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Inspiraling corrugation-induced quantum effects on neutron star binary plane. (English)

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Summary: We use the path-integral formula and investigate some dynamical quantum effects induced by the inspiraling lateral corrugation of orbital plane in gravitationally bound neutron star (NS) binaries, with orbital separation of $10^9$ m. Based on Dewitt’s approach, we calculate the gravitational Casimir energy cost of the binary plane, which consists of statically gravitational effects and deformation-induced effects. It is found that the static effects include a term coming from the self-gravity of the orbital plane and the contribution of Newtonian gravitational potential of the binary system. While the deformation-induced effect also results from two parts, i.e. the instability of orbital binding energy, scaling as $\frac{1}{(R-r)^2}$, and the dynamically Casimir energy cost of the orbital binding energy, decaying as $\frac{1}{(R-r)^4}$. The dynamically gravitational Casimir phenomena and the corresponding energy cost modify the spiral-in orbital motion of the binary and thus the frequency of released gravitational waves (GWs). We consider the mechanical response of two NS components and qualitatively study the corrections to the orbital motion of the system and the GW frequencies. It is found that the dynamical Casimir effects exert a dissipative force on the binary plane, depending on the frequency of GWs. The resultant dissipation may enhance with the decaying separation and increasing GW frequencies, which subsequently accelerates the orbital decay of the binary. However, the dissipation rate just has an order of $10^{-70}$ eV/s. So the corrections to the dynamics of NS binaries are very marginal, by considering the wide separation, the cosmological coalescence time, and low-frequency GWs of the system.

MSC:

85A05 Galactic and stellar dynamics
83F05 Relativistic cosmology
81S40 Path integrals in quantum mechanics
70M20 Orbital mechanics
81V35 Nuclear physics
70F05 Two-body problems
14D15 Formal methods and deformations in algebraic geometry
47A10 Spectrum, resolvent
81P55 Special bases (entangled, mutual unbiased, etc.)
83C35 Gravitational waves

Full Text: DOI arXiv

References:

[1] Plunien, G.; Muller, B.; Greiner, W., Phys. Rep., 134, 87-193 (1986)
[2] Mostepanenko, V. M.; Trunov, N. N., The Casimir Effect and Its Applications (1997), Clarendon Press: Clarendon Press Oxford
[3] Casimir, H. B.G., Proc. K. Ned. Akad. Wet., 51, 793 (1948)
[4] Bordag, M.; Mohideen, U.; Mostepanenko, V. M., Phys. Rep., 353, 1-205 (2001)
[5] Mostepanenko, V. M.; Trunov, N. N., Sov. Phys. Usp., 31, 965-987 (1988)
[6] Krech, M., The Casimir Effect in Critical Systems (1994), World Scientific: World Scientific Singapore
[7] Balia, R.; Duplantier, B., Ann. Phys., 112, 165-208 (1978)
[8] Bordag, M.; Klimchitskaya, G. L.; Mostepanenko, V. M., Phys. Lett. A, 200, 95-102 (1995)
[9] Li, H.; Kardar, M., Phys. Rev. Lett., 67, 3275-3278 (1991)
[10] Li, H.; Kardar, M., Phys. Rev. A, 46, 6490-6500 (1992)
[11] Moore, G. T., J. Math. Phys., 11, 2679-2691 (1970)
[12] Fulling, S. A.; Davies, P. C.W., Proc. R. Soc. Lond. Ser. A, 348, 393-414 (1976) · Zbl 0404.53024
[13] Ford, L. H.; Vilenkin, A., Phys. Rev. D, 25, 2569-2575 (1982)
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