非線形現象の解析とシミュレータの開発

Analysis of Non Linear Phenomenon and Development of Its Simulator

氏名:大西理允(c1102005) 河村拓馬(c1102007) 細井健太(c1102020) 石橋勇太(c1102045)

Name: Takanobu Onishi, Takuma Kawamura, Kenta Hosoi, Yuta Ishibashi

1. 概要 Outline

当プロジェクトの目標は、非線形現象の理解、可視化技術の習得である。今回は、前期の内容を踏まえ、n次式による回転体に拘束された質点の運動について考えた。

It is the goal on our project that understanding non linear phenomenon and getting the skill of visualization of the phenomenon. Here, on the basis of contents at the first semester, we studied about motion of mass point restricted in body of rotation by expression degree of n.

2. 設定したモデル Model

n次式回転体は、$y = x^n$ をy軸に回転させた曲面である。

A body of rotation by expression degree of n is that of $y = x^n$ around y axis.

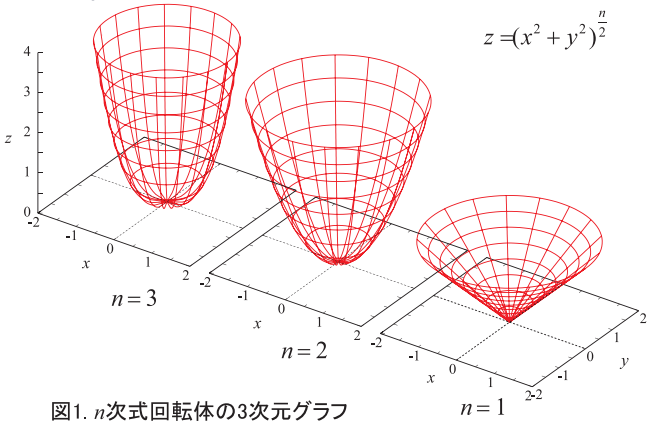

図1. n次式回転体の3次元グラフ

Fig1. 3D Graph of the body of rotation by expression degree of n.

n次式回転体を周期外力(回転磁界)内に置き、n次式回転体に拘束された質点の運動について考えた。

Suppose we put body of rotation by expression degree of n into the periodic external force (roating magnetic field), and put a mass point into there.

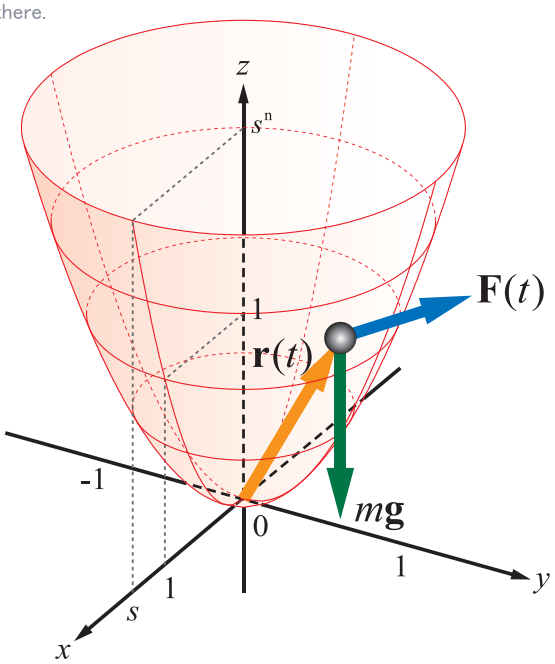

図2. n次式回転体に拘束された質点の運動のモデル

Fig2. The model of Dynamics of the mass point on the body of rotation by expression degree of n

3. 運動方程式 Dynamic Equations

$$\begin{cases} \ddot{x} = -k\dot{x} + F_x - nxr^{n-2}\Lambda(t) \\ \ddot{y} = -k\dot{y} + F_y - nyr^{n-2}\Lambda(t) \\ \ddot{z} = -k\dot{z} - g + \Lambda(t) \end{cases} \qquad \begin{aligned} r &= \sqrt{x^2 + y^2} \\ F_x &= A\cos(\omega t) \\ F_y &= A\sin(\omega t) \end{aligned}$$

$$\Lambda(t) = \frac{n(n-2)r^{n-4}(x\dot{x} + y\dot{y})^2 + nr^{n-2}(\dot{x}^2 + \dot{y}^2 + xF_x + yF_y) + g}{n^2 r^{2n-2} + 1}$$

$\Lambda(t)$:	拘束力のベクトルの係数	Coefficient of Vertical Drag
k:	減衰定数	Damping Coefficient
g:	重力加速度	Gravitational Acceleration
A:	周期外力の振幅	Ampritude of Periodic External Force
ω:	周期外力の角速度	Angular Speed of Periodic External

4. 解析とシミュレーション Analysis and Simulation

運動方程式の定常解をハーモニック・バランス法を用いて解析し、応答曲線、位相特性を導出した。n=2を境に、跳躍の方向が変わることを発見した。

We analyzed the steady-state of dynamical equation by Harmonic Balance Method, then we got the equation of responce curves and phase properties. We found the change in direction and size of jump by the variable n. n=2 form the division of the direction between plus and minus.

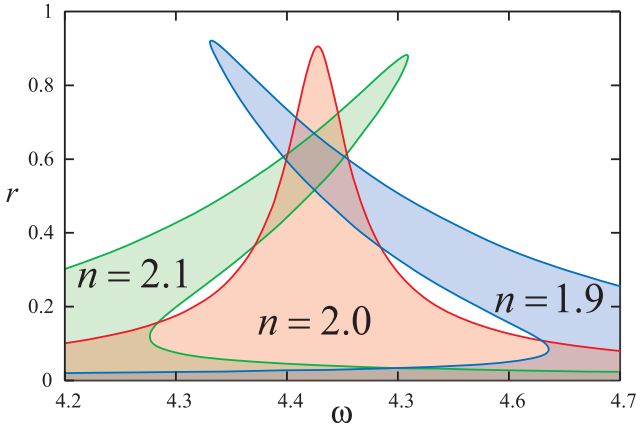

図3. 応答曲線(A = 0.2, k = 0.05)

Fig3. Responce Curves (A = 0.2, k = 0.05)

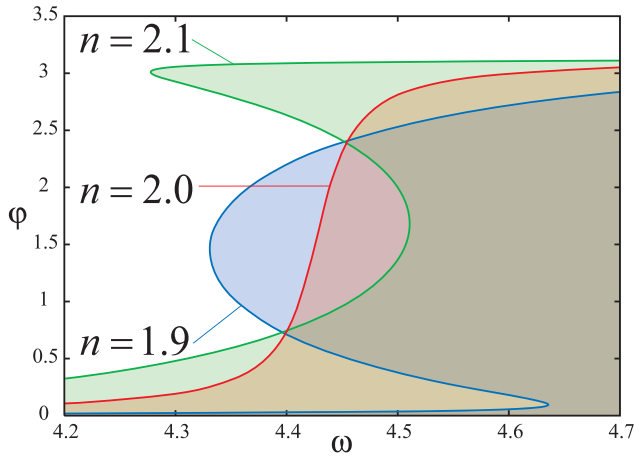

図4. 位相特性(A = 0.2, k = 0.05)

Fig4. Phase Properties(A = 0.2, k = 0.05)