

ISSN 0304-9892 (Print)

ISSN 2455-7463 (Online)

Jñānābha ज्ञानाभ

(University Grants Commission Approved Journal No. 26013)

VOLUME 47

NUMBER 2

DECEMBER 2017

Published by :

The Vijñāna Parishad of India
DAYANAND VEDIC POSTGRADUATE COLLEGE
(Bundelkhand University)

ORAI-285001, U.P., INDIA

www.vijnanaparishadofindia.org/jnanabha

ON A BI DIMENSIONAL BASIS INVOLVING SPECIAL FUNCTIONS FOR PARTIAL IN SPACE AND TIME FRACTIONAL WAVE MECHANICAL PROBLEMS AND APPROXIMATION

By

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(Received: August 02, 2017 ; Revised : September 28, 2017)

Abstract

In this work, we construct a fractional time dependent wave mechanical problem consisting partial in space and time fractional derivatives and solved it on introducing a bi dimensional basis function involving Hermite and Mittag – Leffler functions. Then, we use it to approximate the solution of above two variable wave mechanical problem and then discuss its various cases in which it is computable.

2010Mathematics Subject Classification: Primary; 41A30. Secondary; 33C45, 33C90, 26A33.

Keywords: Approximation, bi dimensional basis solution, Hermite and Mittag – Leffler functions, Application, Fractional derivatives.

1. Introduction

The Hermite functions play an important role in the wave mechanical treatment of the harmonic oscillator. (see Mott and Sneddon [11, p. 50], Eravanis [1]). It also has great importance in the application to the quantum theory of radiation [19]. In this connection, the time independent Schrödinger equation corresponding to harmonic oscillator of point mass m with vibrational frequency ν is given by (Sneddon [17])

$$\frac{d^2\psi_n}{dx^2} + \left(\frac{2T}{h\nu} - x^2\right)\psi_n = 0, \quad (1)$$

where, T is the total energy of the oscillator and h is the Plank's constant. Here, the wave functions ψ_n have the property that

$$\psi_n \rightarrow 0 \text{ as } |x| \rightarrow \infty; \quad (2)$$

and

$$\int_{-\infty}^{\infty} |\psi_n|^2 dx = 2\pi \sqrt{\frac{m\nu}{h}} \quad (3)$$

In Eqn. (1), there is the Hermite function $\psi_n = e^{-\frac{x^2}{2}} H_n(x)$ and $\frac{2T}{h\nu} = 2n + 1$, where, $H_n(x)$ being the Hermite polynomials [13] for all $n = 0, 1, 2, \dots$, satisfying the differential equation

$$\frac{d^2 H_n(x)}{dx^2} - 2x \frac{d H_n(x)}{dx} + 2n H_n(x) = 0 \quad (4)$$

The $H_n(x)$ is defined by

$$H_n(x) = \begin{cases} (-1)^n e^{x^2} \frac{d^n}{dx^n} e^{-x^2}, & (\text{the operational formula}) \\ (2x)^n \sum_{r=0}^{\infty} \frac{\Gamma(-\frac{n}{2}+r) \Gamma(\frac{1}{2}-\frac{n}{2}+r)}{\Gamma(-\frac{n}{2}) \Gamma(\frac{1}{2}-\frac{n}{2}) \Gamma(1+r)} (-x^2)^r, & (\text{the series formula}) \end{cases} \quad (5)$$

The function ψ_n also satisfies the recursion formula

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