**Working Title: Advanced Interferometric Gravitational-wave Detectors**

**Outline for: EO components / photodetectors (Quetschke)**

## 11.1 Electro-optic components

Introduction on the general use of electro-optic modulators in the scope of GW detection

### 11.1.1 Sidebands

Short introduction to sideband generation by applying phase modulation to a main light field. (Maybe also treat AM sidebands for completeness).

### 11.1.2 The electro-optic effect

Derivation of phase retardation in birefringent crystals depending on light field and applied voltage.

### 11.1.3 Generation of unwanted AM by polarization rotation

Short excursion in the primary reason of residual AM in parallel cut crystals.

### 11.1.4 Material selection of electro-optic crystals for GW detectors

This section treats the selection of the “right” modulator material and geometry for high power beams. Thermal lensing, absorption, reflection losses and modulation efficiency are taken into account and compared for various materials.

### 11.1.5 Resonant phase modulators

Two methods (with Pi networks or transformators) are shown to achieve resonant enhancement of the modulation depth and impedance matching.

### 11.1.6 Multi frequency resonant modulators

GW detectors require more than one modulation frequency, but each additional crystal surface adds additional losses and or beam distortions. Two methods (separate electrodes with individual resonant circuits and multiple resonant modulator) are shown to apply multiple resonant frequencies to a single modulator crystal.

### 11.1.7 The sideband on sideband problem

Anytime multiple modulation frequencies are applied to a light field the sidebands are not only applied on the main carrier, but also on the sidebands of the other modulation frequencies. This can have unwanted effects and two methods are shown to avoid this:

* Parallel modulation
* Complex modulation

### 11.1.8 Suppressing AM generation

The method that is used by the aLIGO modulators to suppress unwanted AM using wedged crystal surfaces is shown.

### 11.1.9 The aLIGO modulator

A detailed overview about the aLIGO modulators is presented.

## 11.2 Photodetectors

Introduction on the general use of photo detectors in the scope of GW detection

### 11.2.1 Photodiodes

Description of the light sensitive element and definition of relevant terms.

### 11.2.1 Speed of response / bandwidth

### 11.2.2 Noise

### 11.2.3 Photodetector circuits

Description of basic low noise electronics for amplified readout of photodiodes.

* Photovoltaic
* Transimpedance and
* Resonant circuits

are ashown.

### 11.2.5 Noise limitations

The coupling of beam pointing to amplitude (power) fluctuations because of

* Clipping at the sensor aperture
* Inhomogenities of the detector chip

is shown.

Shot noise limitations are also addressed.

### 11.2.4 Specialty photodetectors

Resonant quadrant detector for Hermite-Gauss wavefront sensing.

Resonant bull’s eye detector for Laguerre-Gauss wavefront sensing.

High power, low noise photodetector: The in-vacuum intensity stabilization PD array as used in aLIGO is shown.