

Contents

1	Introduction	1
1.1	Background	1
1.2	Academic Merits and Significance	3
1.3	Research Status Survey	5
1.3.1	Progress in Astronautic Dynamics	5
1.3.2	Progress in Planetary Science	8
1.3.3	Progress in Nonlinear Dynamics	10
1.4	Content and Innovations	12
1.4.1	Content of the Thesis	12
1.4.2	Innovations of the Thesis	13
	References	14
2	Modelling Orbital Dynamics in the Potential of Small Bodies	19
2.1	Introduction	19
2.2	Mechanical Environment in the Vicinity of Small Bodies	20
2.3	Descriptions of the Gravitational Field	24
2.3.1	Mass Point Cluster	25
2.3.2	Spherical/Ellipsoidal Harmonics	26
2.3.3	Polyhedral Method	29
2.4	Motion Equations	31
2.5	Dynamical Factor κ	33
2.6	Summary	36
	References	37
3	Stability of Equilibrium Points and Behaviour of Nearby Trajectories	39
3.1	Introduction	39
3.2	Equilibrium Points of Asteroid 216 Kleopatra	40
3.2.1	Equilibrium Points	40
3.2.2	Zero-Velocity Surface	43

3.3	Stability of the Equilibrium Points	45
3.4	Structure of Local Manifolds.	47
3.4.1	Three Types of Invariant Manifolds at E_1 and E_2	48
3.4.2	Three Types of Invariant Manifolds at E_3 and E_4	50
3.4.3	Periodic Orbital Families Determined from Central Manifolds.	51
3.5	Orbital Behaviours in the Neighbourhood of Equilibrium Points.	54
3.5.1	Behaviours of Trajectories Near E_1 and E_2	56
3.5.2	Behaviours of Trajectories Near E_3 and E_4	57
3.6	Summary	59
	References	59
4	Topological Classification and Stability of Large-Scale Periodic Orbits	61
4.1	Introduction	61
4.2	Periodic Orbits Around 216 Kleopatra	62
4.2.1	Hierarchical Grid Search Method	63
4.2.2	Families Generated Around Kleopatra	66
4.3	Stability of Families 1–29.	71
4.4	Topological Classification of Periodic Orbits.	74
4.5	Behaviours of Trajectories Near Periodic Orbits of 216 Kleopatra	76
4.5.1	Periodic Orbits of Complex Saddle Type	78
4.5.2	Periodic Orbits of Real Saddle Type	80
4.5.3	Periodic Orbits of Central Saddle Type	80
4.5.4	Periodic Orbits of General Centre Type	81
4.6	Summary	82
	References	82
5	Orbital Resonance Near the Equatorial Plane of Small Bodies.	85
5.1	Introduction	85
5.2	1:1 Resonant Orbits Near the Small Bodies	86
5.2.1	Energy Equations	87
5.2.2	A Mechanism of 1:1 Resonance	88
5.2.3	Typical Resonant Orbits.	90
5.3	Parameter Dependence of the Resonance	90
5.4	Resonant Orbits Near the Equatorial Plane of 216 Kleopatra.	93
5.4.1	Parameter Conditions for Orbital Resonance.	94
5.4.2	Distribution of the Ejecting Orbits.	94
5.5	Summary	97
	Reference.	98

- 6 Natural Motion Near the Surface of Small Bodies 99**
 - 6.1 Introduction 99
 - 6.2 Modelling Mechanics of the Surface 100
 - 6.2.1 Modified Polyhedral Method 100
 - 6.2.2 C^1 Surface Interpolation over the Polyhedron 102
 - 6.2.3 Equation of Motion on Surface 104
 - 6.3 Modelling the Natural Motion Near the Surface 106
 - 6.3.1 Triggering Events Within Orbital Motion Segments. 106
 - 6.3.2 Triggering Events Within Surface Motion Segments 108
 - 6.3.3 Global Trajectory Patching Technique 109
 - 6.4 Verification and Assessment 111
 - 6.4.1 Example 1: Gravitational Field of a Solid Sphere 111
 - 6.4.2 Example 2: Demonstration Trajectories over Different Bodies 112
 - 6.5 Analysis of the Natural Motion Near Asteroid 1620 Geographos 114
 - 6.5.1 Surface Slope and Equilibrium Area 114
 - 6.5.2 Surface Curvature and Liftoff Speed 115
 - 6.5.3 Behaviours of Global Trajectories over 1620 Geographos. 117
 - 6.6 Summary 118
 - References 119
- 7 Conclusions and Future Directions 121**
 - 7.1 Conclusions 121
 - 7.2 Future Directions. 122