Interaction-Free Which-Path Information and Some of Its Consequences

Luiz Carlos Ryff

Universidade Federal do Rio de Janeiro, Instituto de Física, Caixa Postal 68528,
Rio de Janeiro 21945-970, RJ, Brazil

Reprint requests to Dr. L. C. R.; Fax: +55-21-5627368; E-mail: ryff@if.ufrj.br

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Let us consider a single particle in an interferometer. If one of the two possible paths is blocked and the particle is detected, we know that the particle has followed the path which is not blocked. This would be an interference-free "which-path" information experiment. However, we no longer have an interferometer, since one path is blocked. An alternative is to interact with the particle, but this would change its momentum and as a consequence the interference fringes would disappear, as discussed by Feynman. We can also consider two particles entangled in direction. Knowing the path followed by one of the particles, it is possible to know the path followed by the other. On the other hand, when this information is erased, interference can be observed. However, this is a two particle interference: no single particle interference can be observed. Retrodiction experiments are also possible, but these are not conclusive. Here we propose a much less intuitive experiment in which, without blocking one path or directly interacting with the particle, it is possible to know the path which is being followed by the particle in the interferometer. According to quantum mechanics, this is sufficient to lose the single particle interference. The same idea can be used to test the local pilot wave interpretation, to test quantum nonlocality under new conditions, and to devise an interferometer for a two-photon wave packet. This last result strongly suggests that there must be some connection between the deBroglie wavelength of an N-particle wave packet and entanglement.

Key words: Interaction-free Measurement; Pilot-wave Interpretation; Quantum Nonlocality; de Broglie Wavelength of an N-particle Wave Packet.