Final Report for Period: 07/2009 - 06/2010

Principal Investigator: Kuzmich, Alex M.
Organization: GA Tech Res Corp - GIT

Submitted By:
Kuzmich, Alex - Principal Investigator

Title:
Telecommunication wavelength quantum repeater

### Project Participants

<table>
<thead>
<tr>
<th>Senior Personnel</th>
<th>Project Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Kuzmich, Alex</td>
<td>Name: Kuzmich, Alex</td>
</tr>
<tr>
<td>Worked for more than 160 Hours:</td>
<td>Yes</td>
</tr>
<tr>
<td>Contribution to Project:</td>
<td></td>
</tr>
<tr>
<td>Name: Kennedy, T.A. Brian</td>
<td>Yes</td>
</tr>
<tr>
<td>Worked for more than 160 Hours:</td>
<td></td>
</tr>
<tr>
<td>Contribution to Project:</td>
<td></td>
</tr>
<tr>
<td>Name: Chapman, Michael</td>
<td>Yes</td>
</tr>
<tr>
<td>Worked for more than 160 Hours:</td>
<td></td>
</tr>
<tr>
<td>Contribution to Project:</td>
<td></td>
</tr>
<tr>
<td>Name: Jenkins, Stewart</td>
<td>Yes</td>
</tr>
<tr>
<td>Worked for more than 160 Hours:</td>
<td></td>
</tr>
<tr>
<td>Contribution to Project:</td>
<td></td>
</tr>
<tr>
<td>Name: Radnaev, Alexander</td>
<td>Yes</td>
</tr>
<tr>
<td>Worked for more than 160 Hours:</td>
<td></td>
</tr>
<tr>
<td>Contribution to Project:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Post-doc</th>
<th>Graduate Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Dudin, Yaroslav</td>
<td>Name: Dudin, Yaroslav</td>
</tr>
<tr>
<td>Worked for more than 160 Hours:</td>
<td>Yes</td>
</tr>
<tr>
<td>Contribution to Project:</td>
<td></td>
</tr>
<tr>
<td>Name: Kim, Soo</td>
<td>Yes</td>
</tr>
<tr>
<td>Worked for more than 160 Hours:</td>
<td></td>
</tr>
<tr>
<td>Contribution to Project:</td>
<td></td>
</tr>
<tr>
<td>Name: Gibbons, Michael</td>
<td>Yes</td>
</tr>
<tr>
<td>Worked for more than 160 Hours:</td>
<td></td>
</tr>
<tr>
<td>Contribution to Project:</td>
<td></td>
</tr>
<tr>
<td>Name: Jen, Richard</td>
<td>Yes</td>
</tr>
<tr>
<td>Worked for more than 160 Hours:</td>
<td></td>
</tr>
<tr>
<td>Contribution to Project:</td>
<td></td>
</tr>
</tbody>
</table>
Name: Collins, Odell
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Zhao, Ran
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Campbell, Corey
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Lan, Shau-Yu
Worked for more than 160 Hours: Yes
Contribution to Project:

Undergraduate Student
Name: Naylor, David
Worked for more than 160 Hours: No
Contribution to Project:

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:
Major activity is in a developing elements of a quantum repeater that is capable to function over telecommunication fiber networks. Our approach utilizes cold samples of rubidium atoms confined in optical dipole traps. We are using acousto-optical scanning of a cold sample to independently address a large number of memory elements.

Findings:
1) We have achieved long (300 seconds) lifetime of atoms trapped in optical lattices. We have explored limitation to the lifetime due to heating arising from laser frequency and amplitude noise.
2) We have loaded optically thick samples of cold atoms into a YAG-laser based optical dipole trap. We have created single spin excitations in this cold sample and observed memory times longer than in free-falling samples.
3) We have been able to create independent elements of a quantum memory array in a rubidium sample (up to 12), and realized matter-light
entanglement using an arbitrary pair of the elements as the matter qubit.
4) We have achieved long (>6 ms) quantum memory lifetimes and used these to realize a high-quality source of deterministic single photons.

**Training and Development:**
Graduate and undergraduate students are being trained in modern AMO and electronics techniques.

**Outreach Activities:**
1) Organized a visit, with demonstrations, to the School of Physics for a pre-K class.
2) Organized laboratory visits and demonstrations for elementary school classes.

**Journal Publications**

Lan, SY; Radnaev, AG; Collins, OA; Matsukevich, DN; Kennedy, TAB; Kuzmich, A, "A Multiplexed Quantum Memory", OPTICS EXPRESS, p. 13639, vol. 17, (2009). Published,

Zhao, R; Dudin, YO; Jenkins, SD; Campbell, CJ; Matsukevich, DN; Kennedy, TAB; Kuzmich, A, "Long-lived quantum memory", NATURE PHYSICS, p. 100, vol. 5, (2009). Published, 10.1038/NPHYS115

Dudin, YO; Jenkins, SD; Zhao, R; Matsukevich, DN; Kuzmich, A; Kennedy, TAB, "Entanglement of a Photon and an Optical Lattice Spin Wave", PHYSICAL REVIEW LETTERS, p. , vol. 103, (2009). Published, 10.1103/PhysRevLett.103.02050

**Books or Other One-time Publications**
Editor(s): R. Cote, P. L. Gould, M. Rozman, and W. W. Smith
Bibliography: pp. 88-97

**Web/Internet Site**

**Other Specific Products**

**Contributions within Discipline:**
the work supported by this grant provides a foundation for long-distance quantum networks over optical fibers.

**Contributions to Other Disciplines:**

**Contributions to Human Resource Development:**
Graduate and undergraduate students have been trained in AMO science.
Two Ph. D. dissertation have been defended based on work supported by this grant:
University of California at Berkeley.
2) Soo Yeon Kim, 'Cold Single Atoms for Cavity QED Experiments'
Advisor: Michael Chapman
Current Position: Process Technology Development Engineer,
Intel Corporation, Oregon

**Contributions to Resources for Research and Education:**
Resources from this research program have been used in two undergraduate laboratory courses: Optics (M. Chapman) and Advanced Lab (A. Kuzmich).

**Contributions Beyond Science and Engineering:**

---

**Conference Proceedings**

---

**Categories for which nothing is reported:**
Organizational Partners
Any Web/Internet Site
Any Product
Contributions: To Any Other Disciplines
Contributions: To Any Beyond Science and Engineering
Any Conference