1998 rok Zatgamik nr 16

Complex geometrical optics application to the gaussian light beam Raman-Nath diffraction description

R. J. Bukowski
Institute of Physics, Silesian Technical University, ul. Krzywoustego 2, 44-100 Gliwice, Poland

ABSTRACT

The description of the gaussian light beam diffraction on the planar ultrasound wave in Raman-Nath region by complex optical rays method is presented in this works. The case of the perpendicular light beam incidence (i.e. its axis) relatively to the direction of propagation of the ultrasound beam of Δz width was considered. The influence of such parameters as a size and position of the gaussian beam waist, a laser-screen (detector) distance, a position of the ultrasound beam and Raman-Nath parameter value on diffraction pattern was analysed. That was proved that in some cases the diffraction beams have a fine structure. The final analytical formulas were illustrated by some graphs of the light intensity distributions in beams diffracted on ultrasound waves propagated in water.

Keywords: Raman-Nath diffraction, complex geometrical optics, gaussian light beams, geometrical optics of nonhomogeneous media, perturbation calculus.

1. INTRODUCTION

Light beams with the gaussian profile of the light intensity distribution are widely applied in scientific and commercial devices. It is caused by their unique properties, in which are small angular divergence, stability, disturbances missing in many optical systems. Because of that properties the theoretical description of the gaussian beams propagation is relatively simple.

When the gaussian beam is propagated in optically nonhomogeneous medium the situation is more complicated. I that case the intensity distribution in beam profile can undergo essential change. These changes contain an information, which may be very important. This situation we have, e.g., in acoustooptical interactions or in photothermal investigations with photodeflectional detection (mirage effect).

The full description of the gaussian beam propagation in that conditions need the wave optics law applications, i.e. the appropriate wave equation solution. In many cases the exact solutions of that equation are unknown. In this situation approximative methods become very important. For acoustooptical interactions many effective methods for wave equation approximate solution were worked out, especially for different particular cases, as e.g. Raman-Nath interaction or Bragg interaction. These methods went into acoustooptics theoretical grounds and it may be found in many school-books[1, 2, 3]. It must be marked that these methods are mathematically complicated in general, especially when they are used for the description of wave beams with complex amplitude and phase distributions interaction.

Mentioned above approximative methods for acoustooptics wave equations solutions were applied already in first works on this topic, e.g.[4, 5]. Independently of that at initial stage of acoustooptics evolution the geometrical optics methods were used too, e.g. in one of the first work[6]. That work and another ones similar to that are discussed in books[7, 8]. Because of wave theory successes the geometrical optics methods were forgotten for many years. But in last years an important progress in geometrical optics was attained. Thanks to that these methods become competitive relatively to "exact" wave optics methods, especially for problems, in which approximative methods for wave equation solution are used (because of different reasons).

In present work, geometrical optics method for Raman-Nath acoustooptical interaction description was used. In first part of that work the geometrical optics fundamental equations[9, 10, 11] for homogeneous and nonhomogeneous media are discussed. Next, these equations are used for gaussian beam propagation description in medium disturbed by the plane ultrasound wave