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A Simple Experiment for Simultaneous Observation of Wave-Particle Duality of Light

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***Abstract* - We propose an extremely simple experimental arrangement to simultaneously observe both wave and particle behaviors, i.e., wave-particle duality, of light and compare this technique with the results of the most recently done highly sophisticated experiment by L. Piazza et al. We also address about the basic question of whether Bohr's complementarity principle is really violated in these kinds of recent experiments or it is, indeed, being preserved inherently.**

***Keywords:* simultaneous, Wave-Particle Duality, Complementarity**

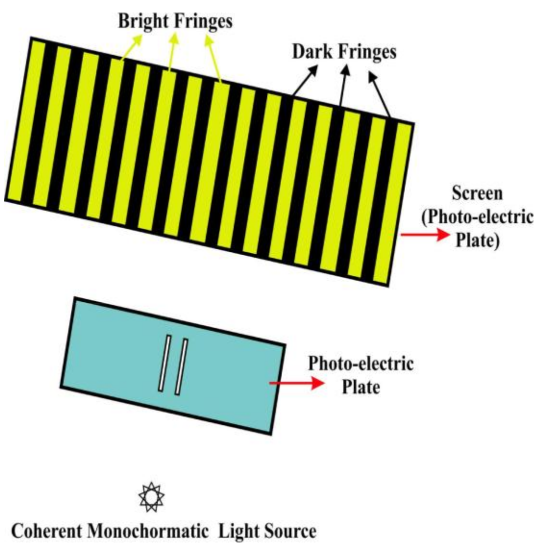
1. A BRIEF INTRODUCTION TO WAVE-PARTICLE DUALITY IN QUANTUM MECHAN-ICS

It is found that wherever wave nature is successful in explaining the observed physical phenomena there the particle nature fails to provide any reasonable ex-planation for the same phenomena and vice versa. Though light can be observed to exhibit both wave and particle behaviors, they are mutually exclusive imply-ing that one can not observe both these natures simultaneously. This is, indeed, known as Bohr's complementarity principle.

Nevertheless, there are some recent experiments where researchers claimed that they have observed both wave and particle behaviors of light simultane-ously.

2. OUR PROPOSED SIMPLE EXPERIMENT FOR OBSERVING SIMULTANEOUS WAVE-PARTICLE BEHAVIOR OF LIGHT

Consider a thin rectangular shaped photoelectric plate in which two narrow slits were made at close separation. Light from a coherent source is made to fall on this photoelectric plate with slits.



The light passing through the slits exhibits INTERFERENCE (because this is nothing but the Young's double slit experiment) where as the light falling on the photoelectric plate shows PHOTOELECTRIC EFFECT. This is indeed the case of light behaving simultaneously as both wave and particles. Further, one can make the interference pattern to fall on a photoelectric plate instead of making it to fall on a screen. In this case, one can observe more number of electrons being emitted from the positions of bright fringes and less or no electrons getting emitted from the regions of dark fringes.

Interference pattern occurs due to the wave nature of light where as the photoelectric e ect occurs due to the particle nature of light in the interference pattern.

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In L. Piazza et al. experiment [1], electrons were made to fall on the standing wave of light in the nanowire, whereas in our case, interference pattern is made to fall on electrons (in the photoelectric plate). One must notice that these two situations viz., electrons falling on light (standing wave in the nanowire) and light (interference pattern) falling on electrons in the photoelectric plate are indeed relatively identical.

3. DISCUSSIONS AND CONCLUSIONS

L. Piazza et al. experiment is highly sophisticated and involves advanced instruments like ultrafast microscope, nanowire etc. Finally, what they are doing is forming a standing wave of light on which an electron beam is shined to photograph the standing wave in the nanowire. When the electrons strike the standing wave of light, that time light behaves like photons. Since the standing wave of light survives in the nanowire for a short time, one has to photograph it using electrons quickly before it dies. So one uses the ultrafast microscope. However one must notice that only a fraction of light forming the standing wave interacts with the striking electrons like photons. That fraction of light behaving like photons with electrons are not participating in the formation of standing wave, i.e., they are not exhibiting the wave nature. Therefore Bohr's complementarity principle is not at all violated.

Unlike Piazza et al.'s case where electrons fall on light, in our proposed ex-periment, light falls on electrons. But the nal results of these two experiments are one and the same in the sense that whether electrons fall on light or light falls on electrons are indeed relatively identical situations. In fact our experiment can be carried out even in the undergraduate laboratories where as the former can't be. Further the nal conclusions of Piazza et al., i.e. they have pho-tographed simultaneously wave and particle behavior of light is in a sense false because that fraction of light which behaved like photons when colliding with electrons never exhibited wave nature and participated in the standing wave formation. Standing wave is formed by the remaining photons which never un-derwent the collisions with the falling electrons in the beam. Also, according to quantum mechanics, it is possible to obtain a standing wave even with only two photons (or with one photon for that matter, like a particle in a box) traveling in opposite directions inside the nanowire. If one shines electron beam on this two photon standing wave, as in the case of Piazza et al.'s experiment, then we are sure that one can not obtain any information to photograph the standing wave because only any two electrons among the beam of electrons interact with the two photon standing wave producing only a set of two data points which is insu cient for reconstructing the entire two photon standing wave.

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