Spectral density of oscillations of inertial active Brownian particles in a harmonic trap in the overdamped rotational regime

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We investigate the spectral characteristics of inertial active Brownian particles confined in a harmonic trap in the overdamped regime. Numerical simulations are performed over a wide range of activity parameters and trap stiffnesses. An analytical expression for the oscillation spectral density is derived neglecting rotational inertia and shown to accurately reproduce the numerical spectra, even for particles with finite rotational inertia. Increasing activity enhances the low-frequency contribution and changes the spectral shape, while the active-force spectrum approaches a Lorentzian form characteristic of the active Ornstein-Uhlenbeck particle model, establishing a link between the two models. Significant deviations between theory and simulations arise only for strong traps, where rotational inertia becomes more pronounced. These results can help interpret the oscillation spectra of active colloids and light-absorbing microspheres levitating in gas-discharge plasma.

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