Experimental generation and application of the superposition of higher-order Bessel beams

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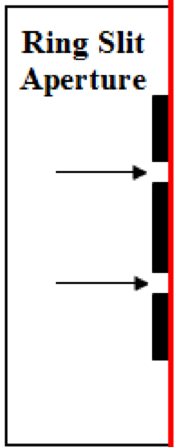
Generation of Bessel Fields:

• METH



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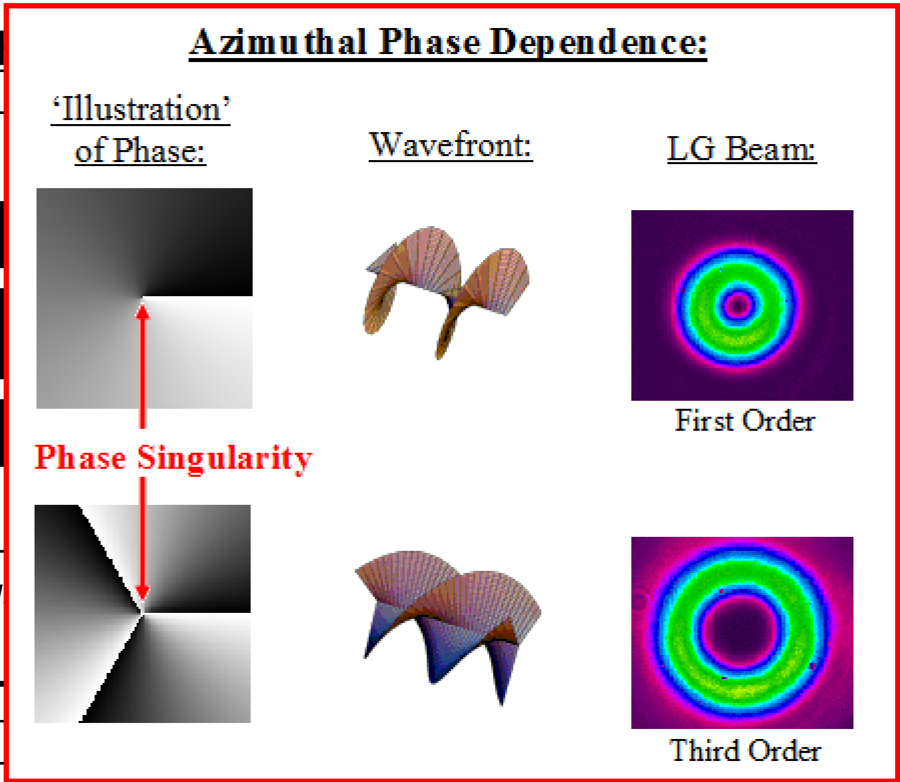
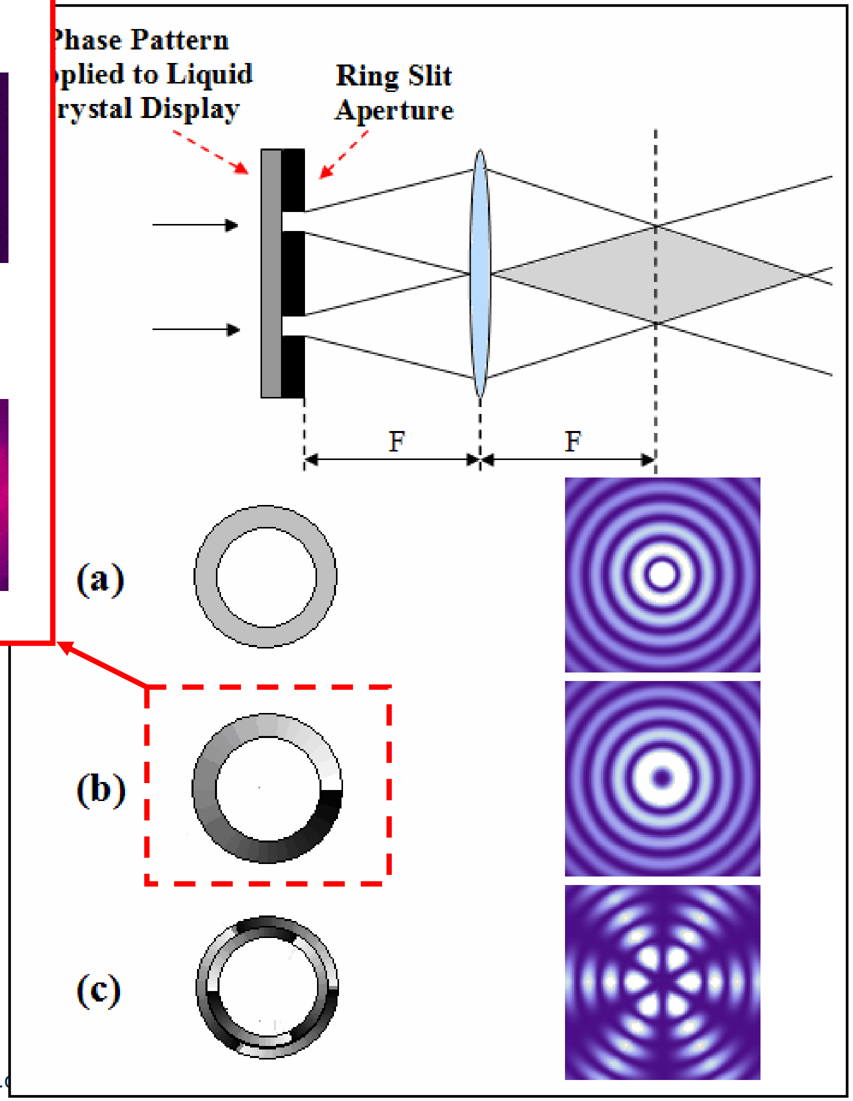
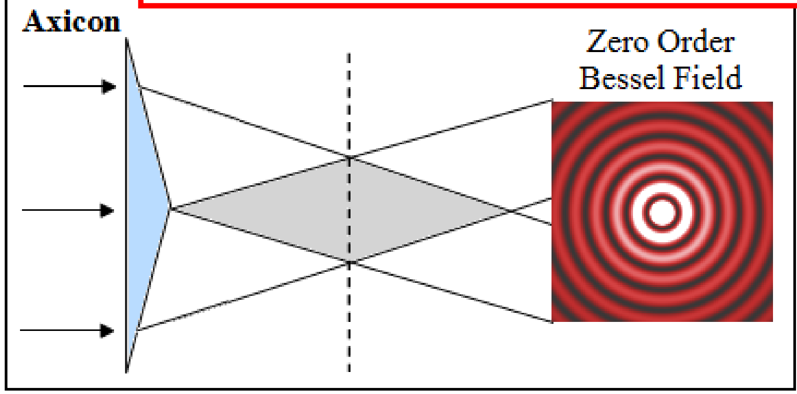


Adaptation of method 1 to produce
perpositions of higher-order Bessel beams:



• MET



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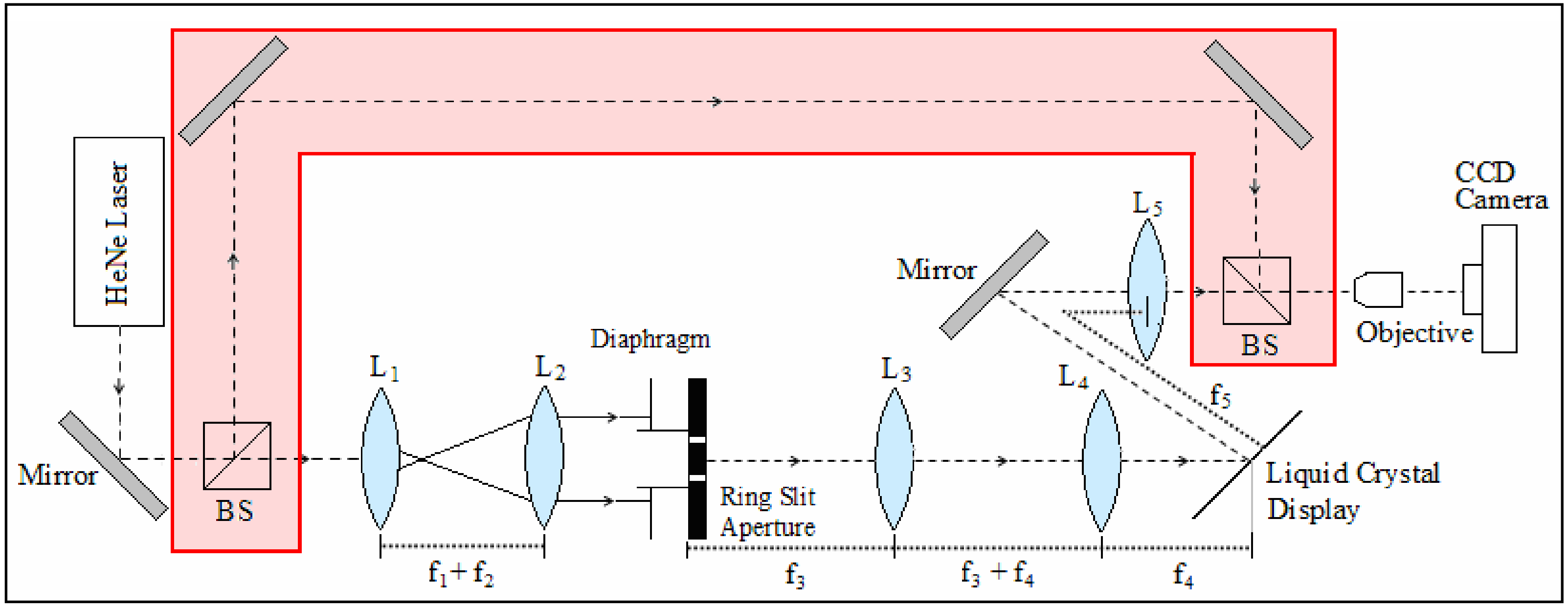
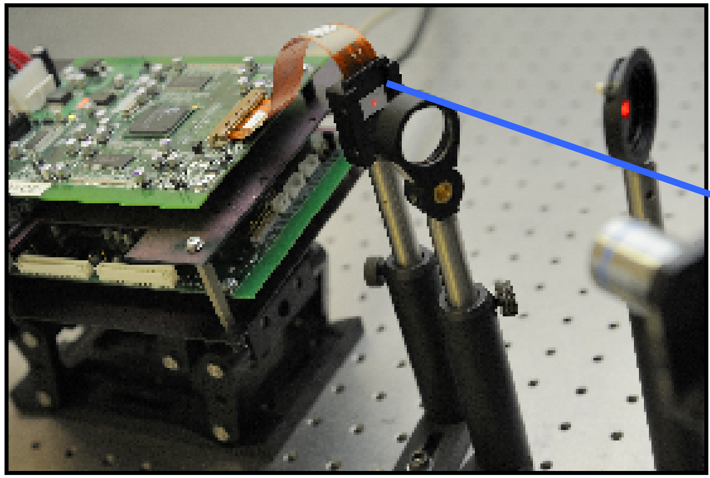
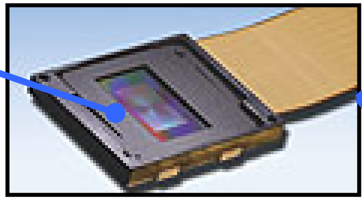
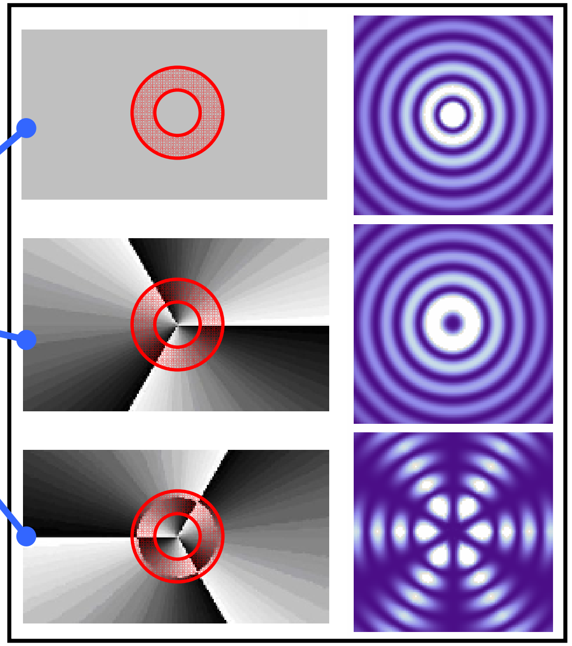
Experimental Setup:









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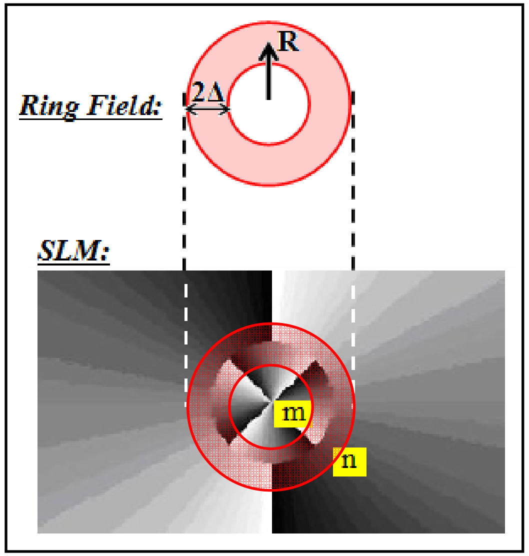
Theoretical Background:

Transmission function of ring slit aperture:

$$\tau(r,\varphi)=\begin{cases}\exp(im\varphi) & R\geq r\geq (R-\Delta)\\ \exp(in\varphi) & R\leq r\leq (R+\Delta)\end{cases}$$



Diffraction Integral:

$$A(r,\varphi,z)=\frac{-i}{\lambda z}\int_0^{2\pi}\int_{R-\Delta}^{R+\Delta}\tau(r,\varphi)\exp\left[i\frac{k_0}{2f}\left(1-\frac{z}{f}\right)r_1^2\right]\exp\left[-i\frac{k_0 r r_1}{f}\cos(\varphi_1-\varphi)\right]r_1 dr_1 d\varphi_1$$

Resulting Field:

$$A_{m,n}(r,\varphi,z)=A_m(r,\varphi,z)+A_n(r,\varphi,z)$$

$$A_m(r,\varphi,z)=\frac{-ik_0}{f}\int_{R-\Delta}^{R}\left(i^m\exp(im\varphi)J_m\left(\frac{k_0 r r_1}{f}\right)\right)\exp\left[-\frac{r_1^2}{w^2}+\frac{ik_0 r_1^2}{2f}\left(1-\frac{z}{f}\right)\right]r_1 dr_1$$

$$A_n(r,\varphi,z)=\frac{-ik_0}{f}\int_{R}^{R+\Delta}\left(i^n\exp(in\varphi)J_n\left(\frac{k_0 r r_1}{f}\right)\right)\exp\left[-\frac{r_1^2}{w^2}+\frac{ik_0 r_1^2}{2f}\left(1-\frac{z}{f}\right)\right]r_1 dr_1$$

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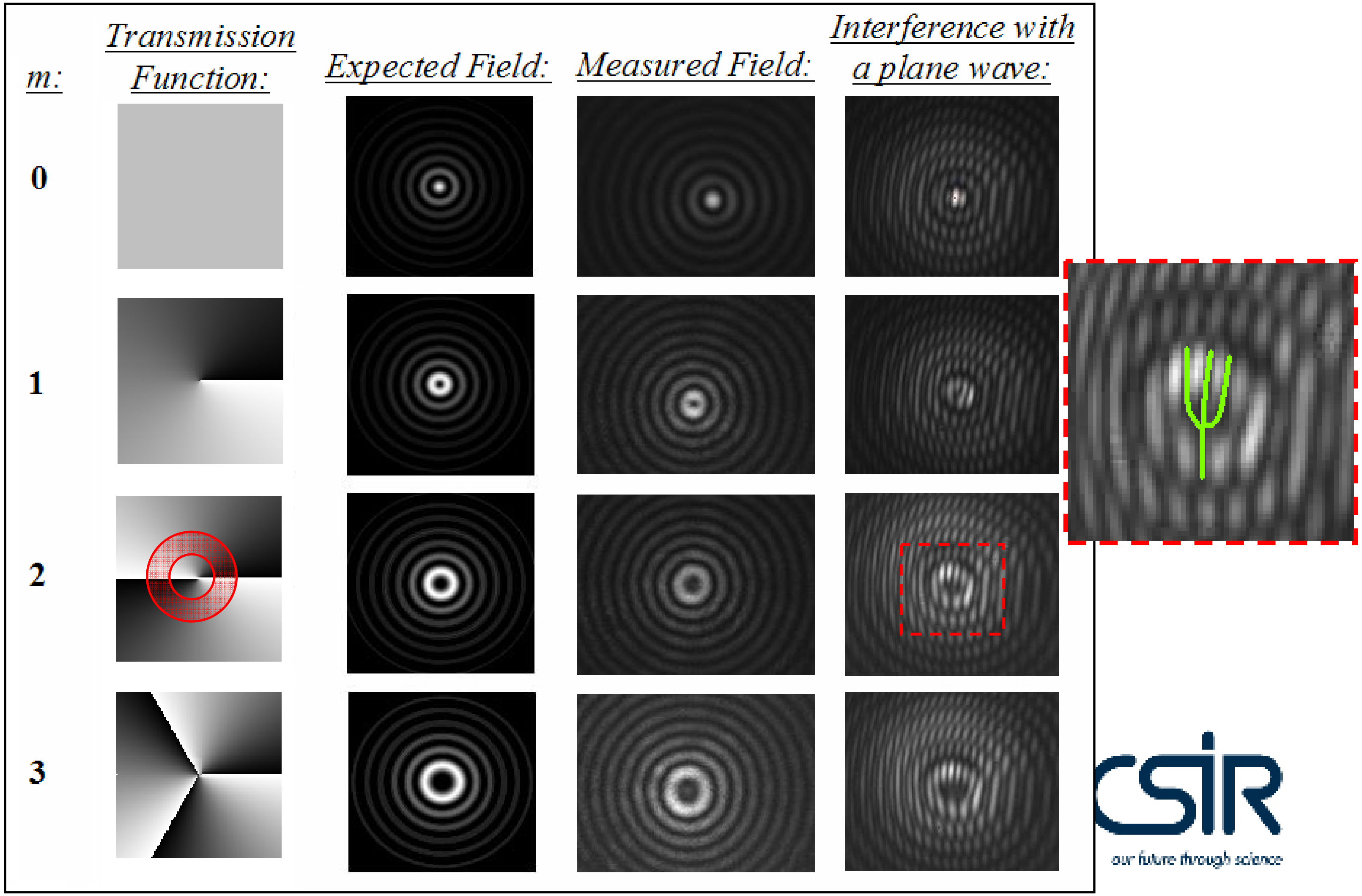
Experimental Results: Single Bessel Field

Transmission Function: $\tau(r,\varphi) = \exp(im\varphi) \quad (R+\Delta) \geq r \geq (R-\Delta)$

Resulting Field: $A_m(r,\varphi,z) \propto J_m\left(\frac{k_0 r}{f}\right)$



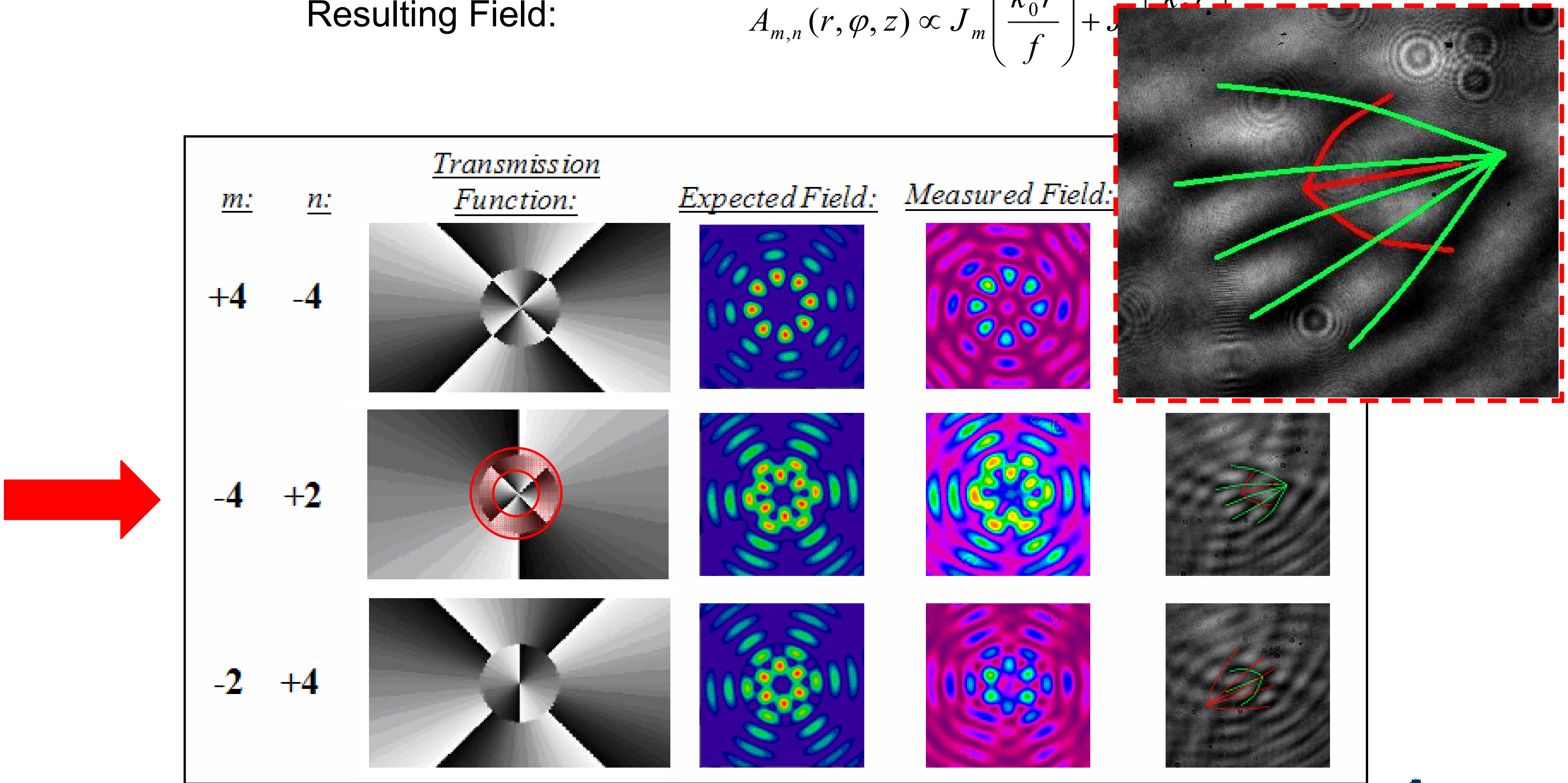
Experimental Results: Superposition of 2 Bessel Fields

Transmission Function:

$$\tau(r,\varphi) = \begin{cases} \exp(im\varphi) & R \geq r \geq (R-\Delta) \\ \exp(in\varphi) & R \leq r \leq (R+\Delta) \end{cases}$$

Resulting Field:

$$A_{m,n}(r,\varphi,z) \propto J_m\left(\frac{k_0 r}{f}\right) + J$$



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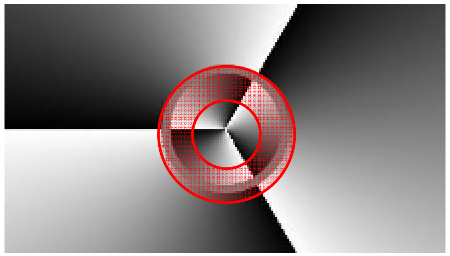
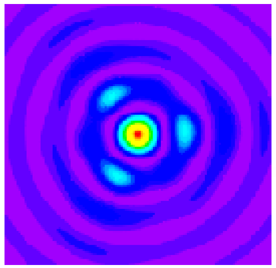
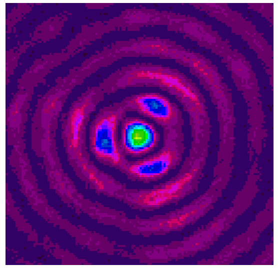
Experimental Results: Superposition of 3 Bessel Fields

Transmission Function:

$$\tau(r,\varphi)=\begin{cases}\exp(im\varphi) & (R-\frac{\Delta}{2})\geq r\geq(R-\Delta)\\ \exp(in\varphi) & (R+\frac{\Delta}{2})\geq r\geq(R-\frac{\Delta}{2})\\ \exp(io\varphi) & (R+\Delta)\geq r\geq(R+\frac{\Delta}{2})\end{cases}$$

Resulting Field:

$$A_{m,n,o}(r,\varphi,z)\propto J_m\left(\frac{k_0 r}{f}\right)+J_n\left(\frac{k_0 r}{f}\right)+J_o\left(\frac{k_0 r}{f}\right)$$

m:	*n:*	*o:*	*Transmission function:*	*Expected Field:*	*Measured Field:*
+3	**0**	**-3**			

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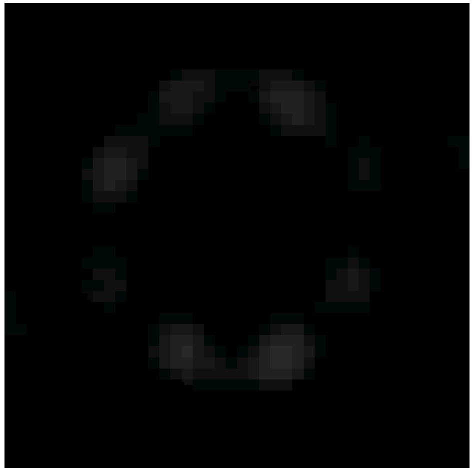
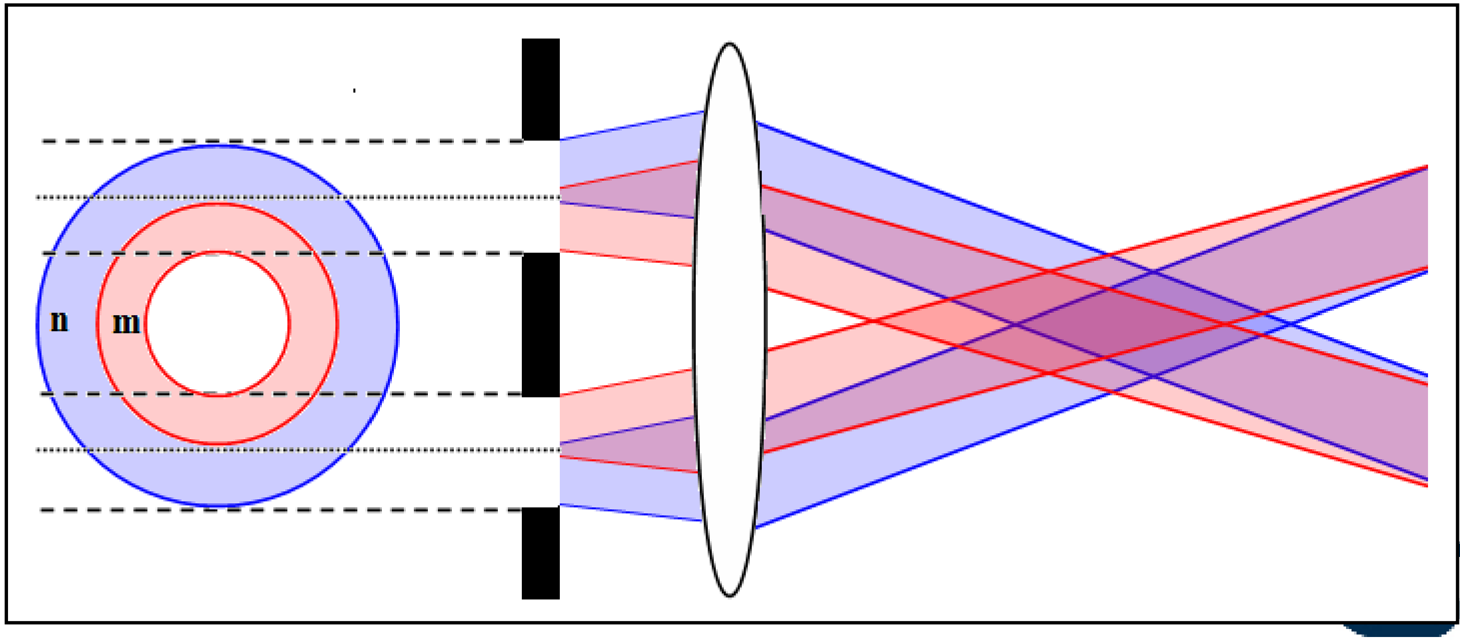
Experimental Results: Propagation





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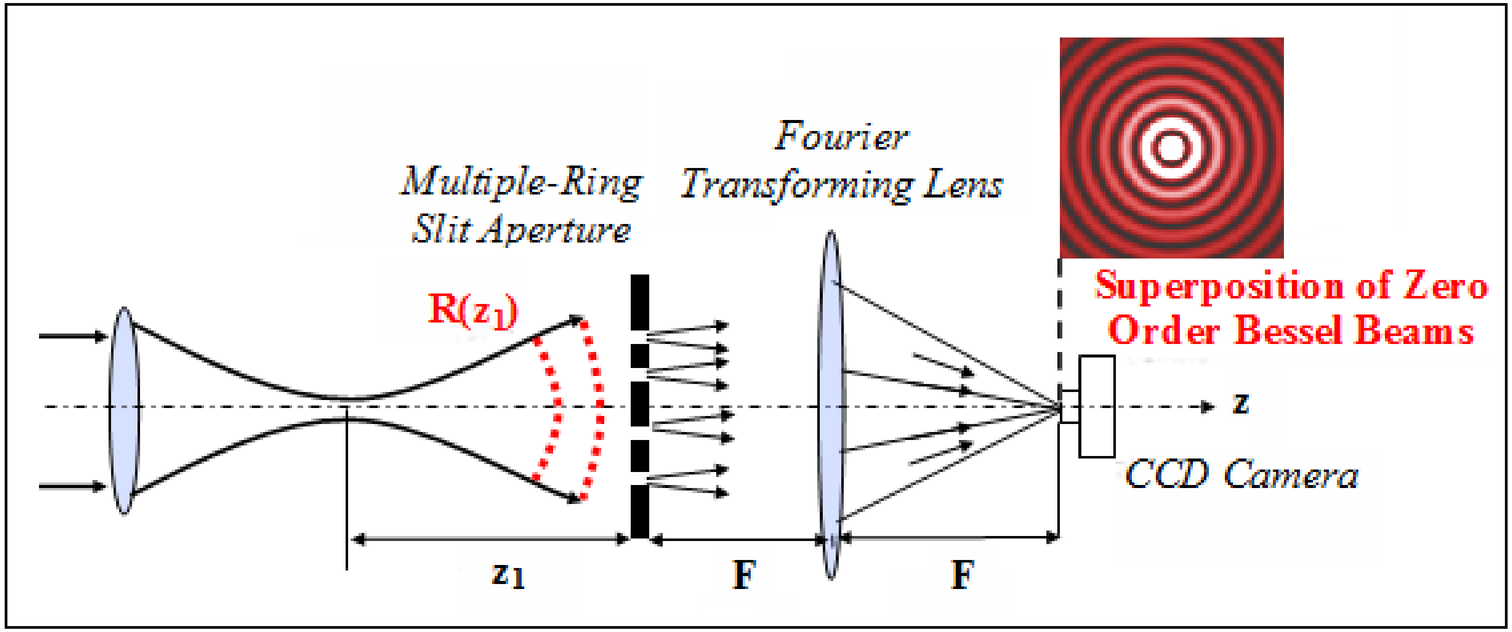
Application: Characterising the radius of curvature by the use of superimposed Bessel fields

The superposition of zero order Bessel beams can be used to measure the radius of curvature of a reflecting surface.

This approach is based on the fact that the intensity distribution of the superimposed Bessel beams is a sensitive function of the relative phases between the constituting beams.



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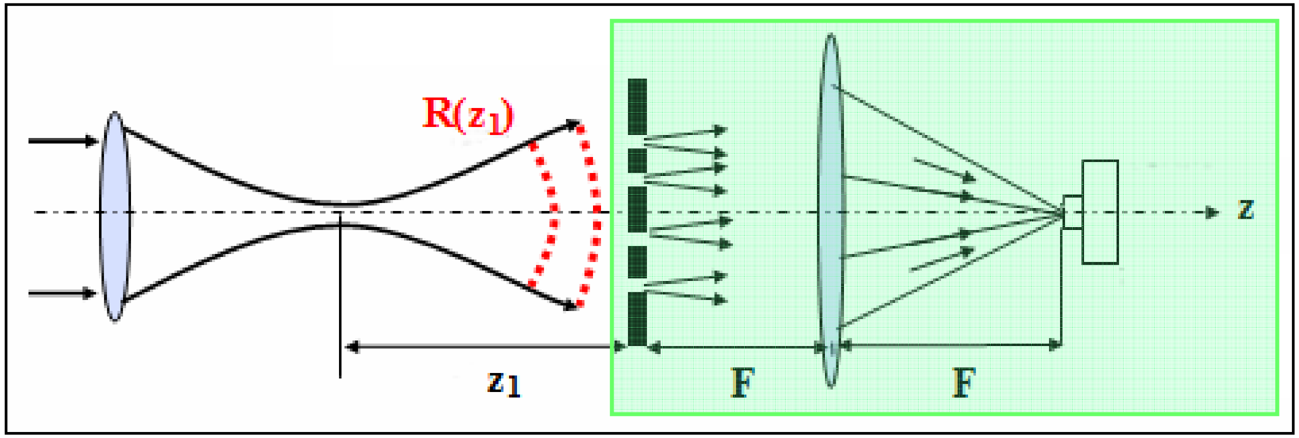
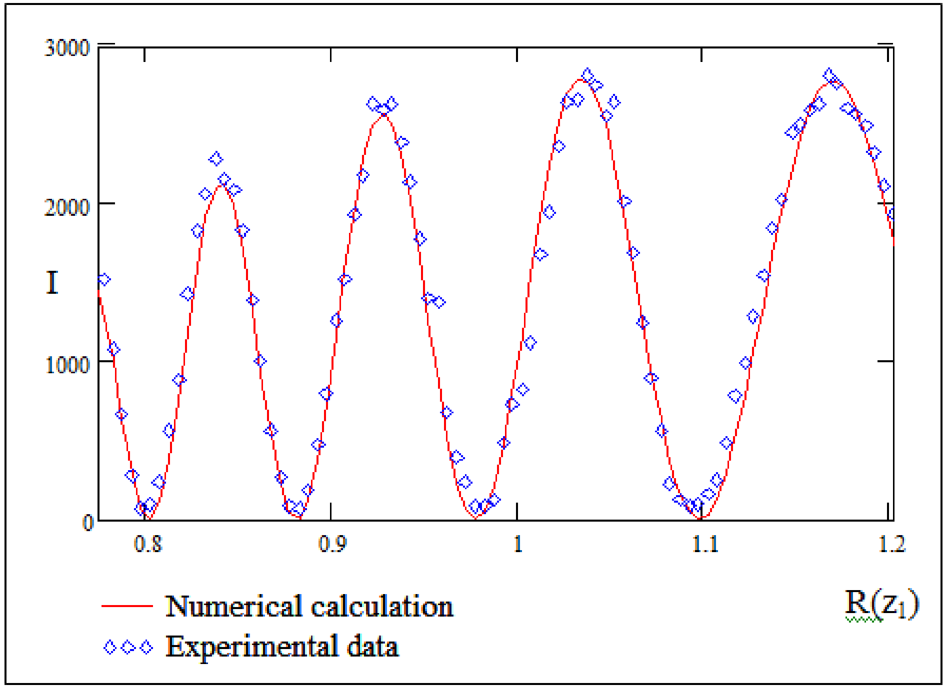
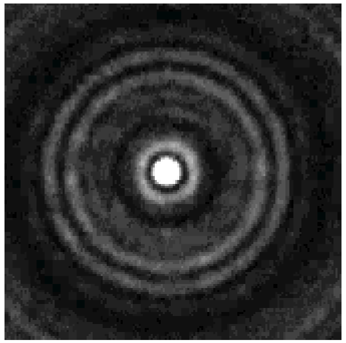
Experimental Setup and Results: Two superimposed Bessel fields







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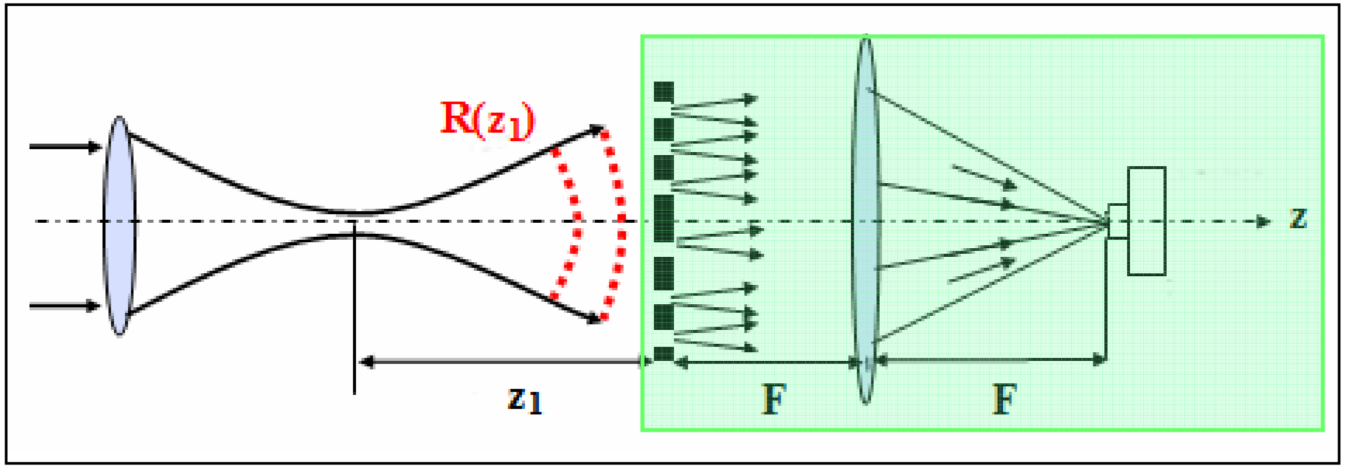
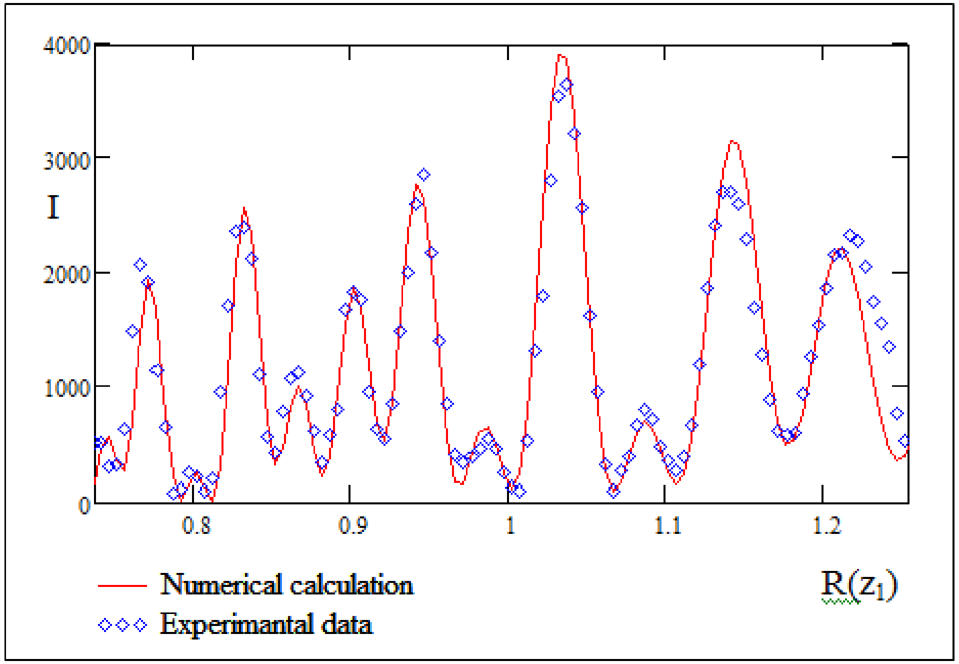
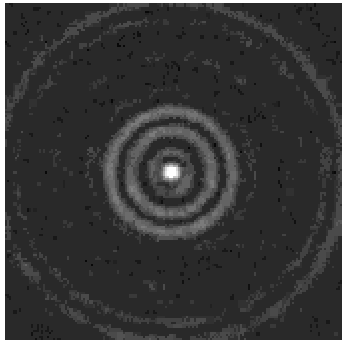
Experimental Setup and Results: Three superimposed Bessel fields







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Thank You

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