$$-\frac{3}{2}iH\gamma^0\psi = 2\psi, \tag{29}$$

$$2\dot{H} + \frac{1}{2}i(\overline{\psi}\gamma^0\dot{\psi} - \dot{\overline{\psi}}\gamma^0\psi) = 0. \tag{30}$$

Now we take the Dirac 2-spinor as $\overline{\psi} = (\psi_1, \psi_2)^\dagger \gamma^0$, the equation for spinor reads as

$$\dot{\psi} + \frac{3}{2}H\psi + 2i\gamma^0\psi = 0. \tag{31}$$

Thus we must solve the next system of ODEs:

$$\frac{d\log\psi_a}{dt} = \frac{3}{2}H\psi_a \pm 2, a = \{1,2\} = \{+,-\}, \tag{32}$$

which posses the following solution

$$\psi^T = (\psi_1(0)a(t)^{3/2}e^{2t}, \psi_2(0)a(t)^{3/2}e^{-2t}). \tag{33}$$

Using this form of the 2-spinor we can obtain the scale factor from the following equation

$$\ddot{y} + ie^{3y}\{|\beta|^2 e^{-4t} - |\alpha|^2 e^{4t}\}, \tag{34}$$

here $y \equiv \log(a(t)), \{\alpha, \beta\} \equiv \{\psi_1(0), \psi_2(0)\}$.

The work was carried out with the financial support of the Ministry of Education and Science of the Republic of Kazakhstan, Grant No. 0118RK00935.

References

1. Felice A., Gerard J.M., Suyama T. Cosmological perturbation in f(R,G) theories with a perfect fluid // Physical Review D. 2010. P. 6.
2. Feng B., Li M., Piao Y., Zhang X. Oscillating quintom and the recurrent universe // Physics Letters B. 2006. P. 101-105.
3. Harko T., Lobo F. S. N., Nojiri S., Odintsov S. D. f(R,T)gravity // Physical Review D. 2011. P. 2.
4. R. A. Campos, C. G. OliveiraHamiltonian formulation for a translation gauge theory of gravitation // Il NuovoCimento B (1971-1996). 1983. P. 83–92.
5. M. Jamil, F.M. Mahomed, D. Momeni Noether symmetry approach in f (R)–tachyon model // Physics Letters B. 2011. P. 315-319.
6. M. Jamil, Y. Myrzakulov, O. Razina, R. MyrzakulovModified Chaplygin gas and solvable F-essence cosmologies // Astrophysics and Space Science. 2011. P. 315–325.

UDC 517.957, 532.5

NONLINEAR WAVES FOR KUDRYASHOV-SINELSHCHIKOV EQUATION

Mussayeva Akniyet
mussayeva1999@gmail.com
Student of the Department General and Theoretical Physics, L.N. Gumilyov ENU, Nur-Sultan, Kazakhstan
Supervisor – G. Shaikhova

In this paper, we consider the (3+1)-dimensional Kudryashov-Sinelshchikov (KS) equation in the following form [1]

$$(u_t + \alpha u u_x + \gamma u_{xxx})_x + d u_{yy} + e u_{zz} = 0 \quad (1)$$

where $u(x, y, z, t)$ represents the fluid velocity in the horizontal direction x, a, d, e, γ is a positive constants. The equation (1) describes the physical characteristics of nonlinear waves in a bubbly liquid. The goal of this work is to study the (3+1)-dimensional Kudryashov-Sinelshchikov equation by sine-cosine method [3].

Sine-cosine method

In this section, we apply sine-cosine method to the (3+1)-dimensional KS equation (1). By wave variable

$$u(x, y, z, t) = u(\xi)\ ,\ \xi=(x+y+z-ct) \quad (2)$$

the equation (1) can be converted to

$$-cu' + \frac{\alpha}{2} u^2 + \gamma u''' + (d + e)u' = 0 \quad (3)$$

Integrating (3) and assuming the integration constant to be zero, we obtain

$$(d + e - c)u + \frac{\alpha}{2} u^2 + \gamma u'' = 0\ . \quad (4)$$

By the sine-cosine method we then use the cosine assumption

$$u = \lambda cos^{\beta}(\mu\ \zeta), \quad (5)$$

with next derivatives

$$u' = -\beta\mu\lambda cos^{\beta-1}(\mu\zeta)\sin(\mu\zeta)\ , \quad (6)$$

$$u'' = -\mu^2\beta^2\lambda cos^{\beta}(\mu\zeta) + \mu^2\lambda\beta(\beta - 1)cos^{\beta-2}(\mu\ \zeta) \quad . \quad (7)$$

We substitute equation (5) and (7) in to (4) and obtain

$$(d + e - c)\lambda cos^{\beta}(\mu\xi) + \frac{\alpha}{2}\lambda^2 cos^{2\beta}(\mu\xi) - \gamma\mu^2\beta^2\lambda cos^{\beta}(\mu\xi) + \gamma\mu^2\beta(\beta - 1)cos^{\beta-2}(\mu\xi) = 0 \quad (8)$$

From (8) we find

$$2\beta=\beta-2 \rightarrow \beta=-2 \quad (9)$$

Then by substituting (9) into equation (8) we have

$$(d + e - c)\lambda cos^{-2}(\mu\xi) + \frac{\alpha}{2}\lambda^2 cos^{-4}(\mu\xi) - 4\gamma\mu^2\lambda cos^{-2}(\mu\xi) + 6\gamma\mu^2 cos^{-4}(\mu\xi) = 0 \quad (10)$$

Equating the exponents and the coefficients of each pair of the cosine function in (10), we obtain a system of algebraic equations

:

$$cos^{-2}(\mu\xi) \qquad (d + e - c)\lambda - 4\lambda\gamma\mu^2 = 0 \quad (11)$$

$$cos^{-4}(\mu\xi): \qquad \frac{\alpha}{2}\lambda^2 + 6\lambda\mu^2\gamma = 0\ , \quad (12)$$

and by solving the algebraic system (11)-(12) we obtain next parameters

$$\mu = \frac{1}{2}\sqrt{\frac{(d+e-c)}{\gamma}}, \tag{13}$$

$$\lambda = -\frac{3(d+e-c)}{\alpha}, \tag{14}$$

$$\beta = -2 \tag{15}$$

Then by substituting expressions (13)-(15) into equation (5), we can find cosine solution for (1) in the next form

$$u_1(x,y,z,t) = -\frac{3(d+e-c)}{\alpha}\cos^{-2}\left(\frac{1}{2}\sqrt{\frac{(d+e-c)}{\gamma}}(x+y+z-ct)\right) \tag{16}$$

By same way we can find sine solution for (1) that is

$$u_2(x,y,z,t) = -\frac{3(d+e-c)}{\alpha}\sin^{-2}\left(\frac{1}{2}\sqrt{\frac{(d+e-c)}{\gamma}}(x+y+z-ct)\right) \tag{17}$$

The graphical representation of solutions (16) and (17) is depicted

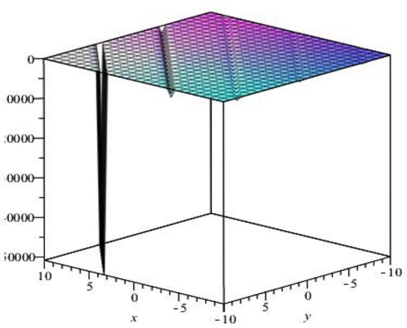

Figure 1: The solution $u_1(x,t)$ of equation (1) equation (1) t=5, d=0.5, e=0.5 , α=1, z=1

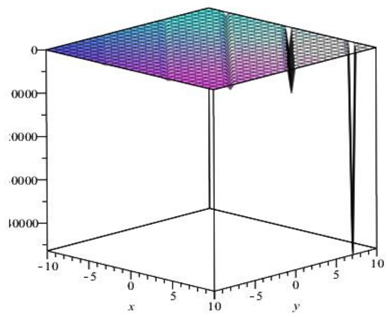

Figure 2: The solution $u_2(x,t)$ of t=5, d=0.5, e=0.5 , α=1, z=1

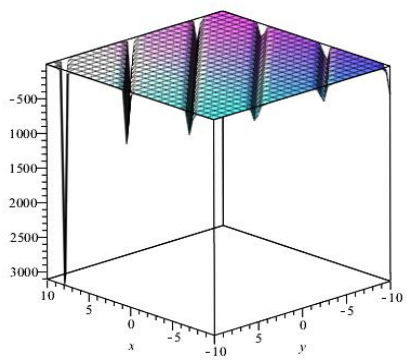

Figure 3: The solution $u_1(x,t)$ of equation (1) equation (1) t=0, d=0.5, e=0.5 , α=1, z=1

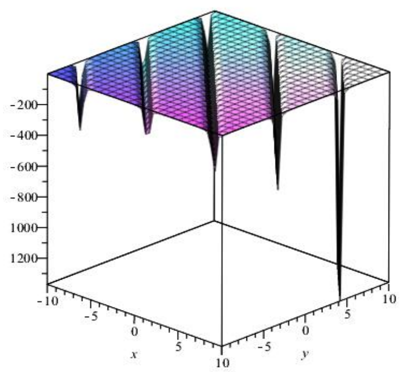

Figure 4: The solution $u_2(x,t)$ of t=0, d=0.5, e=0.5 , α=1, z=1

In this paper, we study the (3+1) demensional Kudryashov-Sinelshchikov equations. Using the sine-cosine, we constructed various exact wave solutions for this equation. The graphical representation of the obtained solutions is presented in the figures.

References

1. Kudryashov N A, Sinelshchikov D I Equation for the three-dimensional nonlinear waves in liquid with gas bubbles // Physica Scripta 85, 025402, 2012.
2. Wazwaz A M A sine-cosine method for handlingnonlinear wave equations // Mathematical and Computer Modelling 40 (5) 499–508, 2004.

UDC 524.832

BEHAVIOR OF THERMODYNAMIC PARAMETERS OF $F(T)$ GRAVITY

[1]Nabi A., [2]Zhadyranova A., [2]Baurzhan G.

nabi.aida@list.ru

[1]Master student of department of «General and theoretical physics» LN Gumilyov ENU, Nur-Sultan, Kazakhstan

[2]Doctor student of department of «General and theoretical physics» LN Gumilyov ENU, Nur-Sultan, Kazakhstan

Scientific supervisor – Nurkasymova S.N.

The main problem of general relativity in the modern general view is the impossibility of creating a quantum field model in the form of a canonical model [1]. The time of the general theory of relativity is macroscopic. On this basis, it cannot be described in terms of quantum mechanics.Understanding the formation and evolution of the visible world is the main theme of modern cosmology. There are several candidates on the first issue, including the supposed standard cosmological model with the peculiarities of the birth of our universe. Other models, such as cyclic models, assume the cyclical nature of cosmic evolution due to the transition of the world from one singular state (big bang) to another.Another interesting theoretical issue is the phenomenon of cosmic acceleration, which is now referred to as "dark energy". There are many ways to study these phenomena, which are well proven, many of which seem like hopeless actions of theoretical parties. In this case, we sometimes need to study in detail the mathematical nature of the basic gravitational equations.Following this idea, we study Einstein's equation (Friedmann's equation) with some integrated and non-integrated abbreviations. The connection between Einstein's equation and the solutions of Chazi's equations is established [2]. Friedmann's equations are a set of equations in physical cosmology that govern the expansion of space in homogeneous and isotropic models of the universe in general. Alexander Friedmann of Russia At that time, Einstein, Willem de Sitter of the Netherlands, and George Lemitre of Belgium were developing equations to model the universe. Friedman developed it as a relativistic equation based on general relativity, but the non-relativistic version is based on Newton's laws [3].

Wecanwritethe general action of gravity F (T) asfollows:

$$S = \frac{1}{2}\int d^4 x e\left(F(T) + L_m\right), \tag{1}$$

We can record the action by variation as follows

$$S = 2\pi^2 \int F - \lambda \quad \left[T - 6\left(\frac{\dot{a}^2}{a^2}\right)\right] \tag{2}$$

We vary T so that we have such values of λ:

$$\lambda = eF_T \, . \tag{3}$$

After integrating into parts, Lagrangian is given as follows.

$$L = a^3 F \;\; - 6\dot{a}a^2 F_T T - a^3 F_T T + 6\dot{a}^2 a F_T \, , \tag{4}$$