

¹ Abstract

² Going to make LIGO the best possible ever.

3 Adaptive Mode Matching in Advanced LIGO

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6 Preface

7 The era of gravitational waves astronomy was ushered in by the LIGO (Laser
8 Interferometer Gravitational-Wave Observatory) collaboration with the detec-
9 tion of a binary black hole collision (Detection paper). The event that shook
10 the foundation of space-time allowed mankind to view the cosmos in a way that
11 had never been done previously.

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Chapter 1

Introduction

1.1 Gravitational Waves

1.2 The LIGO Instrument

The LIGO Interferometers are considered dual

1.2.1 Dual-recycled Fabry-Perot Interferometer

A fabry perot cavity is:

Power Recycling If the interferometer is operating such that the 4 km arms are exactly different in arms a pi over two times the wavelength, then the intensity of the light at antisymmetric port will be close to null. This means the power from the arms will

Signal Recycling

1.2.2 Limitations

Noise budget: - Quantum Noise - Seismic - Thermal Noise

1.3 Squeezed States of Light

The Quantum Noise is a fundamental source that can be helped by squeezing.

This is Squeezing (Caves, Dwyer, Kwee, Miao)

1.4 The Effects of Mode-Matching

Theory section of modematching.

An example of how mode-matching can affect the overall sensitivity.

66 Chapter 2

67 Modeling Mode-Matching

68 2.1 How it works

69 2.2 Defining Mode-Matching

70 2.2.1 Misalignment

71 Anderson, Kognelik and Li

72 Guido Paper

73

74 2.2.2 Waist Size and Location

75 Anderson, Kognelik and Li

76 In contrast to the misalignment orthoganlity

77 2.3 Finesse Simulations

78 2.3.1 ALIGO Design with FC and Squeezer

79 2.3.2 Looking at just Modal Change

80 2.3.3 QM Limited Sensitivity

81 2.4 Results

82 * Signal recycling cavity mismatches

83 * Mismatches before the OMC

84 * Mismatch contour graph: Comparing all of ALIGO cavities

85 * Optical Spring pops up at 7.4 Hz in the Signal-to-Darm TF, re-run with
86 varying SRM Trans which should.

87 Chapter 3

88 Mode Matching Cavities at 89 Syracuse

90 3.1 Adaptive Mode Matching

91 Real time digital system and model.

92 3.2 Actuators

93 3.2.1 Thermal Lenses

94 Fabian's work and UFL paper.

95 3.2.2 Translation Stages

96 3.3 Sensors

97 3.3.1 Mode Converters

98 3.3.2 Bullseye Photodiodes

99 Chapter 4

100 Mode Matching Cavities at 101 LIGO Hanford

102 4.1 Beam Jitter

103 Current measurements of mode-matching.

104 Chapter 5

105 High Power Commissioning

106 5.1 Effect on Mode-Matching

107 What is the effect on mode-matching when you change the laser power?

108 Chapter 6

109 Solutions for Next 110 Generation Detectors

- 111 * SR3 Heater
- 112 * SRM Heater
- 113 * Operation: range (in terms of watts and
- 114 * Translation stages
- 115 * Mechanical description (Solidworks designs)
- 116 * Constraints (range, vacuum, alignment, integration)
- 117 * Electronics
- 118 * Software

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