

Khatua, Bansal, and Shahar Reply: The preceding Comment [1] on our Letter [2] does not discuss any technical or mathematical aspects of the experiment or analysis but remarks on interpretational issues. These remarks are in turn based on the critique of Feynman's thought experiment itself [3]: "a thorough reappraisal of Feynman's arguments" is deemed necessary [1].

The fundamental objection that Tiwari [1] raises is based on the incorrect assumption that, "In a strictly quantum domain of the double-slit experiment which-path information *probed by magnetic field* would destroy the interference phenomenon" [emphasis added]. A static magnetic field does not collapse the wave function.

Secondly, a distinction must be made between the "Aharonov-Bohm [AB] effect" and the quantum-mechanical "Aharonov-Bohm phase." We have consistently used only the latter phrase in our Letter [2]. Absence of the magnetic field (with nonzero vector potential) is a sufficient but not a necessary condition for an electron to pick up the Aharonov-Bohm phase [4]. Quantum mechanically, the only way the magnetic field can act on an electron (ignoring spin) is through the minimal coupling of the charge to the vector potential, and the consequence of this is that its wave function acquires an additional (Aharonov-Bohm) phase.

Furthermore, for any physically observable phenomenon the vector potential comes within a line integral (as a necessary requirement of gauge invariance) [4]. Hence, what is important is the enclosed flux. That identical answers are obtained from the quantum-mechanical calculations based on the experimental situations in Fig. 15–7 and 15–8 in Ref. [3], as long as the enclosed flux is the same, is thus neither "fortuitous" nor "puzzling." Figure 15–7 of Ref. [3] describes the Aharonov-Bohm effect that further reveals the nontrivial topological nature of the vector potential, but the electron acquires an Aharonov-Bohm phase for both Figs. 15–7 and 15–8 of Ref. [3].

The preceding Comment [1] specifically discusses three sentences from our Letter [2]. The sentences in the Abstract, (i) "He shows that the addition of an AB phase is equivalent to shifting the zero-field wave interference pattern by an angle expected from the Lorentz force calculation for classical particles," and the introductory paragraph, (ii) "An interplay of these two distinct phenomena, beautiful in its simplicity and pedagogical richness, occurs when the electrons in the Young's double-slit experiment are also subjected to weak magnetic field," are claimed to be "confusing on the real import of Feynman's thought experiment." The sentence in the concluding paragraph, (iii) "In summary, we have

experimentally illustrated the equivalence of the abstract quantum formulation of electron waves with an added topological phase and classical picture for free-space propagation of electrons under Lorentz force using the single slit diffraction experiment," is designated "untenable."

"The real import of Feynman's thought experiment" is, of course, subjective. To us, as is explicitly stated in sentences (i) and (ii) and the discussion around Eq. 3 in Ref. [2], the essence of his thought experiment is the mapping of θ and B via the relationship $k \sin \theta = (eBL/2\hbar)$ [2], and the fact that the same relationship is also inferred from classical Lorentz force calculation. We agree that sentence (iii) cannot be rigorously defended, though perhaps not for the same reasons as mentioned in the preceding Comment. The stated quantum-to-classical correspondence in sentence (iii) is limited to the narrow qualitative sense of the above-mentioned mapping between θ and B .

In summary, we assert that a clean fully quantum-mechanical analysis based on the Schrödinger equation was sufficient to unambiguously model the results in our Letter. The experimental diffraction pattern survives the external magnetic field. As there is no inconsistency in Feynman's argument or in the analysis or interpretation of our experiment, an appeal to speculative ideas needs to be argued for more concretely. The discussion on modular momentum [5] is thus out of context and beyond the scope of our work.

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