Analytically Modeling the Gravitational Radiation Generated From a Quasistar System

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The mechanics behind the evolution of supermassive black holes have eluded researchers for decades. Quasistars, consisting of a black hole embedded inside a massive star-like envelope, are objects theorized to precede supermassive black holes. Discovering a Quasistar would aid in understanding how supermassive black holes formed and how they continue to shape galaxies today. Unlike other Quasistar models, I displace the black hole from the center of the Quasistar. This leads the black hole to orbit inside of the Quasistar and generates gravitational waves, which I could use to detect Quasistars. I derive formulas for the separation between the black hole and the envelope's center, the induced gravitational wave strain, and the gravitational wave radiation frequency. Then, I numerically model these formulas for various initial mass and separation conditions. The gravitational wave strain model can be compared to the noise curves of gravitational wave observatories, such as µAres, in order to determine the detectability of the Quasistar. I find that the black hole-envelope separation increases over time, unexpected of a system involving a gravitational force. Additionally, my model produces gravitational waves with peak strains between 10^-20 and 10^-24 at frequencies between 10^-5 Hz and 10^-9 Hz, 2 to 6 orders of magnitude below the sensitivity curve of µAres. Since they are below the µAres sensitivity curve, I determine that Quasistars are not detectable by modern gravitational wave observatories, but next-generation observatories that exhibit more generous sensitivity curves could allow for their discovery in the future.

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