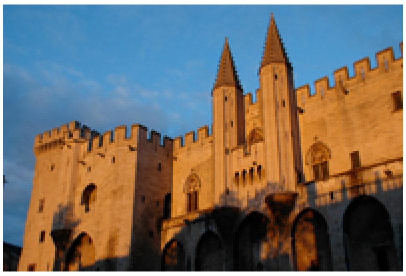

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Exploring the Role of Self-Interacting Scalar Dark Matter in Dynamical Friction and GW Emission

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We present a comprehensive study of the dynamics of self-interacting scalar dark matter around a black hole, focusing on the dynamical friction and the impact of such a force on gravitational wave emission.
Specifically, we explore the large scalar mass limit with quartic self-interactions in both subsonic and supersonic regimes. Our analysis reveals that the scalar field behaves as a perfect gas with an adiabatic index $\gamma_{\rm ad}$=2 at large radii. However, close to the Schwarzschild radius, the accretion rate is dominated by the relativistic regime. To obtain analytical results, we rely on large-radius expansions that are also linked to small-scale relativistic accretion rates.
In the subsonic regime, we find that the accretion rate for self-interacting scalar dark matter is greater than for collisionless particles, by a factor $c/c_{\rm s}$ 1, but smaller than for a perfect gas, by a factor $c_{\rm s}/c$ 1, where $c_{\rm s}$ is the speed of sound. Moreover, we show that the dynamical friction is smaller than for a perfect gas by $c_{\rm s}/c$ 1.
In the supersonic regime, a Chandrasekhar term appears naturally as a correction to the friction force.
Our investigation has revealed that both of these terms induce a phase shift in gravitational wave emission, of -4PN and -5.5PN respectively. The upcoming gravitational wave detectors may provide constraints on the model, emphasizing the importance of accurately accounting for environmental effects in future studies.

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