Analysis of Collimation of Astigmatic Diode Laser Beam by Objective Lens
Task/System Illustration

- high NA laser diode
- collimating objective lens
- quality of beam collimation = ?
- dot diagram
- wavefront error
- phase view
- beam parameters

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Highlights

• laser diode modeling including astigmatism

• various options for evaluation of beam collimation
  → influence of astigmatism

• quality analysis of beam truncated by lens aperture
## Specification: Light Source

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description / Value &amp; Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>type/number</td>
<td>single mode IR diode laser from Laser Components: WSLD-1064-050m-1-PD</td>
</tr>
<tr>
<td>coherence/mode</td>
<td>single Hermite Gaussian (0,0) mode</td>
</tr>
<tr>
<td>wavelength</td>
<td>1064 nm</td>
</tr>
<tr>
<td>polarization</td>
<td>linear in y-direction (90°)</td>
</tr>
<tr>
<td>FWHM of beam divergence with astigmatism</td>
<td>20° × 10° (i.e. 16.97° × 8.49° referring to the 1/e² waist radius), astigmatic shift set to 11.6µm</td>
</tr>
<tr>
<td>initial $M^2$ in x- and y-direction</td>
<td>1.00 × 1.00</td>
</tr>
</tbody>
</table>
Specifying the high NA laser diode with a collimating lens.

**Parameter** | **Value & Unit**
--- | ---
Types of lens surfaces | 3 lenses with 6 spherical surfaces
Numerical aperture (NA) | 0.63
Materials | M₁: N-SF6*
            | M₂, M₃: N-BK7*  

* from catalog "Schott_2014"
# Specification: Detectors

![High NA Laser Diode Diagram](image)

## High NA Laser Diode

- **Position Modeling Technique**
  - **Position**
  - **Modeling Technique**
  - **Detector/Analyzer**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>full system</td>
<td>3D system ray tracing</td>
<td>general overview of light behavior in system</td>
</tr>
<tr>
<td>a</td>
<td>ray tracing</td>
<td>phase aberrations (RMS of wavefront error)</td>
</tr>
<tr>
<td>a</td>
<td>ray tracing</td>
<td>ray directions from dot diagram</td>
</tr>
<tr>
<td>a</td>
<td>field tracing</td>
<td>intensity distribution</td>
</tr>
</tbody>
</table>
| a        | field tracing      | beam parameters (for x × y):
  - full 1/e² angle divergence
  - M² value            |
Results: 3D System Ray Tracing

Collimation Investigation via Ray Illustration

high NA laser diode
Results: Wavefront Error without Astigmatism

Collimation Investigation via Wavefront Error

RMS = 0.03\,\lambda
Results: Wavefront Error with Astigmatism

Collimation Investigation via Wavefront Error

→ Astigmatism of source causes asymmetric & stronger wavefront error.

RMS = 0.70\,\lambda
Collimation Investigation via Ray Directions

→ The x- and y-component of the direction vector of every ray are almost zero.

Results: Ray Directions without Astigmatism
Collimation Investigation via Ray Directions

→ The x- and y-component of the direction vector of every ray are still negligible.
→ Astigmatism of source causes asymmetric distribution of directions.
Result: Field Evaluation without Astigmatism

Collimation Investigation via Beam Parameters

Simulation Time ~4s

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<tr>
<th>Parameter</th>
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<tr>
<td>full 1/e² divergence angle</td>
<td>0.02° × 0.04°</td>
</tr>
<tr>
<td>M² value</td>
<td>1.09 × 1.01</td>
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</table>

high NA laser diode

intensity

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Result: Field Evaluation with Astigmatism

Collimation Investigation via Beam Parameters

→ Astigmatism of source causes changes of
  • divergence angle
  • beam quality

Simulation Time ~4s

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Specifications of PC Used for Simulation

<table>
<thead>
<tr>
<th>Processor</th>
<th>i7-4910MQ (4 CPU cores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM</td>
<td>32 GB</td>
</tr>
<tr>
<td>Operating System</td>
<td>Windows 10</td>
</tr>
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</table>