Abstract

Two magnets are arranged on top of each other such that one of them is fixed and the other one can move vertically. The oscillations of the magnet were investigated. When the system is in equilibrium, the magnetic force is balanced with gravitational force. If the magnet is perturbed from its equilibrium position, it exhibits different oscillation patterns depending on the initial conditions and the resistive forces. The magnets can be modeled as magnetic dipoles, and the interaction between them is the dipole-dipole interaction. The oscillations were recorded by a high speed video recorder, and compared with the patterns generated by theoretical calculations.

Large Amplitude Confinement

Two confinement with large amplitude and finite damping.

Weak Damping Confinement

Beam confinement with negligible friction.

Magnetic Force

\[ F_B(r) = C \left( \frac{1}{r^2} + \frac{1}{(r+2l)^2} - \frac{2}{(r+l)^2} \right) \]

Consistency between the magnetic force calculated by magnetic dipole model and measured value.

Equation of Motion

\[ \tau = \tau^2 \times \frac{d^2 y}{dt^2} \]

There are only three parameters in this problem.

For small amplitude oscillation, the force can be linearized. Oscillation period \( T_s = \sqrt{\frac{2m}{C d^2[I r_0]^3}} \)

One of the parameters can be written in terms of \( T_s \),

\[ \frac{C d^2}{I r_0^3} = \frac{2m^2}{(1+2l/r_0)^3 - 2(1+1/r_0)^3} \]

In finite damping case, zeroth and first order term of resistive force are considered.

Numerical Modeling

Comparison between numerical result and experimental result in weak damping cases (left) and finite damping case (right).

Summary

- Three confinements with different purpose are designed.
- Numerical results fit the practical experimental results.
- The results are summarized by period ratio, rescaled amplitude, and rescaled magnet length.