Vibration Characteristics of HTS Maglev System Levitated Above a Halbach Permanent Magnet Track

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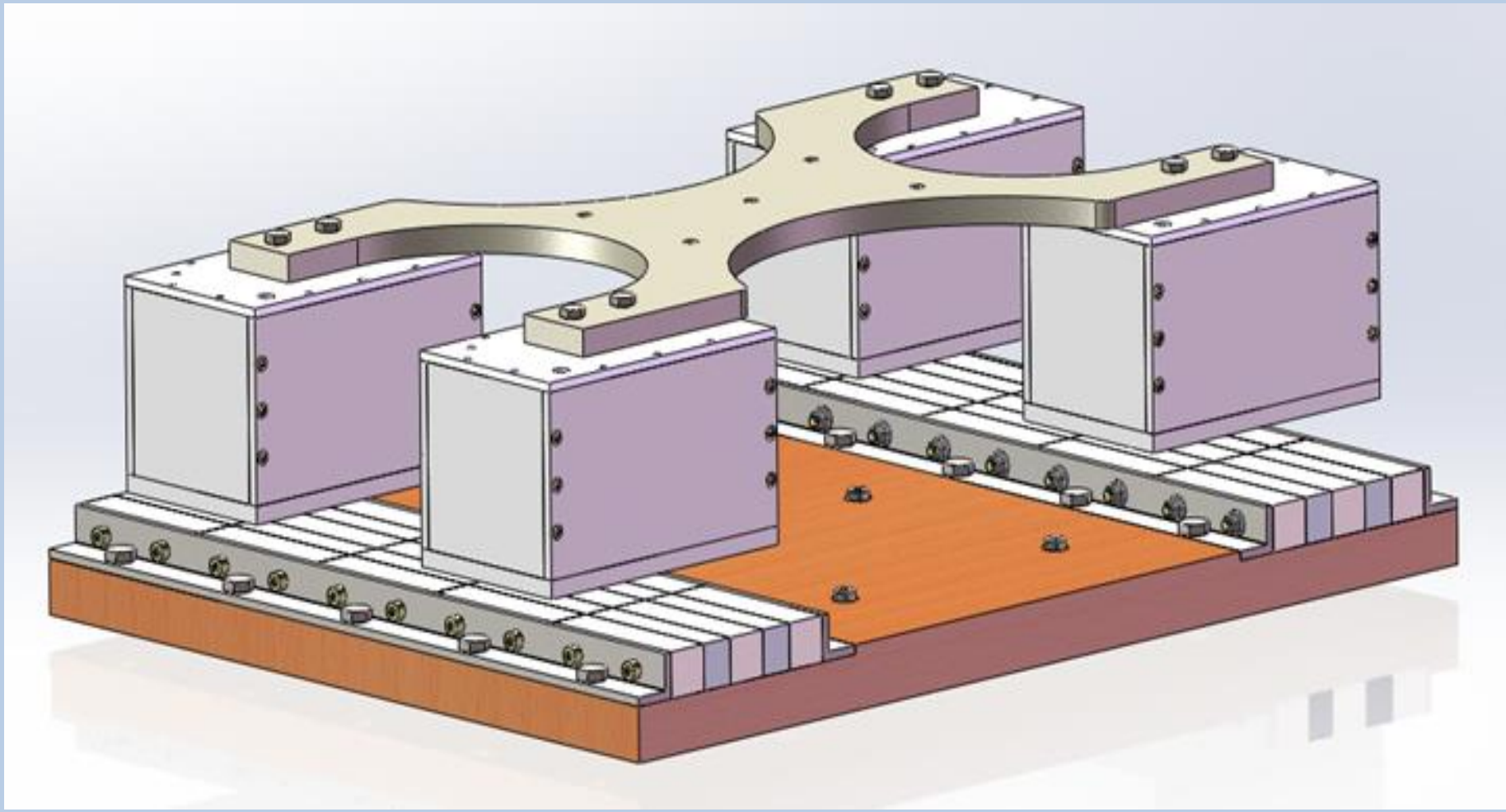
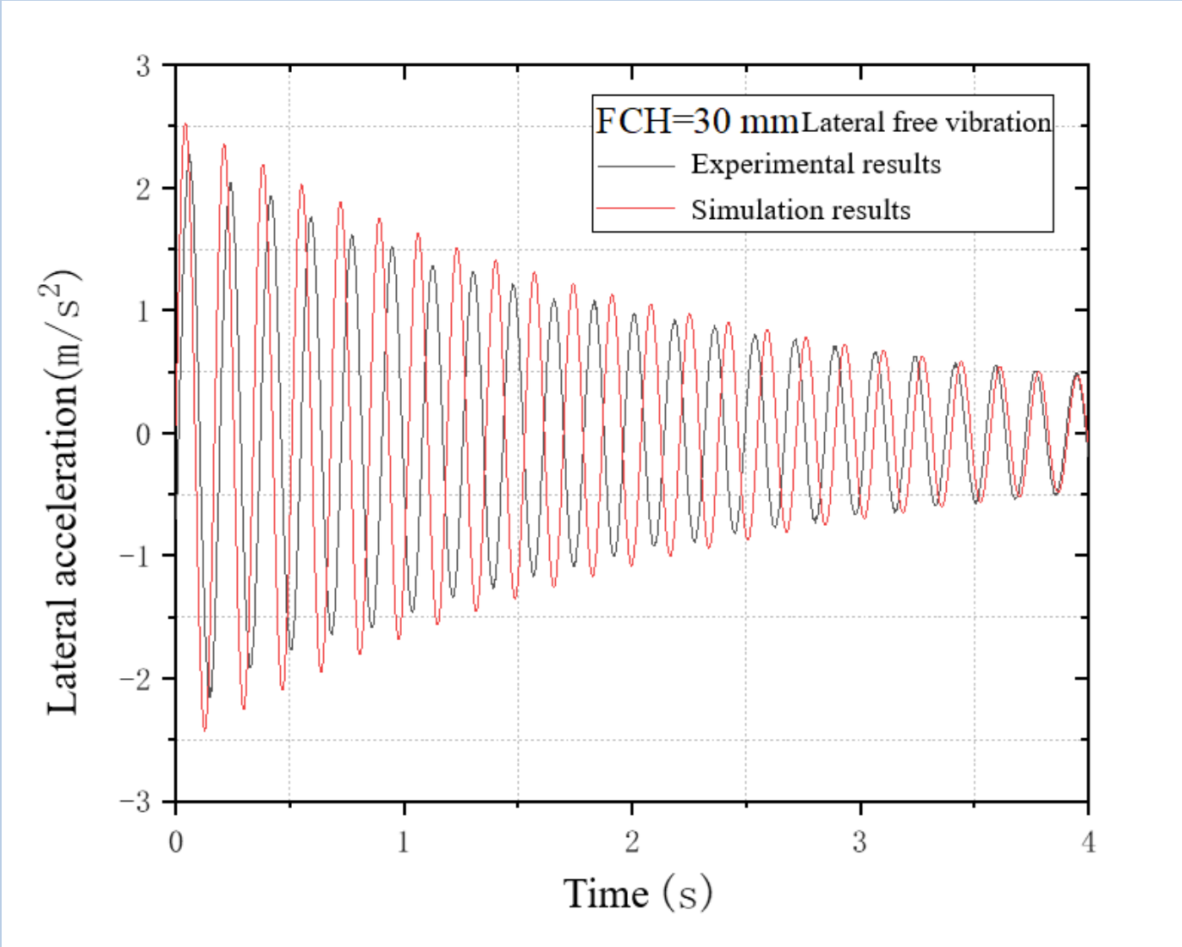
Content

A lateral-vertical coupling dynamic model is established in this paper, and the response of the maglev system under forced vibration is analyzed. Firstly, we use a scaled-down suspension frame to carry out the free vibration experiment of the maglev system. Secondly, based on a mathematical model of two-dimensional force, a damping term is added to reflect the hysteresis, so as to establish a lateral-vertical coupling dynamic model. After com-paring the simulation results of the dynamic model with the experimental results, the accuracy of the dynamic model is verified. Finally, this dynamic model is used to simulate the forced vibration of the maglev system, and the lateral-vertical coupling vibration characteristics of the maglev system under different working conditions are studied. Results show that the lateral-vertical coupling effect of the maglev system is significant, and the coupling vibration has strong nonlinear characteristics.

Experiment



Suspension frame model

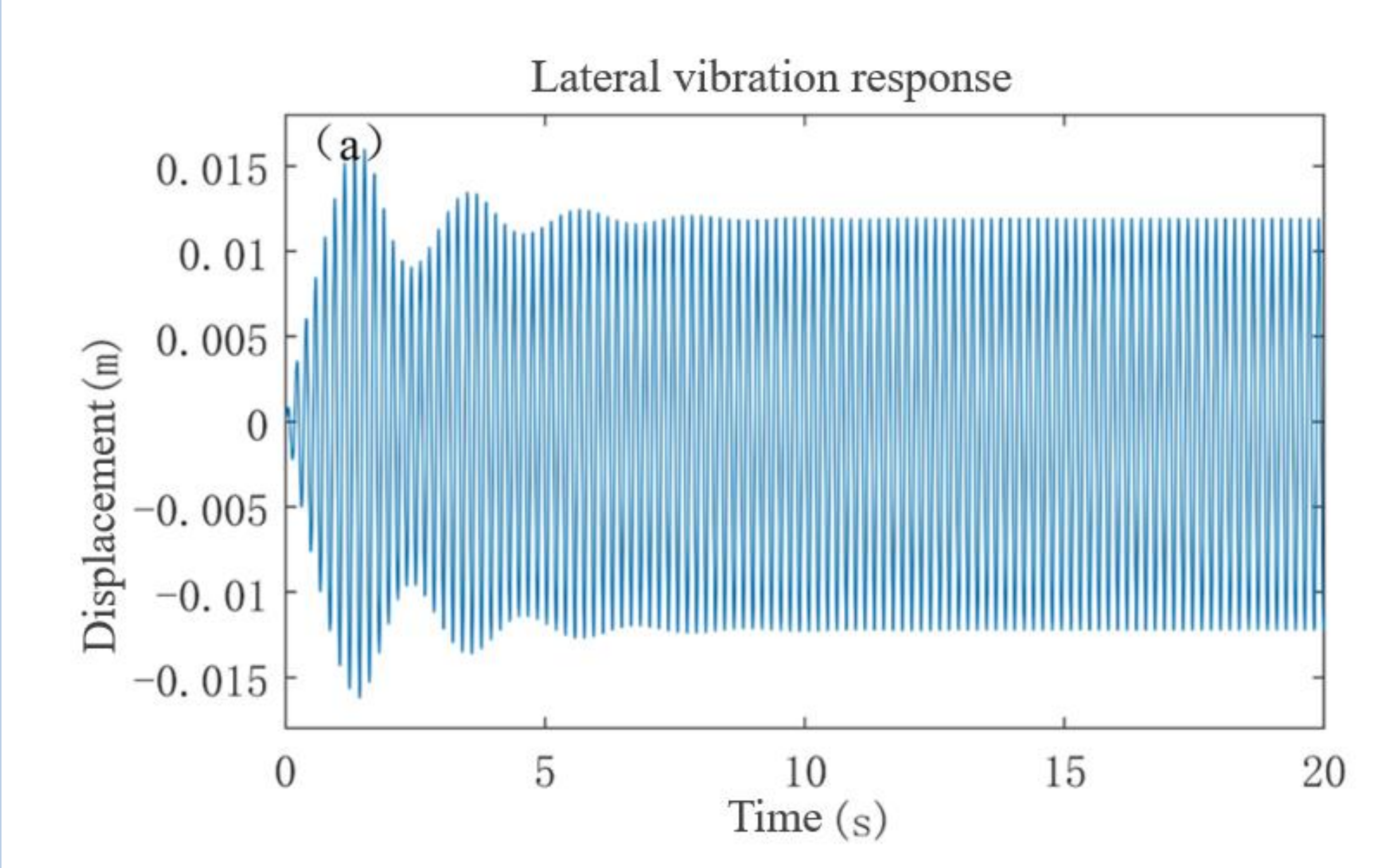


Comparative data

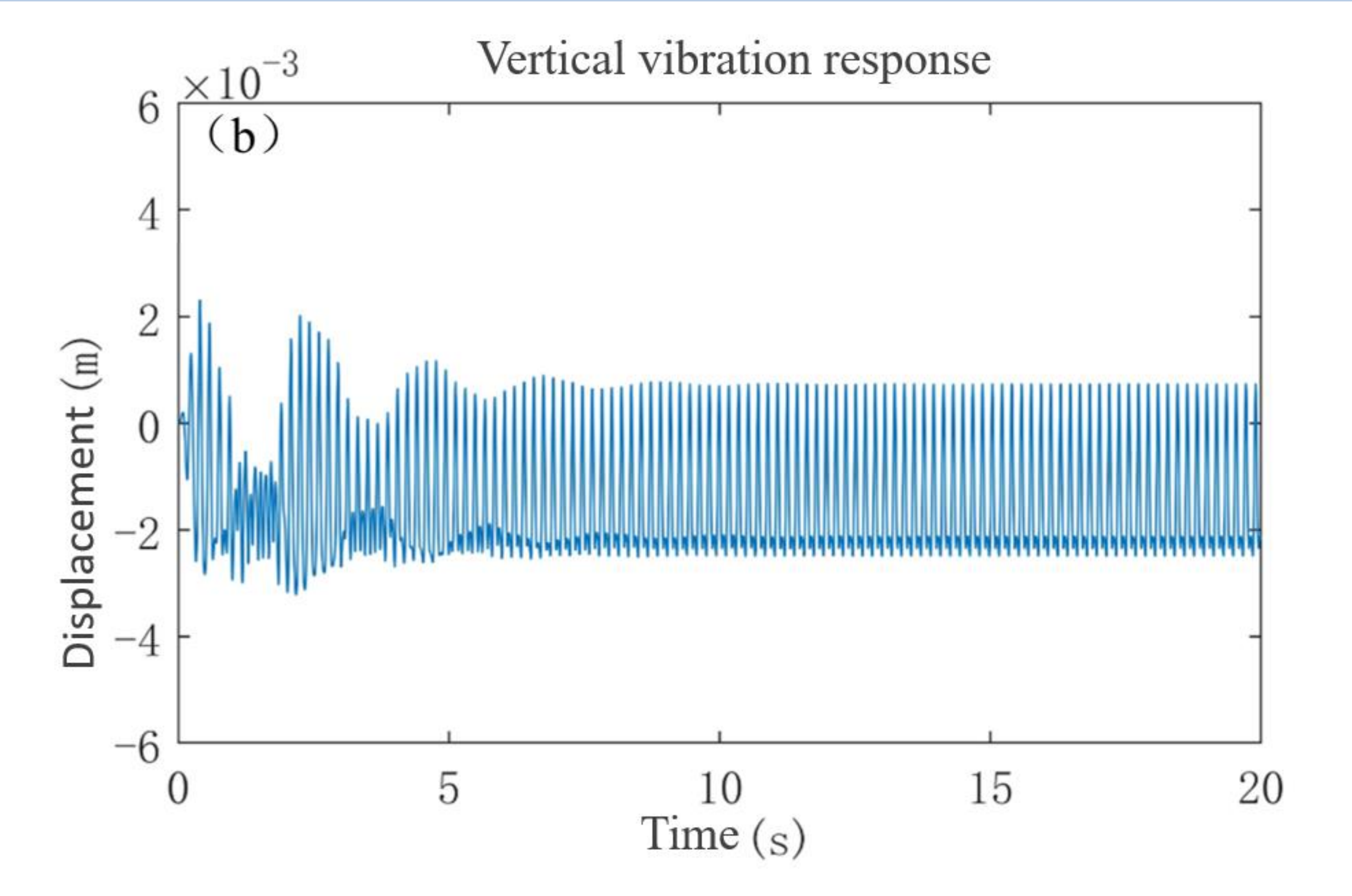
the lateral-vertical coupled dynamic model

$$\begin{cases} \dot{z}_1 = z_2 \\ \dot{z}_2 = -\left[\begin{array}{l} c_z z_2 + \left(\alpha_1 + \eta_1 \cdot e^{\beta_1 z}\right) \\ + \lambda_1 \cdot \sin\left(\dfrac{\pi \cdot \left(y_1 - y_c\right)}{\omega}\right) \end{array}\right] / \mathrm{m} \\ + A_z \left(2\pi\omega_z\right)^2 \cos\left(2\pi\omega_z t\right) \\ \dot{y}_1 = y_2 \\ \dot{y}_2 = -\left[c_y y_2 + \lambda_2 \cdot \sin\left(\psi y_1\right) \cdot \left(\alpha_2 + \eta_2 \cdot e^{\beta_2 z}\right)\right] / m \\ + A_y \left(2\pi\omega_y\right)^2 \cos\left(2\pi\omega_y t\right) \end{cases}$$

Simulation



Lateral vibration under lateral forced vibration



Vertical vibration under lateral forced vibration

Conclusion

(1) The vertical vibration of the suspension system hardly causes lateral vibration, but the lateral vibration will cause obvious vertical vibration.

(2) The model can reproduce the experiment well, which fully verifies the accuracy of the model.

(3) It can be seen from the simulation results of lateral forced vibration that the suspension system will have different degrees of resonance and coupled vibration in the lateral and vertical directions under the excitation of the lateral natural frequency or the vertical natural frequency.