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Final Report: Apparatus for laser slowing and cooling of molecules

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5c. PROGRAM ELEMENT NUMBER
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6. AUTHORS
David DeMille

5d. PROJECT NUMBER

5e. TASK NUMBER

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New Haven, CT 06520 -8327

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The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT
This is the final report for our DURIP grant entitled "Apparatus for Laser Slowing and cooling of Molecules". We have successfully acquired and assembled all parts for a new cryogenic molecular beam source, and recently used the source for preliminary work on laser cooling of a new molecular species, TlF. We have also successfully acquired and assembled the parts for a custom laser system, which produces long (~200 microsecond), single-frequency pulses with energy ~1.1 Joules at 1064 nm and/or ~0.4 Joules at 532 nm. We have acquired all parts for producing tunable laser pulses based on optical parametric amplification of an external cavity diode laser with this

15. SUBJECT TERMS
Laser cooling; ultracold molecules; pulsed laser

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 15. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | David DeMille |
| UU | UU | UU | UU | | 19b. TELEPHONE NUMBER 203-432-3833 |

## Report Title

Final Report: Apparatus for laser slowing and cooling of molecules


## ABSTRACT

This is the final report for our DURIP grant entitled "Apparatus for Laser Slowing and cooling of Molecules". We have successfully acquired and assembled all parts for a new cryogenic molecular beam source, and recently used the source for preliminary work on laser cooling of a new molecular species, TlF. We have also successfully acquired and assembled the parts for a custom laser system, which produces long (~200 microsecond), single-frequency pulses with energy ~1.1 Joules at 1064 nm and/or ~0.4 Joules at 532 nm. We have acquired all parts for producing tunable laser pulses based on optical parametric amplification of an external cavity diode laser with this system, and assembled all but the final, yet-to-be-tested stage.


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## Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

### (a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

**TOTAL:**

**Number of Papers published in peer-reviewed journals:**

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### (b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

**TOTAL:**

**Number of Papers published in non peer-reviewed journals:**

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### (c) Presentations

APS DAMOP meeting, May 2016: Abstract: K1.00165 : Towards Stimulated-Force Slowing of SrF Molecules

Gordon Conference on Atomic Physics, June 2015: Towards Stimulated-Force Slowing of SrF Molecules

**Number of Presentations:** 0.00

## Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

**TOTAL:**

**Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):**

## Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

**TOTAL:**

**Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):**

## (d) Manuscripts

Received Paper

**TOTAL:**

**Number of Manuscripts:**

## Books

Received Book

**TOTAL:**

| Received | Book Chapter |
|---|---|

**TOTAL:**

## Patents Submitted

## Patents Awarded

## Awards

### Graduate Students

| NAME | PERCENT_SUPPORTED | Discipline |
|---|---|---|
| Eustace Edwards | 0.00 | |
| **FTE Equivalent:** | **0.00** | |
| **Total Number:** | **1** | |

### Names of Post Doctorates

| NAME | PERCENT_SUPPORTED |
|---|---|
| Eric Norrgard | 0.00 |
| **FTE Equivalent:** | **0.00** |
| **Total Number:** | **1** |

### Names of Faculty Supported

| NAME | PERCENT_SUPPORTED | National Academy Member |
|---|---|---|
| David DeMille | 0.00 | |
| **FTE Equivalent:** | **0.00** | |
| **Total Number:** | **1** | |

### Names of Under Graduate students supported

| NAME | PERCENT_SUPPORTED |
|---|---|
| **FTE Equivalent:** | |
| **Total Number:** | |

## Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: ..... 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense ..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: ..... 0.00

## Names of Personnel receiving masters degrees

NAME

**Total Number:**

## Names of personnel receiving PHDs

NAME

**Total Number:**

## Names of other research staff

NAME PERCENT_SUPPORTED

**FTE Equivalent:**
**Total Number:**

## Sub Contractors (DD882)

## Inventions (DD882)

## Scientific Progress

For this equipment grant, we have successfully acquired and assembled all parts for a new cryogenic molecular beam source, and recently used the source for preliminary work on laser cooling of a new molecular species, TIF. We have also successfully acquired and assembled the parts for a custom laser system, which produces long (~200 microsecond), single-frequency pulses with energy ~1.1 Joules at 1064 nm and/or ~0.4 Joules at 532 nm. We have acquired all parts for producing tunable laser pulses based on optical parametric amplification of an external cavity diode laser with this system, and assembled all but the final, yet-to-be-tested stage.

## Technology Transfer