Abstract

Going to make LIGO the best possible ever.

Adaptive Mode Matching in Advanced LIGO

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Preface

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

Contents

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.

Chapter 2

Modeling Mode-Matching

2.1 How it works

2.2 Defining Mode-Matching

2.2.1 Misalignment

Anderson, Kognelik and Li
Guido Paper

2.2.2 Waist Size and Location

Anderson, Kognelik and Li
In contrast to the misalignment orthoganlity

2.3 Finesse Simulations

2.3.1 ALIGO Design with FC and Squeezer

2.3.2 Looking at just Modal Change

2.3.3 QM Limited Sensitivity

2.4 Results

* Signal recycling cavity mismatches
    * Mismatches before the OMC
    * Mismatch contour graph: Comparing all of ALIGO cavities
    * Optical Spring pops up at 7.4 Hz in the Signal-to-Darm TF, re-run with varying SRM Trans which should.

Chapter 3

Mode Matching Cavities at Syracuse

3.1 Adaptive Mode Matching

Real time digital system and model.

3.2 Actuators

3.2.1 Thermal Lenses

Fabian's work and UFL paper.

3.2.2 Translation Stages

3.3 Sensors

3.3.1 Mode Converters

3.3.2 Bullseye Photodiodes

Chapter 4

Mode Matching Cavities at LIGO Hanford

4.1 Beam Jitter

Current measurements of mode-matching.

Chapter 5

High Power Commissioning

5.1 Effect on Mode-Matching

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

Chapter 6

Solutions for Next Generation Detectors

* SR3 Heater
    * SRM Heater
    * Operation: range (in terms of watts and
    * Translation stages
    * Mechanical description (Solidworks designs)
    * Constraints (range, vacuum, alignment, integration)
    * Electronics
    * Software

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