Astrium had developed a heterodyne laser interferometer as possible concept for the optical read-out of the LISA proofmass. Its highly symmetrical design with only 20 mm beam height was mounted on an aluminium breadboard. This first generation heterodyne interferometer enabled measurements within an accuracy of a few picometer (translation) and a few nanoradian (tilt) in the LISA measurement band. In the last two years an advanced, second generation was integrated and tested which incorporates some major improvements:

- compact setup on a Zerodur baseplate for optimal thermo-mechanical stability
- optical components integrated with Astrium’s adhesive bonding technology
- achieved contrast > 90 % on the QPDs
- all new QPD design, using stabilised bias voltage of 5 V, developed to enable detection at LISA beat frequencies
  - DC channels for frequencies up to 10 kHz
  - AC channels for frequencies 2 – 20 MHz

### Phasemeter Development

A phasemeter was realised in VHDL working with PLLs for multi tone tracking at LISA beat frequencies. As ADC timing jitter reduces the performance, an aliased pilot-tone correction at 100.3 MHz was implemented.

![Timing Diagram](image1)

### Measurement Results

#### Silicon Sensor QP22-Q:
- measurement duration \( \approx 12 \) h per scan
- the spot pattern over the whole active area results from interruptions of the isolating reflection layer on the backside, required to connect the diode to the electrode, which locally reduces the responsivity.
- the diode shows major crosstalk between its quadrants during measurement, caused by the diffuse back-reflections of the intentionally roughed reflection layer.

#### Hamamatsu InGaAs G6849-01:
- measurement duration \( \approx 4 \) h per scan
- the spots in the intensity map are most likely contaminations on the active area
- the spatial deviations in phase are near the resolution limit of the measurement setup and are interpreted as measurement noise
- during measurement no significant crosstalk between the quadrants was noticeable.

### Characterisation of Quadrant Photo Diodes

Two possible diodes for the required QPDs of the LISA/LTP space mission were selected, the enhanced silicon (Si) diode Silicon Sensor QP-22Q and the indium gallium arsenide (InGaAs) diode Hamamatsu G6849-01. Both diodes were spatially resolved characterised to check their applicability, as deviations result in phase center offset effects which could cause detrimental coupling to pointing jitter.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon Sensor QP-22Q</td>
<td>Si (enhanced)</td>
<td>5.3</td>
<td>0.55</td>
<td>2 @150Vbias</td>
</tr>
<tr>
<td>Hamamatsu G6849-01</td>
<td>InGaAs</td>
<td>1.0</td>
<td>0.68</td>
<td>20 @1Vbias</td>
</tr>
</tbody>
</table>

### Measurement Setup

- 1064 nm laser wavelength
- laser beam diameter \( \approx 40 \mu m \)
- InGaAs single element reference diode (DSI-FCA-InGaAs 1090)
- QPD moved by motorized translation stages
- scanning stepsize 20 μm (QP-22Q) and 10 μm (G6849-01)
- phase measurement using FPGA based phasemeter at 10kHz
- diodes connected to LET QPD front-end with stabilised bias voltage of 5 V
- front window of diode removed
- measuring noise reduction by averaging 5 values per position

### Intensity and Phase of the Measurement Setup

![Intensity Map](image2)

![Phase Map](image3)

Harald Kögel\(^1\), Martin Gohlke\(^1,2\), Richard Samani\(^1\), Achim Peters\(^2\), Ulrich Johann\(^1\), Claus Braxmaier\(^1,3\) and Dennis Weise\(^1\)

\(^1\) Astrium GmbH - Satellites, 88039 Friedrichshafen, Germany
\(^2\) Humboldt University, 12489 Berlin, Germany
\(^3\) University of Applied Sciences Konstanz, Institute for Optical Systems, 78462 Konstanz, Germany