Effects of spacetime topology and curvature on the resonance interatomic energy

Wenting Zhou[a], Hongwei Yu[b]

[a] *Center for Nonlinear Science and Department of Physics, Ningbo University, Ningbo, Zhejiang 315211, China*

[b] *Department of physics, Synergetic Innovation Center for Quantum Effects and Applications, Hunan Normal University, Changsha, Hunan 410081, China*

We study, using the formalism proposed by Dalibard, Dupont-Roc, and Cohen-Tannoudji [1], the resonance interatomic energy (RIE) of two identical two-level static atoms in a symmetric/antisymmetric entangled state, which are coupled to massless scalar fields, in a number of different spacetimes. We first show that the presence of a boundary in a flat Minkowski spacetime can dramatically modify the RIE of the two static atoms, resulting in an enhanced or weakened and even nullified RIE, as compared with that in the unbounded case (Fig. 1 for example); we then show that the RIE of the two atoms in the spacetime of a Schwarzschild black hole can be sharply affected by the spacetime curvature on one hand, but on the other hand it is surprisingly undisturbed by the Hawking radiation of the black hole [2]; we finally show that (Fig. 2 for example) the nontrivial topological structure of the spacetime with an infinite and straight cosmic string imprints on the RIE of the two static atoms, making it behaves in a manner very similar to that near a perfectly reflecting boundary in a flat Minkowski spacetime [3].

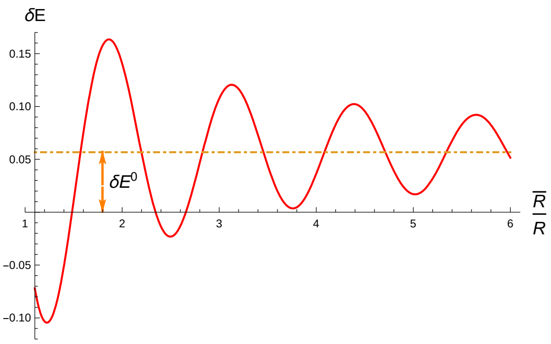

Figure 1: The RIE (δE) of two static atoms near a perfectly reflecting boundary in a Minkowski spacetime. We denote the RIE of two atoms in a free space, the interatomic separation and the separation between an atom and the image of another atom with δE_0, R and $\bar{R}$ respectively. The ordinate is of unit $\mp\frac{\lambda^2\omega_0}{16\pi}$.

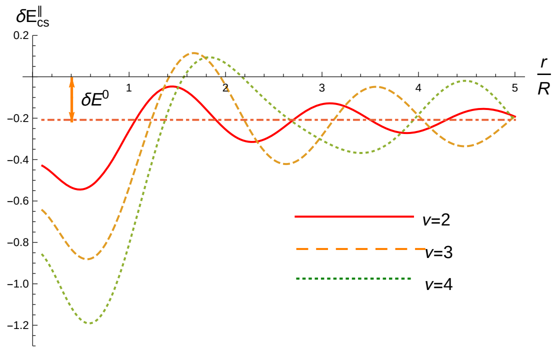

Figure 2: The RIE of two static atoms aligned with their separation parallel to an infinite and straight cosmic string. We denote the interatomic separation and the atom-string separation by R and r respectively, and choose $\omega_0 R = 2$. The ordinate is of unit $\mp\frac{\lambda^2\omega_0}{16\pi}$.

[1] J. Dalibard, J. Dupont-Roc, and C. Cohen-Tannoudji, J. Phys. France **43**, 1617 (1982); **45**, 637 (1984).

[2] W. Zhou and H. Yu, Phys. Rev. D **96**, 045018 (2017).

[3] W. Zhou and H. Yu, Phys. Rev. D **97**, 045007 (2018).