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**Comment on:
"Interference Effects Between Independent Gamma Rays"**

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In a recent Letter [1], E. Ikonen proposed a Hanbury Brown and Twiss (HBT) intensity interferometry experiment to demonstrate interference effects between independent gamma rays. Ikonen suggests that in order to obtain a measurable correlation signal with gamma or x-radiation, it would be necessary to use a highly monochromatic beam such as that produced by a monochromator based on the Mossbauer effect, operating on a high brilliance beamline at a synchrotron storage ring. In this Comment, we wish to point out that, although this is a possible approach, it is unnecessary to utilize the extremely narrow bandwidth afforded by nuclear resonant monochromatization to demonstrate the HBT effect with x-rays. Furthermore, we do not agree that the proposed experiment would provide evidence of interference between independent quanta in the x-ray region, or that the results of such an experiment depend on quantum phenomena which are fundamentally different than those which apply to conventional (amplitude) interferometry.

HBT showed experimentally that both the counting of photons and the measurement of photocurrents are practical ways to measure the correlation of intensity fluctuations in a partially coherent photon beam [2]. It can be shown [3] that the information provided by the two techniques is equivalent. The measurement time required for both depends on the available number of quanta per spatial mode [4]. But, owing to sensitivity and dynamic range limits on the performance of real radiation detectors, a current-mode experiment is better suited to intensity interferometry with spectrally broad-band beams, whereas the counting technique is more suitable for highly monochromatic beams.

The application of intensity interferometry to characterization of synchrotron radiation sources was proposed by Shuryak [5]. Howells [6] and Gluskin [7,8] discussed experimental considerations for x-ray HBT experiments using high brilliance undulator sources at future third generation synchrotron

storage rings such as the Advanced Photon Source or the Advanced Light Source. Additionally, one of us [7] also advocated the photon-counting technique using a Mossbauer-effect monochromator.

Existing x-ray sources are probably not brilliant enough for the photon-counting approach to succeed; very little flux would remain after the required degree of monochromatization. However, a current-mode experiment (where the resolving time t_r of the interferometer is substantially larger than the coherence time $t_c \sim \lambda^2/c\Delta\lambda$ of the radiation) should be feasible with a high brilliance undulator source on a second generation storage ring. Based on the results of HBT using broad-band visible light [2], we anticipate that the modulus of the complex degree of coherence $|\mu_{12}|$ of the beam produced by the Soft X-ray Undulator at the National Synchrotron Light Source could be measured in several minutes, provided that the interferometer accepts the full extent of the photon beam in the electron orbital (horizontal) plane [8]. A one-dimensional measurement, sensitive only to photon correlations in the vertical plane, would be more appropriate to the asymmetric shape of the source and many orders of magnitude faster than a two-dimensional measurement. Moreover, because the coherent flux is proportional to the cube of the wavelength for fixed coherence length $l_c = ct_c$, the experiment should require much less time using soft x-rays than hard x-rays. We concur with Ikonen that it should be possible to enhance the signal-to-noise ratio by ignoring spurious correlations between pulses of the radiation.

Finally, in our opinion, both intensity and amplitude interferometry are governed by the same quantum process [9-11]. The two techniques simply utilize different means to measure $|\mu_{12}|$, which is manifested as the fringe visibility in a Michelson stellar interferometer or as an electronic correlation in a HBT interferometer. Consequently, an x-ray version of the intensity interferometer developed by Hanbury Brown and Twiss would *not* give evidence of interference between independent photons. It merely offers a different blend of practical considerations for measuring the same coherence properties that, in principle, could be measured by more conventional means.

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