Simulation of a quad-silts interferometer for measuring the transverse beam size in HLS-II

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Abstract: A quad-slits interferometer using visible light is designed to measure the transverse beam size of Hefei Light Source-II (HLS-II). According to the basic beam parameters of the B7 source point, the preliminary simulation results are obtained by using the Synchrotron Radiation Workshop (SRW) code. Furthermore, the core parameters of the quad-slits components in the interferometer are optimized. Among, the optimum slits-separations of d_H and d_V are acquired to be 6.0 and 10.0 mm, respectively. It is shown that the simulated results are consistent with the theoretical values, which provides a reference value for performing the related experimental measurement in the future.

INTRODUCTION

It is known that the synchrotron radiation (SR) refers to the electromagnetic wave radiated when the acceleration state of the charged particles changes. So far the SR light source has been widely used in the fields of condensed-matter physics, medical research, biochemistry, materials and advanced manufacturing processes due to its significant characteristics of high-brightness, high polarization and good stability. With the advancement of accelerator science and technology, the transverse beam size becomes smaller and smaller and reaches few dozens of micrometers. There is no doubt that it requires a huge engineering challenge to accurately measure such a small beam size. The current mainstream technology for the measurement of the transverse beam size is to employ the SR optical system. It is especially pointed out that this SR system has the excellent advantage of real-time and online measurement without damage to the stored bunched beam [1]. Up to now, the traditional methods for measuring the transverse beam size include FZP imaging [2], double-slits and quad-slits interferometry [3,4], pinhole imaging [5] and so on [6,7]. Among them, the FZP imaging method is considered as uneconomical because of the smaller beamline layout in HLS-II and the expensive optical diffractive element FZP. As for the pinhole imaging method, it is difficult to measure the small transverse beam size owning to the inevitable optical diffraction effect. In addition to the double-slits interferometer proposed by T. Mitsuhashi [8], which possesses high resolution that can be used in visible light and even X-ray bands. In combination with the remarkable merits of the optical interference measurement system, the B7 beamline of HLS-II has been achieved the online measurement of the transverse beam size. This previous double-slit interferometry occupies a large space and has a high maintenance cost. In order to further precisely obtain the beam size of B7 source point, we are devoted to designing a simple suitable quad-slits interferometer which can reduce the complexity of the optical system.

principle and physical design

1.Theoretical calculation of transverse beam size

$$\begin{cases} \sigma_x^2 = \varepsilon_x\beta_x + \left(\eta_x \dfrac{\Delta p}{p}\right)^2 \\ \sigma_y^2 = \varepsilon_y\beta_y \end{cases}$$

2.Measurement equation

$$\sigma = \frac{\lambda q}{\pi d}\sqrt{\frac{1}{2}ln\left(\frac{1}{V}\right)}$$

3.Fitting equation $I(x) = a_0 + a_1 sinc^2(a_2\,x + a_3)[1 + a_4 cos\,(a_5 x + a_6)]$

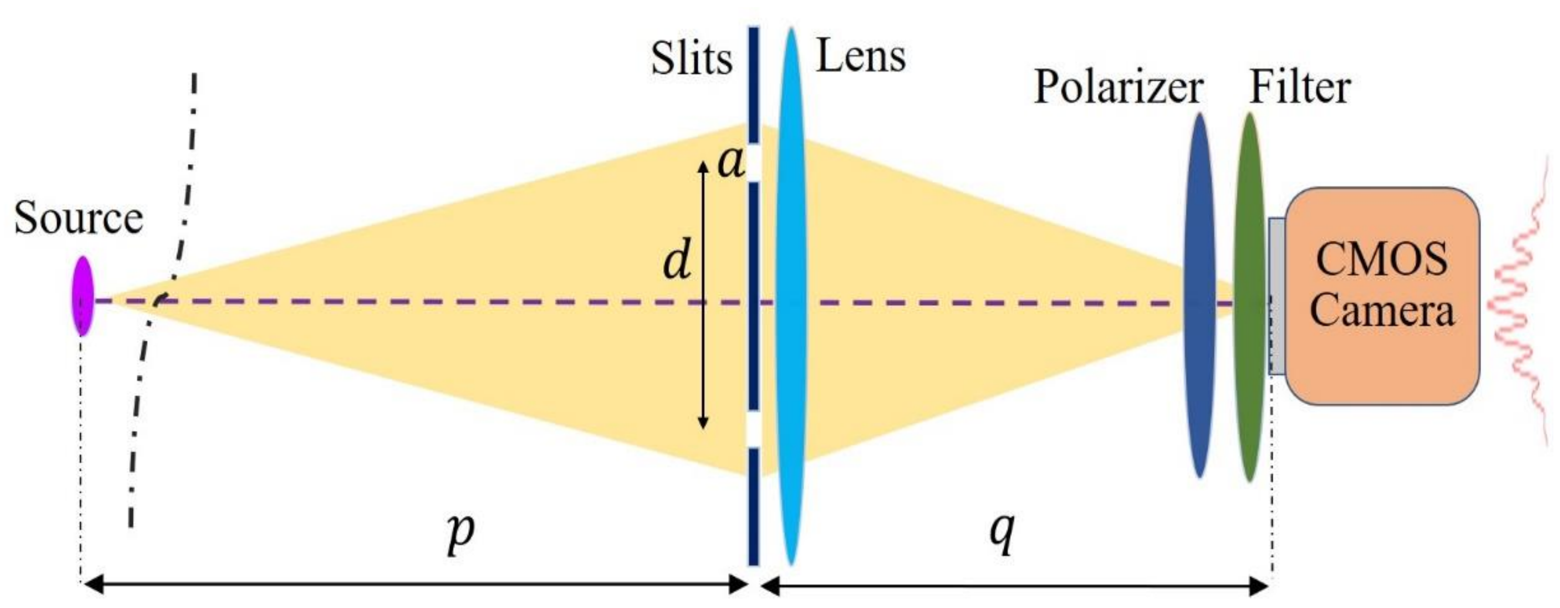

Fig. 1: The optical path layout of the quad-slits interferometer.

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SIMULATION RESULTS

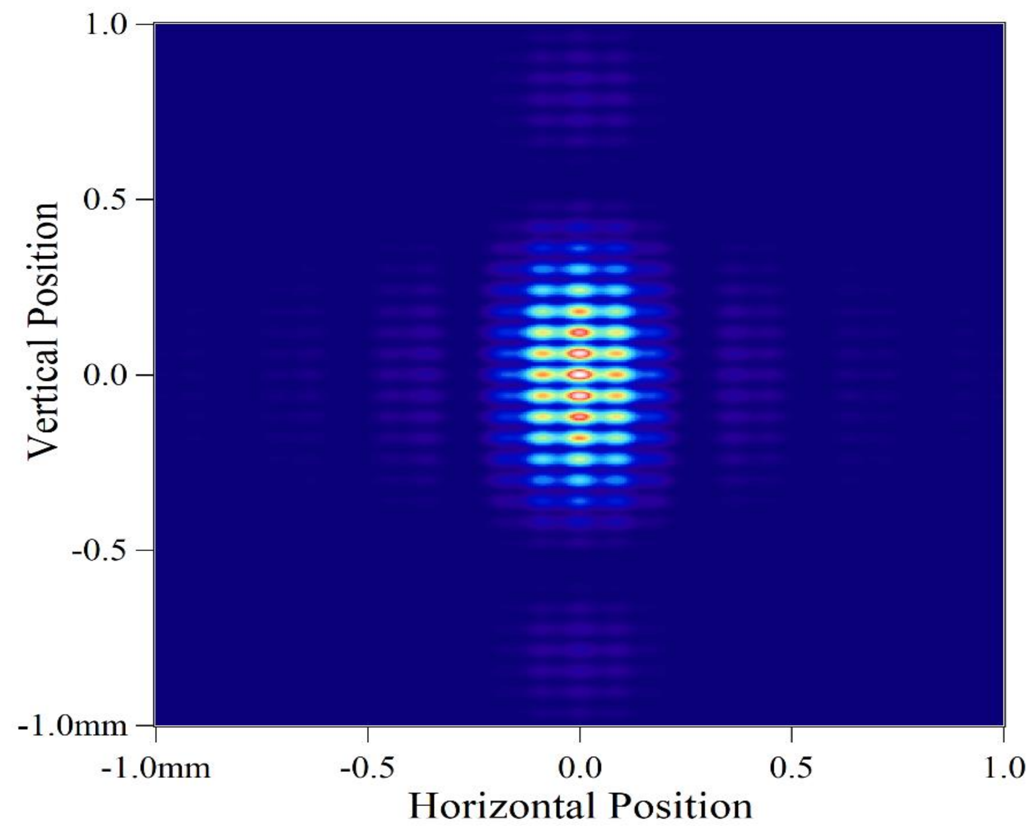

Fig. 2: Simulated interferogram of the quad-slits interferometer.

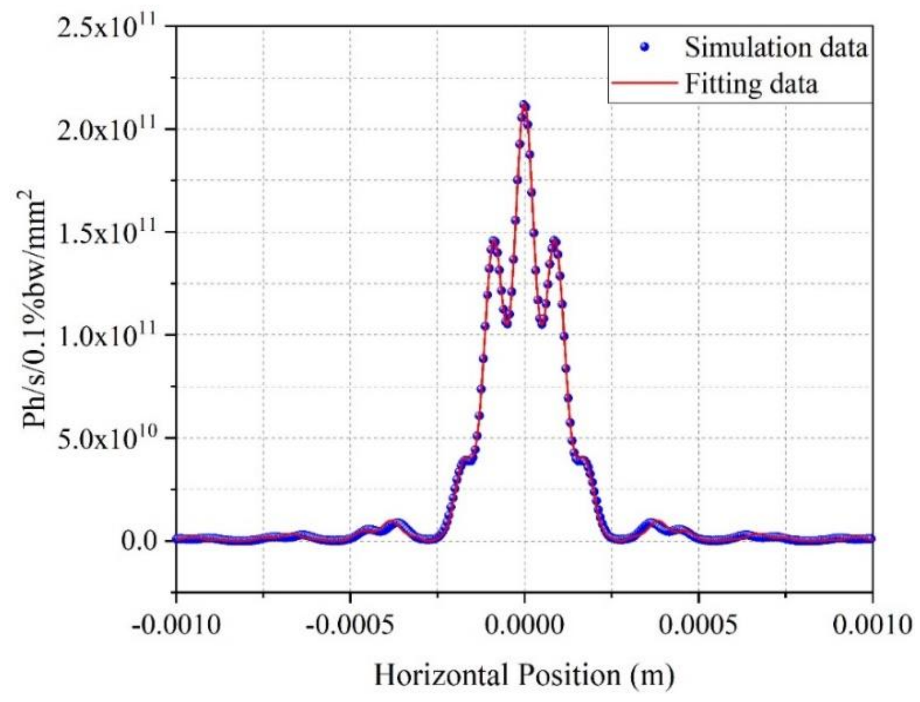

Fig. 3: Data fitting in the middle of the horizontal interferogram.

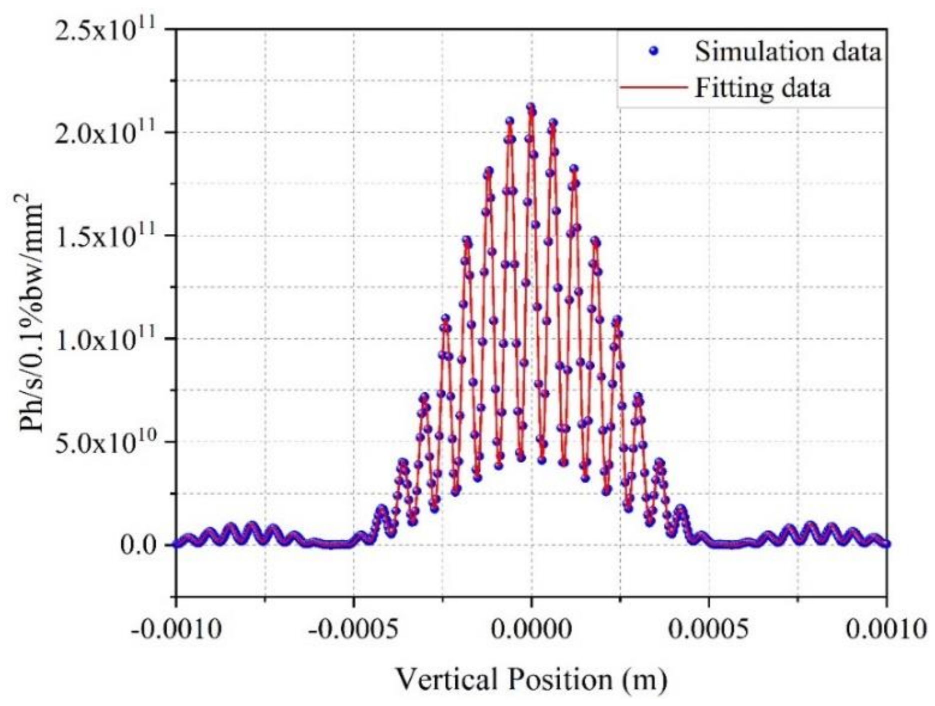

Fig. 4: Data fitting in the middle of the vertical interferogram.

CONCLUSION

In this paper, a quad-slits interferometer using visible light was proposed according to the characteristics of the light source. And then, the SRW code is used to obtain the intensity distribution of B7 source point based on the relevant machine parameters of HLS-II. The simulation results of the horizontal and vertical size are obtained as 249.90 and 84.78 μm, respectively. This is of guiding significance to the subsequent optimization and improvement of the experimental measurement system performance. In the next research work, we will further verify the reliability and applicability of the designed interference measurement system.

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