論 文 内 容 の 要 旨

Systems which are in equilibrium will remain in equilibrium unless perturbed. In other words, no external work is required to keep a system in an equilibrium position. However, in the case of unstable equilibrium, even the smallest perturbation can cause a system to leave equilibrium. Take for example the classical case of an inverted pendulum: if the pendulum is perfectly balanced, it will remain inverted without external forces applied. However, even the slightest disturbance will cause the pendulum to leave the inverted unstable equilibrium and swing down to the stable equilibrium.

In magnetic levitation, one method of reducing power consumption is to levitate a system in an equilibrium position. In such an equilibrium, the external force required, and therefore the power required, approaches zero. In the simple single-degree-of-freedom case where a magnetically permeable ball is suspended below a permanent magnet, this equilibrium occurs when the ball is at the correct distance from the magnet such that the upward attractive magnetic force is exactly equal to the downward gravitational force. This is an unstable equilibrium where if the distance is decreased, the ball will tend towards the magnet, and if increased, the ball will tend towards the ground.

Because the attractive force of between permeable targets and permanent magnets is dependent on air-gap distance, in magnetically levitated platforms, the equilibrium orientation, e.g. the tip-tilt of the platform, typically cannot be freely selected.

In this research, methodologies are developed which allow magnetically levitated platforms to have active control over the platform's tip-tilt while simultaneously remaining in zero-power equilibrium.