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REPRESENTATION OF NAGENDRAM Γ-SEMI SUB NEAR-FIELD SPACES OF A Γ-NEAR-FIELD SPACE OVER NEAR-FIELD

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ABSTRACT

In this paper we recall a representation of Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field from N to the general linear near-field space of some finite dimensional near-field space by defining a mapping ρ : N $\rightarrow$ NL(N) be such a representation. With the basic information available is being derived irreducibility representations of T^n, SU (2), SL(2, C) I and SL(2, C) , complexification of Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field.

Keywords: *sub representation, representation,Γ-near-field space; Γ-Semi sub near-field space of Γ-near-field space; Semi near-field space of Γ-near-field space, Nagendram Γ-semi sub near-field space, smooth, space deformation retracts, Nagendram Γ-semi near-field space, closed Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field.*

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SECTION 1: REPRESENTATION OF NAGENDRAM Γ-SEMI SUB NEAR-FIELD SPACES OF A Γ-NEAR-FIELD SPACE OVER NEAR-FIELD.

Definition 1.1: A sub-representation is a Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field $W \subseteq N$ such that for any $g \in N$, $w \in W$ we have $\rho(g)w \in W$. In other words, W is a N-invariant Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field.

If $\rho_1 : N \rightarrow NL(N_1)$ and $\rho_2 : N \rightarrow NL(N_2)$ are two representations of N, then we have $\rho_1 \oplus \rho_2 : N \rightarrow NL(N_1 \oplus N_2)$; $(\rho_1 \oplus \rho_2)(g(n_1 + n_2)) = \rho_1(g(n_1)) + \rho_2(g(n_2))$.

A representation (either real or complex) $\rho : N \rightarrow NL(N)$ is irreducible if it has no nontrivial invariant Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field if $W \subseteq N$ is such that $\rho(g)W \subseteq W$ for all $g \in N$ then either W = {0} or W = N.

Example 1.2: $\rho : S' \rightarrow NL(1, C)$ given by $\rho(\lambda)$ is lambda is irreducible since dim C = 1.

Example 1.3: $\rho : SU(2) \rightarrow NL(2, C)$ is irreducible. SU(2) acts transitively on S^3 and span $C(S^3) = C^2$.

Example 1.4: $\rho : R \rightarrow N : (2, R)$ given by $\rho(t) = \begin{bmatrix} 1 & t \\ 0 & 1 \end{bmatrix}$ is not irreducible R x {0} is invariant.

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Definition 1.5: A complex representation $\rho : N \to NL(N)$ is unitary if there is a Hermitian inner product < , > on N such that $< \rho(g)v, \rho(g)w > = <v>w$, $\forall\, g \in N$, $\forall\, v, w \in N$ i.e. the representation of N on N preserves < , >.

Example 1.6: $\rho : S' \to NL(2, C)$ given by $\rho(e^{i\theta})z = e^{i\theta}z$ is unitary but not irreducible C_z is invariant Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field for any z.

Lemma 1.7: Let $\rho : N \to NL(N)$ be a unitary representation then ρ is a direct sum of irreducible representations.

Proof: This we can prove by induction on $\dim_C (N)$. If $\dim_C (N) = 1$, then ρ is irreducible. Suppose $\dim_C N > 1$ and N is not irreducible. Then there exists an N-invariant Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field W, $\dim_C W \neq \dim_C N$. Let $W^{\perp}$ denote the orthogonal complement Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field of W with respect to the Hermitian inner product on N.

Claim: $W^{\perp}$ is invariant Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field of W.

To prove that,

Let us take $v \in W^{\perp}$ the for any $w \in W$ and $\forall\, g \in N$ $< \rho^{-1}(N)w, v > = < \rho(g)\rho(g^{-1})w, \rho(g)v > = < w, \rho(g)v >$. Since, W is invariant Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field of N, $\rho(g^{-1})w \in W$ and so $0 = < \rho(g^{-1})w, v > = < w, \rho(g)v >$. Hence $\rho(g)v \in W^{\perp}$ for all $g \in N$. Thus, $N = W \oplus W^{\perp}$ where by induction and assumption both W and $W^{\perp}$ are invariant Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field of N. This completes the proof of the lemma.

Definition 1.8: A representation $\rho : N \to NL(N)$ is completely reducible if it is a direct sum of irreducible representation.

Example 1.9: The representation rho: $N \to NL(2, C)$ is neither irreducible nor completely reducible. C x {0} is invariant. If $w \notin C \times \{0\}$ say $w = (w_1, w_2)$ then $w_2 \neq 0$. So $\begin{bmatrix} 1 & t \\ 0 & 1 \end{bmatrix}\begin{bmatrix} w_1 \\ w_2 \end{bmatrix} = \begin{bmatrix} w_1 + tw_2 \\ w_2 \end{bmatrix}$. Set $t = -w_1/w_2$ so that $\rho(t^2)w = w_2\begin{bmatrix} t \\ 1 \end{bmatrix}$.

Hence $\text{span}_C \left\{ \rho(t)\begin{bmatrix} w_1 \\ w_2 \end{bmatrix} \text{ such that } t \in C \right\} = C^2$.

Proposition 1.10: Any complex representation of a finite invariant Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field of N is unitary.

Proof: Let $\rho : N \to NL(N)$ be a representation. Pick a Hermitian inner product <, > on N. It need not be invariant Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field of N.

Now define $<< v, w >> = \frac{1}{|N|}\sum_{g \in N} < \rho(g)v, \rho(g)w >$ where | N | is the cardinal number in N. then for any $a \in N$, $v, w \in N$.

Consider, $<< \rho(a)v, \rho(a)w >> = \frac{1}{|N|}\sum_{g \in N} < \rho(g)\rho(a)v, \rho(g)\rho(a)w > = \frac{1}{|N|}\sum_{g \in N} < \rho(ga)v, \rho(ga)w >$

But, $R_a : N \to N$ is a bijection. So let $g' = ga$. then the last equality becomes

$\frac{1}{|N|}\sum_{g' \in N} < \rho(g')v, \rho(g')w > = << v, w >>$.

It follows that << , >> is invariant Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field of N. It is clear that << , >> is sesquillinear and moreover for $v \neq 0$, $<< v, v >> > 0$. Hence << , >> is an invariant Hermitian inner product as well as Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field of N. This completes the proof of the proposition.

I being an author and in depth study makes me to do the same thing for Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field of N if < , > is a Hermitian inner product on a representation $\rho : N \to NL(N)$ of N the for fixed v, w $\in$ N g $\mapsto$ < ρ(g)v, ρ(g)w > is a function on N.

Also for v ≠ 0 , $f_v(g)$ = < ρ(g)v, ρ(g)w > > 0 for all g. Thus for an appropriate measure $d\mu_g$ we have, $\int_N f_v(g)\, d\mu_g$ > 0. If | N | = $\int_N \mu_g < \infty$, then << v, w >> = $\frac{1}{|N|}\sum_N < \rho(g)v,\ \rho(g)w > d\mu_g$ makes sense and is a Hermitian inner product.

Note 1.11: Any representation of a compact Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field of N is completely reducible.

SECTION 2: IRREDUCIBLE REPRESENTATIONS OF T^N AND REPRESENTATIONS OF SU (2), REPRESENTATIONS OF SL(2, C) I AND SL(2, C) II.

Lemma 2.1: Any complex irreducible representation $\rho : T^n \to NL(N)$ is of the form ρ (exp v) = ρ (v mod Z^n) = $e^{2\pi i \delta\rho(v)}$ where $\delta_\rho : N^n \to N^n$ satisfies δ_ρ (Z^n) $\subseteq Z^n$ i.e. $\delta_\rho \in Hom_Z(Z^n, Z)$.

Proof:
(⇒) If $\mu \in Hom_Z(Z^n, Z) \subseteq Hom_N(N^n, N)$ then $\xi_\mu : N^n/Z^n \to N/Z$ and ξ_μ (v, mod Z^n) = μ(v) mod Z is well defined. we identify N/Z with $S^|$: a mod Z $\mapsto e^{2\pi ia}$. So ξ_μ is a representation $\xi_\mu : T^n \to NL(C)$ and ξ_μ (v mod Z^n) = $e^{2\pi i(v)}$.

(⇐)Converse: Suppose that $\rho : T^n \to NL(C) \cong C \setminus \{0\}$ is a representation. Since $\rho(T^m) \subseteq C^x$ is compact, $\rho(T^n) \subseteq S^|$. we have a commuting diagram

$$\begin{tikzcd} R^n \arrow[r, "\delta_\rho"] \arrow[d, "Exp"'] & R \arrow[d, "exp"] \\ T^n \arrow[r, "\rho"'] & S^| \end{tikzcd}$$

So δ_ρ (ker exp) $\subseteq$ ker exp = Z. Therefore, $\delta_\rho \in Hom_Z(Z^n, Z)$. This proves irreducible, unitary representations of N are in one-one correspondence with elements of the weight lattice. This completes the proof of the lemma.

Definition 2.2: If N is any compact, connected abelian Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field of N i.e. a torus Z_N= ker{exp : g → N } is called the integral lattice. The set $Z^*_N = Hom_Z(Z_N, Z)$ is called the weight lattice.

Note 2.5: Representations of SU (2):

We start constructing complex irreducible representation of SU(n). let V_n be the set of all complex homogeneous polynomials of degree n in two variables. i.e. $v_n = span_C\{ z_1^n, z_1^{n-1}, ..., z_2^n\}$ note that V_0 = C and $V_1 \cong C^2$. We have an action of NL(2, C) on V_n.

(A . f) (z_1, z_2) = f ((z_1,z_2)A) where (z_1, z_2)A is regarded as matrix multiplication.

It is left as an exercise to the reader to prove this indeed defines an action. This also gives us a representation A. (λf + μg) = λ (A.f) + μ (A.g) for all $\lambda, \mu \in C$, $f, g \in V_n$ and A $\in$ NL(2, C).

Note 2.4: Let V_n be as above defined. Then (i) V_n is an irreducible representation of SU(n) for all n ≥ 0 (ii) If V is an irreducible representation of SU(n) of dimension n + 1 then $V \cong V_n$ as representations.

Representation of SL(2, C) I:

Lemma 2.5: There is a bijection between complex representations of SU(2) and of SL(2, C).

Proof: Since π_1SU(2) is trivial, there is a bijection between representations of SU(2) and su(2). Any complex representation of su(2) extends to a unique complex representation of $SL(2)_C$ = SL(s, C).

Conversely, a representation of SL(2, C) restricts to a representation of su(2) $\subseteq$ sl(2, C).

This completes the proof of the lemma.

Lemma 2.6: Any finite dimensional complex representations of SL(2, C) is completely reducible.

Proof: Obvious that representations of SU(2) are completely reducible.

Theorem 2.7: Irreducible representations of SL(2, C) are classified by non-negative integers for any n = 0, 1, 2, ... there exists a unique representation of SL(2, C) of dimension n + 1 we observe [H, E] = 2E, [H, F] = - 2F , [E, F] = H.

Lemma 2.8: Let τ : SL(2, C) $\rightarrow$ NL(N) be a representation. Suppose τ (H)n = cn for some c $\in$ C. Then τ (H)(τ (E)n) = (c + 2) (τ (E)n) and τ (H)(τ (F)n) = (c - 2) (τ (F)n).

Proof : 2 τ (E)n = τ ([H, E])n = τ (H) τ (H) τ (E)n - τ (E) τ (H)n = τ (H)(τ (E)n) - c τ (E)n
and so τ (H)(τ (E)n) = (c + 2) τ (E)n.

$\therefore$ - 2 τ (F)n = τ ([H, F])n) = τ ([H, F]n) - c τ (F)n and so τ ([H, F]n) - (c - 2) (τ (F)n).

This completes the proof of the lemma.

Note 2.9: for k = 1,2,3,..... we see that by induction τ (H)(τ (E)^{k}n) = (c + 2k)(τ (E)^{k}n). But, τ (H) has only finitely many eigenvalues and so there exists k $\geq$ 1 such that τ (E)^{k}n =0, τ (E)$^{k-1}$n $\neq$ 0. We conclude that there exists a $n_0 \in$ N such that $n_0 \neq 0$, τ (E)n_0 = 0 and τ (H)$n_0 = \lambda n_0$ for some $\lambda \in$ C.

Representation of SL(2, C) II:

Lemma 2.10: Let τ : SL(2, C) $\rightarrow$ NL(N) be a representation , $n_0 \in$ N. let $n_k = \dfrac{1}{k!}\tau(F)^k n_0$ and $n_{-1} \equiv 0$. Then

(i) τ (H)n_k = (λ - 2k)n_k,
(ii) τ (F)n_k = (k + 1) n_{k+1}
(iii) τ (E)n_k = (λ - k +1)n_{k-1}.

Proof: To prove (i):

Let τ : SL(2, C) $\rightarrow$ NL(N) be a representation. Suppose τ (H)n = cn for some c $\in$ C. Then τ (H)(τ (E)n) = (c + 2) (τ (E)n) and τ (H)(τ (F)n) = (c - 2) (τ (F)n).
Proved (i).

To prove (ii):

τ (F)n_k = τ (F)($\dfrac{1}{k!}\tau(F)^k n_0$) = (k + 1) $\left[\dfrac{1}{(k+1)!}\tau(F)^{k+1} n_0\right]$ proved (ii).

To prove (iii):

Proceed by induction on k : τ (E)n_0 = (λ + 1) n_{-1} = 0.

Now k τ (E)n_k = τ (E)(τ (F)n_{k-1}) = ((τ (E) τ (F) - τ (F) τ (E) + τ (F) τ (E)n_{k-1}
= τ (H)n_{k-1} + τ (F)(τ (E)n_{k-1})
= (λ - 2(k-1))n_{k-1} + τ (F)((λ - (k -1) + 1)n_{k-2})
= ((λ - 2k + 2) + (λ - k + 2)(k – 1))n_{k-1}
= k(λ - k + 1)n_{k-1}
Hence τ (E)n_k = (λ - k + 1)n_{k-1}.
Proved (iii).

This completes the proof of the lemma.

Note 2.11: Let τ : AL(2, C) $\rightarrow$ NL(N) be a representation and H = $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$ Then, τ (H) is diagonalizable i.e. Nagendram Γ-semi sub near-field spaces of a Γ-near-field space over near-field N has a basis of eigenvectors.

SECTION 3: COMPLEXIFICATION OF NAGENDRAM Γ-SEMI SUB NEAR-FIELD SPACES OF A Γ-NEAR-FIELD SPACE OVER NEAR-FIELD.

Definition 3.1: Let N be Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field. The complexification N_C of N is N ⊗ C.

Let N_C is a complex Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field for any a, b, c ∈ C, n ∈ N we have a (n ⊗ b) = n ⊗ ab. Also N is embedded in N_C as a real Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field $N \mapsto N_C$, $n \mapsto n \otimes I$.

We now identify N with $N \otimes I \subseteq N_C$ and we write an for n ⊗ a, n ∈ N, a ∈ C.

As a real Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field, $N_C = N \otimes i\,N$,
where $i\,N = \{n \otimes i \,/\, n \in N\}$.

Note 3.2: If $\{ n_1, n_2, ..., n_n \}$ is a basis of Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field N, then it is also a complex basis of N_C. considered as a real Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field, N_C has a basis the set $\{ n_1, n_2, ..., n_n, i\,n_1, i\,n_2, ..., i\,n_n \}$.

Lemma 3.3: Let N be a real Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field, W a complex Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field and T : N → W on a R – linear map. Then, there exists a unique C-linear map $T_C : N_C \to W$ extending T.

Proof: Uniqueness. for any s, t ∈ N we have $T_C (s + i\,t) = T_C (s) + i\,T_C(t) = T(s) + i\,T(t)$.
Existence. Let $\{ n_1, n_2, ..., n_n \}$ be a basis for N. we define $T_C \left(\sum a_i\, n_i\right) = \sum a_i\, T(n_i)$ for a_i ∈ C. Then T_C is complex linear and extends T. By uniqueness, T_C does not depend on the choice of basis.

Lemma 3.4: Let N be a real Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field, W a complex Nagendram Γ-semi sub near-field space of a Γ-near-field space over near-field and b : N x N → W and R – bilinear map. Then, there exists a unique C-bilinear map $b_C : N_C \times N_C \to W$ extending b.

Corollary 3.5: If g is a real Nagendram algebras then the Nagendram bracket on g extends to a unique C-bilinear map $[\ ,\ ]_C : g_C \times g_C \to g_C$ such that $(g_C, [,]_C)$ is a Nagendram algebras.

Example 3.6: SU(2) ≅ SL(2, C) to see this first let T : SU(2) → SL(2, C) denote the inclusion. Then, there exists a unique T_C : SU(2) → SL(2, C) extending T now SU(2) = $\text{span}_g \left\{ \begin{bmatrix} i & 0 \\ 0 & -i \end{bmatrix}, \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}, \begin{bmatrix} 0 & i \\ i & 0 \end{bmatrix} \right\}$ so that $SU(2)_C$ is the complex span of the same matrices.
Let H = $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$; E = $\begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}$; F = $\begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}$. Then, SL(2, C) = span_C [H, E, F]. But,
H = $(-i) \begin{bmatrix} i & 0 \\ 0 & -i \end{bmatrix} \in T_C (SU(2))$; E = $\frac{1}{2}\left(\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} - i \begin{bmatrix} 0 & i \\ i & 0 \end{bmatrix} \right) \in T_C(SU(2)_C)$
And F = $\frac{1}{2}\left((-i) \begin{bmatrix} 0 & i \\ i & 0 \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \right) \in T_C(SU(2)_C)$. Thus T_C is onto and hence an isomorphism by dimension count.

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