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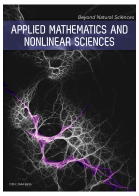

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Use of Quantum Differential Equations in Sonic Processes

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Abstract

Emerging as a new field, quantum computation has reinvented the fundamentals of Computer Science and knowledge theory in a manner consistent with quantum physics. The fact that quantum computation has superior features and new events than classical computation provides benefits in proving mathematical theories. With advances in technology, the nonlinear partial differential equations are used in almost every area, and many difficulties have been overcome by the solutions of these equations. In particular, the complex solutions of KdV and Burgers equations have been shown to be used in modeling a simple turbulence flow. In this study, Burger-like equation with complex solutions is defined in Hilbert space and solved with an example. In addition, these solutions were analyzed. Thanks to the Quantum Burgers-Like equation, the nonlinear differential equation is solved by linearizing. The pattern changes of time made the result linear. This means that the Quantum Burgers-Like equation can be used to smoothen the sonic processing.

Keywords: Quantum Computing; Quantum Differential Equation; Sound Smoothing; Sonic Processes.
AMS 2010 codes: 00A69, 82D77, 81Q80, 81P68, 93C20, 93B18, 94A05

1 Introduction

In recent years, there has been a rapid contraction in computer technology. If the trend continues this way, starting from 2023, the basic memory components of a computer will descend to the level of individual atoms. This means that the current calculation model based on a known mathematical idealization is completely invalid. In this case, the laws of quantum physics will apply. Quantum theory is a linear theory. It is based on mathematics, linear algebra and vector spaces. The "quantum computing", which emerges as a new field, rediscovers the foundations of computer science and information theory in a way compatible with quantum physics. Quantum computation is the newest and most accurate model based on quantum physics of computation.

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Today, computer technology has given us the ability to calculate. Computers can compute much faster than a human being, and store more information than a person can have at the same time, allowing them to be accessed quickly. Primitive computers have a mechanical architecture, which is then replaced by relays, vacuum tubes, transistors, integrated circuits, increasing the number of elements in the integrated circuits each day and reducing the size of the transistors in these circuits. This development will face some microelectronic element models in the near future. Rather than just looking at computers as mathematical idealizations, one should look at them as physical systems. The downsizing of the computer world means that quantum rules apply instead of classical rules.

The fact that quantum computation is superior to classical computation at the basic level and the emergence of some new phenomena provides us with significant benefits in the proof of mathematical theorems. We know that the classical proof of mathematical theory can only be achieved by step-by-step monitoring of several suggestions and axioms. However, it can be said that a proof made using quantum effects lags behind the old proof definition and that the proof is not a step-by-step result, it is a calculation as a process [1].

In addition to advances in technology, solutions of nonlinear partial differential equations are used in almost every field, and solutions to these equations overcome many difficulties [2–5]. In particular, it has been shown that KdV and Burgers equations can be used to model a simple turbulence flow by performing complex solutions [6–10]. However, it has been proven that the Burgers equation is a simple simulation of a nonlinear diffusion equation that can be used in this model [11].

Recent studies have shown that image processing can be done by solutions of partial differential equations [10, 12]. Even with the techniques used, image enhancement can be done by nonlinear partial differential equations. Nonlinear partial differential equations can be used to ensure smoothing of an image without additional computational load [12].

In this study, Burgers Likes equation, which is complex solutions by Gençoğlu, will be defined in Hilbert space and will be solved on a sample and the solutions will be analyzed.

1.1 Linear Processors

In a vector space, a linear process that maps each vector to another vector is called a linear processor. In finite-dimensional vector spaces, linear processors are represented by matrices.

1.2 Hermitic Matrix

Matrice, which is equal to Adjointi itself, is called a self-adjoint or hermitic matrix.

2 Experimental Method

Let's take the Burgers-Like equation;

$$U_t + U_x + U.U_x + V.U_{xx} = 0, \tag{1}$$

Here,

For $U(x,t) = i(x - ct)$ and $V = \frac{1}{2}$

$$U_t + U_x + U.U_x + \frac{1}{2}.U_{xx} = 0, \tag{2}$$

obtained. Solutions of (2)

$$\begin{aligned} U_1 &= (c-1)[1 - i.\tan[(c-1).i(x-ct)]] \\ U_2 &= (c-1)[1 + i.\cot[(c-1).i(x-ct)]], \end{aligned} \tag{3}$$

was found as [10].

$U_1, U_2 \in H$, in this case, the equation (2) is a quantum Burgers-Like equation. If this equation of U_1, U_2 solutions and $U_t = ic, U_x = i, U_{xx} = 0$ values are written in equation (2), the following equations are obtained.

$$\begin{aligned} -ict + i + U.i + V.0 &= 0, \\ i(U + 1 - c) &= 0, \\ U &= c - 1, \end{aligned} \tag{4}$$

if the equation (4) is solved separately for U_1 *ve* U_2, there are 2 separate situations for each value, and their solutions are also Hilbert spaces.

For $U_1 \in [0, 2\pi]$ from equation (4) following equations are obtained.

$$\begin{aligned} &(c-1)[1 - i.\tan[(c-1).i(x-ct)]] = (c-1), \\ &1 - i.\tan[(c-1).i(x-ct)] = 0. \end{aligned} \tag{5}$$

Solutions of (5);

$$\begin{aligned} x_1 &= ct \\ x_2 &= \frac{2\pi}{1-c} i + ct. \end{aligned} \tag{6}$$

Similarly; For $U_2 \in [\frac{\pi}{2}, \frac{3\pi}{2}]$ from equation (4) following equations are obtained.

$$\begin{aligned} &(c-1)[1 + i.\cot[(c-1).i(x-ct)]] = (c-1) \\ &i.\cot[(c-1).i(x-ct)] = 0. \end{aligned} \tag{7}$$

Solutions of (7);

$$\begin{aligned} x_1 &= \frac{\pi}{2(1-c)} i + ct \\ x_2 &= \frac{3\pi}{2(1-c)} i + ct. \end{aligned} \tag{8}$$

Example

Assuming that c is the frequency of an electromagnetic waveguide in the function $U(x,t) = i(x - ct)$ (the frequency does not depend on the center), the extreme red frequency is 4,1014 Hz. and purple frequency 8,1014 Hz. t, provided that indicate the time;If obtained x values in (6) and (8) are separately calculated by using MATLAB for red and purple frequencies, the values in Table 1, Table 2, Table 3, Table 4, Table 5, Table 6, Table 7 and Table 8 are obtained;

When the values given in these tables are plotted with the help of MATLAB, the following Figures 1 and 2 are obtained.

3 Results and Discussions

As can be seen from the tables and figures, the nonlinear differential equation is solved by linearizing the quantum Burgers-Like equation. The resulting change in time is linearly reduced. This indicates that the Quantum Burgers-Like equation can be used to smoothen the sound, image and signal processing.

Since the x values obtained from the solutions of the quantum Burgers-Like equation are the elements of Hilbert space, 4 basic quantum states in Hilbert space;

$$|00\rangle = |0\rangle = (0,0,0,1)^T$$

Table 1 U_1, Case 1 ($x = ct$), C=4,1014

t	x
16	65,6224
48	196,8672
80	328,1120
112	459,3568
144	590,6016
176	721,8464
208	853,0912
240	984,3360

Table 2 U_1, Case 1 ($x = ct$), C=8,1014

t	x
16	129,6224
48	388,8672
80	648,1120
112	907,3568
144	1166,6016
176	1425,8464
208	1685,0912
240	1944,3360

Table 3 U_1 Case 2 ($x = \frac{2\pi}{1-c}i + ct$), C=4,1014

t	x
16	65,6224-116,0766
48	196,8672-116,0766
80	328,1120-116,0766
112	459,3568-116,0766
144	590,6016-116,0766
176	721,8464-116,0766
208	853,0912-116,0766
240	984,3360-116,0766

Table 4 U_1, Case 2 ($x = \frac{2\pi}{1-c}i + ct$), C=8,1014

t	x
16	129,6224-50,6942
48	388,8672-50,6942
80	648,1120-50,6942
112	907,3568-50,6942
144	1166,6016-50,6942
176	1425,8464-50,6942
208	1685,0912-50,6942
240	1944,3360-50,6942

Table 5 U_2, Case 1 ($x = \frac{\pi}{2(1-c)}i + ct$), C=4,1014

t	x
16	65,6224-29,0191
48	196,8672-29,0191
80	328,1120-29,0191
112	459,3568-29,0191
144	590,6016-29,0191
176	721,8464-29,0191
208	853,0912-29,0191
240	984,3360-29,0191

Table 6 U_2, Case 1 ($x = \frac{2\pi}{1-c}i + ct$), C=8,1014

t	x
16	129,6224-12,6735
48	388,8672-12,6735
80	648,1120-12,6735
112	907,3568-12,6735
144	1166,6016-12,6735
176	1425,8464-12,6735
208	1685,0912-12,6735
240	1944,3360-12,6735

Table 7 U_2, Case 2 ($x = \frac{3\pi}{2(1-c)}i + ct$), C=4,1014

t	x
16	65,6224-87,0574
48	196,8672-87,0574
80	328,1120-87,0574
112	459,3568-87,0574
144	590,6016-87,0574
176	721,8464-87,0574
208	853,0912-87,0574
240	984,3360-87,0574

Table 8 U_2, Case 2 ($x = \frac{3\pi}{2(1-c)}i + ct$), C=8,1014

t	x
16	129,6224-38,0206
48	388,8672-38,0206
80	648,1120-38,0206
112	907,3568-38,0206
144	1166,6016-38,0206
176	1425,8464-38,0206
208	1685,0912-38,0206
240	1944,3360-38,0206

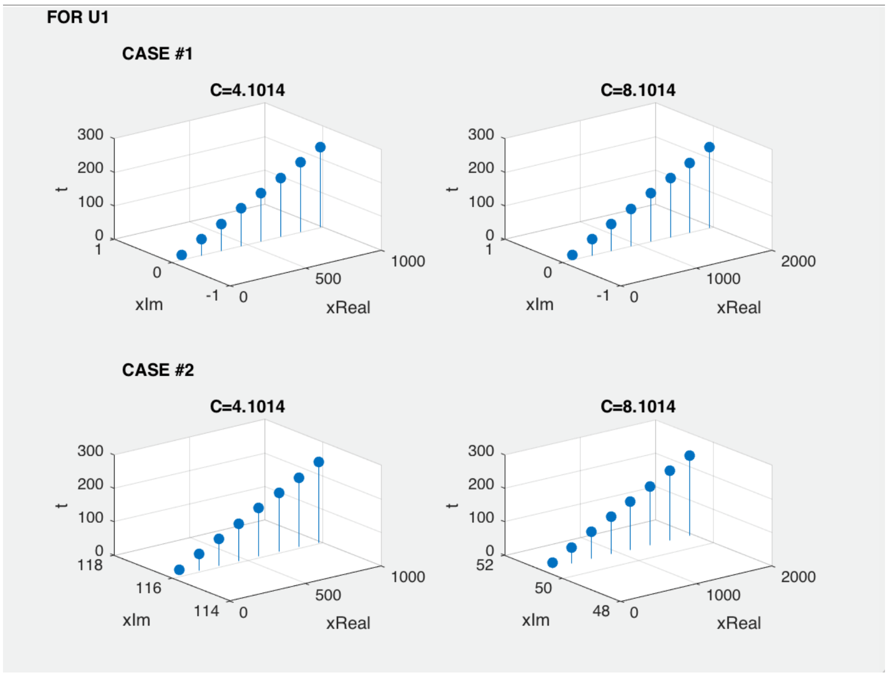

Fig. 1 Case 1 and 2

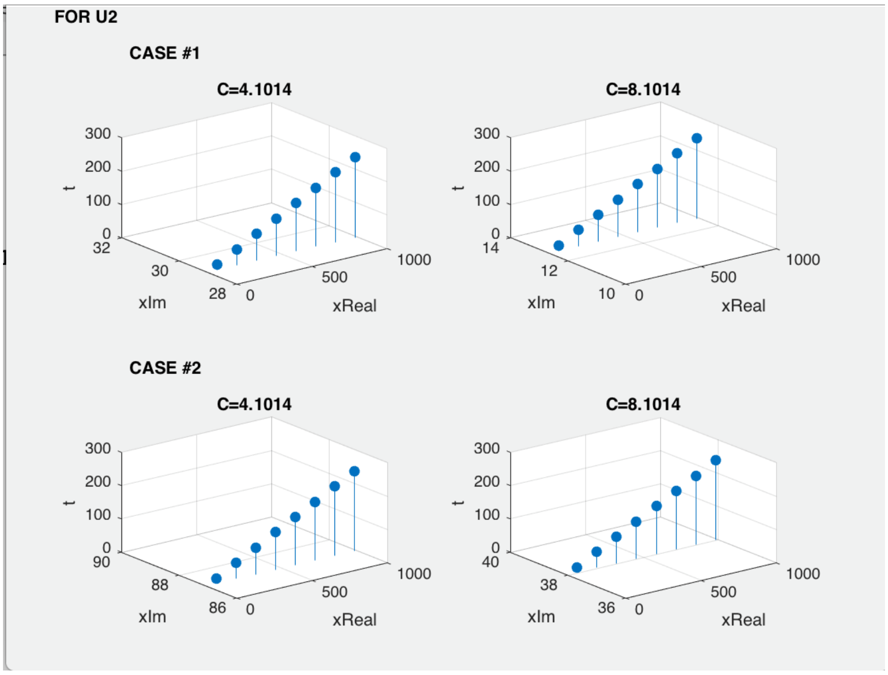

Fig. 2 Case 1 and 2

$$|01\rangle = |1\rangle = (0,0,1,0)^T$$

$$|10\rangle = |2\rangle = (0,1,0,0)^T$$

can be written as [13]. From here, the following Hermitian matrices can be written.

$$U_{q_1} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \frac{1}{\sqrt{3}}U_1 & \frac{1}{\sqrt{3}}\bar{U}_1 & 0 \\ 0 & \frac{1}{\sqrt{3}}\bar{U}_1 & \frac{1}{\sqrt{3}}U_1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$U_{q_2} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \frac{1}{\sqrt{3}}U_2 & \frac{1}{\sqrt{3}}\bar{U}_2 & 0 \\ 0 & \frac{1}{\sqrt{3}}\bar{U}_2 & \frac{1}{\sqrt{3}}U_2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

If these Hermitian matrices are considered as Entangling Quantum Gates;
1. Can nonlinear partial differential equations be simulated?
2. Can these doors be used for linear diffusion?
3. Can these doors be used as a collision operator?
4. Can a quantum random number be used as a generator?

4 Conclusion

This study showed that; Quantum Burgers-Like equation, the nonlinear differential equation is solved by linearization. This means that the Quantum Burgers-Like equation can be used to smoothen the sound, image and signal processing. By solving nonlinear partial differential equations, it will be possible to smoothen an image without additional computation overhead. If we express what is done from another angle; The values obtained are possible values, not absolute values of the observables. That is the uncertainties in the Quantum Mechanism [13, 14]. This quantum equation is also a linear processor at the same time, as can be seen from the operations performed and the results obtained. Thanks to the Hermitian matrices described above, this linear processor is now a Hermitic processor. Furthermore, if the above , hermitian matrices are defined as quantum gates, this is proof that these quantum gates can be copied. This means that quantum states can transmit safely between the two sides. This is mark an era in quantum cryptography [14].

By solving nonlinear partial differential equations, it will be possible to smoothen an image without additional computation overhead. This study will contribute to the studies in the field of software engineering and especially in the National cybersecurity solutions. According to my research in literature, there are not many studies in this field, and this is the first study of quantum Burgers-like equations.

References

[1] Yepez J., An Efficient quantum algorithm for the one-dimensional Burgers equation, Cornell University Library arXiv: quant-ph/0210092 (2002)
[2] Wang M.L., Exact Solutions for a compound KdV-Burgers equation, Physics Letters A, 213, 279-287(1996)
[3] Wang M.L., Zhou Y.B., Li Z.B., Application of a homogeneous balance method to exact solutions of nonlinear equations in mathematical physics, Physics Letters A, 216, 67-65 (1996)
[4] İnç M., Gençoğlu M.T., Akgül A., Application of Extended Adomian Decomposition Method and Extended Variational Iteration Method to Hirota-Satsuma coupled KdV equation, Journal of Advanced Physics, 6(2), 216-222 (2017)
[5] Gençoğlu M.T., Akgül A., İnç M., On new traveling wave solutions of the Hirota-Satsuma coupled KdV equation, New Trends in Mathematical Science, 5(3), 262-272 (2017)
[6] Kumar S., Kumar A., Baleanu D., Two analytical methods for time-fractional nonlinear coupled Boussinesq–Burger's equations arise in propagation of shallow water waves, Nonlinear Dynamics, 85(2), 699-715 (2016)
[7] Duran S., Uğurlu Y., İnan İ.E., Expansion Method for (3+1) – dimensional Burgers and Burgers Like equation, World Applied Journal, 20(12), 1607-1611 (2012)

[8] İnan İ.E., Uğurlu Y., Duran S., Complex solution for night-order korteweg-de Vries (nkdV) equation and 2- dimensional Burgers equation, Türkish Journal of Science &Technology, 5(1), 37-42 (2010)

[9] Zhang H., A direct algebraic method applied to obtain complex solutions of some nonlinear partial differential equations, Chaos, Solitons&Fractals, 39, 1020-1026 (2009)

[10] İnan İ.E., Bulut H., Complex solutions for fifth-order KdV equation and (3+1) dimensional Burgers equation, e-Journal of New World Science Academy Physical Sciences, 3A0007 4(3), 0-65 (2009)

[11] Pravia M.A., Chen Z., Cory D.G., Experimental demonstration of Quantum Lattice Gas computation, Quantum Information Processing, 2, 1-2 (2003)

[12] Coffey et all., Method for signal and image processing with Lattice Gas Processes, United States Patent document no: US, 7, 930, 152, B2 (2011)

[13] Gençoğlu M.T., Complex Solution for Burgers-Like Equation, Türkish Journal of Science &Technology, 8(2), 121-123 (2013)

[14] Buğdaycı, N., Mathematics of Quantum Theory, Quantum Workshop, İzmir-Türkiye, Appril (2011)

[15] Toyran M., Quantum Cryptography, M.Sc. Thesis, Istanbul Technical University, Graduate School of Natural and Applied Sciences, İstanbul (2003)