Advanced Interferometric Gravitational-wave Detectors Volume II: Advanced LIGO, Advanced Virgo and beyond.

Detector Subsystems: chapter 17

**Test mass suspensions**

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**1. Introduction**

The purpose of the suspension system is to support the main optics in the interferometer in such a way as to allow them to act as test masses free to move in response to a gravitational wave, while minimizing the various noise sources which could mask the motions we are looking for.

The two most important noise sources to be minimized are thermal noise in the suspension itself, and seismic noise acting at the support point. In addition there are other requirements for the system: low frequency suspension resonances need to be damped (local control) and the means to maintain interferometer arm lengths (global control) needs to be provided. The implementation of control must not compromise the achieved thermal noise performance nor introduce electronic noise through control loops.

Further considerations are that the system must interface with the seismic isolation system and support the optic so that it is constrained against damage from earthquakes. Finally the design may be required to accommodate auxiliary systems such as a thermal compensation scheme.

Advanced LIGO and Advanced Virgo differ in their approach to seismic isolation and control, as described in the previous chapter. Thus although the final stage of the suspension system in the two projects have clear similarities, in particular in the ways in which suspension thermal noise is addressed, there are differences in the overall systems. References will be made to the chapter on seismic isolation as needed to allow a full description of the two approaches to suspension, isolation and control.

**2. Advanced LIGO test mass suspension**

Introduction to the quadruple pendulum suspension design and brief explanation of contents of the following sections.

**2.1 Mechanical design**

2.1.1 General requirements

2.1.2 Suspended masses

2.1.3 Support structures

2.1.4 Blades and wires

2.1.5 Auxiliary components

2.1.6 Assembly and testing

**2.2 Suspension Thermal Noise and its Minimization**

Intro - Refer here to volume 1 chapter 5 for description of thermal noise and its manifestation in suspensions

2.2.1 Bonding and ear design

2.2.2 Silica fibres

2.2.3 Welding

**2.3 Damping and Control**

2.3.1 Sensors and Actuators

2.3.2 Local control

2.3.3 Global control

Note that chapters 20 and 21 will cover global control in detail.

**2.4 Expected Performance and Current Status**

**3. Advanced Virgo test mass suspension.**

Intro describing split between isolation and control discussed in previous chapter and what is covered in this chapter

**3.1 Overall Mechanical Design**

**3.2 Thermal Noise Considerations**

**3.3 Anything Else**

**3.4 Expected Performance and Current Status**

**4. Conclusions**