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Research Paper Engineering

Rate Sequence Space $(S_2)_\pi$

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ABSTRACT

In this paper, the various properties of the rate sequence space (S2)π are discussed. The terms of the sequences are complex numbers and many results are obtained. Also α, β and γ -duals of the space (S2)π are found out.

Keywords : Rate Sequence Space, Space (S2)π, Solid Space, α, β, γ -Duals 2000 - Mathematics Subject Classification: 46A45

1. Introduction

The Rate Sequence Space was studied by Jurimae [3, 4] and others. The space S2 (a non separable Banach space which is solid and monotone) is studied by K. Chandrasekhara Rao [2]. The monotone norm is defined in [6].

2. Preliminaries

Any sequence, whose kth them is (), will be denoted by () or ()

Now we define the following vector Sequence Spaces.

c0 = { = () : → 0 as k → ∞ }

c = { = () : → ℓ} as k → ∞

ℓ∞ = { = () : ׀ ׀ ≤ M k } M being a positive constant.

Always $c_0 \subset c \subset l_\infty$. The norm on the Vector Sequence Spaces, c and is given by $\|x\|_\infty = \sup_k |x_k|$. The norm on the space ℓ is given by $\|x\|_1 = \sum_{k=1}^{\infty} |x_k|$.

3. Definitions

Let $\{\pi_k\}$ be a sequence of positive terms,

Definition 1. $(S_2)_\pi$ is the set of all sequences (x_k) with (x_k) ϵ C, and $\frac{|x_k|}{2^k \pi_k} \leq$ M, M > 0 is a constant and X is the set of complex numbers. The norm of the sequence is $\|\bullet\|$.

Definition 2. Let X be a normed space. Then X is said to have monotone norm if $\|x^{(m)}\| \geq \|x^{(n)}\|$ for m > n and $\|x\| = sup\|x^{(m)}\|$

Definition 3. A sequence space X is said to be solid if $\{x_k\}$ϵ X and $|y_k| \leq |x_k|$ for all k ⇒ $\{y_k\} \in X$

4. Results

Theorem 1. $(\ell\infty)_\pi \subset (S_2)^\pi$, where
$(l_\infty)_\pi = \{x = (x_k): \|x\|_\pi = \sup_k |\frac{x_k}{\pi_k}| \leq \infty\}$

Proof. Let $x \epsilon (l_\infty)_\pi$

$\Rightarrow \sup_k |\frac{x_k}{\pi_k}| \leq M$

$\Rightarrow \quad |\frac{x_k}{\pi_k}| \leq M$

$\Rightarrow |\frac{x_k}{2^k \pi_k}| \leq |\frac{x_k}{\pi_k}| \leq M$

$\Rightarrow x \epsilon (S_2)_\pi$

Hence $(l_\infty)_\pi \subset (S_2)_\pi$.

Theorem 2. $(S_2)_\pi$ is a normed space.

Proof. Let $\|x\| = \sup_k \frac{|x_k|}{2^k \pi_k}$

We have $\frac{|x_k|}{2^k \pi_k} \geq 0 \Leftrightarrow \|x\| \geq 0$

Also $\frac{|x_k|}{2^k \pi_k} = 0 \Leftrightarrow \|x\| = 0$

Hence $\|x\| = 0 \Leftrightarrow x = 0$

Also $\|\alpha x\| = \sup_k \frac{|\alpha x_k|}{2^k \pi_k} = |\alpha| \sup_k \frac{|x_k|}{2^k \pi_k}$

$= |\alpha| \|x\|$ where α is a scalar.

Moreover $\|x + y\| = \sup_k \{\frac{|x_k + y_k|}{2^k \pi_k}\}$

$\leq \sup_k \{\frac{|x_k| + |y_k|}{2^k \pi_k}\}$

$= \|x\| + \|y\|$

Thus $\|x + y\| \leq \|x\| + \|y\|$

Hence $\|x\|$ is the norm of x.

$\Rightarrow (S_2)_\pi$ is a normed space.

Theorem 3. $(S_2)_\pi$ is a Banach space.

Proof. Let $\{x^{(n)}\}_{n=1}^{\infty}$ be a Cauchy sequence in $(S_2)_\pi$.

Where $x^{(n)} = (x_1{}^{(n)}, x_2{}^{(n)}, \ldots)\ \forall\ n$

In other words,

$x^{(1)} = (x_1{}^{(1)}, x_2{}^{(1)}, \ldots)$

$x^{(2)} = (x_1{}^{(2)}, x_2{}^{(2)}, \ldots)$

……

……

$\Rightarrow ||x^{(n)} - x^{(m)}|| \leq \in \forall\ n,\ m \geq n_0$

$\Rightarrow \{x_k^{(n)}\}_{n=1}^{\infty}$ is a Cauchy sequence in C

But C is complete.

Hence $x_k{}^{(n)} \to x_k$ as $n \to \infty$

Take $x = \{\frac{x_k}{2^k \pi_k}\}$

Then $x \in (S_2)_\pi$ and $x^{(n)} \to x$ in $(S_2)_\pi$ in $(S_2)_\pi$

Therefore $(S_2)_\pi$ is complete.

Theorem 4. $(S_2)_\pi$ is not separable.

Proof. Let D be any dense subset of $(l_\infty)_\pi$

Let A be the set of all these sequences whose terms are 0 or 1.

Then A is an uncountable subset of $(l_\infty)_\pi$

Define a surjection $f : A \to D$ by

$f(x) = z_x\ \forall\ x = (x_1, x_2, \ldots x_n, \ldots) \in A$

with $||x - z_x|| < \frac{1}{2}$

Let , x, y ϵ A with x ≠ y

But then $||x - y|| = \sup_k |\frac{x_k}{2^k \pi_k} - \frac{y_k}{2^k \pi_k}| = 1$

Now $||x - y|| \leq ||x - z_x|| + ||z_x - y||$

and so $||y - z_x|| \geq ||x - y|| - ||x - z_x||$

$\geq 1 - \frac{1}{2} = \frac{1}{2}$

But $f(y) = z_y$ with $||y - z_y|| < \frac{1}{2}$.

Hence $z_x \neq z_y$ or equivalently $f(x) \neq f(y)$.

Thus f is a bijection.

Since A is uncountable it follows that

f (A) = D is uncountable

Consequently $(S_2)_\pi$ cannot be separable.

Theorem 5. $(S_2)_\pi$ is solid.

Proof $(S_2)_\pi = \{(x_k) : \frac{|x_k|}{2^k \pi_k} \leq M\ for\ some\ M > 0\}$

Suppose that $(x_k) \in (S_2)_\pi$

Let $|u_k| \leq |x_k|\ \forall\ k$

Hence $\frac{|u_k|}{2^k \pi_k} \leq \frac{|x_k|}{2^k \pi_k}\ \forall\ k$

But $(x_k) \in (S_2)_\pi$

$\Rightarrow \frac{|x_k|}{2^k \pi_k} \leq M\ for\ some\ M > 0$

Hence $\frac{|u_k|}{2^k \pi_k} \leq \frac{|x_k|}{2^k \pi_k} \leq M$

$\Rightarrow \frac{|u_k|}{2^k \pi_k} \leq M$

$\Rightarrow \{u_k\} \in (S_2)_\pi$

Therefore $(S_2)_\pi$ is solid.

Theorem 6. $(S_2)_\pi$ has monotone norm.

Proof. Let m > n, consider the sequence

$x^{(n)} = (x_1, x_2, \ldots x_n, 0, 0, \ldots)$

But then $x^{(m)} = (x_1, x_2, \ldots x_m, 0, 0, \ldots)$

Hence $|x^{(m)}|| = sup\ \{\frac{|x_1|}{2^1 \pi_1}, \frac{|x_2|}{2^2 \pi_2}, \ldots \frac{|x_m|}{2^m \pi_m}, 0, 0, \ldots\}$

Obviously, for m > n, we have $|x^{(m)}|| \geq ||x^{(n)}||$

Also

$\lim_{n \to \infty} ||x^{(n)}|| = ||x||$

$\Rightarrow \sup_k ||x^{(n)}|| = ||x||$

Therefore $(S_2)_\pi$ has monotone norm.

Notation

The α, β, γ duals of $(S_2)_\pi$ are denoted by $(S_2)_\pi^\alpha$, $(S_2)_\pi^\beta$, $(S_2)_\pi^\gamma$ respectively.

Theorem 7. $(S_2)_\pi^\alpha = (S_2)_\pi^\beta = (S_2)_\pi^\gamma = (T_2)_{\frac{1}{\pi}}$ where

$(T_2)_{\frac{1}{\pi}} = \{y_k : \sum_{k=1}^{\infty} 2^k\ |\pi_k y_k| < \infty\}$

Proof. Since $(S_2)_\pi$ solid, α, β ,γ duals are equal.

We shall show that $(S_2)_\pi^\beta = (T_2)_{\frac{1}{\pi}}$

Let $y = (y_k) \in (T_2)_{\frac{1}{\pi}}$

$|\sum_{k=1}^{\infty} x_k y_k| \leq \sum_{k=1}^{\infty} |x_k||y_k|$

$= \sum_{k=1}^{\infty} \frac{|x_k|}{2^k \pi_k}\ 2^k\ |\pi_k y_k|$

$\leq ||x||\ \sum_{k=1}^{\infty} 2^k |\pi_k y_k|$ ≤ because $||x|| = \sup_k \frac{|x_k|}{2^k \pi_k}$

Hence $y \in (S_2)_\pi^\beta$

Therefore $(T_2)_{\frac{1}{\pi}} \subset (S_2)_\pi^\beta$ Similarly $(S_2)_\pi^\beta \subset (T_2)_{\frac{1}{\pi}}$

and β – dual of $(S_2)_\pi$ is $(T_2)_{\frac{1}{\pi}}$

Thus $(S_2)_\pi^\alpha = (S_2)_\pi^\beta = (S_2)_\pi^\gamma = (T_2)_{\frac{1}{\pi}}$

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