How does energy separate in the fringes produced by intersecting beams?

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Abstract: Spatial energy re-distribution as interference fringes are recorded when two spatially and temporally coherent beams intersect. We show simple experiments with different recording materials to explain this energy re-distribution process. Interference effects are manifest in materials as dictated by their quantum properties because optical fields do not interfere with (or operate on) each other.

OCIS codes: (260.3160) Interference; (030.1640) Coherence

Summary

Except for beat spectroscopy and laser mode locking phenomena, almost all of the interference effects are recorded as time average interferograms. We also know that intersecting light beams in free space or in a linear, non-interacting medium, do not modify each others wave fronts or other properties. Classically, we explain this by stating that light does not interfere with light. More sophisticated explanation is that electromagnetic fields (EMF) can occupy the same space without influencing or operating on each other. Material particles, if allowed by their quantum mechanical properties, can respond to all the locally present (superposed) EMF's. This is the reason why EMFs from billions of galaxies and stars can cross each other over billions of kilometers and still preserve the characteristic properties of each star. This is also the reason why natural scenes of our environment are reproducibly stable even though the scattered light beams from trillions of little points on the objects, are crisscrossing each other. Yet, when we record the effects of superposition of two or more coherent beams in appropriate materials, our interferograms, placed within the domain of beam overlap, show clear, spatially redistributed energy. If the experiment is being carried out with two spatially well defined Gaussian beams, generated from the same laser, the energy distribution of the beams, before and after the intersection, remains unaltered. This apparent contradiction in the energy re-distribution within the domain of overlap, and no change outside the domain of overlap, is well understood as non-interference of light. However, by explicitly recognizing that the energy redistribution due to superposition is actually a material property, one can appreciate the various effects when different materials with different quantum properties are inserted within the physical region of the superposed beams, like photographic plates, CCD cameras, photo-chromic materials, photo-refractive materials, ultra-fast photo detectors, resonant fluorescent atomic gases, etc. We will discuss these issues with some simple experimental demonstrations.

Eighth International Topical Meeting on Education and Training in Optics and Photonics,
edited by Barry L. Shoop, Grover Swartzlander Jr., Proc. of SPIE Vol. 9663, 96632O
 · doi: 10.1117/12.2208386