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Gravitational waves in spacetime with extra dimensions

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We study the effect of compact extra dimensions on the gravitational wave luminosity and waveform. We consider a toy model, with a compactified fifth dimension, and matter confined on a brane. We work in the context of five dimensional (5d) general relativity, though we do make connections with the corresponding Kaluza-Klein effective 4d theory. We show that the luminosity of gravitational waves emitted in 5d gravity by a binary with the same characteristics (same masses and separation distance) as a 4d binary is 20.8% less relative to the 4d case, to leading post-Newtonian order. The phase of the gravitational waveform differs by 26% relative to the 4d case, to leading post-Newtonian order. Such a correction arises mainly due to the coupling between matter and dilaton field in the effective 4d picture and agrees with previous calculations when we set black holes' scalar charges to be those computed from the Kaluza-Klein reduction. The above corrections to the waveform and the luminosity are inconsistent with the gravitational-wave and binary pulsar observations and thus they effectively rule out the possibility of such a simple compactified higher dimensions scenario. We also comment on how our results change if there are several compactified extra dimensions, and show that the discrepancy with 4d general relativity only increases.

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