Boson star under cornell potential

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Introduction

Signals coming from Quark Gluon Plasma (QGP) at high density and temperature can give information about evolution of the early universe expansion. Supernova explosion of universe expansion represents the phase transition in the early universe. There is formation of the compact stars after the supernova explosion. Neutron stars are one of the probable signals of early universe formation in which the quark and gluons are defined in free degree of freedom. Like neutron star, a boson star (BS) may have been formed through gravitational collapse during the primordial stages of the big bang. For these type of stars to exist there must be a stable type of BS that possesses a small mass of magnitude [1–3]. However, it may possibly detect them by the gravitational radiation emitted by a pair of co-orbiting boson stars [4, 5].

Classical treatment of BS

Such system under weak field approximation is studied and the results are obtained for rotation of BS. The coupled equations for radial wave function and potential are obtained under this approximation and solutions of those equations are plotted [6]. The potential of such system is modified by adding a perturbation to the original potential. The modified term is in the form of Coulombic nature and it is believed to exist between the interacting quark, gluon and anti-quark. It is a linear depndencce on distance given by $\frac{\alpha}{r}$ Where α is constant parameter [7].

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Perturbing Potential

There exists another kind of potential called Cornell potential [8] which exists in quark gluon plasma. It is expressed as

$$V = \frac{\alpha}{r} + \beta * r \qquad (1)$$

Where α and β are constant whose values are chosen depending on the system under study. The first term in this corresponds to potential due to gluon exchange between quark and its anti-quark and it is known as Coulombic part of potential. The second term represents the confinement part of potential.

Result and Discussion

The results obtained with Cornell potential are shown in Fig.[1-3]. The Fig. 1 shows the radial wave function and ground state having energy equals to 2.0 GeV. It is found to be exponentially decreasing with distance at this particular ground state energy. The maximum amplitude of wavefunction is at 0.00456 attained around the value of r equal to 0.1.

Excited states are shown in Fig.[2-3]. For first excited state the orbital angular momentum,l is equal to 1 and coressponding magnetic quantum number m values are -1, 0,+1. In Fig.2 the radial wavefunction of first excited state having m=0 and 1 are shown. The energy for this case is found to be around 1.1 GeV. From figure it is clear that for m=0 it has maximum amplitude around 0.038 while for m=1 case it attains a maximum at 0.033.

Similarly for second excited state l=2 and m values are -2,-1,0,+1,+2. The radial wavefunction of second excited state is shown in Fig.3. The energy for this state is 0.97 GeV which is further lower than energy of first excited state. Similar to first excited state the

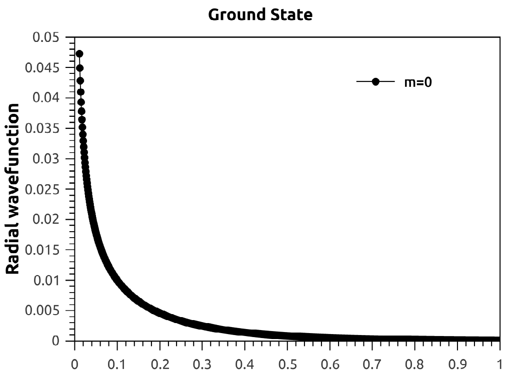

FIG. 1: Ground state radial wave function, R with radial distance r.

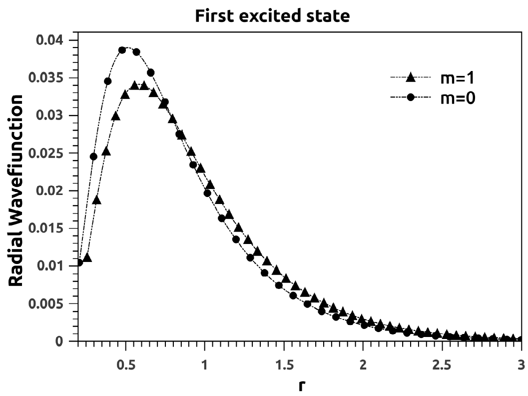

FIG. 2: First excited state radial wavfunction,R with distance r for orbtial angular momentum l=1 and m=0 and 1.

radial wavfunction shows the similar pattern here also. The range of amplitude for this excited state varies from 0.0009 to 0.018. The lower value of m has maximum amplitude of radial wave function. The radial wavefunction is excatly same for positive and negtive values of m.

For cornell potential the wave function is get shifted with respect to distance r. The lower angular momentum state are more prone to oscillations. The energy of ground state is maximum and keep on decreasing while going to higher excited states. The behaviour of radial wavefunction and energy is similar to the pattern is obtained these refs. [6, 7]. The modification added to Newtonian potential has the same scale measurement with the different oscillating amplitudes and shows improved oscillating amplitudes.

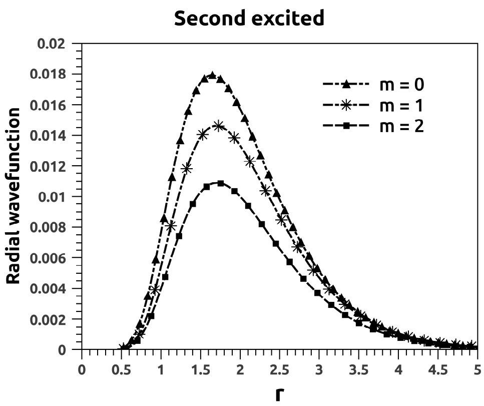

FIG. 3: Second excited state radial wavfunction,R with distance r for l=2 and m=0,1 and 2.

Acknowledgments

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