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MD simulations for oscillatory behavior of non-Maxwellian fluid moments in a magnetized plasma

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In magnetized plasmas, the perpendicular components of non-Maxwellian fluid moments exhibit oscillations under the influence of a magnetic field. Analytical solutions for uniform plasmas predict both the relaxation rate and oscillation frequency of these moments [1]. In this work, we reproduce the temporal behavior of non-Maxwellian moments using molecular dynamics (MD) simulations. The results confirm that the perpendicular components of rank-l moments oscillate at harmonic frequencies of the gyrofrequency, consistent with theoretical predictions. Figure 1 shows the oscillatory behavior of rank-2 and 3 moments. We also extract the eigenmodes of these oscillations by applying suitable linear combinations of the moment components as shown in Fig. 2. Additionally, we observe how the behavior depends on the coupling parameter. This study provides insight into magnetized plasma dynamics driven by non-Maxwellian moments, such as the time evolution of heat flux in tokamak plasmas.

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References

[1] J.-Y. Ji and E. D. Held, Phys. Rev. E, **82**, 016401 (2010)

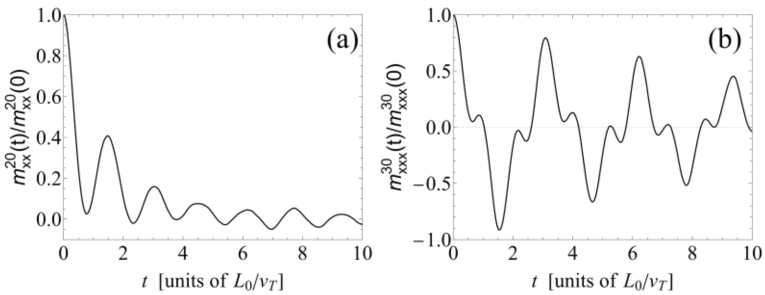

Figure 1. Time evolutions of (a) m^{20}_{xx} and (b) m^{30}_{xxx} normalized by its initial value. Simulation for one-component plasma with a total particle number of 41,984 and coupling parameters of (a) 1 and (b) 0.3. Magnetic field (z-axis) and temperature, both set to 1 in simulation units. Initial particle velocities distributed by 4-dimensional Monte-Carlo method $(f, \mathbf{v})$.

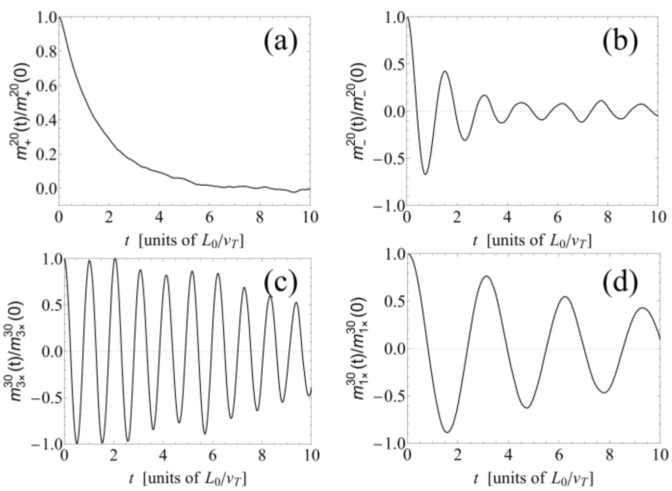

Figure 2. Eigenmodes of m^{20} and m^{30}. Linear combinations of (a) $m^{20}_{+} = (m^{20}_{xx} + m^{20}_{yy})/2$, (b) $m^{20}_{-} = (m^{20}_{xx} - m^{20}_{yy})/2$, (c) $m^{30}_{3\times} = (m^{30}_{xxx} - 3m^{30}_{xyy})/2$, and (d) $m^{30}_{1\times} = (m^{30}_{xxx} + m^{30}_{xyy})/2$.