Thermal expansion calculations:

For a mirror:

I assume the optical axis is $\hat{z}$, for transversal axis I choose y.
For a mirror, we have from Jeremy's paper:

$$R_{\text{th}}^{-1} = -N\frac{\alpha P}{\kappa w^2}$$

And

$$\left[\frac{1}{\text{m}} = \frac{\frac{\cancel{1}}{\cancel{K}} \cdot \frac{\cancel{J}}{\cancel{s}}}{\frac{\frac{\cancel{J}}{\cancel{s}} \cdot \text{m}}{\cancel{m^2} \cdot \cancel{K}} \cancel{m^2}} = \frac{1}{\text{m}}\right] \checkmark$$

$$R^{-1} = R_0^{-1} + R_{\text{th}}^{-1}$$

For a lens:

I will calculate everything for every facet of the lens independently.
Let us start by calculating the relation between the optical length $\xi(y,z)$, [m] and R, n of one facet of the lens:
The facet of the lens is defined be:

$$z^2 + y^2 = R^2 \quad \backslash - y^2$$

$$z^2 = R^2 - y^2 \quad \backslash\sqrt{}$$

$$z = \sqrt{R^2 - y^2} \quad \backslash \text{Simplify}$$

$$z = R\sqrt{1 - \frac{y^2}{R^2}}$$

To leading order this equals:

$$z = R\left(1 - \frac{y^2}{2R^2}\right)$$

Multiplying it be n we get (all is up to an additive constant):

$$\xi = n \cdot z(y) = nR\left(1 - \frac{y^2}{2R^2}\right)$$

And also it is useful to write:

$$\frac{d^2\xi}{dy^2} = \frac{d^2}{dy^2}\left[nR\left(1 - \frac{y^2}{2R^2}\right)\right]$$

$$\frac{d^2\xi}{dy^2} = \frac{n\cancel{R}}{R^{\cancel{2}}} = \frac{n}{R}$$

$$\left[\frac{1}{\text{m}} = \frac{1}{\text{m}}\right] \checkmark$$

An important note is that $\frac{d^2\xi}{dy^2} =\propto n, R^{-1}$, and so if we later find that $\frac{d^2\xi}{dy^2}$ should be increased by a we can either transform $n \to n + aR$ (such that the new $\frac{d^2\xi}{dy^2}$ is

$$\frac{d^2\xi_{\text{new}}}{dy^2} = \frac{n + aR}{R} = \frac{n}{R} + a \tag{1}$$

) or transform $R \to R' = \frac{nR}{n+aR}$ (so that the new

$$\frac{d^2\xi_{\text{new}}}{dy^2} = \frac{n}{R'} = \frac{\cancel{n}}{\frac{\cancel{n}R}{n+aR}} = \frac{n + aR}{R} = \frac{n}{R} + a \checkmark \tag{2}$$

)

more generally, the total optical length is (up to a constant):

$$\xi\left(y\right) = \int\limits_0^{z(y)} n\left(y, z\right) dz$$

Where $z\left(y\right)$ is like before, the location of the end of the lens.
And so ξ can be modified by changing $n\left(y, z\right)$ or by changing $z\left(y\right)$.
As said before, this is the change due to the thermal effects only in one side of the lens:

The change ξ due to the change in n: This size can be expressed as:

$$\Delta\xi_n = \int\limits_0^{z(y)} \Delta n\left(y, z\right) dz = \int\limits_0^{z(y)} \frac{\delta n\left(y, z\right)}{\delta T} \cdot \delta T\left(y, z\right) dz$$

For an approximately constant $\frac{\delta n}{\delta T}$ we can write:

$$\Delta\xi_n = \frac{\delta n}{\delta T} \int\limits_0^{z(y)} \delta T\left(y, z\right) dz$$

The change in ξ due to the change in the thickness of the lens We start by writing an expression for how much the thickness $z\left(y\right)$ changes due to the heating:

$$\Delta z\left(y\right) = \alpha \cdot \frac{1 + \nu}{1 - \nu} \cdot \int\limits_0^{z(y)} \delta T\left(y, z\right) dz \tag{3}$$

$$\left[\mathrm{m} = \frac{1}{\cancel{K}} \cdot 1 \cdot \cancel{K} \cdot \mathrm{m} = \mathrm{m}\right] \checkmark$$

$$\Delta\xi_d = n \cdot \Delta z\left(y\right) = n \cdot \alpha \cdot \frac{1 + \nu}{1 - \nu} \cdot \int\limits_0^{z(y)} \delta T\left(y, z\right) dz$$

Assuming:

$$\int_{0}^{z(y)} \delta T\left(y,z\right)dz \propto \left(T_{\max}-T_0\right)\cdot w\cdot F\left(y,\sigma=w\right) \tag{4}$$

For some dimensionless symmetrical function F with typical width of w, mean of 0, and maximum of w (like $we^{-\frac{y^2}{w^2}}$). The typical width of w is there because the wider the beam is, the wider the heating profile, and the typical height of w is because the wider it is, the deeper the heat will go into the lens before dissipating.

Moreover, $\left(T_{\max}-T_0\right)$ should go like

$$\left(T_{\max}-T_0\right)\propto\frac{\beta P_{\text{Laser}}}{\kappa w_{\text{on lens}}}\Rightarrow$$

$$\left(T_{\max}-T_0\right)=C\cdot\frac{\beta P_{\text{Laser}}}{\kappa w_{\text{on lens}}}$$

$$\left[\mathrm{K}=1\cdot\frac{1\cdot\frac{\cancel{\mathrm{J}}}{\mathrm{s}}}{\frac{\frac{\cancel{\mathrm{J}}}{\mathrm{s}}\cdot\cancel{\mathrm{m}}}{\cancel{\mathrm{m}^2}\cdot\mathrm{K}}\cdot\cancel{\mathrm{m}}}=\mathrm{K}\right]\checkmark$$

Where C is some dimensionless constant, β is the absorption coefficient on the face of the lens $[\beta]=1$, κ is the heat conductivity $[\kappa]=\frac{\frac{\cancel{\mathrm{J}}}{\mathrm{s}}\cdot\cancel{\mathrm{m}}}{\cancel{\mathrm{m}^2}\cdot\mathrm{K}}$, $w_{\text{on lens}}$ is the width of the laser $[w_{\text{on lens}}]=\mathrm{m}$ and P_{laser} is the laser power $[P_{\text{laser}}]=\frac{\mathrm{J}}{\mathrm{s}}$.

Plugging it back to (4):

$$\int_{0}^{\infty} \delta T\left(y,z\right)dz \approx C\cdot\frac{\beta P_{\text{Laser}}}{\kappa \cancel{w_{\text{on lens}}}}\cdot\cancel{w_{\text{on lens}}}\cdot F\left(y\right) \tag{4}$$

$$[\mathrm{K}\cdot\mathrm{m}=\mathrm{K}\cdot\mathrm{m}]\checkmark$$

And so

$$\frac{d^2\Delta\xi}{dy^2}=\frac{d^2\Delta\xi_n}{dy^2}+\frac{d^2\Delta\xi_d}{dy^2}\approx\frac{C\cdot\frac{\beta P_{\text{Laser}}}{\kappa}}{w^2_{\text{on lens}}}\left(\underbrace{\frac{\delta n}{\delta T}}_{\text{change in refractive index term}}+\underbrace{n\cdot\alpha\cdot\frac{1+\nu}{1-\nu}}_{\text{change in thickness term}}\right)=C\cdot\frac{\beta P_{\text{Laser}}}{\kappa w^2_{\text{on lens}}}\left(\frac{\delta n}{\delta T}+n\cdot\alpha\cdot\frac{1+\nu}{1-\nu}\right)$$

$$\left[\frac{1}{\mathrm{m}}=\frac{\mathrm{m}}{\mathrm{m}^2}=1\cdot\frac{1\cdot\frac{\cancel{\mathrm{J}}}{\mathrm{s}}}{\frac{\frac{\cancel{\mathrm{J}}}{\mathrm{s}}\cdot\mathrm{m}}{\cancel{\mathrm{m}^2}\cdot\cancel{K}}\cdot\cancel{\mathrm{m}^2}}\cdot\cancel{\left(\frac{1}{K}+\frac{1}{K}\right)}=\frac{1}{\mathrm{m}}\right]\checkmark$$

Where $\frac{\delta n}{\delta T},\nu,\alpha,n_0,k,P_{\text{laser}},\kappa,w_{\text{on lens}},\beta$ are constants of the system.

Having this, we can substitute back to (1) and (2):

$$n\rightarrow n'=n+aR=n+C\cdot\frac{\beta P_{\text{Laser}}}{\kappa w^2_{\text{on lens}}}\cdot\frac{\delta n}{\delta T}\cdot R$$

$$R\rightarrow R'=\frac{nR}{n+aR}=\frac{nR}{n+\left(C\cdot\frac{\beta P_{\text{Laser}}}{\kappa w^2_{\text{on lens}}}n\cdot\alpha\cdot\frac{1+\nu}{1-\nu}\right)R}$$

The new origin of the sphere will be:

$$z'(0) - R'$$

where $z'(0)$ is the new position of the edge of the lens, which is

$$z'(0) \overset{(3)}{=} z(0) + C \cdot \frac{\beta P_{\text{Laser}}}{\kappa w_{\text{on lens}}^2} \alpha \cdot \frac{1+\nu}{1-\nu}$$