We demonstrate that within the paraxial ray approximation the propagation of light through a complex optical system can be formulated in terms of a Huygens principle expressed with the complete system’s ABCD-matrix elements. As such, propagation through an optical system reduces to that of calculating the relevant matrix elements and substituting these into the expressions derived here. We have introduced complex-valued matrix element to represent apertures, thus having diffraction properties inherent in the description.

We have extended the treatments of Baues and Collins to include partially coherent light sources, optical elements of finite size, and distributed random inhomogeneity along the optical path. In many cases (e.g., laser beam propagation and Gaussian optics) we have been able to derive simple analytical expressions for the optical field quantities at an observation plane.

A series of laser-based optical measurement systems have been analyzed and analytical expressions for their main parameters have been given. Specifically, scattering from rough surfaces not giving rise to a fully developed speckle field, various anemometers and systems for measuring rotational velocity have been treated in order to show the benefits of the complex ABCD matrices.