Quantum Sensors

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DARPA / CECOM

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Project Data (internal use only)

- Project Number: 0707D070-QS
- Ceiling Source: CECOM
- Principal Investigator: Dr Gerald Gilbert
- DARPA Office: STO
- Sponsor: Dr Michael Zatman
- FY07 Funding Level: $700K
- Technical Area: Sensors and Environment

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Problem

- The best possible image resolution is constrained by the laws of physics: in classical physics this is known as the Rayleigh limit.

- Is it possible to achieve better image resolution than that allowed by the Rayleigh limit?

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Background

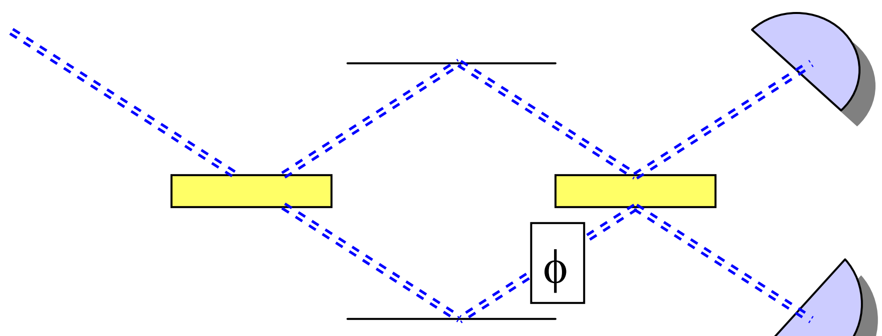
- **Quantum sensing, an application of the new field of quantum information science, allows for the possibility of improving image resolution beyond the classical optics Rayleigh limit. This is due to the special properties of entangled states of photons: entanglement is a quintessential quantum mechanical phenomenon. This project carries out both theoretical and experimental research at the fundamental and applied levels.**

$$\Delta\phi_{HL} = \frac{\Delta A_N}{|d\langle A_N\rangle / d\phi|} = \frac{1}{N}$$

Heisenberg limit

$$\Delta\phi_{SL} = \frac{\Delta A_R}{|d\langle A_R\rangle / d\phi|} = \frac{1}{\sqrt{N}}$$

shot-noise limit



Mach-Zehnder interferometer

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Objective

- **The objective of the project is to perform research on practical quantum sensing carried out in realistic environments, aimed at determining the viability of this application as a practical technology.**

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Activities

- We carry out detailed analyses on a number of topics, *e.g*., physical characteristics of bi-photons, *N*00*N* and other entangled states, diffraction, noise and losses, and practical constraints in order to achieve improved image resolution relative to classical methods. We also carry out detailed phenomenological analyses directed to broadly constraining experimental activities.

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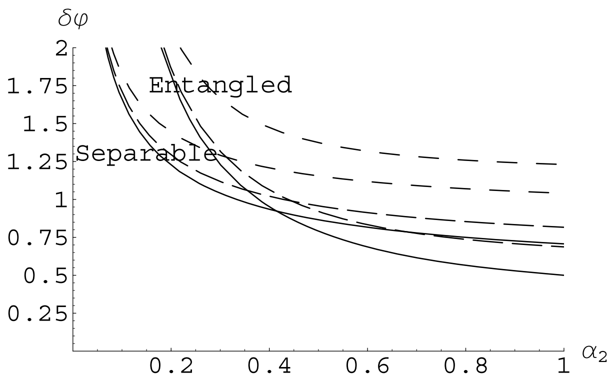
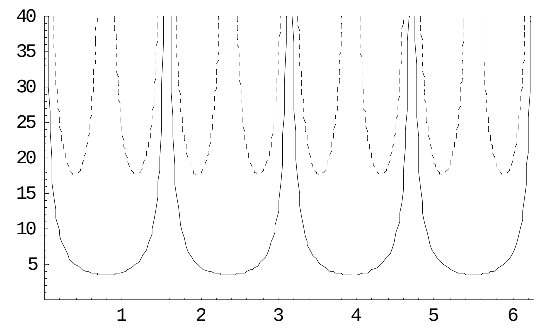
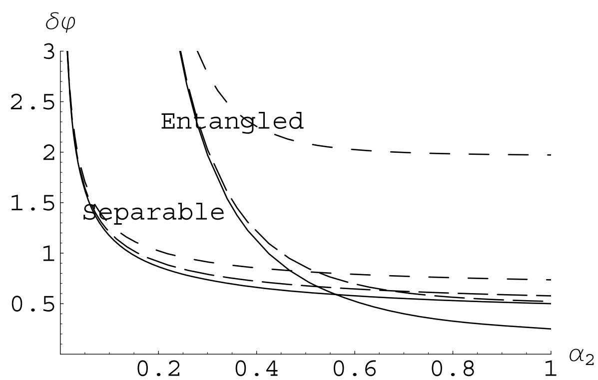
Highlight



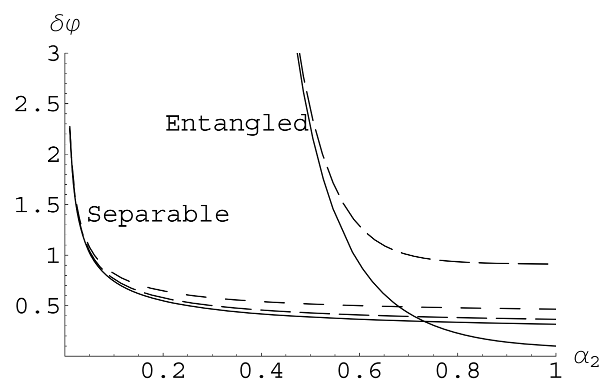
comparison of entangled and separable photons, *N* = 2



N00N state phase resolution in the presence of loss (*δϕ* vs *ϕ*)



comparison of entangled and separable photons, *N* = 4



comparison of entangled and separable photons, *N* = 10

Analyses of practical quantum sensing constraints

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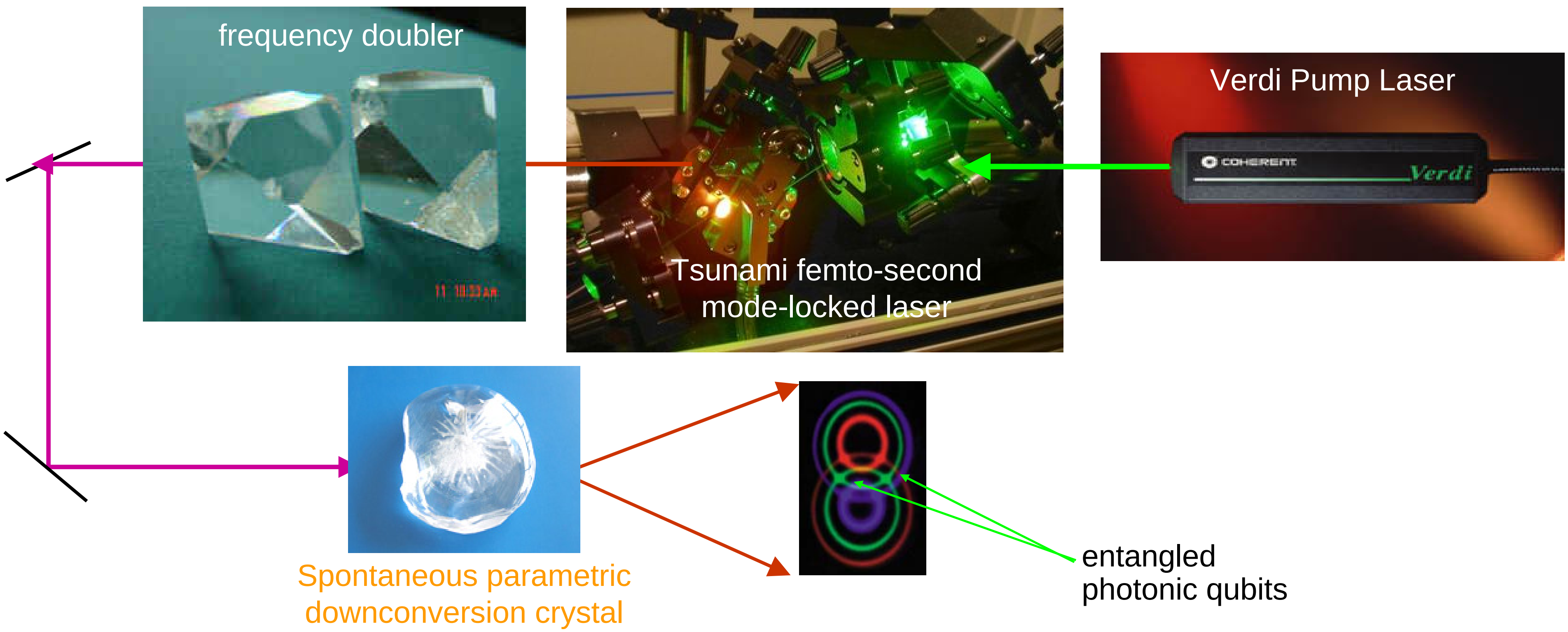
Demonstration

Creating entangled photons at the Optics Laboratory of MITRE's Quantum Information Science Group



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Impacts

- The demonstration of successful and practical quantum sensing through realistic atmospheres will have revolutionary implications for optical sensors across the DoD and the Intelligence Community. This technology has the potential to enable significantly enhanced sensor capabilities compared to classical sensor technology, including much-improved resolution and increased robustness against diffraction effects.

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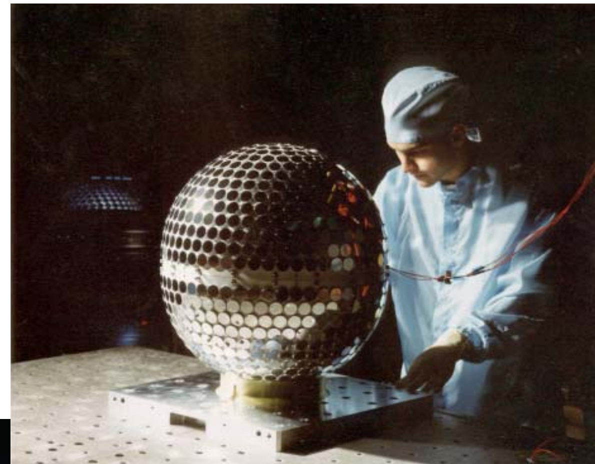
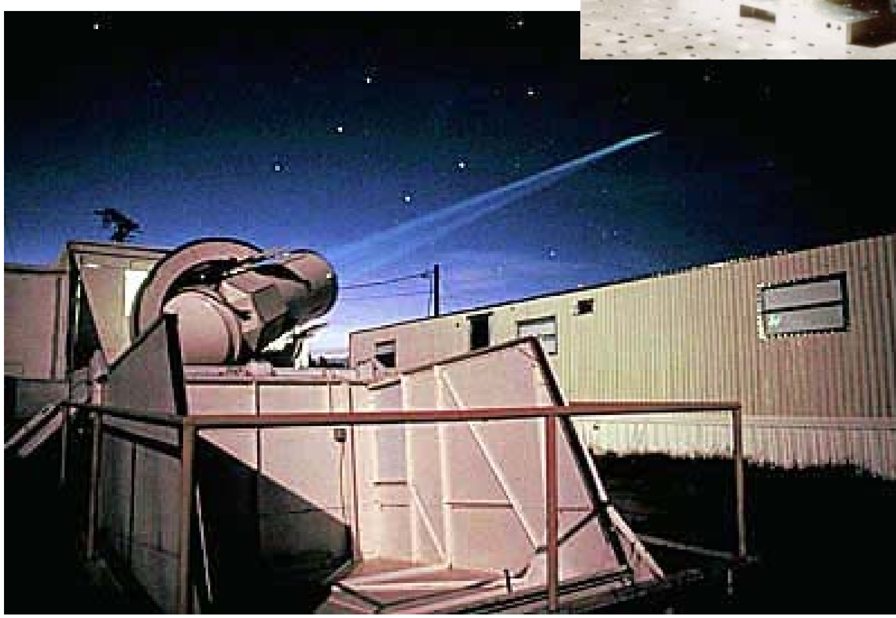
Future Plans





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