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Probing beyond standard model physics via Hawking radiated gravitational waves

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We propose a novel technique to probe the high energy physics beyond the standard model (BSM). By observing gravitational waves emitted by the Hawking radiation of black holes, we can scan the unknown high energy physics for the following reasons.
(i) A particles is emitted by black holes only if its mass is smaller than the Hawking temperature T_{BH} of a black hole.
(ii) Since a black hole starts radiating BSM particles when T_{BH} reaches the BSM mass scale, the time evolution of T_{BH} is sensitive to the mass spectrum of the high enertgy physics.
(iii) Although gravitons are not directly affected by the emissions of BSM particles, their radiation depends on the evolution of T_{BH}.
Therefore the information of the BSM theory (including a dark sector) is imprinted in the gravitational wave spectrum $\Omega_{GW}(\nu)$ produced by light black holes. As an interesting exmaple, we calculate $\Omega_{GW}(\nu)$ generated by primordial black holes which are light enough to evaporate in the early universe and explore how the degrees of freedom in BSM theory distort the spectrum $\Omega_{GW}(\nu)$.

Summary

We propose a novel technique to probe the high energy physics by observing the spectrum of Hawking radiated gravitational waves. The gravitational spectrum $\Omega_{GW}(\nu)$ has a step-like feature where the frequency corresponds to the mass scale of the BSM physics. The size of the step indicates the degrees of freedom that belong to the corresponding mass scale. Thus, in principle, it is possible to reconstrust the entire mass spectrum of the BSM physics up to the Planck scale. Note that this technique is also sensitive to the so-called dark sector because any particle can be radiated by a black hole if it has the gravitational coupling. In order to observe the gravitational wave spectrum generated by primordial black holes, a very high frequency detector with great sensitivity is required. A recently proposed detector which uses the Gertsenshtein effect may satisfy the requirement in the future.

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