Optical tomography on simple Riemannian manifolds

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Abstract

Optical tomography refers to the use of near-infrared light to determine the optical absorption and scattering properties of a medium. In the stationary Euclidean case the dynamics are modeled by the radiative transport equation, which assumes that, in the absence of interaction, particles follow straight lines. Here we shall study the problem in the presence of a (simple) Riemannian metric where particles follow the geodesic flow of the metric. This non-Euclidean geometry models a medium which has a continuously varying refractive index. We will present results for all dimensions $n \geq 2$, but will focus on the more delicate and interesting problem in dimension two where the geometry is more apparent. We show that knowledge of the albedo operator, that which maps incoming flux to outgoing flux at the boundary, uniquely determines the absorption and scattering properties of the medium. In dimensions three and higher we assume prior knowledge of the metric while in dimension two it can be shown that the albedo operator also determines the metric.