**Colour code:**

Known.

Not known. (Please see the bottom of page 2 and the top of page 3.)

**Equations concerning the medium**

**Material discontinuity:**

: Unit vector in the direction of the refracted ray.

: Ratio of refractive indices; Units: 1.

: Complex refractive index of the medium surrounding the unit lenses.

: Complex refractive index of the unit lens material (the P-doped Si).

: Unit vector in the direction of the incident ray.

: (Just a help variable.)

: Angle of incidence. Units: .

: Angle of refraction. Units: .

: Unit vector normal to the material discontinuity.

: Transmission coefficient, parallel (p) polarised.

: Transmission coefficient, perpendicular (s) polarised.

: th principal wavefront curvature of refracted rays defined for direction . Units: .

: th principal radius of curvature of the refracted rays. Units: .

: th principal wavefront curvature of incident rays. Units: .

: Vector tangent to incident wavefront.

: th principal curvature of the surface of the unit lenses. Units: .

: Off-diagonal element in the wavefront curvature tensor of the refracted rays. Units: .

: Off-diagonal element in the wavefront curvature tensor of the incident rays. Units: .

: Off-diagonal element in the curvature tensor of the surface of the unit lenses. Units: .

: th principal wavefront curvature of refracted rays defined for direction . Units: .

: th principal radius of curvature of the refracted rays. Units: .

: th principal wavefront curvature of incident rays. Units: .

: th principal curvature of the surface of the unit lenses. Units: .

**Equations concerning the rays**

**Release rays from grid:**

**:** Wave vector of the rays; Units: .

: Wave number of the rays in vacuum. Units: .

: frequency of the rays in vacuum. Units: .

: Speed of light in vacuum, .

: Initial ray direction vector; .

**Ray properties (Monochromatic, 23.0 keV):**

**Initial conditions:**

* Unpolarised plane wave.

**Geometric optics:**

Units:

: time since the rays were released. Units: .

: Angular frequency of the rays; Units: .

: Ray position vector; Units: .

**Ray properties:**

“*In 3D models [such as the one used in this work], each ray is treated as a wavefront for which two principal radii of curvature, and , are defined*” (COMSOL Inc., 2018).

; Units:

: Initial Stokes parameter i; Units: .

: the imaginary part of the refractive index.

: Stokes parameter i; Units: .

: First initial principal radius of curvature of the rays; Units: .

: Second initial principal radius of curvature of the rays; Units: .

, within the unit lenses.

and : First and second principal radii ~~of curvature of the rays~~, “*which represent the maximum and minimum radii of curvature of the intersection of the wavefront with an arbitrary plane*” (COMSOL Inc., 2018); Units: .

: Distance that the rays have travelled; Units: ? Ray trajectory?

, within the unit lenses.

**Deposited ray power:**

; Units:

In this expression every ray is treated as an infinitesimally small point source.

: Heat power deposited into the unit lenses due to the rays; Units: .

: The amount of power lost by ray as it transfers power into the unit lenses.

: Total number of rays.

: Summation index for the rays.

: Position vectors of points that constitute the unit lenses; Units:

: Position vector of ray ; Units: .

: Dirac delta function.

**Ray termination:**

If or , disappear

: Power of any ray that is being simulated. Units: .

: Threshold/minimum power of the rays for them to be simulated. Units: .

: Intensity of any ray that is being simulated. Units: .

: Threshold/minimum intensity of the rays for them to be simulated. Units: .

**Equations concerning heat transfer**

**Ray heat source (Multiphysics):**

(Same equation as that for Deposited ray power.)

**Heat transfer in solids:**

; Units: 🡪 🡪 🡪 🡪

: Mass density of the material (the P-doped Si). Units: .

: Heat capacity of the material (the P-doped Si) at constant pressure. Units: .

: Fluid Velocity field of the unit lenses; Units: . The x, y and z components of all equal 0 because the unit lenses were in solid phase.

: Temperature of the material (the P-doped Si). Units: .

: Gradient vector of the surface normal; Units: .

: Conductive heat flux vector; Units: .

(The unit lenses are a continuous medium)

: Thermal conductivity of the material (the P-doped Si). Units: .

: Temperature gradient in the direction of the surface normal vector . Units: .

: Heat source for the Heat Equation; Units: .

: Thermoelastic damping in the unit lenses. Units: .

**Thermal insulation of the right-side faces of the unit lenses:**

: The vector normal to each face.

**Surface-to-ambient radiation:**

**:** Radiative heat flux; Units: .

: Surface emissivity of the material (the P-doped Si).

: Stefan-Boltzmann constant.

: Ambient temperature.

**References**

COMSOL Inc. (2018). *Ray Optics Module User's Guide*, 5.4 ed. Internet: COMSOL Inc.