International Journal of the Physical Sciences Vol. 5(6), pp. 1225-1226, 4 August 2010
Available online at http://www.academicjournals.org/IJPS
ISSN 1992 - 1950 ©2010 Academic Journals

Review

The solution of the real scalar field in SdS and RNdS spaces

Zaiguo Liu* and Mengmeng Zheng

Shandong Provincial Key Laboratory of Laser Polarization and Information Technology, Department of Physics, Qufu Normal University, Qufu, 273165, P. R. China.

Accepted 23 April, 2010

In this letter, several works about the solutions of the real scalar field in SdS and RNdS are compared. Some previous works gave out that the wave amplitude near the potential peak is harmonic versus the radius, some gave out the wave amplitude near the potential peak increases, and others showed contrary results. By a simple mathematical calculation, here we unite the aforementioned results and denote that the wave amplitude near the potential peak increases in both SdS and RNdS spaces.

Key words: Black hole, real scalar field, der sitter space.

INTRODUCTION

Recently the solutions of the wave equation for a real scalar field in different spaces have been investigated. Brevik and Simonsen solved the scalar field equation in the Schwarzschild–de Sitter (SdS) space and found that the wave amplitude near the horizons in the SdS space is close to that of a harmonic wave, even near the potential peak (Simonsen and Brevik 2001). Following their work, Guo and his co-workers solved the scalar field equation in the extreme Reissner Nordstrom de Sitter (RNdS) space and obtained the similar result (Guo et al., 2003). Worthwhile, Tian and his co-workers re-discussed the solution of the scalar field equation in SdS space and found that the wave amplitude in SdS space increases near the potential peak (Tian et al., 2003). Guo and his co-workers discussed again the scalar field in the extreme RNdS space and found that the wave amplitude in the extreme RNdS space decreases near the potential peak (Guo et al., 2005).

Among the works above, they have such common conditions as (although they are the works in two different spaces):

(1) The wave equation for a real scalar field reads $\Phi = 0$.
(2) The separate solution of wave equation Φ with spherical harmonic function is investigated.
(3) The tortoise coordinate x versus r is introduced to change the variables in the radial equation $\Psi_{\omega l}(r)$ of wave equation Φ.
(4) The potential function $V = V(r) = V(x)$ has a potential peak (the maximum value point).
(5) The radial equation is solved numerically.

Condition (4) demands that the relation of the radial function versus its variable ($\Psi_{\omega l}(r)$ versus r or $\Psi_{\omega l}(x)$ versus x) should be identical qualitatively. But the previous results do not keep consistent with each other (Simonsen and Brevik 2001; Guo et al., 2003;Tian et al., 2003;Guo et al., 2005). In this short letter, we judge which result is correct by a simple way. The common radial equation in both SdS and RNdS spaces is written as (Simonsen and Brevik 2001; Guo et al., 2003; Tian et al., 2003; Guo et al., 2005).

$$\left[-\frac{d^2}{dx^2}+4V\left(x\right)\right]\Psi_{\omega l}\left(x\right)=4\Psi_{\omega l}\left(x\right) \qquad (1)$$

Here M and ω^2 have been chosen to be 1 as reported by Simonsen and Brevik (2001), Guo et al. (2003), Tian et al. (2003) and Guo et al. (2005). In order to study the behavior of the wave amplitude near the

*Corresponding author. E-mail: liuzaiguozmm@yahoo.cn.

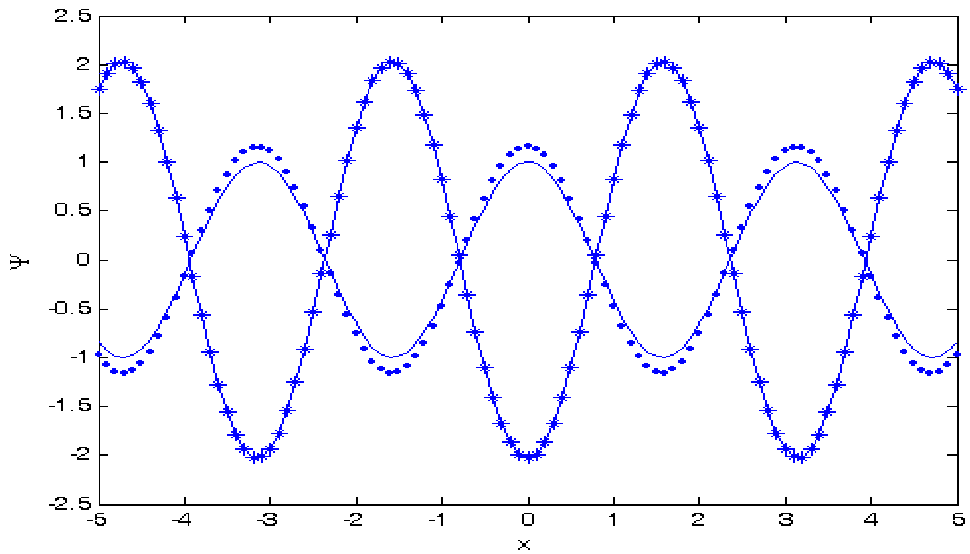

Figure 1. The solution of Equation (1) with constant potential. Solid line: $V_{00}=0$; dotted line: $V_{01}=7.5\times10^{-4}$;*- line: $V_{02}=7.5\times10^{-3}$.

potential peak, we choose several constant values of potential $V(x)$ and compare the corresponsive values of wave amplitudes. The wave amplitude with constant potential is harmonic. Thus the comparison is simple. Now let $V_{00}=0$, $V_{01}=7.5\times10^{-4}$, $V_{02}=7.5\times10^{-3}$, and the boundary condition is $\Psi(x=100)=\Psi(x=-100)=\cos 200$ as done by (Simonsen and Brevik 2001; Guo et al., 2003;Tian et al., 2003;Guo et al., 2005). Then the solution of Equation (1) can be solved by Matlab software and is now shown in Figure 1. From Figure 1, ones easily obtain the result as

$$\max(\Psi_{\omega l}(x)|_{00})<\max(\Psi_{\omega l}(x)|_{01})<\max(\Psi_{\omega l}(x)|_{02}) \quad (2)$$

It means that the wave amplitude of $\Psi_{\omega l}(x)$ increases near the potential peak. This relation will be reflected in the curve of $\Psi_{\omega l}(r)$ versus r naturally. Thus we note here that the wave amplitude near the potential peak increases in both SdS and RNdS spaces. The results according to Simonsen and Brevik (2001), Guo et al. (2003), Guo et al. (2005) are wrong and the results in Tian et al. (2003) are correct.

ACKNOWLEDGEMENTS

The National Natural Science Foundation of China under Grant No. 10804061, the Natural Science Foundation of Shandong Province under Grant No. Y2006A06, and the foundation from QFNU and DUT have supported this work.

REFERENCES

Guo GH, Han Y, Chao G, Chao G, Zhan Z, Bin B (2005). "Three Kinds of Special Relativity via Inverse Wick Rotation". Chinese Phys. Lett. 22: 2477–2480.doi:10.1088/0256-307X/22/10/006. arXiv:hep-th/0508094.

Guo GH, Hong RY, Guo QJ, Luo GH, Zhang JY, Ding J (2003). On the jet penetration height in fluidized beds with two vertical jets, Powder Technol. p. 18.

Simonsen B, Brevik I (2001). The Scalar Field Equation in Schwarzschild–de Sitter Space, Gen. Relativ. Gravit., p. 33.

Tian JX, Gui Y, Guo G, Lv Y, Zhang S, Wang W (2003). The Real Scalar Field in Schwarzschild-de Sitter Spacetime. Gen. Relativ. Gravit. p. 35.