Gravitational Waves of Triple System in Einstein-aether Theory

Anzhong Wang[a,b*]
[a] *Physics Department, Baylor University, Waco, TX 76798-7316, USA*
[b] *Institute for Theoretical Physics & Cosmology, Zhejiang University of Technology, Hangzhou 310032, China*
(Dated: February 28, 2019)

Gravitationally bound hierarchies containing three or more components are very common in our Universe. In this paper we study *periodic* gravitational wave (GW) form, their polarizations, response function, its Fourier transform, and energy loss rate of a triple system through three different channels of radiation, the scalar, vector and tensor modes, in Einstein-aether theory of gravity. The theory violates locally the Lorentz symmetry, and yet satisfies all the theoretical and observational constraints by properly choosing its four coupling constants c_i's. In particular, in the weak-field approximations and with the recently obtained constraints of the theory, we first analyze the energy loss rate of a binary system, and find that the dipole contributions from the scalar and vector modes could be of the order of $\mathcal{O}\left(c_{14}\right)\mathcal{O}\left(G_N m/d\right)^2$, where c_{14} ($\equiv c_1+c_4$) is constrained to $c_{14}\lesssim\mathcal{O}\left(10^{-5}\right)$ by current observations, and G_N, m and d are, respectively, the Newtonian constant, mass and size of the source. On the other hand, the "strong-field" effects for a binary system of neutron stars are about six orders lower than that of GR. So, in this paper we ignore these "strong-field" effects and first develop the general formulas to the lowest post-Newtonian order, by taking the coupling of the aether field with matter into account. Within this approximation, we find that the scalar breather mode and the scalar longitudinal mode are all suppressed by a factor of $\mathcal{O}\left(c_{14}\right)$ with respect to the transverse-traceless modes (h_+ and $h_\times$), while the vectorial modes (h_X and h_Y) are suppressed by a factor of $c_{13}\lesssim\mathcal{O}\left(10^{-15}\right)$. Applying the general formulas to a triple system with periodic orbits, we find that the corresponding GW form, response function, and its Fourier transform depend sensitively on the configuration of the triple system, their orientation with respect to the detectors, and the binding energies of the three compact bodies.

• **Ref.:** K. Lin, X. Zhao, C. Zhang, T. Liu, B. Wang, S.-J. Zhang, X. Zhang, W. Zhao, T. Zhu, and A. Wang, *Gravitational waveforms, polarizations, response functions, and energy losses of triple systems in Einstein-aether theory*, Phys. Rev. D**99**, 023010 (2019) [arXiv:1810.07707].