define ***(fog]***as

$$(fog](x) = \bigvee_{x \leq y\gamma z}(fog)(y\gamma z), \forall x, y, z \in S, \gamma \in \Gamma.$$

DEFINITION 3.15 : A fuzzy ideal *f* of a **po - Γ- semigroup 'S'**is known as***globally idempotent if***$(f^n] = (f]$ **,** ∀n.
DEFINITION3.16 : A po - Γ- semigroup 'S' is known as ***fuzzy globally idempotent*** if $(S^n] = S$ **,** ∀n.
THEOREM**3.17 : A po - Γ- semigroup 'S'*with* '*e*',*unity*****and***f* , *afuzzyideal*of S **with**$\boldsymbol{f(e) = 1}$ **then**$\boldsymbol{f = S = f_S}$**.**
***Proof*:** Let $x \in S, \gamma \in \Gamma$. Consider$f(x) = f(x\gamma e)$ ≥f(e)=1
⇒ $f(x) \geq 1 \Rightarrow f(x) = 1, \forall$ x∈S. Therefore $f = f_S = S$.

DEFINITION 3.18:*A fuzzy idealf which is non-zero of* S*is known as a* ***proper fuzzy ideal****if* $f \neq C_S = S$.
DEFINITION3.19: A fuzzy ideal 'f' of 'S' is ***maximal***if no proper fuzzy ideal 'g' of 'S' existed ∋ $f \subset g$**.**
THEOREM 3.20*: If** $\{f_i\}$is a sequence fuzzy ideals ofa po-Γ***-semigroup ***S then***$\cup f_i(x)$ ***is fuzzy ideal of S.***
***Proof*:** let $\{f_i\}$be a sequence of fuzzy ideals of S.
Let $x, y \in S$ such that $x \leq y$.
Consider $\cup f_i(x) = max\{f_1(x), f_2(x), f_3(x), \dots\dots\}$
$= f_1(x) \vee f_2(x) \vee f_3(x) \vee \dots\dots$
$\geq f_1(y) \vee f_2(y) \vee f_3(y) \vee \dots\dots$ since each f_i is a fuzzy ideal.
= max$\{f_1(y), f_2(y) \dots\}$= $\cup f_i(y)$
Therefore $\cup f_i(x) \geq \cup f_i(y)$ if $x \leq y$
Let$x, y \in S$and$\gamma \in \Gamma$
Consider $\cup f_i(x\gamma y) = f_1(x\gamma y) \vee f_2(x\gamma y) \vee f_3(x\gamma y) \vee \dots\dots$
$\geq f_1(y) \vee f_2(y) \vee f_3(y) \vee \dots\dots$ since each f_i is a fuzzyleftideal.
$= \cup f_i(y)$
Therefore $\cup f_i(x\gamma y) \geq \cup f_i(y)$, Similarly $\cup f_i(x\gamma y) \geq \cup f_i(x)$.Hence the theorem.

THEOREM3.21:The union of all proper fuzzy ideals($\cup f_i$**) of a PO-Semigroup S with 'e' unity is the uniquefuzzy maximal ideal of S.**
***Proof*:**let's take$f_M = \cup f_i$.
⇒ $f_M$would bea fuzzyideal of S (fromTh 3.20).
Supposef_M is not proper then $f_M = C_S \Rightarrow f_M(x\gamma y) = 1, \forall x \in S, \gamma \in \Gamma$

⇒ □□(□) = *1* for some fuzzy ideal □□ since ∪ □□ = □□
⇒ □□ = □□ but □□ is proper.∴□□ is a *fuzzyideal of*S which is proper.
Since □□*contains all proper fuzzyideals*of Stherefore□□is maximalfuzzyideal of S.suppose□□is any other maximalfuzzy ideal of S then □□ ⊆ □□ ⊆ □□.
∴□□ = □□. Hence □□is*fuzzymaximal ideal*of S,which is Unique.

THEOREM 3.22**:If S is FLSPOΓS(FRSPOΓS)then S is fuzzy simple** po-**Γ-semigroup.**

Proof**:** Assume S *is a***FLSPOΓS(FRSPOΓS)**.
consider any fuzzyideal 'f' of S⇒f is a fuzzyleft(right)ideal of S.
⇒ *f isa constantfunction*⇒S *isfuzzy simple*po-**Γ**-*semigroup*.

THEOREM 3.23: If fuzzyordered element □□***of S is semisimple and idempotent then***□□ ⊆< □□ >□**,** ∀□.

Proof**:**Suppose □□ is semisimple and idempotent ,□ ∈ □ and n∈ □.
□□ ⊆< □□ > □which holds for n=2 since □□is fuzzy semisimple.
Assume the result holds for n=n-1.i.e□□ ⊆< □□ >□−□
Consider < □□ >□=< □□ >□−*1* Γ < □□ >
⊇ □□Γ□□ = □□*2* = □□, since □□ is idempotent.
Therefore < □□ >□ ⊇ □□ , ∀□.

4.CONCLUSION:

The objective of this paper is describing fuzzy left(□(□□□]) and fuzzy right (□(□□□]) ideals of S.We established the relationship between fuzzy left simple po –**Γ-** semigroup and fuzzy simple **Γ-** semi group.*The unionof all proper fuzzy ideals(*∪ □□*) of*po –**Γ** - semigroup *S with unity 'e'is the unique fuzzy maximal ideal of 'S.'*

ACKNOWLEDGEMENTS

We are immensely grateful to authors for their valuable effort in the area of research.

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