

# Two-photon interference with two (and only two) independent photons

Frank King (College of Wooster), Margaret Trias (Mount Holyoke College), and Martin Ligare (Bucknell University)

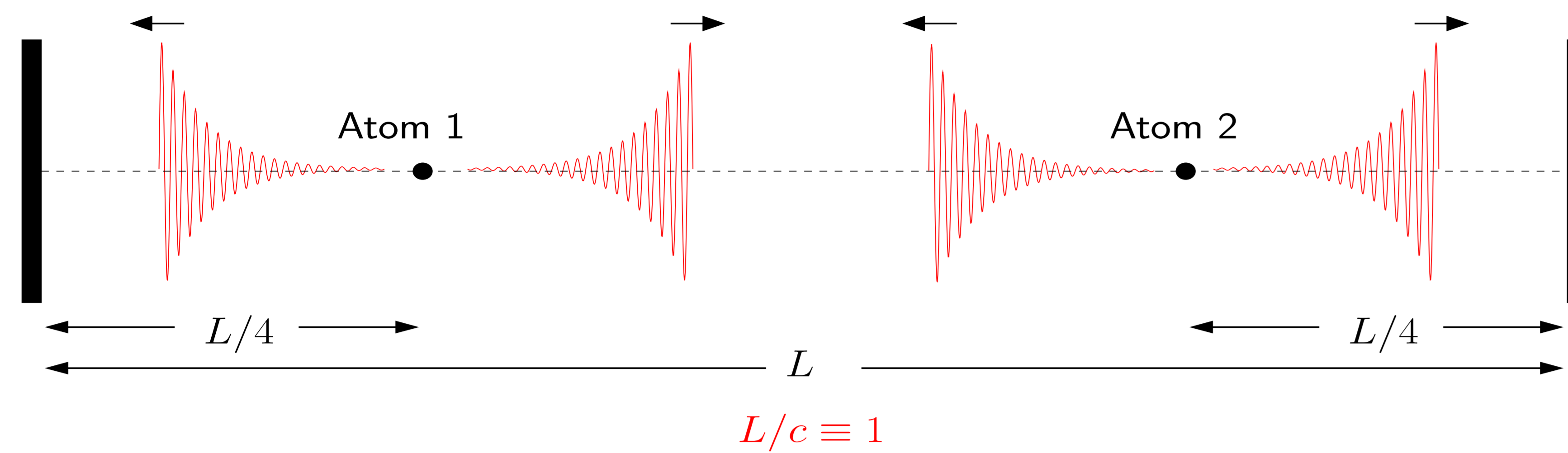


Bucknell



REU PHY-0552790

## A new take on some old quantum optics



Localized Spontaneously Emitted Quantum Fields (Photons)

vs.

Classical Fields From Random Phase Dipole Oscillators

Initial State: Two Excited Atoms

Interference/Correlation in Regions of Field Overlap?

### Model Features:

- "Modes of the universe" (1-D); Quantized standing wave modes
- Multiple modes (201) → quasi-continuum
- Spontan. emission via interaction with multiple empty modes.
- Schrödinger picture.
- → "Localized" photons.

### Basis States:

- $|e e; 0\rangle$ : both atoms excited, no photons
- $|e g; 1_k\rangle$ : atom 1 excited, atom 2 in g.s., 1 photon (mode  $k$ )
- $|g e; 1_k\rangle$ : atom 1 in g.s. atom 2 excited, 1 photon (mode  $k$ )
- $|g g; 1_k, 1_{k'}\rangle$ : both atoms in g.s., 2 photons in distinct modes
- $|g g; 2_k\rangle$ : both atoms in g.s., 2 photons in same mode

Initial State:  $|\psi(0)\rangle = |e e; 0\rangle$

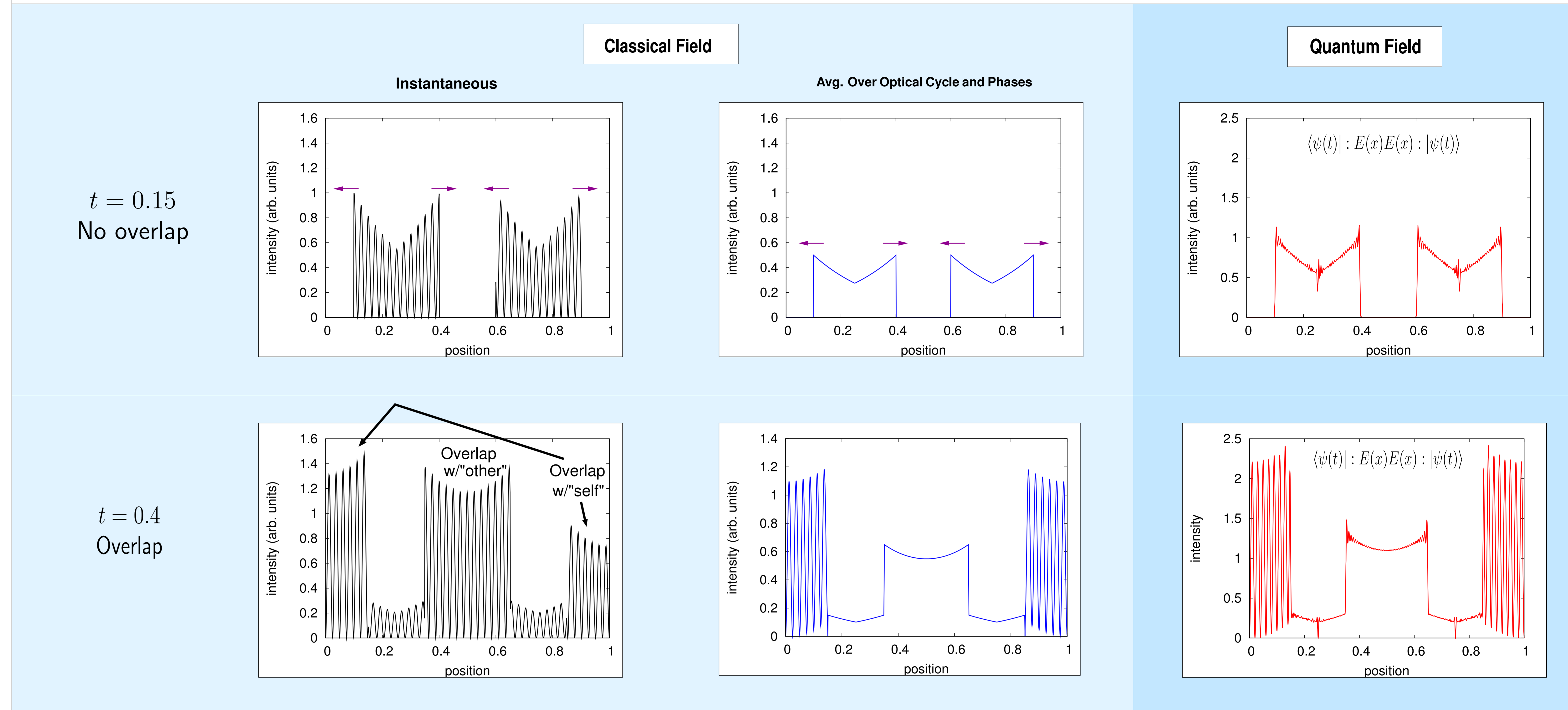
### Time-Dependent State:

$$|\psi(t)\rangle = a(t)|e e; 0\rangle + \sum_k b_{1k}(t)|e g; 1_k\rangle + \sum_k b_{2k}(t)|g e; 1_k\rangle + \sum_{k, k' < k} c_{k, k'}(t)|g g; 1_k, 1_{k'}\rangle + \sum_k d_k(t)|g g; 2_k\rangle$$

Hamiltonian: Two-level atoms, RWA, multimode.

$$H = H_{\text{atoms}} + H_{\text{field}} + H_{\text{interaction}} = \hbar\omega_{eg}^{(1)}\sigma_3^{(1)} + \hbar\omega_{eg}^{(2)}\sigma_3^{(2)} + \sum_k \hbar\omega_k \left( a_k^\dagger a_k + \frac{1}{2} \right) + \sum_k \hbar \left( \Omega_1 \sigma_+^{(1)} a_k + \Omega_1^* \sigma_-^{(1)} a_k^\dagger \right) \sin \left[ (k_0 + k) \frac{\pi x_1}{L} \right] + \sum_k \hbar \left( \Omega_2 \sigma_+^{(2)} a_k + \Omega_2^* \sigma_-^{(2)} a_k^\dagger \right) \sin \left[ (k_0 + k) \frac{\pi x_2}{L} \right],$$

## Intensity



## Spatial Intensity Correlation at $t = 0.45$

