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A NOTE ON DIVIDED NEAR-FIELD SPACES AND ϕ-PSEUDO – VALUATION NEAR-FIELD SPACES OVER REGULAR δ-NEAR-RINGS (DNF-ϕ PVNFS-O-δ-NR)

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ABSTRACT

Let N be a commutative near-field space with 1 and T(N) be the total quotient near-field space such that Nil(N) is a divided prime ideal of a near-field space N. Then N is called a ϕ-chained near-field space (ϕ-CNF) if for every x, y $\in$ N \ Nil(N) either x / y or y / x. Also, N is called a ϕ-pseudo –valuation near-field space (ϕ-PVNF) if for every x, y $\in$ N \ Nil (N) either x / y or y / xm where for each non-unit element m $\in$ N. We show that a near-field space N is a ϕ-PVNF iff Nil (N) is a divided prime ideal and N/Nil(N) is a pseudo-valuation domain. Also, we show that every over near-field space of a Quasi-local near-field space N with maximal ideal M is a ϕ-PVNF iff N (v) for each v $\in$ (M: M) \ N iff every over- near-field space of N is a quasi-local iff every ϕ-CNF between N and T(N) other than N and (M : M) is of the form N_p for some non-maximal prime ideal P of N. Among other results, we show that if A is an over-near-field space of a ϕ-PVNF and J is a proper ideal of A, then there is a ϕ-CNFC between A and T(N) such that JC $\neq$ C. Also, we show that the integral closure N^c of a near-field space N in T(N) is the intersection of all the ϕ-CNFs between N and T(N).

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Keywords: *Near-field, Near–field space, total quotient near-field space, divided prime ideal, quasi near-field space, Quasi-local near-field space, over-near-field space, pseudo –valuation near-field space, maximal ideal, maximal ideal.*

SECTION 1: INTRODUCTION

Throughout this paper, N denotes as Near-field space has zero symmetric near-ring with identity. We begin by recalling some background material. With reference to ([1], [4]) the author generalized the study of pseudo-valuation domains to the context of extending to arbitrary near-field spaces possibly with non-zero zero divisors. For a near-field space N with total quotient near-field space T(N) such that Nil(N) is divided prime ideal of N, we define a map $\phi : T(N) \rightarrow K := N_{Nil(N)}$ such that $\phi(a/b) = a/b\ \forall\ a \in N$ and $b \in n \setminus Z(N)$. Then ϕ is a near-field homomorphism from T(N) into K, and ϕ is restricted to near-field space N is also a near-field homomorphism from N into K given by $\phi(x) = x/1\ \forall\ x \in N$. For an equivalence characterization of a ϕ-PVNFS, $\forall\ n \geq 0\ \exists$ a ϕ-CNFS of krull dimension n that is not a PVNFS.

In this paper, we show that a quasi-local near-field space N with maximal ideal M is a ϕ-PVNFS if and only if N(v) is a quasi-local near-field space for each v $\in$ (*M* : *M*) \ N if and only if every over-near-field space of N is quasi-local near-field space if and only if every over-near-field space contained in (*M* : *M*) is quasi-local near-field space if and only if each ϕ-CNFS between N and T(N) other than (M : M) is of the form N_q for some non-maximal prime ideal P of N.

Among the other results, we show that if A is an over-near-field space of a ϕ-PVNFS and J is a proper ideal of A, then there is a ϕ-CNFS C between A and T(N) such that $JA \neq A$. Also show that the integral closure of near-field space N in T(N) is the intersection of all the ϕ-CNFS's between N and T(N).

The following notations will be used throughout. Let N be a near-field space. Then T(N) denote the total quotient near-field space of a near-field space N. *Nil* (N) denotes the near-field spaces of all nilpotent elements of N, and Z(N) denotes the set of zero divisors of N. If *J* is an ideal of N, then *Rad* (*J*) denotes the radical ideal of *J* in N.

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I summarize some basic properties of PVNFSs and ϕ-PVNFSs as below:

Property 1.1: A PVNFS is a divided near-field space and hence is quasi-local near-field space.

Property 1.2: A ϕ-PVNFS is a divided near-field space and hence is quasi-local near-field space.

Property 1.3: A sub–near-field space is a PVNFS *iff* it is a ϕ-PVNFS *iff* it is a PVD.

Property 1.4: A near-field space N is a PVNFS *if and only if* $\forall$ a, b $\in$ N, either a/b $\in$ N or b/a $\in$ N for each non-unit c $\in$ N.

Property 1.5: A near-field space N is a ϕ-PVNFS *if and only if* N*il*(N) is a divided prime ideal of N and $\forall$ a, b $\in$ N \ N*il*(N), either a/b $\in$ N or b/a $\in$ N $\forall$ non-unit c $\in$ N.

Property 1.6: If N is a PVNFS or a ϕ-PVNFS, then N*il*(N) and Z(N) are divided prime ideals of a near-field space N.

SECTION 2: PRELIMINARY RESULTS AND EXAMPLES

Definition 2.1: A near-field space N, with quotient near-field space K of N is called a pseudo-valuation domain [PVD] near-field space in case each prime ideal P of N is strongly prime in the sense that xy $\in$ P $\forall$ x $\in$ K, y $\in$ K $\Rightarrow$ either x $\in$ P or y $\in$ P.

Definition 2.3: A prime ideal P of a near-field space N is said to be strongly prime in N if aP and bP are comparable under inclusion of near-field spaces $\forall$ a, b $\in$ N.

Definition 2.4: A near-field space N is called a pseudo-valuation near-field space (PVNFS) if each prime ideal of N is strongly prime. A PVNFS is necessarily quasi-local near-field space.

Note 2.5: A near-field space is a pseudo-valuation near-field space (PVNFS) if and only if it is pseudo-valuation domain [PVD].

Definition 2.6: A prime ideal P of a near-field space N is called divided if it is comparable under inclusion to every ideal of near-field space N.

Definition 2.7: A near-field space N is called a divided near-field space if every prime ideal of a near-field space N is divided.

Definition 2.8: A prime ideal Q of ϕ(N) is called a K-strongly prime ideal if xy$\in$Q, $\forall$ x $\in$ K, y $\in$ K $\Rightarrow$ either z $\in$ Q or y $\in$ Q.

Definition 2.9: If each prime ideal of ϕ(N) is K-strongly prime, then ϕ(N) is called a K-pseudo-valuation near-field space (K-PVNFS).

Definition 2.10: A prime ideal P of near-field space N is called a ϕ-strongly prime ideal if ϕ(P) is a K-strongly prime ideal of ϕ(N).

Definition 2.11: A prime ideal P of N is called a ϕ-strongly prime ideal if ϕ(P) is a K-strongly prime ideal of ϕ(N). If each prime ideal of near-filed space N is ϕ-strongly prime, then N is called a ϕ- pseudo-valuation near-field space (ϕ-PVNFS).

Definition 2.12: a near-field space N is called a ϕ-chained near-field space (ϕ-CNFS) if Nil(N) is a divided prime ideal of N and $\forall$ x $\in$ $N_{Nil(N)} \setminus \phi(N)$, we have $x^{-1} \in \phi(N)$.

Note 2.13: A chained near-field space (ϕ-CNFS) is a division near-field space and hence is quasi-local near-field space. Hence, $\forall$ n $\geq$ 0 $\exists$ a ϕ-CNFS of krull dimension n that is not a chained near-field space.

Definition 2.14: A proper ideal of a near-field space N is called a divided ideal if J is comparable under inclusion to every principal ideal of N; equivalently, if J is comparable to every ideal of N. If every prime ideal of N is divided, then N is called a divided near-field space.

Definition 2.15: A prime ideal Q of a near-field space B is branched if Rad (J) = Q for some primary ideal J $\neq$ Q of B.

Note 2.16: A prime ideal Q of a near-field space domain D is branched *iff* Rad (J) = Q for some ideal J ≠ Q of D. In the following result I will show that this result is still valid for divided near-field spaces.

Definition 2.17: An ideal of a near-field space N is called regular if it contains a non-zero divisor of N. If every regular ideal of N is generated by its set of non-zero divisors, then N is called as Nagendram near-field space.

Definition 2.18: A near-field space N has few zero-divisors if Z(N) is a finite union of prime ideals.

SECTION 3: RESULTS ON DIVIDED NEAR-FIELD SPACES AND ϕ-PVNFS

In view of the proof of [5, Proposition 2.1], we see that the result in [5, proposition 2.1] valid iff assume that the near-field space N is a divided near-fields domain. Hence, I state the following result without proof.

Proposition 3.1: [5, Proposition 2.1] Let D be division near-field space domain with maximal ideal K and krull dimension n, say $K = Q_n \supset Q_{n-1} \supset Q_{n-2} \supset \ldots\ldots\ldots \supset Q_1 \supset \{0\}$, where the Q_js are the distinct prime ideals of division near-field space domain D. Let, j, m, d ≥ 1 such that $1 \le j \le m \le n$. Choose $z \in D$ such that Rad ((y)) = Q_j. Let P:= Q_m and I := $y^{j+1}D_P$. Then

(i) I is an ideal of near-field space domain D and rad (I) = Q_j .
(ii) N:= D/I is a divided near-field space with maximal ideal K/I, Z(N) = Q_m/I, and Nil (N) = Q_j /I. Furthermore, v:= y + I $\in$ Nil (N) and $v^d \neq 0$ in N.
(iii) Dim (N) = n – j. (iv) if $j \le m \le n$, then Nil (N) is properly contained in Between Z(N) and M/I.

Proposition 3.2: Let N be a divided near-field space and let Q be a prime ideal of N such that Q ≠ Nil (N). Then Q is branched *if and only if* Rad (J) = Q or some ideal J ≠ Q of near-field space N.

Proof: Obvious.

Corollary 3.3: Let N be a near-field space such that Nil (N) is a divided prime ideal near-field space of N, and let Q be a divided prime of ideal of N such that Q ≠ Nil (N). Then Q is branched if and only if Rad (J) Then Q is branched iff Rad (j) = Q for some ideal J ≠ Q of near-field space N.

Proposition 3.4: Let N be a near-field space such that *Nil* (*N*) is a divided prime ideal of N. Suppose that J is a proper ideal of N such that J contains a non-nilpotent sub-near-field space of N and for some N ≥ 1, J^n is a divided ideal of near-field space N for each n ≥N. Then Q = $\bigcap_{n \ge 1} J^n$ is a divided prime ideal of near-field space N.

Proof: Obvious.

In view of the above proposition, we have the following corollary.

Corollary 3.5: Let N be a near-field space such that *Nil* (N) is a divided prime ideal of N, and let J be proper ideal of N such that J contains a non-nilpotent of N. Then the following statements are equivalent:

(i) $J^n = J^m$ for some positive integers n ≠ m and J^n is a divided ideal of N.
(ii) J is a divided prime ideal of N and $J = J^2$.

Proof: Obvious

The following result follows directly from the definition of strongly prime ideal and a quasi-local near-field space with maximal ideal M is a PVNFS if and only if M is strongly prime.

Proposition 3.6: Let N be a near-field space such that Nil (N) is a divided prime ideal of N, and let J be a proper ideal of N such that J contains a non-nilpotent of N. Then the following statements are equivalent:

(i) N is ϕ-PVNFS (ii) bM is a divided ideal of N for each b $\in$ N \ Nil (N).

Proof: Obvious

An element d in a near-field space N is called a proper divisor of s $\in$ N if *s = dm* for some non-unit m $\in$ N.

Proposition 3.7: For a quasi-local near-field space N with maximal ideal M, the following statements are equivalent:

(i) N is a PVNFS; bM is a divided ideal for each b $\in$ M.

Proof: Obvious

In the following proposition we make connection between ϕ-PVNFS's and PVNFS's.

Proposition 3.8: A near-field space N is a ϕ-PVNFS $\Leftrightarrow$ *Nil* (N) is a divided prime ideal of N and $\forall$ a, b $\in$ N \ *Nil* (N), either b |a $\in$ N or d | b $\in$ N for each proper divisor d of a.

Proof: Obvious

Proposition 3.9: A near-field space N is a ϕ-PVNFS $\Leftrightarrow$ *Nil* (N) is divided prime ideal of N and N/*Nil*(N) is a PVNFS.

Proof: Obvious.

SECTION 4: MAIN RESULTS ON DIVIDED NEAR-FIELD SPACES, ϕ-PVNFS AND ϕ-CPVNFS

In this section, let a valuation domain VD and VNFS valuation near-field space and chained near-field space CNFS. We then have the following implications, none of which are reversible.

V D $\Rightarrow$ PVD $\Rightarrow$ VNFS $\Rightarrow$ PVNFS $\Rightarrow$ ϕ - PVNFS and VD $\Rightarrow$ CNFS $\Rightarrow$ ϕ - CNFS $\Rightarrow$ ϕ - PVNFS. We start with the following lemma.

Lemma 4.1: Let N be a ϕ - PVNFS, and let Q be a prime ideal of N. then $x^{-1}Q \subset Q$ for each x $\in$ T(N) \ N.

Proof: Obvious.

Proposition 4.2: Let N be a ϕ - PVNFS and z$\in$T(N) \ N be integral over N. Then there is a minimal monic polynomial *f*(x) $\in$ N[x] such that *f(x) = 0* and all non-zero coefficients of *f(x)* are units in N. Furthermore, if *g(x)* is a minimal monic polynomial in N[x] such that *g(x)* =0, then *g(0)* is a unit in N.

Proof: Obvious

It is well-known ([15],[1],[4],[7]) that the integral closure of a PVNFS is a PVNFS. In view of the above result, one can give replica proof of this fact. For a near-field space N, let N′ denotes the integral closure near-field space of N inT (N).

Proposition 4.3: Let N be a ϕ - PVNFS with maximal ideal M, and let A be a over near-field space of N such that A $\subset$ N′. Then A is a ϕ - PVNFS with maximal ideal M.

Proof: Obvious

Proposition 4.4: Let N be a ϕ - PVNFS with maximal ideal M, and Let A be a over-near-field space of N. Then the following statements are equivalent:

(i) A = A_Q is a ϕ - CNFS for some non-maximal prime ideal Q of N
(ii) IA = A for some proper ideal J of N
(iii) 1/s $\in$ A for some non-zero divisor s $\in$ M.

Proof: Obvious

Corollary 4.5[6, theorem 3]**:** Let N be a ϕ - PVNFS with maximal ideal M, and let A be a over-near-field space of N such that A is a ϕ - CNFS with maximal ideal N. If Q = N $\cap$ K $\neq$ M, then A = N_Q.

Proof: is obvious.

Proposition 4.6: Let N be a ϕ - PVNFS with maximal ideal M and u $\in$ (M: M)\N. Then N (v) is a ϕ - PVNFS if and only if N (v) is quasi-local near-field space. Furthermore, if N (v) is quasi-local near-field space for some u$\in$(M: M)\N, then N (v) is a ϕ - PVNFS with maximal ideal M.

Proof: is obvious.

Corollary 4.7: Let N be a ϕ - PVNFS with maximal ideal M. If C is a over-near-field space of N such that C does not contain an element of the forth 1/s for some non-zero divisor s $\in$ M, then C $\subset$ (M: M).

Proof: is obvious.

Corollary 4.8: Let N be a ϕ - PVNFS with maximal ideal M. Then every over-near-field space C of N is a ϕ - PVNFS *iff N (v)* is quasi-local near-field space for each u $\in$ (M: M)\N.

Proof: Obvious

Note 4.9: A near-field space N is ϕ - CPVNFS *if and only if Nil(N)* is a divided prime ideal of N and $\forall$ a, b $\in$ N*Nil(N)*, either a|b $\in$ N or b|a $\in$ N.

We have the following result which is a generalization of [6, proposition 6].

Proposition 4.10: Let N be a ϕ - PVNFS. Then (i) N is a Nagendram near-field-space. (ii) If N $\neq$ T (N), then T(N) is ϕ - CPVNFS.

Proof: To prove (i): Since Z(N) is a prime ideal of N by property 1.6, N has few zero divisors. Hence, N is a Nagendram near-field space by [16, theorem 7.2]. Proved (i).

To prove (ii): Since *Nil(N)* is a divided prime ideal of N, *Nil(T(N)) = Nil(N)*. Now let x, y $\in$ T(N) \ *Nil(N)*. Then x = a/s and y = b/s $\forall$ a, b $\in$ N \ *Nil(N)* and s $\in$ N \ Z(N). by note 4.9, we need to show that either x|y in T(N) or y|x in T(N). if a|b in N, then x|y in T(N). Hence assume that a|b in N. Since, N is a ϕ - PVNFS and N $\neq$ T(N), *b|ad* in N for some d $\in$ M \ Z(N). Thus, *ad = bc* for some c $\in$ N. Thus, a/s = (b/s)(c/d). Thus, y |x in T(N). Proved (ii).

Therefore, this completes the proof of proposition.

Remark 4.11: Let N be a ϕ - PVNFS with maximal ideal M such that M contains a non-zero divisor of N, and J be a proper ideal of N. Since U =(M : M) is a ϕ - CPVNFS with maximal ideal M of N, it is easy to see that there exists a ϕ - CPVNFS U between N and T(N) such that IU $\neq$ U.

Theorem 4.12: Let N be a ϕ - PVNFS with maximal ideal M such that M contains a non-zero divisor of N, let C be a over near-field space of N (N $\subset$ C $\subset$ T(N)), and let J be a proper ideal of C. Then there exists a ϕ - CPVNFS A such that C $\subset$ A $\subset$ T(N) and JA $\neq$ A.

Proof: Obvious.

Proposition 4.13: Let N be a ϕ - PVNFS and be a over near-field space of N such that A is a ϕ - CPVNFS. Then, N′ $\subset$ A.

Proof: we prove this in the way of Negative proof. Then there is an x $\in$ N′\A. Hence, since N′ is a ϕ - PVNFS with maximal ideal M by proposition 4.3, x is a unit in N′. Since x $\notin$ A and A is a ϕ - CPVNFS, x^{-1} $\in$ A. Since, x $\in$ N′, x $\in$ N[x^{-1}] by [17, theorem 15]. Hence, x $\in$ N[x^{-1}] $\subset$ A, which is a contradiction, thus N′ $\subset$ A. This completes the proof of the proposition.

Theorem 4.14: Let N be a ϕ - PVNFS with maximal ideal M such that M contains a non-zero divisor. Then N′ is the intersection of all the ϕ - CPVNFs between N and T(N).

Proof: By proposition 4.13, N′ is contained in the intersection of all the ϕ - CPVNF between N and T(N). Let y $\in$ the intersection of all the ϕ - CPVNFs between N and T(N). we must show that y $\in$ N′. Suppose not. By [17, theorem 15], y $\notin$ C = N[y^{-1}]. Let J = y^{-1}C. Then J is a proper ideal of C. by theorem 4.12 there is a ϕ - CPVNF A between C and T(N) such that JA $\neq$ A. But by hypothesis y $\in$ A, and we have our contradiction. This completes the proof of the theorem.

Theorem 4.15[4, Th. 15(1)]**:** Let N be a ϕ - PVNFS with maximal ideal M. Then every over-near-field space of N is a ϕ - PVNFS $\Leftrightarrow$ every ϕ - CNFS between N and T(N) other than (M:M) is of the form N_Q for some non-maximal prime ideal Q of N.

Proof: $\Rightarrow$(if) If T(N) = N, then there is nothing to prove. Hence, assume that M contains a non-zero divisor of N. Suppose that every over near-field space of N is a ϕ - PVNFS. Then N′ = (M: M). Let C be a over near-field space of N such that C $\neq$ (M : M) and C is ϕ - CNFS. Since every over near-field space of N not contained in N′ = (M: M) by proposition 4.7 and hence is a ϕ - PVNFS with maximal ideal M by proposition 4.3 and (M : M) is the only ϕ - CNFS between N and T(N) that has maximal ideal M by [6, lemma 3.1(1)], C $\not\subset$ N′ = (M: M). Then, C must contain an element of the form 1/s for some non-zero divisor s $\in$ M. Hence, C = N_q for some non-maximal prime ideal Q of N by proposition 4.4.

$\Leftarrow$(only if) Suppose that $\forall$ ϕ - CNFS between N and T(N) other than (M : M) is of the form N_q for some non-maximal prime ideal Q of N. Then (M: M) is contained in every ϕ - CNFS between N and T(N). Hence, (M : M) is the intersection of all the ϕ - CNFS between N and T(N). Thus, by Theorem 4.14, N′ = (M: M). Hence, every over near-field space of N is a ϕ - PVNFS. This completes the proof of the theorem.

Corollary 4.16: Let N be a ϕ - PVNFS with maximal ideal M $\ni$ N′ $\neq$ (M: M). Then there is a ϕ - CPVNFS that is properly contained between N′ and (M:M).

Remark 4.17: By making use all [4, prop. 15(1)], Prop. 4.3, 4.4, 4.8 and theorem 4.14, we arrive at the following result that is a generalization of main result on divided near-field spaces, ϕ-PVNFS and ϕ-CPVNFS.

Corollary 4.17: Let N be a ϕ - PVNFS with maximal ideal M. Then the following statements are equivalent:

(a) Every over-near-field-space of N is a ϕ - PVNFS.
(b) N (v) is a ϕ - PVNFS $\forall$ u $\in$ (M: M)\N.
(c) N (v) is quasi-local near-field space $\forall$ u $\in$ (M:M)\N.
(d) If A is an over-near-field-space of N and A$\subset$ (M: M), then A is a ϕ - PVNFS with maximal ideal M.
(e) If A is an over-near-field-space of N and A$\subset$ (M: M) then A is a quasi-local near-field space.
(f) Every over-near-field space of N is quasi-local near-field space.
(g) Every ϕ - CPVNFS between N and T(N) other than (M:M) is of the form N_Q for some non-maximal prime ideal Q of N.
(h) N′ = (M: M).

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GLOSSARY

1. N be the commutative near-field space
2. T(N) be the total quotient near-field space
3. *Nil*(N) be the prime ideal of a near-field space N
4. N is ϕ-CNFS - ϕ- chained near-field space
5. (ϕ-PVNFS) is - ϕ-pseudo –valuation near-field space
6. N(v) - is a divided prime ideal
7. M – maximal ideal of a near-field space N
8. N^c – integral closure of a near-field space
9. (*M*: *M*) is quasi-local near-field space.

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