

## Table of Contents

### 1. Executive Summary

|   |   |
|---|---|
| 1.1 Science Goals                               | 6 |
| 1.2 The Telescope and its Instrumentation       | 7 |
| 1.3 Importance for the United States and Mexico | 7 |
| 1.4 The Large Millimeter Telescope Observatory  | 8 |
| 1.5 Relation to Other Telescope Projects        | 8 |
| 1.6 References                                  | 8 |

### 2. Introduction

|  |    |
|--|----|
| 2.1 INAOE and Astronomy in Mexico                        | 9  |
| 2.2 Astronomy at the University of Massachusetts Amherst | 12 |
| 2.3 Goals of the LMT Project                             | 14 |
| 2.3.1 Science  | 14 |
| 2.3.2 Human Resources                                    | 15 |
| 2.3.3 Development of New Technology                      | 16 |
| 2.4 The Large Millimeter Telescope                       | 16 |
| 2.4.1 Antenna  | 16 |
| 2.4.2 Site   | 18 |
| 2.4.3 Instrumentation                                    | 19 |
| 2.4.4 Very Long Baseline Interferometry with the LMT     | 21 |
| 2.5 Relation to Other Telescope Projects                 | 22 |
| 2.6 Overview of This Booklet                             | 23 |
| 2.7 References   | 24 |

### 3. Cosmology and the Origin and Evolution of Galaxies

|   |    |
|---|----|
| 3.1 Introduction  | 25 |
| 3.2 The History of Optically Obscured High-Redshift Star Formation                    | 26 |
| 3.2.1 Cosmological Surveys with the LMT   | 27 |
| 3.2.2 Resolving the Far-Infrared-to-Millimeter-Wavelength Extragalactic Background    | 29 |
| 3.2.3 Measuring the Redshift Distribution of Optically Obscured Galaxies with the LMT | 30 |
| 3.3 High-Redshift Active Galactic Nuclei  | 33 |
| 3.3.1 Continuum-Emission and Molecular-Line Surveys of AGN                            | 35 |
| 3.3.2 The Environment of AGN at Millimeter Wavelengths                                | 36 |
| 3.4 Detecting Cosmic Microwave Background Anisotropies with the LMT                   | 37 |
| 3.4.1 Primary (Primordial) CMB Fluctuations   | 38 |
| 3.4.2 Secondary CMB Fluctuations due to the Sunyaev-Zel'dovich Effect                 | 38 |
| 3.5 Gamma-ray Bursts (GRBs)   | 39 |
| 3.6 References  | 42 |

**4. Galaxies in the Local Universe**

4.1 Introduction \_\_\_\_\_ 45

4.2 Molecular Gas Distributions \_\_\_\_\_ 45

4.3 Instabilities and Star Formation \_\_\_\_\_ 46

4.4 Probing Physical Conditions in the Interstellar Medium \_\_\_\_\_ 48

4.5 Large Imaging Surveys of Nearby Galaxies \_\_\_\_\_ 51

4.6 Exploring the Galaxy with VLBI \_\_\_\_\_ 52

    4.6.1 Imaging a Black Hole Event Horizon \_\_\_\_\_ 52

    4.6.2 Cosmic Accelerators: How AGN Launch and Collimate Relativistic Jets \_\_\_\_ 54

4.7 References \_\_\_\_\_ 54

**5. Star Formation and the Interstellar Medium in the Milky Way**

5.1 Processes of Star Formation \_\_\_\_\_ 56

5.2 Astrochemistry \_\_\_\_\_ 59

5.3 Stellar Mass Loss: How Evolved Stars Return Mass to the Galaxy \_\_\_\_\_ 60

5.4 References \_\_\_\_\_ 61

**6. Planetary Science and Astrobiology**

6.1 Small Bodies \_\_\_\_\_ 62

    6.1.1 Comets \_\_\_\_\_ 62

    6.1.2 Asteroids, Centaurs and Kuiper Belt Objects \_\_\_\_\_ 65

6.2 Planetary and Satellite Atmospheres \_\_\_\_\_ 67

6.3 Extrasolar Planets and Protoplanetary Disks \_\_\_\_\_ 69

6.4 Astrobiology \_\_\_\_\_ 70

6.5 Radar Astronomy \_\_\_\_\_ 71

6.6 References \_\_\_\_\_ 72

**7. Development of New Technology**

7.1 Active Surface System \_\_\_\_\_ 74

    7.1.1 Correction of Gravitational Errors \_\_\_\_\_ 74

    7.1.2 Correction of Thermally Induced Errors \_\_\_\_\_ 76

    7.1.3 Correction of Errors due to Wind Loading \_\_\_\_\_ 77

7.2 Pointing of the LMT \_\_\_\_\_ 77

7.3 Monitor and Control System \_\_\_\_\_ 80

    7.3.1 General Approach \_\_\_\_\_ 80

    7.3.2 Object-Oriented Design and Automation \_\_\_\_\_ 80

    7.3.3 Global State System \_\_\_\_\_ 82

    7.3.4 LMT Monitor and Control System \_\_\_\_\_ 83

    7.3.5 Implementation on Existing Telescopes \_\_\_\_\_ 85

7.4 Large Coordinate Measuring Machine \_\_\_\_\_ 85

7.5 Instrumentation Development \_\_\_\_\_ 86

7.6 References \_\_\_\_\_ 87

**8. Scientific Instruments**

|   |     |
|---|-----|
| 8.1 Introduction  | 88  |
| 8.2 First-Generation Continuum Cameras                    | 88  |
| 8.2.1 AzTEC   | 89  |
| 8.2.2 SPEED   | 91  |
| 8.3 First-Generation Heterodyne Receivers                 | 93  |
| 8.3.1 SEQUOIA: The World's Fastest 3 mm Focal-Plane Array | 93  |
| 8.3.2 Redshift Search Receiver                            | 94  |
| 8.3.3 1 mm SIS Commissioning Receiver                     | 96  |
| 8.4 LMT Wideband Spectrometer                             | 97  |
| 8.5 Next Generation of LMT Instrumentation                | 98  |
| 8.5.1 Next-Generation Continuum Instruments               | 98  |
| 8.5.2 Next-Generation Heterodyne Instruments              | 99  |
| 8.6 References  | 100 |

**9. Development of Human Resources**

|   |     |
|---|-----|
| 9.1 University of Massachusetts Amherst | 101 |
| 9.2 INAOE                               | 103 |

**10. The LMT Outreach Program**

|  |     |
|--|-----|
| 10.1 The National Park                 | 105 |
| 10.2 The LMT and the Local Communities | 108 |
| 10.3 The LMT and the General Public    | 110 |
| 10.4 References                        | 111 |

**11. Management Structure: The Large Millimeter Telescope Observatory**

|                          |     |
|--------------------------|-----|
| 11.1 The LMT Observatory | 112 |
| 11.2 Facilities          | 113 |
| 11.3 Operating the LMT   | 114 |

**12. Opportunities for Participation by the Astronomical Community**

|                             |     |
|-----------------------------|-----|
| 12.1 Observing with the LMT | 116 |
| 12.2 Guest Instruments      | 116 |

|              |     |
|--------------|-----|
| 13. Glossary | 118 |
|--------------|-----|