Montgomery Interferometer with complementary phase gratings

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As a continuation of earlier research [1] we investigate the self-imaging effect in a general form, based on Montgomery’s theory for periodic wave fields. The objective is to construct an interferometer, that may serve as a tapped delay line filter for the shaping of very short time signals in the range of femtoseconds. The advantage of the new design, compared with the Talbot interferometer, is the linear time-behaviour of the interferometer. One possible application is an equalizer in long distance optical transmission lines.

The result of the Montgomery theory [2] is that any optical element can create periodic wave fields in the propagating direction, if only the far field shows the characteristic Montgomery ring pattern on the whole or partial; see also [3]. An example for this pattern is shown in fig. 2 left. This pattern serves as input for an iterative Fourier transform algorithm (IFTA), that yields pixel patterns for complementary phase gratings, consisting of \(513^2\) pixels each sized \(8 \times 8\) (\(\mu m\))^2. The four-level gratings then are fabricated with the help of our clean-room facilities.

For Montgomery phase gratings, one observes a complex amplitude identical to that of the object at distances \(\Delta z = M z_M\) behind the element where \(z_M\) is the Montgomery distance. The idea for our experimental setup was, to illuminate two complementary phase gratings separated by \(\Delta z = z_M\) with a plane wave. If both gratings are properly aligned, a plane wave should again emerge behind the second grating.

Our first experiment verifies this prediction. Fig. 1 shows the setup for the test of two complementary phase gratings. Behind the second element the plane wave is collimated by a lens. In the focus we observe the predicted spot (Fig. 2 right). The calculated Montgomery distance for our design was \(z_M = 9.105\) mm, confirmed by the measurement with the value 9.1 mm.

