Subject: Centroid Shifts: Theoretical Approach Clarifications
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Dear Professor Lusk,

I have a couple questions about the "Theoretical Approach" section of the most recent draft. Just to restate a point that we discussed a couple time in the meeting, there will only be one wave number k_0 that is the magnitude of the $\mathbf{k}$ (wave vector) for all of the plane waves that compose our beam. The interference that creates the beam profile comes from different wave vector directions represented by $\mathbf{\kappa}$. Is this thinking correct?

In the equation $\tilde{\mathbf{E}} = \tilde{E}(f_1\mathbf{u_1} + f_2\mathbf{u_2})$, are f_1 and f_2 just constants and there is no $\mathbf{u_3}$ component because that is the direction of propagation?

How do we solve for f_1 and f_2? It seems that our end goal is $\tilde{\mathbf{E}}_R$ in the form of

$$\begin{aligned}\tilde{\mathbf{E}}_R =& \tilde{E}\Big\{\left[f_1 R^{(\mathrm{TM})} - f_2\kappa_2 \mathrm{Cot}(\theta)(R^{(\mathrm{TM})} + R^{(\mathrm{TE})})\right]\mathbf{u}_1 \\ &+\left(f_2 R^{(\mathrm{TE})} + f_1\kappa_2\mathrm{Cot}(\theta)(R^{(\mathrm{TM})} + R^{(\mathrm{TE})})\right)\mathbf{u}_2 \\ &-\left[f_1 R^{(\mathrm{TM})}\kappa_1 + f_2 R^{(\mathrm{TE})}\kappa_2\right]\mathbf{u}_3\Big\}.\end{aligned} \tag{9}$$

And from this equation with the $R^{(TE)}$ or $R^{(TM)}$ for a single or double interface we can solve for the entire reflected beam after integrating over $d\kappa_1$ and $d\kappa_2$. From the reflected beam we can do the centroid calculations

$$\begin{aligned}\langle u_1\rangle &= \frac{\iint_{\mathbb{R}^2} du_1 du_2 |\mathbf{E}_R(\mathbf{r})|^2 u_1}{\iint_{\mathbb{R}^2} du_1 du_2 |\mathbf{E}_R(\mathbf{r})|^2} \\ \langle u_2\rangle &= \frac{\iint_{\mathbb{R}^2} du_1 du_2 |\mathbf{E}_R(\mathbf{r})|^2 u_2}{\iint_{\mathbb{R}^2} du_1 du_2 |\mathbf{E}_R(\mathbf{r})|^2}.\end{aligned} \tag{14}$$

And to be certain, the centroid shifts that we are talking about are centroids of polarization?

I'm sure I have more questions about further sections, but I believe these clarifications will prepare me to assist Jared in converting our Gaussian beam to a Laguerre Gaussian and calculate centroid shifts with a single interface. If you think there are other sections I should get highly familiar with before getting to this first milestone just let me know, and I will look into them. Thanks for your help.

Best,

Josiah