Circular fringes can be observed when an (air) film is formed between a convex and a plane glass surface. A light ray is reflected from the hollow and the plane surface as well. If the phase difference, \(2nf \cdot d(r) = (m+1/2) \cdot \lambda\), there will be constructive interference where \(m\) is an integer.

\[
\mu_m = 10^{-6} \cdot m \quad \text{nm} = 10^{-9} \cdot m \quad k = \frac{2 \cdot \pi}{\lambda}
\]

For the thickness, \(d\), of the film with refractive index, \(n_f\), as a function of the radius, \(r\), we can write approximately:

\[
i, j : 0 \ldots N - 1 \quad x_i := \frac{-\text{size}}{2} + i \cdot \frac{\text{size}}{N - 1} \]

\[
j, j : 0 \ldots N - 1 \quad y_j := \frac{-\text{size}}{2} + j \cdot \frac{\text{size}}{N - 1} \]

\[
r_{i,j} := \sqrt{(x_i)^2 + (y_j)^2} \quad d_{i,j} := \frac{(r_{i,j})^2}{2 \cdot R}
\]
The phase becomes: \( \Delta \phi := 2 \cdot n_f \cdot d \cdot k \)

Because of the internal reflection from the air-glass interface we have to add \( \pi \) radians to the phase:

\[ \Delta \phi := \Delta \phi + \pi \]

We substitute the phase in the field: \( F_1 := \text{LPBegin} \left( \frac{s}{m}, \frac{\lambda}{m}, N \right) \).

\( F_1 := \text{LPSubPhase} \left( \Delta \phi, F_1 \right) \) to obtain the field reflected from the hollow surface of the convex lens.

Next we define a second field, \( F_2 := \text{LPBegin} \left( \frac{s}{m}, \frac{\lambda}{m}, N \right) \), reflected from the plane surface and add it to \( F_1 \): \( F := \text{LPBeamMix} \left( F_1, F_2 \right) \).

Finally we calculate the intensity and observe the fringes:

\( I := \text{LPIntensity} \left( 2, F \right) \)
Interference pattern, or Newton’s rings, by reflection just above the lens.

If the transmitted light is observed there will be a bright spot in the middle because in that case there is no extra \( \pi \) radians phase shift. This can be observed by deleting the extra addition of \( \pi \) to the phase.