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Permuting Jordan Left Tri – Derivations On Prime and semiprime rings

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Abstract :
Let $\mathfrak{R}$ be a 2 and 3 – torsion free prime ring then if $\mathfrak{R}$ admits a non-zero Jordan left tri- derivation $B:\mathfrak{R}\times\mathfrak{R}\times\mathfrak{R}\rightarrow\mathfrak{R}$, then R is commutative ,also we give some properties of permuting left tri - derivations.

Keywords: prime ring , semiprime ring , left tri-derivation, Jordan left tri-derivations.

Mathematics Subject Classification: 16A12; 16A68; 12A72

1.Introduetion:

Throughout this paper we will use $\mathfrak{R}$ to represent an associative ring with center $Z(\mathfrak{R})$, $\mathfrak{R}$ is said to be n-torsion free if $na = 0$, $a \in \mathfrak{R}$ implies $a = 0$ [5].

A ring $\mathfrak{R}$ is called prime(semiprime) if $a\mathfrak{R}b = 0$ ($a\mathfrak{R}a = 0$) implies that $a = 0$ or $b = 0$($a = 0$) [3] .A mapping $D:\mathfrak{R}\times\mathfrak{R}\times\mathfrak{R}\longrightarrow\mathfrak{R}$ is said to be permuting if

$$D(x_1,x_2,x_3) = D\left(x_{\pi_1},x_{\pi_2},x_{\pi_3}\right)$$

hold for all $x_1,x_2,x_3 \in \mathfrak{R}$ and every permute π_1,π_2,π_3 .

A mapping $d:\mathfrak{R}\rightarrow\mathfrak{R}$ defined by $d(x) = D(x,x,x)$ is called the trace of $D(.,.,.)$ where $D:\mathfrak{R}\times\mathfrak{R}\times\mathfrak{R}\rightarrow\mathfrak{R}$ is permuting tri- additive mapping [3] , a tri-additive mapping $D:\mathfrak{R}\times\mathfrak{R}\times\mathfrak{R}\rightarrow\mathfrak{R}$ is called tri – derivation if

$D(x_1x_2,y,z) = x_1D(x_2,y,z) + D(x_1,y,z)x_2$,
$D(x,y_1y_2,z) = y_1D(x,y_2,z) + D(x,y_1,z)y_2$ and
$D(x,y,z_1z_2) = z_1D(x,y,z_2) + D(x,y,z_1)z_2$ are hold for all $x,y,z,x_i,y_i,z_i \in \mathfrak{R}$ [3] .

The trace d of D satisfy the relation

$$d(x + y) = d(x) + d(y) + 3D(x,x,y) + 3D(x,y,y)$$

for all $x,y \in \mathfrak{R}$ [7].

A. K. Faraj in [1] and R. C. Shaheenin [6] define the permuting left tri- derivation as follows a permuting tri-additive mapping $D:\mathfrak{R}\times\mathfrak{R}\times\mathfrak{R}\to v$ is called permuting left tri – derivation if $D(x_1x_2,y,z)=x_1D(x_2,y,z)+x_2D(x_1,y,z)$
$D(x,y_1y_2,z)=y_1D(x,y_2,z)$
$+y_2D(x,y_1,z)$
and
$D(x,y,z_1z_2)=\ z_1D(x,y,z_2)$
$+z_2D(x,y,z_1)$
are hold for all $x,y,z,x_i,y_i,z_i\in\mathfrak{R},\ \ i=1,2$ also D is called permuting Jordan left tri – derivation if $D(x^2,y,z)=2xD(x,y,z)$, $D(x,y^2,z)=2yD(x,y,z)$ and $D(x,y,z^2)=2zD(x,y,z)$ are hold for all $x,y,z\in\mathfrak{R}$

In this paper , we gave some properties of permeating left tri-derivation, also we prove that if $\mathfrak{R}$ is a prime ring of characteristic not equal 2 and 3 and $\mathfrak{R}$ is admit anon-zero Jordan left-tri-derivation on $\mathfrak{R}$, Then $\mathfrak{R}$ is commutative.

2.Permuting left tri-derivations:-

In the following theorem we introduce some properties of permuting Jordan left tri –derivation on a ring

Theorem 2.1:

Let v a 2 - torsion free ring . If $B:\mathfrak{R}\times\mathfrak{R}\times\mathfrak{R}\to\mathfrak{R}$ is a Jordan left tri – derivation then for all $a,b,y,z\in\mathfrak{R}$ we have.

i) $B(ab+ba,y,z)=2aB(b,y,z)+2bB(a,y,z)$

ii) $B(aba,y,z)=a^2B(b,y,z)+3abB(a,y,z)-baB(a,y,z)$

iii) $B(abc+cba,y,z)=(ac+ca)B(b,y,z)+3abB(c,y,z)+3cbB(a,y,z)$
$-baB(c,y,z)-bcB(a,y,z)$

iv) $[a,b]aB(a,y,z)=a[a,b]B(a,y,z)$

v) $[a,b]\{B(ab,y,z)-aB(b,y,z)-bB(a,y,z)\}=0$

Proof:

i) Since $B(a^2,y,z)=2aB(a,y,z)$

replace a by $a+b$

$B((a+b)^2,y,z)=B(a^2+ba+ab+b^2,y,z)$
$=B(a^2,y,z)+B(b^2,y,z)+B(ab+ba,y,z)$
$=2aB(a,y,z)+2bB(b,y,z)+B(ab+ba,y,z)$ … (1)

Now

$B((a+b)^2,y,z)=2(a+b)B(a+b)y,z)$
$=2aB(a+b),y,z)+2bB(a+b,y,z)$
$=2aB(ay,z)+2aB(b,y,z)+2bB(a,y,z)+2bB(b,y,z)$ ...(2)

comparing (1) and(2)we get

$B(ab+ba,y,z)=2aB(b,y,z)+2bB(a,y,z)$

ii) From(i) we have for $a,b,y,z\in\mathfrak{R}$.

$B(a(ab+ba)+(ab+ba)a,y,z)=2aB(ab+ba,y,z)+2(ab+ba)B(a,y,z)$
$=2a\{2aB(b,y,z)+2bB(a,y,z)\}+2abB(a,y,z)+2baB(a,y,z)$
$=4a^2B(b,yz)+6abB(a,y,z)+2baB(a,y,z)$ ….(3)

On the other hand , we have

$B(a(ab+ba)+(ab+ba)a,y,z)=B(a^2b+aba+aba+ba^2,y,z)$
$=B(a^2b+ba^2,y,z)+2B(aba,y,z)$
$=2a^2B(b,y,z)+4abB(a,y,z)+2B(aba,y,z)$ …(4)

Composing (3)and(4) we get

$2B(aba,y,z)=2a^2B(b,y,z)+6abB(a,y,z)-2baB(a,y,z)$

So that

$2B(aba,y,z)=2(a^2B(b,y,z)+3abB(a,y,z)-baB(a,y,z))$

Since R is 2-torsion free we have

$B(aba,y,z)=a^2B(b,y,z)+3abB(a,y,z)$
$-baB(a,y,z)$.

iii) Linearizing (ii) on a we get

$B\big((a+c)b(a+c)\ ,y,z\big)$
$=(a+c)^2B(b,y,z)+3(a+c)bB(a+c,y,z)-b(a+c)B(a+c,y,z)$
$=a^2B(b,y,z)+acB(b,y,z)+caB(b,y,z)$
$+c^2B(b,y,z)$
$+3abB(a+c,y,z)$
$+3cbB(a+c,y,z)-baB(a+c,y,z)-bcB(a+c,y,z)$
$=a^2B(b,y,z)+acB(b,y,z)+caB(b,y,z)+c^2B(b,y,z)+3abBca,y,z)$

$+3abB(c,y,z)+3cbB(a,y,z)+3cbB(c,y,z)-baB(a,y,z)$
$-baB(c,y,z)-bcB(a,y,z)-bcB(c,y,z)$ …(5)

In other hand

$B\big((a+c)b(a+c),y,z\big)=B(aba+abc+cba+cbc,y,z)=B(aba,y,z)+B(abc+cba,y,z)+B(cbc,y,z)=a^2B(b,y,z)+3abB(a,y,z)-baB(a,y,z)+B(abc+cba,y,z)+c^2B(b,y,c)+3cbB(c,y,z)-bcB(c,y,z)$ …(6)

Comparing (5) and(6) we have.

$B(abc+cba,y,z)=(ac+ca)B(b,y,z)+3abB(c,y,z)+3cbB(a,y,z)$

$-baB(c,y,z)-bcB(a,y,z)$

(iv) Assume that $w = B(ab(ab) + (ab)ba, y, z)$
Then by (iii) we obtain

$$w = (a(ab) + (ab)a)B(b,y,z) + 3abB(ab,y,z) + 3(ab)bB(a,y,z) - baB(ab,y,z) - b(ab)B(a,y,z)$$

$$w = (a^2b + aba)B(b,y,z) + 3ab\,B(ab,y,z) + 3ab^2B(a,y,z) - ba\,B(ab,y,z) - babB(a,y,z) \quad \ldots(7)$$

On the other hand

$$w = B\big((ab)(ab) + (ab)ba, y, z\big) = B((ab)^2, y, z) + B(ab^2a, y, z)$$
$$= 2abB(ab,y,z) + a^2B(b^2,y,z) + 3ab^2\,B(a,y,z) - b^2aB(a,y,z)$$

So by definition of B

$$w = 2abB(ab,y,z) + 2a^2bB(b,y,z) + 3ab^2\,B(a,y,z) - b^2aB(a,y,z) \quad \ldots(8)$$

By comparing (7) and (8)

$$[a,b]B(ab,y,z) + abaB(b,y,z) - b(ab)B(a,y,z) - a^2bB(b,y,z) + b(ba)B(a,y,z) = 0$$

Then

$$[a,b]B(ab,y,z) - a[a,b]B(b,y,z) - b[a,b]B(a,y,z) = 0$$

so

$$[a,b]B(ab,y,z) = a[a,b]B(b,y,z) + b[a,b]B(a,y,z) \quad \ldots(9)$$

Replace b by $a+b$ in (9)

$$[a,a+b]B(a(a+b),y,z) = [a,b]B(a^2,y,z) + [a,b]B(ab,y,z)$$
$$= 2[a,b]aB(a,y,z) + a[a,b]B(b,y,z) + b[a,b]B(a,y,z)$$
$$= a[a,a+b]B(a+b,y,z) + (a+b)[a,a+b]B(a,y,z)$$
$$= a[a,b]B(a,y,z) + a[a,b]B(b,y,z) + a[a,b]B(a,y,z) + b[a,b]B(a,y,z)$$

Hence

$$2[a,b]aB(a,y,z) = 2a[a,b]B(a,y,z)$$

Since $\mathfrak{K}$ is 2-torsion free, then

$$[a,b]aB(a,y,z) = a[a,b]B(a,y,z) \quad \ldots(10)$$

(v) In (10) replace a by $+b$,
the left hand give

$$w = [a+b,b](a+b)B(a+b,y,z)$$
$$= [a,b]aB(a,y,z) + [a,b]a\,B(b,y,z) + [a,b]bB(a,y,z) + [a,b]bB(b,y,z) \ldots(11)$$

The right hand give

$$w = (a+b)[a+b,b]B(a+b,y,z)$$
$$= a[a,b]B(a,y,z) + a[a,b]B(b,y,z) + b[a,b]B(a,y,z) + b[a,b]B(b,y,z) \quad \ldots(12)$$

from(9)we have

$$[a,b]B(ab,y,z) = a[a,b]B(b,y,z) + b[a,b]B(a,y,z)$$

So that by using (10)

$$[a,b]B(ab,y,z) = [a,b]\big(aB(b,y,z) + bB(a,y,z)\big)$$
$$[a,b]\{B(ab,y,z) - aB(b,y,z) - bB(a,y,z)\} = 0$$

3.The Main Results:

Theorem 3.1:-

let $\mathfrak{K}$ be prime ring of char $\mathfrak{K} \neq 2,3$,then if R admits a non –zero Jordan left – tri derivation $B: \mathfrak{K} \times \mathfrak{K} \times \mathfrak{K} \to \mathfrak{K}$, then $\mathfrak{K}$ is commutative

Proof:

we divide proof to some steps.

Step1: If $B\,(a,y,z) \neq 0$ for some $a,y,z \in \mathfrak{K}$ then $(a[a,x] - [a,x]a)^2 = 0$ for all $x \in \mathfrak{K}$.

Let a be a fixed element in $\mathfrak{K}$ and $\emptyset: \mathfrak{K} \to \mathfrak{K}$ be a mapping defined by

$$\emptyset(x) = [a,x]$$

for all $x \in \mathfrak{K}$

Now [Theorem 2.1 ,iv] can be written in the form

$$\emptyset^2(x)B(a,y,z) = 0$$

for all $x \in \mathfrak{K}$ …….(13)

Since the mapping $\emptyset(x)$is a derivation, we have

$$\emptyset^2(x_1x_2) = \emptyset^2(x_1)x_2 + 2\emptyset(x_1)\emptyset(x_2) + x_1\emptyset^2(x_2)$$

And from (13) it follows that $\emptyset^2(x_1x_2)B(a,y,z) = 0$

hence

$$\big(\emptyset^2(x_1)x_2 + 2\emptyset(x_1)\emptyset(x_2) + x_1\emptyset^2(x_2)\big)B(a,y,z) = 0$$

So that

$$(\emptyset^2(x_1)x_2 + 2\emptyset(x_1)\emptyset(x_2))B(a,y,z) = 0$$

Hold for all $x_1, x_2 \in \mathfrak{K}$.

In the above relation replace $x_2 by\ \emptyset(x_2x_3)$and the relation (13) we get

$$(\emptyset^2(x_1)\emptyset(x_2)x_3 + \emptyset^2(x)x_2\emptyset(x_2))B(a,y,z) = 0 \ldots\ldots(14)$$

For all $x_1, x_2, x_3 \in \mathfrak{K}$.

In (14) substitute $\emptyset(x_3) for\ x_3, we\ get$

$$\emptyset^2(x_1)\emptyset(x_2)\emptyset(x_3)B(a,y,z) = 0 \quad \ldots(15)$$

Now in (14) replace x_2 by $\emptyset(x_2)$ and using(15) we have

$$\emptyset^2(x_1)\emptyset^2(x_2)x_3B(a,y,z) = 0 \quad \ldots(16)$$

holds for all $x_1, x_2, x_3 \in \mathfrak{K}$

since the relation (16) hold for all $x_3 \in \mathfrak{K}$, we are forced to conclude that B(a,y,z) to which implies that

$$\emptyset^2(x_1)\emptyset^2(x_2) = 0\ for\ all\ x_1, x_2 \in \mathfrak{K}$$

in particular $\big(\emptyset^2(x_1)\big)^2 = 0$ as requaried

Step 2: If $a^2 = 0$ then $B(a,y,z) = 0$ for all $y,z \in \mathfrak{K}$

Let $w = B(a(xay + yax)a, y, z)$

Then by using (ii) in Theorem 2.1 We get

$$w = a^2B(xay + yax, y, z) + 3a(xay + yax)B(a,y,z) - (xay + yax)aB(a,y.z) \quad \ldots(17)$$

Since $a^2=0$ we have
$B(a^2,y,z)=0=2aB(a,y,z)$
But char $\mathfrak{K}\neq 2$, then $aB(a,y,z)=0$
hance (17) becomes
$w=3a(xay+yax)B(a,y,z)$
$=3axayB(a,y,z)+3ayaxB(a,y,z)$ …(18)
From (ii) Theorem 2.1 we have
$B(axa,y,z)=3axB(a,y,z)$
According to (iii) in Theorem 2.1, we find
$B(ax(axa)+(axa)xa,y,z)$
$=(a^2xa+axa^2)B(x,y,z)$
$+3axB(axa,y,z)$
$+3(axa)xB(a,y,z)$
$-x(axa)B(a,y,z)$
Since $a^2=0$, we have
$w=9axaxB(a,y,z)+3axaxB(a,y,z)$ …(19)
Comparing(18)and (19)we get
$6axaxB(a,y,z)=0$
But $\mathfrak{K}$ is of characteristic not equal 2 and 3 so that
$axaxB(a,y,z)=0$ for all x,y and z are arbitrary elements of $\mathfrak{K}$.
so that
$B(a,y,z)=0$ *or* $a=0$
If $a=0$ we have $B(a,y,z)=0$
So that in any case we have
$B(a,y,z)=0$ for all $y,z\in\mathfrak{K}$

Step3 : $\mathfrak{K}$ is commutative.
Take: $a,y,z\in\mathfrak{K}$ such that $B(a,y,z)\neq 0$.
From step1 and step2, it follows in this case that.
$B(a[a,x]-[a,x]a),y,z)=0$ for all $x\in\mathfrak{K}$ … (20)
By using (i) and (ii) in Theorem 2.1, and since
$a[a,x]-[a,x]a=a^2x-2axa+xa^2$
So we obtain from (20)
$0=B(a^2x+xa^2,y,z)-2B(axa,y,z)$
$=2a^2B(x,y,z)+2xB(a^2,y,z)-2a^2B(x,y,z)$
$-6axB(a,y,z)+2xaB(a,y,z)$
$=4xaB(a,y,z)-6axB(a,y,z)+2xab(a,y,z)$
$=6xaB(a,y,z)-6axB(a,y,z)$
hence
$6[x,a]B(a,y,z)=0$
since $char\ (\mathfrak{K})\neq 2,3$, we get
$[x,a]B(a,y,z)=0$ for all $x,y\in\mathfrak{K}$
For all $x,y\in\mathfrak{K}$ we have
$0=[yx,a]B(a,y,z)=y[x,a]B(a,y,z)+[y,a]xB(a,y,z)=[y,a]xB(a,y,z)$
Since we have assumed that $B(a,y,z)\neq 0$
So that $[y,a]=0$ for all $y\in\mathfrak{K}$
consequentially $a\in Z(\mathfrak{K})$
Thus we have proved that $\mathfrak{K}$ is the union of its proper subsets $Z(\mathfrak{K})$ and
$kerB=\{a\in R|B(a,y,z)=0$ for all $y,z\in\mathfrak{K}\}$
It is clear that both subsets $Z(\mathfrak{K})$ and $kerB$ are additive subgroups of , but a group cannot be the union of it is two proper subgroups , so that either $\ker B=\mathfrak{K}$ or $Z(\mathfrak{K})=\mathfrak{K}$ and since $B\neq 0$ by hypothesis we have $ker\ B\neq\mathfrak{K}$
Consequentially $\mathfrak{K}=Z(\mathfrak{K})$ and hence $\mathfrak{K}$ is commutative

Theorem 3.2 : Let $\mathfrak{K}$ be a prime ring and $B:\mathfrak{K}\times\mathfrak{K}\times\mathfrak{K}\to\mathfrak{K}$ a left tri-derivation. If $B\neq 0$ then $\mathfrak{K}$ is commutative .

Proof:
Consider $B(aba,y,z)$ for all $a,b,y,z\in\mathfrak{K}$
Then
$B(a(ba),y,z)=aB(ba,y,z)+baB(a,y,z)$
$=a^2B(b,y,z)+abB(a,y,z)+baB(a,y,z)$ …(21)
On the other hand
$B((ab)a,y,z)=abB(a,y,z)+aB(ab,y,z)$
$=ab\ B(a,y,z)+a^2B(b,y,z)+abB(a,y,z)$
$=2abB(a,y,z)+a^2B(b,y,z)$ …(22)
Comparing (21) and (22) we have
$[a,b]B(a,y,z)=0$ for all $a,b,y,z\in\mathfrak{K}$ ….(23)
Replace b by cb in (23) we get
$0=[a,cb]B(a,y,z)$
$=(a(cb)-(cb)a)B(a,y,z)$
$=(ac-ca)b\ B(a,y,z)+c(ab-ba)B(a,y,z)$
$=[a,c]bB(a,y,z)$ for all $a,b,c,y,z\in\mathfrak{K}$
So that
$[a,c]bB(a,y,z)=0$ for all $a,b,c,z,y\in\mathfrak{K}$ …(24)
It follows that for each $a\in\mathfrak{K}$ we have either
$a\in Z(\mathfrak{K})$ or $B(a,y,z)=0$
But , since $Z(\mathfrak{K})$ and
$kerB=\{a\in\mathfrak{K}\ |\ B(a,y,z)=0\quad for\ all\ y,z\in\mathfrak{K}\}$ are additive subgroups of $\mathfrak{K}$.
We have either $\mathfrak{K}=Z(\mathfrak{K})$ or $\mathfrak{K}=ker\ B$ but $B\neq 0$, so that $\mathfrak{K}=Z(\mathfrak{K})$ and hence $\mathfrak{K}$ is commutative.

Theorem 3.3_: Let $\mathfrak{K}$ be a semi-Prime ring and $B:\mathfrak{K}\times\mathfrak{K}\times\mathfrak{K}\to\mathfrak{K}$ be a left tri –derivations then B is tri-derivation that maps $\mathfrak{K}$ into it is center .

Proof :
Linearize (24)
$[a+d,c]bB(a+d,y,z)=0$
Which gives that
$[a,c]bB(d,y,z)+[d,c]bB(a,y,z)=0$
Which implies that
$[a,c]bB(d,y,z)=-[d,c]bB(a,y,z)$
Since $\mathfrak{K}$ is a ring , for all $a,b,c,d,y,z\in\mathfrak{K}$ we have
$[a,c]bB(d,y,z)x[a,c]bB(a,y,z)$
$=-[d,c]bB(d,y,z)x[a,c]bB(a,y,z)=0$
Since $\mathfrak{K}$ is semiprime , this relation yields
$[a,c]bB(d,y,z)=0$

In particular

$$\{aB(d,y,z) - B(d,y,z)a\}b\{aB(d,y,z) - B(d,y,z)a\} = 0$$

semiprimeness of $\mathfrak{K}$ implies that

$aB(d,y,z) - B(d,y,z)a = 0$

Consequently B is a tri-derivation and $B(d,y,z) \in Z(\mathfrak{K})$

Theorem3.4: Let $\mathfrak{K}$ be a prime ring of $char\mathfrak{K} \neq 2,3$ and $B: \mathfrak{K} \times \mathfrak{K} \times \mathfrak{K} \rightarrow \mathfrak{K}$ a Jordan left tri-derivation, suppose that $ax = 0, a, x \in \mathfrak{K}$ implies that $a = 0$ or $x = 0$ if $B \neq 0$ then $\mathfrak{K}$ is commutative .

Proof:

From (v) of Theorem 2.1 , we have for each pair $a, b \in \mathfrak{K}$

$$[a,b] = 0 \; or \; B\,(ab,y,z) = aB(b,y,z) + bB(a,y,z)$$

Given $a \in \mathfrak{K}$ and let

$G_a = \{b \in \mathfrak{K} | a[a,b] = 0\}$ and

$H_a = \{b \in \mathfrak{K} | B(ab,y,z) = aB(b,y,z) + bB(a,y,z)\}$

We see that $\mathfrak{K}$ is the union of it's additive subgroups $G_a and\ H_a$

Hence $= G_a \; or \; \mathfrak{K} = H_a$, on the other words , $\mathfrak{K}$ is the union of its subgroup's

$G = \{a \in \mathfrak{K} | G_a = \mathfrak{K}\} = Z(\mathfrak{K})$ and

$H = \{a \in \mathfrak{K} | H_a = \mathfrak{K}\}$

$= \{a \in \mathfrak{K} | B(ab,y,z) = aB(b,y,z) + bB(a,y,z)\, , for\ all\ a,b,y,z \in R\}$

Clearly G and H are additive subgroups of $\mathfrak{K}$

Hence $G = \mathfrak{K}$ or $H = \mathfrak{K}$

If $G = \mathfrak{K}$ then $\mathfrak{K}$ is commutative.

If $H = \mathfrak{K}$ then B is a left tri-derivation and hence $\mathfrak{K}$ is commutative by Theorem 3.3

Thus in any way $\mathfrak{K}$ is commutative.

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اشتقاقات جوردان اليسارية الثلاثية التبادلية على الحلقات الاولية والحلقات شبه الاولية

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الملخص :
لتكن Rحلقة اولية طليقة الالتواء من النمط 2 و 3 . اذا كانت R تسمح بوجود اشتقاق جوردان اليساري الثلاثي $B: R \times R \times R \to R$ فانها تكون ابدالية .
كذلك قدمنا بعض الخواص لمشتقات جوردان اليسارية الثلاثية التبادلية