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How a Single Photon Can Act as Many Photons JOSIAH SINCLAIR, GREG DMOCHOWSKI, MATIN HALLAJI, AMIR FEIZPOUR, AEPHRAIM STEINBERG, University of Toronto — We experimentally show how a single, post-selected photon may induce a non-linear cross-phase shift that is five times larger than the nominal single photon effect. Using a weak cross-Kerr interaction, we deterministically couple two coherent state optical fields and exploit weak-value amplification (WVA) to increase the effect that one field (the "signal") has on the other (the "probe"). Due to the (weak) entangling interaction, appropriate preparation and post-selection of the signal field leads to interference of different possible probe states and an anomalously large cross-phase shift. This amplification only occurs for particular pre- and post-selections of the signal field; larger amplification arises when the final state is nearly orthogonal to the initially prepared state and, therefore, occurs less frequently. A laser-cooled cloud of ^{85}Rb atoms is used to mediate the cross-Kerr interaction; the signal field imprints a phase shift on the probe laser, which grows linearly with the photon number in the signal pulse. That is, the probe effectively measures the photon number in the signal beam. The signal field is prepared in a given superposition of two polarizations, one of which interacts with the probe field more strongly than the other. After the interaction, detection of an individual signal photon (using a single photon detector) which is nearly orthogonally polarized causes the probe to acquire an additional single-photon phase shift that is amplified by the degree of orthogonality. We demonstrate an amplification factor of five.

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