JOURNAL OF MODERN OPTICS, 15 APRIL–10 MAY 2004
VOL. 51, NO. 6–7, 1071–1072

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Short communication
Testing decoherence in interference experiments with macromolecules: the theoretical background

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(*Received 24 October 2003*)

We provide a self-contained quantum description of the measured intensity for interferometry with macromolecules under the influence of processes inducing a loss of coherence, consisting both in beam preparation (beam angular divergence and thermal spread in de Broglie wavelength) and environmental disturbances.

Our analysis [1] is based on two main ingredients. The first is the formula for the statistics of particle arrival position and time on a distant surface, according to which the intensity pattern revealed on a distant screen is ruled by the large-distance asymptotic behavior of the time-integrated quantum current. The second ingredient concerns the description of the dynamics of a test particle moving in a quantum medium: the quantum master equation, describing the interaction through collisions of a massive particle with other particles filling the medium, essentially depends on the dynamic structure factor of the surrounding environment, keeping into account both energy and momentum transfer [2]. In particular, in the conditions of recently realized interferometry experiments with large molecules as fullerene [3, 4], the general treatment can be simplified by a phenomenological description, according to which the reduced density matrix of the system evolves autonomously in accordance with a *Boltzmann-type* master equation. The effects of the environment, including the photon emission due to internal cooling of the thermal produced macromolecules, are summarized by a *collision term*, added to the free dynamics of the system, which takes into account the *decoherence*.

Finally, by means of physically justified approximations, we derive an easy relation useful to describe diffraction patterns, which, under suitable conditions, reproduces the formulas of classical optics. We provide a theoretical fit for the experimental data reported in [3] and discuss simulations showing the interference pattern dependence on the mass of the molecules, on the pressure at which the experiment is performed and on the distance of the detection screen. Moreover, we provide theoretical predictions both for the effects due to partial coherence in Talbot interferometry and for the decoherence-like reduction of visibility due to the randomness of arrival times in near-field interferometry.

Our predictions can be of relevance for planning new experiments.

Journal of Modern Optics ISSN 0950–0340 print/ISSN 1362–3044 online © 2004 Taylor & Francis Ltd
http://www.tandf.co.uk/journals
DOI: 10.1080/09500340410001663945

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