

**The Influence of Asteroid Surface Features on the YORP
Effect and Dynamical Evolution**

by

D.A. Baker

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Committee Members:

Jay W. McMahon, Chair

Dr. Daniel J. Scheeres

Dr. Paul Sanchez

Dr. Paul Hayne

Dr. William Bottke

Baker, D.A. (Ph.D., Aerospace Engineering Sciences)

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Thesis directed by Prof. Jay W. McMahon

Often the abstract will be long enough to require more than one page, in which case the macro “\OnePageChapter” should *not* be used.

But this one isn't, so it should.

Dedication

To all of the fluffy kitties.

Acknowledgements

Here's where you acknowledge folks who helped. But keep it short, i.e., no more than one page, as required by the Grad School Specifications.

Contents

Chapter

1	Introduction and Motivation	1
1.1	Asteroid Surfaces	1
1.1.1	Shape Modeling	2
1.1.2	Dynamics and the YORP Effect	2
1.1.3	Thesis Statement	2
1.1.4	Thesis Overview	2
2	Optical-Based Shape Modeling	3
2.1	Observing the Limb	3
2.2	Constraining Convexity	3
2.3	Shape Model Result	3
3	Boulder-Induced YORP Altering Spin Acceleration	4
3.1	Torque Calculation	4
3.2	Boulder Factors	4
4	Pole Stability and Obliquity Evolution under YORP Torques	5
5	Estimates of YORP for Ground-Based Observing	6
6	Future Work	7

Appendix**A** Weird Exam Answers**8****B** Ode to Spot**10**

Tables

Table

Figures

Figure

Chapter 1

Introduction and Motivation

1.1 Asteroid Surfaces

Studying asteroids is important to understanding the origin of our own planet. They are remnants of the protoplanetary disk, and provide insights as to the composition of the original materials that eventually formed rocky planets as well as gaseous ones. In this work, I will be focusing on the smallest members of the asteroid population and the unique dynamics at play in their evolution. Small asteroids are often made up of many separate particles and boulders which is why they are referred to as "rubble piles" (cite). Often originating from a previous impact event of a parent body, the many pieces come together over time and bond by weak gravity and electrostatic cohesion (cite walsh probably). These bodies are resilient and active, frequently resurfacing, losing particles, and experiencing further bombardment. By our recent visits to asteroid targets in the sub-1 km size regime, we have seen high-resolution examples of these bodies and been able to characterize the boulders and regolith on their surfaces. These missions produced shape models that enabled both science and navigation. The OSIRIS-REx mission successfully orbited around the 524 m diameter asteroid Bennu for XXXX years, measuring the gravitational properties and taking images to constrain the shape (cite). We observed the extremely dark and unexpectedly rocky surface of Bennu and even witnessed particle escape (cite). The sample taken from Bennu has already returned to Earth to undergo testing and characterization which will tell us more about the materials we should expect to find on B-type asteroids like Bennu in the future (cite). Another recent mission that demonstrated the capabilities of asteroid rendezvous and high-resolution shape

modeling was Hayabusa2, launched by JAXA in XXXX (cite). This mission characterized the irregularly shaped body Itokawa and also furthered asteroid science in unexpected ways.

1.1.1 Shape Modeling

1.1.2 Dynamics and the YORP Effect

1.1.3 Thesis Statement

1.1.4 Thesis Overview

Chapter 2

Optical-Based Shape Modeling

2.0.1 Observing the Limb

2.1 Constraining Convexity

2.2 Shape Model Result

Appendix A

Weird Exam Answers

About appendices: Each appendix follow the same page-numbering rules as a regular chapter; the first page of a (multi-page) appendix is not numbered. By the way, the following are supposedly authentic answers to English GCSE exams!

- (1) The Greeks were a highly sculptured people, and without them we wouldnt have history.
The Greeks also had myths. A myth is a female moth.
- (2) Actually, Homer was not written by Homer but by another man of that name.
- (3) Socrates was a famous Greek teacher who went around giving people advice. They killed him. Socrates died from an overdose of wedlock. After his death, his career suffered a dramatic decline.
- (4) Julius Caesar extinguished himself on the battlefields of Gaul. The Ides of March murdered him because they thought he was going to be made king. Dying, he gasped out: Tee hee, Brutus.
- (5) Nero was a cruel tyranny who would torture his subjects by playing the fiddle to them.
- (6) In midevil times most people were alliterate. The greatest writer of the futile ages was Chaucer, who wrote many poems and verses and also wrote literature.
- (7) Another story was William Tell, who shot an arrow through an apple while standing on his sons head.

- (8) Writing at the same time as Shakespeare was Miguel Cervantes. He wrote Donkey Hote. The next great author was John Milton. Milton wrote Paradise Lost. Then his wife died and he wrote Paradise Regained.
- (9) During the Renaissance America began. Christopher Columbus was a great navigator who discovered America while cursing about the Atlantic. His ships were called the Nina, the Pinta, and the Santa Fe.
- (10) Gravity was invented by Issac Walton. It is chiefly noticeable in the autumn when the apples are falling off the trees.
- (11) Johann Bach wrote a great many musical compositions and had a large number of children. In between he practiced on an old spinster which he kept up in his attic. Bach died from 1750 to the present. Bach was the most famous composer in the world and so was Handel. Handel was half German half Italian and half English. He was very large.
- (12) Soon the Constitution of the United States was adopted to secure domestic hostility. Under the constitution the people enjoyed the right to keep bare arms.
- (13) The sun never set on the British Empire because the British Empire is In the East and the sun sets in the West.
- (14) Louis Pasteur discovered a cure for rabbis. Charles Darwin was a naturalist who wrote the Organ of the Species. Madman Curie discovered radio. And Karl Marx became one of the Marx brothers.

Appendix B

Ode to Spot

(Data, Stardate 1403827) (A one-page chapter — page must be numbered!) Throughout the ages, from Keats to Giorchamo, poets have composed “odes” to individuals who have had a profound effect upon their lives. In keeping with that tradition I have written my next poem . . . in honor of my cat. I call it. . . Ode. . . to Spot. (Shot of Geordi and Worf in audience, looking mystified at each other.)

Felus cattus, is your taxonomic nomenclature
 an endothermic quadruped, carnivorous by nature?
 Your visual, olfactory, and auditory senses
 contribute to your hunting skills, and natural defenses.
 I find myself intrigued by your sub-vocal oscillations,
 a singular development of cat communications
 that obviates your basic hedonistic predilection
 for a rhythmic stroking of your fur to demonstrate affection.
 A tail is quite essential for your acrobatic talents;
 you would not be so agile if you lacked its counterbalance.
 And when not being utilized to aid in locomotion,
 It often serves to illustrate the state of your emotion.

(Commander Riker begins to applaud, until a glance from Counselor Troi brings him to a halt.)

Commander Riker, you have anticipated my denouement. However, the sentiment is appreciated.

I will continue.

O Spot, the complex levels of behavior you display
 connote a fairly well-developed cognitive array.
 And though you are not sentient, Spot, and do not comprehend
 I nonetheless consider you a true and valued friend.