Photonic Interference Beyo

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Abstract: We propose multipartite Bragg-scattering to pe
frequency modes, realizing an N-level system... We demonstrate the i
pathway towards scalability for freq... domain op

Solving complex problems in quantum information science
In order to advance beyond the NISQ era (noisy, inter
information platforms must scale to larger sizes witho
optical quantum computing proposals that circumvent lo
states as well as the number of information channels
optical modes on a beamsplitter. However, scaling spati
challenging, adding to the resource overhead required

A promising alternative to manipulating the spatial
domain. Utilizing the nonlinear optical process of Bra
realize a beamsplitter transformation between two freq
As in classical telecommunications, the frequency doma
multiplexing. Despite this promise, two-photon interfe
demonstrated, ... have been shown for classical
single or parallel qudits using the electro-optic appr
strong classical pump fields to couple two frequency m
to allow simultaneous ... coupled ... system [

Here we study multipartite Bragg-scattering with thre
three-level system with interaction ... [3
varying the pump power, which in the case of two pumps
beamsplitter. We investigate the quantum behavior in wh
and compare it to the case of injecting two coherent-s

We develop a theoretical model for the single-count a
beamsplitter for the cases of attenuated coherent stat
the three interacting frequency modes, which ... ex
correspond to the wavelengths 1280, 1283, and 1285 nm
corresponding to modes 0 and 2 ... perfect phase ... the
interaction Hamiltonian (in the frame of the pulse) is
for each pair of levels, such that,

= 2 ... + ... + ... + ... ,

where ... is the nonlinearity (proportional ... The observed ... single
field are then proportional ... coincidence rates are given b
... We observe that, in contrast to the singles rat
statistics between the two-mode weak coherent state an

In our experiment, the weak coherent input state is p
1285 nm to the single-photon level. To generate photon
silicon-nitride ring microresonator (200-GHz free spec
from the SFWM pump at the two weak coherent-state freq
mode 1, we strongly filter it through a chain of fiber
pair intensity to avoid contaminating the input state.
with three strong pulsed C-band BS-FWM pumps before en

in the fiber, the transformed O-band fields are separ
superconducting nanowire single-photon detectors (SNSP
each of the three levels. Detection events are then re
FWM pumps (hence the interaction strength) is scanned

A subset of the resulting measured normalized singles
the singles rates for the weak coherent states and is
photon-pair input (Fig. 1b), we plot normalized coinc
the measured delay histogram over the inverse microres
for the coherent state in Fig. 1b, it is evident tha
fundamentally nonclassical nature of the input state.
incorporate multiphoton emission from the microresonat
estimate the multiphoton parameter via a separate hera
losses are based on measurements concurrent with the e
measurements in the absence of multiphoton emission. T
Fig. 1b. This is the first time, to the best of our kn
>2 modes has been observed in × the unf... frequency domain. Th
( ) pumps, which would allow arbitrary control over eac

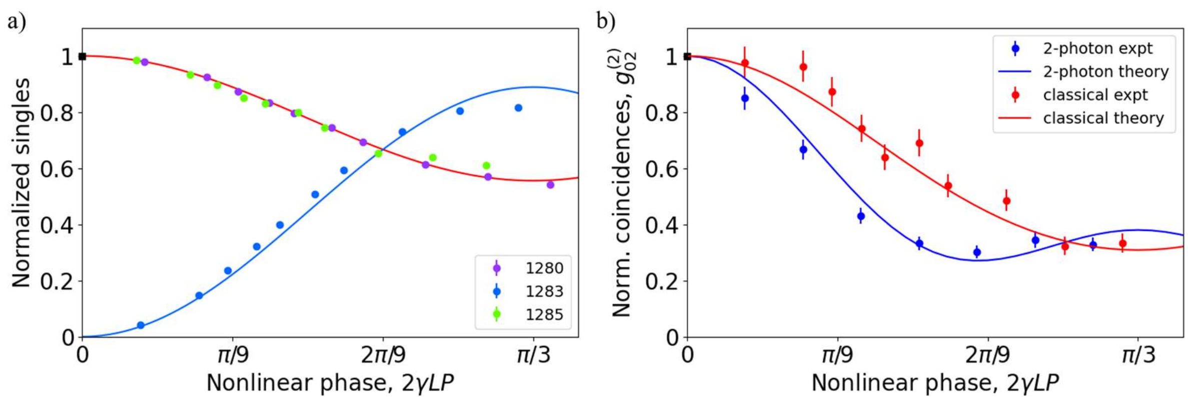

Figure 1. a) Singles rates for the two-mode weak coherent-state inp
marker, computed assuming Poisson statistics. b) Comparison between
.. In both figures, the point at zero nonlinear phase represents the

Our experiment demonstrates the possibility of achie
number of modes in the quantum regime. Through use of a
our system has the potential to enhance the scalabilit
rely on beamsplitter transformations, including boson
show promise for × the scalable quantum information platfor

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