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Observation of the mutual coherence of spontaneous radiation from two undulators separated by an achromatic bend

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Upgrading of the magnetic system of the optical klystron at the VEPP-3 storage ring has made it possible to realize an achromatic bend for electrons between two undulators. The mutual coherence of the radiation from the undulators in the case of such a dispersionless bend has been demonstrated by means of Young's interference method.

In our previous paper [1] we have theoretically treated the conditions for the mutual coherence of radiation from two undulators separated by a system which bends the electron beam at some angle. The achromaticity of such a bend has been proved to be of significance. The present paper is aimed at an experimental realization of such a scheme on the basis of the already operating magnetic system of the optical klystron installed at VEPP-3 [2,3].

For our purposes, we have chosen the scheme comprising four short magnets and a focusing lens (fig. 1). Since there is no sufficient free space between the undulators we have to use half of each undulator for the achromatic bend (fig. 2), i.e. in the middle of each undulator U1 and U2 we have placed the steering coils M2 and M4, each being able to bend electrons by a maximum angle of 4 mrad; besides, between the undulators, near the magnetic buncher, we have placed a quadrupole lens which focuses in the achromatic bend plane (i.e. along the horizontal) with a focal distance $F = 360$ cm. The steering coil M3 of the magnetic buncher is used instead of two of the magnets shown in fig. 1. Thus, the magnets which are to produce the η-function in the lens are half the undulator length ($L = 3.4$ m) away from each other, i.e. they are 1.7 m apart. In accordance with the focal distance of the lens, the maximum possible angle of the achromatic bend (limited by the deflection angle of the steering coils) is $\theta_B = 2$ mrad (the diffraction angular divergence of the radiation emitted from the undulator of length L is

$$\sqrt{\frac{\lambda}{L/2}} = \sqrt{\frac{0.63\ \mu\text{m}}{1.8\ \text{m}}} = 0.6\ \text{mrad}$$

for $\lambda = 0.63$ μm). To compensate the time delay of the radiation from two undulators, we use two flat parallel plates (see fig. 2) each with a thickness d of 2.75 mm; one is placed normal to the radiation from the nearest undulator, while the other is placed at an the angle $\theta \approx 20°$ to the radiation from the distant undulator; this corresponds to an optical path difference:

$$\delta = d\left(\sqrt{n^2 - \sin^2\theta} - \cos\theta - n + 1\right) = 62\ \mu\text{m},$$

where $n = 1.57$ is the refraction index for the glass of the plates. The expected difference in the optical path, corresponding to the geometrical arrangement of the radiation sources, is defined as

$$\delta_c = 2\left(\frac{3}{4} q\lambda + \frac{S}{2}\frac{(2\theta_B)^2}{2}\right) = 64\ \mu\text{m},$$

where $q = 33.5$ is the number of magnetic periods in each undulator and $S = 4$ m is the distance between M2 and M4. In deriving the expression for δ_c we have taken into account the fact that the radiation beams from undulators converge in the image plane corresponding to the object plane which lies in the middle between the undulators (i.e. near quadrupole L and magnet M3).

To register the observed interference patterns we used both the negative film MICRAT and a one-dimensional CCD with a cell size of 20 μm placed in the image plane RS of the imaging lens ML. The interference patterns, obtained at a conventional (non-achromatic) bend (a) and at an achromatic bend without the delay compensation (b) and with the proper com-

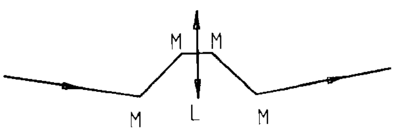

Fig. 1. Schematical view of the achromatic bend: M – bending magnets; L – lens.

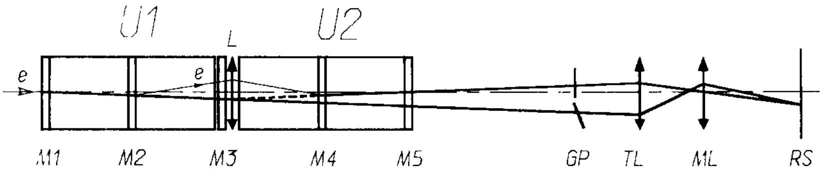

Fig. 2. The scheme for the observation of radiation coherence, at an achromatic bend, of electrons in the optical klystron on VEPP-3: M1–M5 – horizontal bending magnets; L – quadrupole lens focusing in the horizontal direction; U1 and U2 – undulators of the magnetic system of the optical klystron; TL and ML – optical lenses of a telescope and an imaging lens respectively; RS – registering screen (MICRAT or a one-dimensional CCD structure).

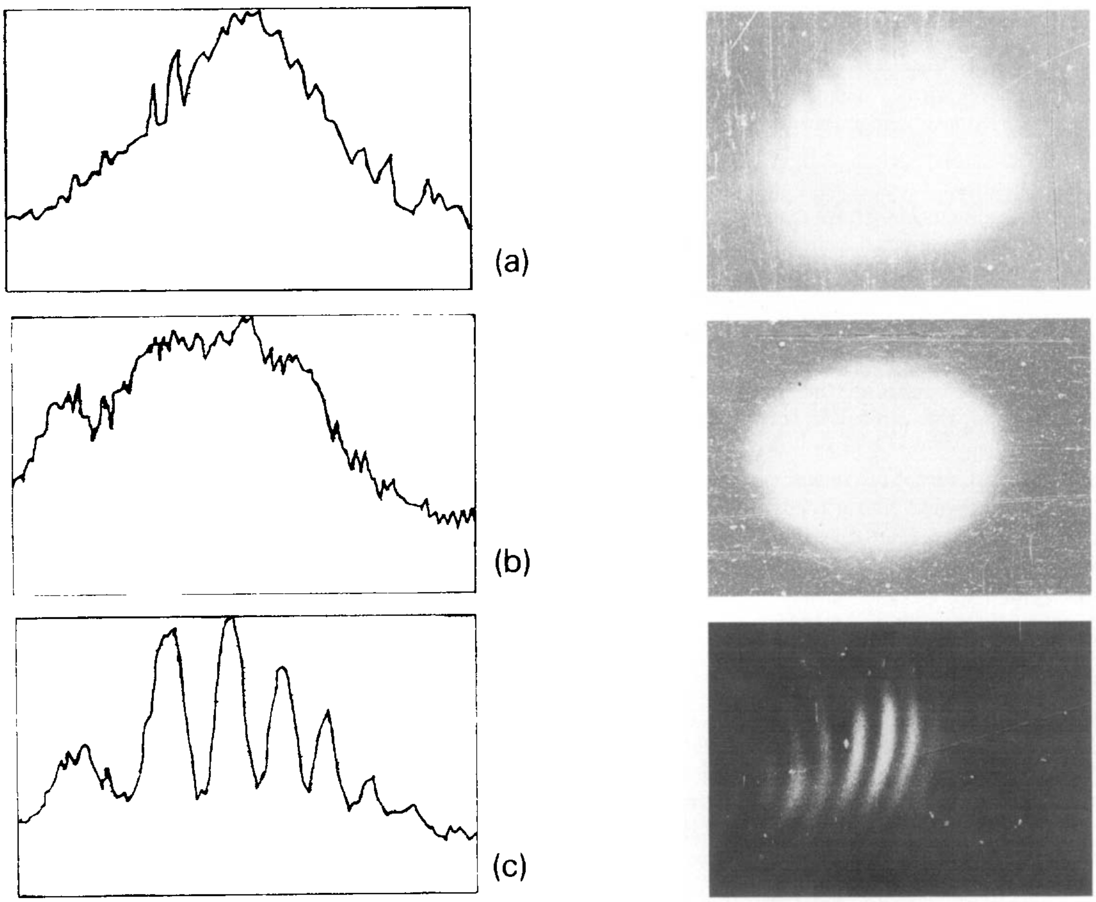

Fig 3. Interference patterns observed at a conventional (nonachromatic) bend (a) and at an achromatic bend without the delay compensation (b) and with the delay compensation (c) (registered by MICRAT on the right and by a one-dimensional CCD structure on the left).

pensation (c), registered by both the film and the CCD are shown in fig. 3. The experimental optimal delay and the number of the interference bands were as expected. Thus, our experiment confirmed the validity of the theoretical considerations [1] on the mutual coherence of spontaneous radiation from two undulators separated by an achromatic bend.

References

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