Semi-riemannian approach to nonimaging optics.

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Nonimaging optics is a field that study optimal concentration of light from a source distribution to a receiver. The interest is to reach the maximum intensity, not image formation. One of its main applications is the design of Solar concentrators.

The relevant information is codified by a field of cones, formed by those rays that we want to reach the receiver (perhaps after some reflections on the wall of the concentrator). Mathematically it can be determined by giving the set of admissible light rays at each point of the aperture surface (usually a plane disc), the equation of the wall of the concentrator, formed by a mirror, and the equation of the receiver where the concentration of light achieves a maximum. At each point inside the concentrator the set of admissible light rays is determined by a cone in the tangent space at that point, and it is possible to determine the concentrator using Lorentz geometry.

Every light ray passing through a point p which is tangent to the cone in p must be a straight line in $\mathbb{R}^3$. This may be described by a coupling between a Lorentz metric g with the euclidean metric δ satisfying the so called restricted optical condition; *every lightlike geodesic of the lorentz metric must be an euclidean geodesic*. If ∇ is the Levi-Civita connection of g and $\overline{\nabla}$ of δ, the above condition is $\nabla_X Y - \overline{\nabla}_X Y = g(X,Y)F$ for every $X, Y \in \mathcal{X}(M)$, being $F \in \mathcal{X}(M)$ a fixed vector field.

It is a system of partial differential equation whose solutions include a family of Lorentz metrics in a suitable open set M of $\mathbb{R}^3$. If G is the matrix of the Lorentz metric in the canonical coordinate basis, then the surface $\left|G^{-1}\right| = 0$, called virtual entry aperture, contains the receiver surface.

The concentrators obtained with this technique which in addition have rotational symmetry, are classified due to the fact that the surfaces $\left|G^{-1}\right| = 0$ are confocal quadrics and they fully determine the concentrators.

For practical proposals, those solutions are optimal in the sense that they achieve the theoretic limit of concentration and are easy to manufacture; they have rotational symmetry and constant refractive index.