Generation and application of high power Flattened Gaussian Beams

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Presented at the
2009 South African Institute of Physics Annual Conference
University of KwaZulu-Natal
Durban, South Africa
6-10 July 2009
Flattened Gaussian Beams (FGBs) change shape as they propagate.

\[ U(r, z) = U_0 \exp\left(-i(\Phi(p, z, w_0) - k_z - kr^2 / 2R(p, z, w_0)) - (r / w(p, z, w_0))^2\right) \]
\[ \times \sum_{n=0}^{p} C_n(p)L_n(2(r / w)^2)\exp(-2in\Phi(p, z, w_0)) \]

\[ C_n(p) = (-1)^n \sum_{m=n}^{p} \left( \frac{m}{n} \right) \frac{1}{2^m} \]

![Graph showing the radial position on mirror (m) vs. height of mirror surface (µm) with different values of N: N = 2, N = 10, N = 100.](image-url)
The Rayleigh range is inversely proportional to the order of the beam

\[ N = 2 \quad N = 10 \quad N = 100 \]
Using a transmission DOE one can convert a Gaussian to flat-top intensity profile.
Modes may be selected by phase inside the optical resonator
Design of a mirror to produce an $N = 10$ FGB
Fox–Li analysis
The mode competition is revealed in the loss convergence per round trip.
Piezoelectric unimorph mirror

- 25.4mm
- Mirror with $N=2$ DOE surface
- Ground electrode
- Piezoelectric disc

15 evenly spaced electrodes

~40 µm

Proc. SPIE 6930, 6930Y1, 2008
Combination of a DOE and adaptive mirror allows in-situ mode selection
Industrial application
Laser based paint stripping

<table>
<thead>
<tr>
<th>TEA CO₂ laser</th>
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<tbody>
<tr>
<td>Pulse energy</td>
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<tr>
<td>Repetition rate</td>
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<tr>
<td>Average power</td>
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</table>

movie
Single mode or multimode?

E~250 mJ, M² ~ 1.1

E~6.3 J, M² ~ 25
Design and fabrication of an intra-cavity DOE

![Graph showing mirror surface versus radius](image)

$E \sim 5.3 \text{ J, } M^2 \sim 9.3$

![Graph showing error across path versus distance](image)

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Proc. SPIE 7062, 706210-1, 2008
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Paint stripping improvement
Thank You
Join the Mathematical Optics research team!

Opportunities: MSc and PhD studentships, Post docs and Sabbaticals

Contact: Dr Andrew Forbes or Dr Stef Roux

www.csir.co.za/lasers/index_mathematical_optics.html