Modeling the formation of contour laser beams

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Introduction

Laser radiation has found wide application in various fields of science and technology, for example, this technology has found its application for cooling atoms, manipulating particles, and processing materials [1, 2]. The possibility of designing optical elements that allow controlling the optical flow opens up promising new prospects for the use of laser radiation [3, 4].

There are situations when there is a need to concentrate radiation in narrow contour areas. To solve this problem, polymorphic contour bundles can be used [3, 4], as well as diffraction optical elements focusing into specified 2D and 3D curves [6-9].

The expected applications of polymorphic contour beams include single-pulse laser lithography, laser surface microtreatment, and photo production of structures for fabrics of engineering frames or other complex structures, transportation of particles along programmed trajectories.

Modelling

At first stage we will set the curve that we want to get in the focal plane.

To set and draw a certain specified curve, a developed program uses the Super Formula[10]: $R(t) = p(t)\left[\left|\frac{1}{a}\cos\left(\frac{m}{4}t\right)\right|^{n_2} + \left|\frac{1}{b}\sin\left(\frac{m}{4}t\right)\right|^{n_3}\right]^{-\frac{1}{n_1}}$,

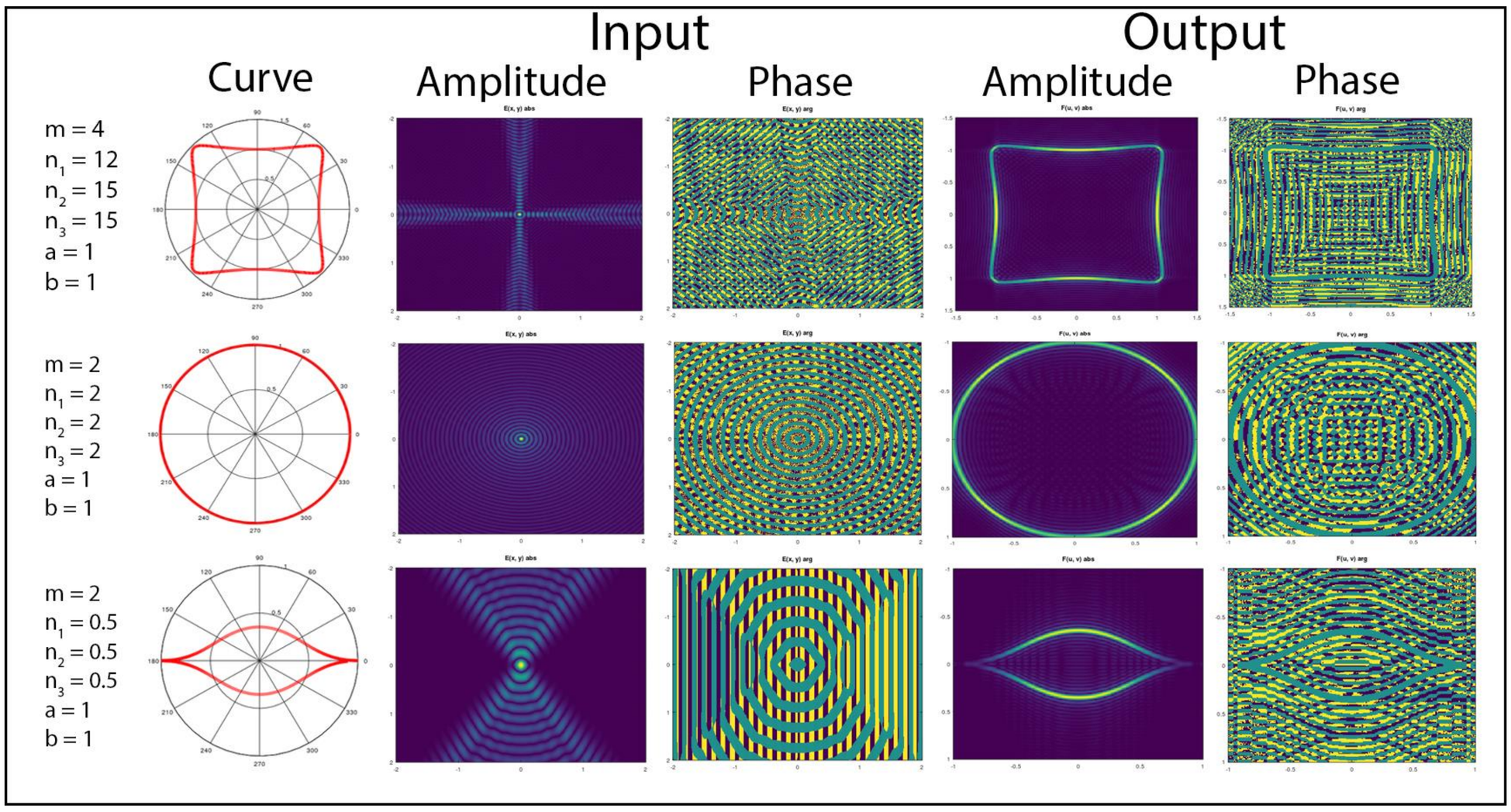
where m is an integer number, parameters a, b, n_1, n_2, n_3, m determine the periodic part of the curve, the function $p(t)$ is the function that is responsible for the asymmetric part, t is the polar angle.

To generate a complex field we use the Whittaker integral [3]: $E(x,y) = \int_0^T g(t)\exp\left[-i\frac{k}{f_0}R(t)(x\cos t + y\sin t)\right]dt$,

where the parameter T defines the maximum value of the azimuth angle t, $k = \frac{2\pi}{\lambda}$, λ is the radiation wavelength, f_0 is the focal length of the lens, $R(t)$ and $g(t)$ are parametric functions describing the shape of the curve and the distribution on the curve, respectively.

To model curve formation we use the Fourier transformation: $F(u,v) = \iint_\Omega E(x,y)\exp\left[i\left(\frac{2\pi}{\lambda f_0}\right)(xu + yv)\right]dxdy$,
where $\Omega : x^2 + y^2 \le R_0$, R_0 is the maximum of field size.

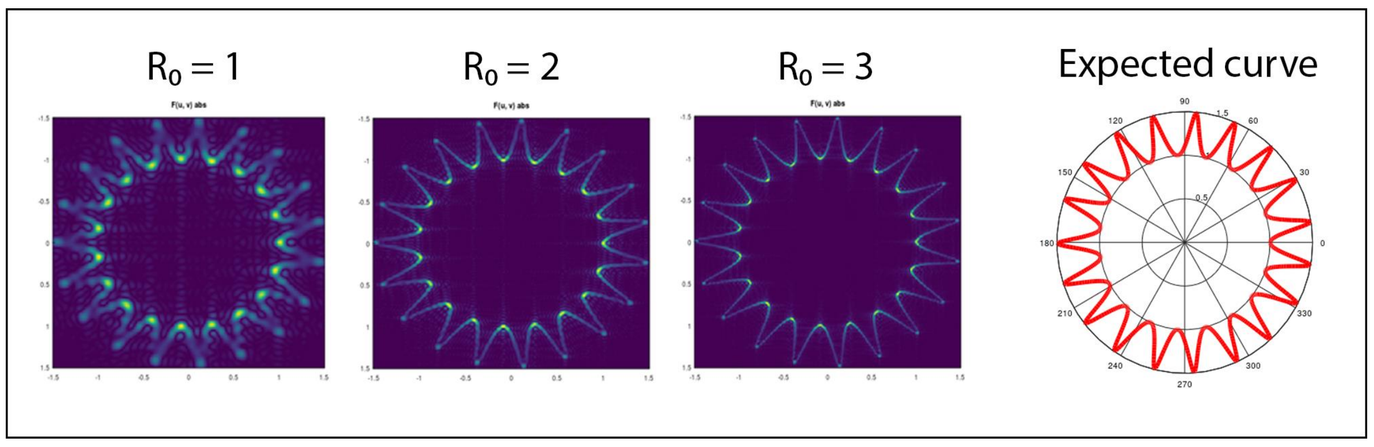
Fig 1. Results of modeling



Investigation

We investigate the effect of the input field size R_0 on the output field, especially on the amplitude.

Fig 2. Results of investigation



Based on the conducted research, it is concluded that the larger the size of the input field, the more accurate the output curve will be.

Conclusion

In this paper, considered and demonstrated approach to model the formation of polymorphic beams by using Super Formula, Whittaker integral and Fourier transformation. Investigations showed that the larger the size of the input field, the more accurate the output curve will be.

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