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Inversion of the transverse mode calculation problem in laser resonators

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Instead of calculating the transverse modal shape for a given resonator configuration, we invert the problem and ask whether a cavity can be designed which supports a given transverse modal structure. This possibility can be advantageous in the design of optical resonators optimized for a given amplifying medium, by matching the geometrical properties of the mode with the gain and saturation profiles of the amplifier. Mode shaping is also of importance when a definite profile is required for the outgoing beam related to a definite application like machining or coupling to a fiber or other device. A formalism was developed based on the Orthogonal Collocation Method. The formalism is based on the expansion of the field in a set of orthogonal functions of number M , for which the propagation properties of each of its composing elements are known. Sampling the field at M special points (collocation points) results in the generation of an orthogonal $M \times M$ matrix which describes the propagation of a wavefront on a resonator round-trip. By suitable matrix operations, like diagonalization, the fundamental and higher order modes are obtained, but more important, the inverse problem can be solved, namely, the synthesis of a suitable optical element of graded transmissivity or reflectivity, which will ensure that the cavity will support a pre-described transverse mode shape. Examples will be given for generating mode patterns by grading the amplitude and/or the phase of mirrors.