Theoret. Appl. Mech., Belgrade 2012, A manuscript

On the spacecraft attitude stabilization in the orbital frame

First Author* **Second Author†**

Abstract

The paper deals with spacecraft in the circular near-Earth orbit. The spacecraft interacts with geomagnetic field by the moments of Lorentz and magnetic forces. The octupole approximation of the Earth's magnetic field is accepted. The spacecraft electromagnetic parameters, namely the electrostatic charge moment of the first order and the eigen magnetic moment are the controlled quasiperiodic functions. The control algorithms for the spacecraft electromagnetic parameters, which allows to stabilize the spacecraft attitude position in the orbital frame are obtained. The stability of the spacecraft stabilized orientation is proved both analytically and by PC computations.

Keywords: spacecraft, attitude stabilization, geomagnetic field.

Mathematics Subject Classification: At the file: http://www.ams.org/mathscinet/msc/pdfs/classifications2010.pdf an author finds for a paper dealing with phase transformations following keys: 74N15 (analysis of microstructure), 74A35 (polar materials) etc. A similar is applied to other fields.

*Russia, St. Petersburg, 198504, Stary Peterhof, Universitetsky pr., 28, St.-Petersburg State University, Faculty of Mathematics and Mechanics, e-mail: antipov_k@rambler.ru

†Russia, St. Petersburg, 198504, Stary Peterhof, Universitetsky pr., 28, St.-Petersburg State University, Faculty of Mathematics and Mechanics, e-mail: aatikhonov@rambler.ru

1 Introduction

The forces of spacecraft electrodynamic interaction with the geomagnetic field considerably influence on the spacecraft attitude dynamics and so can be used for designing control systems of spacecraft attitude orientation.

2 The moment of Lorentz forces

A spacecraft, whose center of mass moves in the Newtonian central Earth's gravitational field in the Keplerian circular orbit of the radius R, is considered. It is assumed that the spacecraft has the electrostatic charge Q distributed within some volume V with the density σ: $Q = \int_V \sigma\, dV$.

2.1 About equations and tables

According to AMSTeX equations may be split in diverse ways. One is following:

$$\begin{aligned}
&\mathbf{U}(X_1, X_2, t=0) = \mathbf{0},\\
&\frac{\partial \mathbf{U}}{\partial t}(X_1 = \pm 1/2, X_2, t=0) = \pm V_1^* \mathbf{e}_1,\\
&\frac{\partial \mathbf{U}}{\partial t}(X_1, X_2 = \pm 1/2, t=0) = \pm V_2^* \mathbf{e}_2,\\
&\frac{\partial \mathbf{U}}{\partial t}(-1/2 < X_1 < 1/2, -1/2 < X_2 < 1/2, t=0) = \mathbf{0},
\end{aligned} \tag{1}$$

Tables should be written in the following way.

Table 1: Experimental frequencies for a woven composite plate.

	1	2	3	4	5	6	7	8
Freq.[Hz]	37.3	85.8	110.9	211.6	222.3	235.6	257.1	268.2

Table 2: Estimates of the elastic constants for the 3.175 mm thick aluminum plate.

Initial E	Initial	Predicted E	Predicted G
[GPa]	[GPa]	[GPa]	[GPa]
120	50	71.04	25.32
115	45	71.04	25.33
110	50	71.06	25.34
105	55	71.02	25.31
100	40	71.02	25.32
95	55	71.04	25.33
90	50	71.06	25.35
85	35	71.03	25.32
80	30	71.06	25.34
75	35	71.04	25.33
70	25	71.03	25.32
65	30	71.05	25.33
65	35	71.03	25.32
60	30	71.01	25.31
55	35	71.07	25.32

Table 3: Estimates of the elastic constants for the 1.6 mm thick (CFRP) composite plate.

	Initial values	Predicted values
	[GPa]	[GPa]
E_{11}	85	136.7
G_{13}	5.32	5.08
G_{23}	2.59	3.16

2.2 Figures in eps format

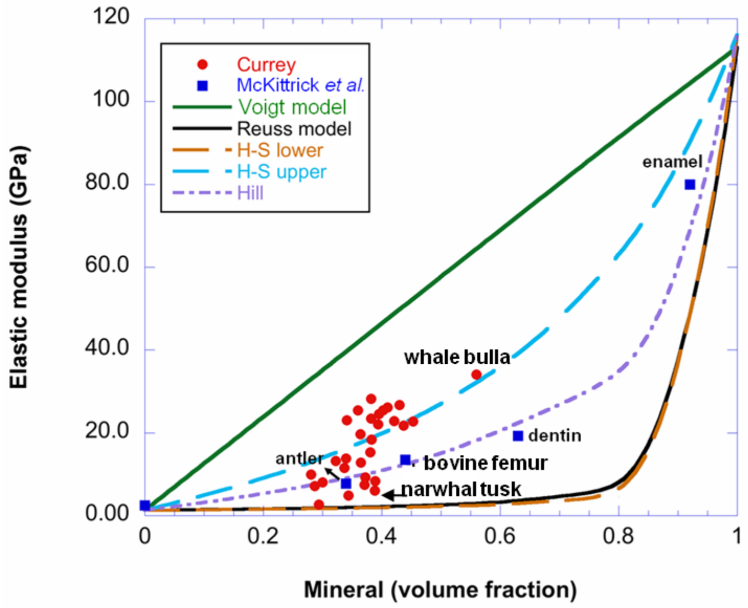


Figure 1: A good looking figure acceptable for TAM

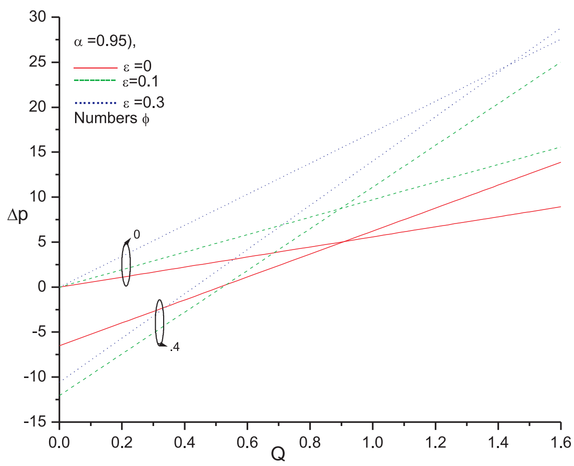
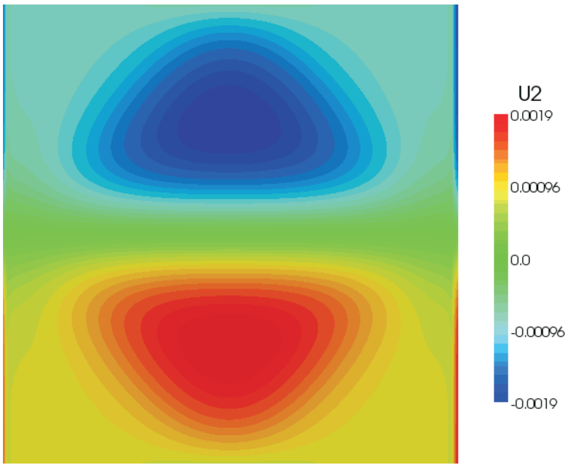
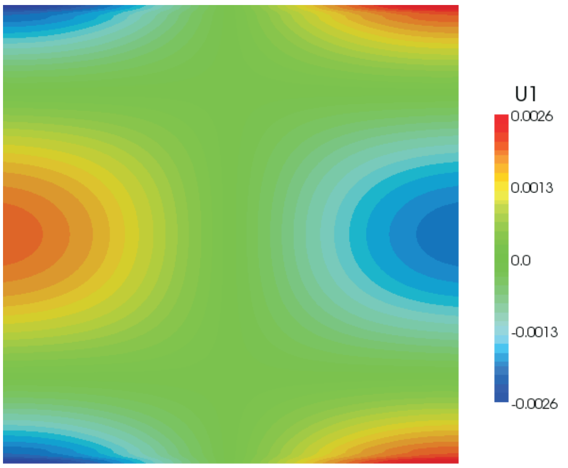


Figure 2: A figure not acceptable for TAM

(a) Snapshot of the space behaviour of U_1 at time $\tau = 0.22$.



(b) Snapshot of the space behaviour of U_2 at time $\tau = 0.22$.



(c) Snapshot of the space behaviour of U_1 at time $\tau = 1.48$.

Figure 3: An acceptable form of figure with subfigures.

3 The third section

Material symmetry group $\aleph$ of an elastic anisotropic material with Hooke's tensor $\mathcal{D}$ is defined by all orthogonal 2-tensors satisfying the relationship: $\mathcal{D} = \mathbf{H} \diamondsuit \mathcal{D}, \quad (\mathbf{H} \in \aleph)$, where the Rayleigh product explicitly reads: ...

Overall symmetry definition

Given elastic and thermal symmetries of the matrix and N ellipsoidal inclusions (whose semiaxes are defined by the rotation tensors $\mathbf{R}_\Lambda$) as follows: $\mathcal{D}_\Lambda = \mathbf{H}^e_\Lambda \diamondsuit \mathcal{D}_\Lambda$, $\mathbf{H}^e_\Lambda \in \aleph^e_\Lambda$, as well as $\boldsymbol{\alpha}_\Lambda = \mathbf{H}^t_\Lambda \diamondsuit \boldsymbol{\alpha}_\Lambda$, $\mathbf{H}^t_\Lambda \in \aleph^t_\Lambda$, $(\Lambda \in \{0, 1, \ldots N\})$ find 2-tensors $\mathbf{H}^e_{eff} \in \aleph^e_{eff}$ and $\mathbf{H}^e_{eff} \in \aleph^e_{eff}$ such that

$$\mathcal{D}_{eff} = \mathbf{H}^e_{eff} \diamondsuit \mathcal{D}_{eff}, \quad \mathbf{H}^e_{eff} \in \aleph^e_{eff} \tag{2}$$

as well as...

Groups $\aleph^e_{eff}$ and $\aleph^t_{eff}$ are then called *effective elastic symmetry group* and *effective thermal symmetry group* respectively.

Obviously, the real task is to find $\aleph^e_{eff}$ and $\aleph^t_{eff}$ when $\aleph^e_\Lambda$ and $\aleph^t_\Lambda$, $(\Lambda \in \{0, 1, \ldots N\})$, are given.

In the special case when ODF depends only on one angle, say θ, averaging over the other two Euler angles leads to the representation

$$\omega(\mathbf{R}) = \sum_{k=0}^{\infty} c_{2k} \, P_{2k}(cos\theta), \tag{3}$$

where P_k, $k \in \{0, 2, 4, \ldots\}$ with values $P_0(x) = 1$, $P_2(x) = (3x^2 - 1)/2$, $P_4(x) = (35x^4 - 30x^2 + 3)/8$, $P_6(x) = (231x^6 - 315x^4 + 105x^2 - 5)/16, \ldots$ are Legendre functions of even order.

Example 1.

First, suppose that an elastomeric matrix is weakened by some identical parallel spheroidal voids with symmetry axis aligned with a Cartesian axis $z_3 = x_3$...

Concluding remarks

Results of this paper may be shortly summarized as follows:

- conclusion 1
- conclusion 2
- conclusion 3

Acknowledgements

This research has been done within the project MM-144038 financially supported by the Ministry of Science and Technology of Serbia.

References

[1] B.D.Vujanovic and S.E.Jones, Variational methods in nonconservative phenomena, Academic Press, Boston, 1988.

[2] E. Reissner, *On one-dimensional finite strain beam theory: the plane problem*, J.Appl.Math.Phys.(ZAMP), **23**, (1972), 795-804.

[3] J.Smith and H.Johnson, *Waves and turbulence*, In Proc. Euromech. Symp. On Fluid Mechanics, ed.H.Schmidt, Gauthier-Villars, Paris (1993), 34-37.

List of Figures

List of Tables