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# RPPR Final Report

as of 08-Aug-2022

Agency Code: 21XD

Proposal Number: 70005PHRIP

Agreement Number: W911NF-17-1-0172

## INVESTIGATOR(S):

**Name:** David DeMille david.demi

**Email:** ddemille@uchicago.edu

**Phone Number:** 2033761619

**Principal:** Y

Organization: **Yale University**

Address: Office of Sponsored Projects, New Haven, CT 065208327

Country: USA

DUNS Number: 043207562

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**Report Date:** 14-Jul-2019

Date Received: 04-Aug-2022

**Final Report** for Period Beginning 15-Apr-2017 and Ending 14-Apr-2019

**Title:** Apparatus for producing a Bose-Einstein condensate of polar molecules

**Begin Performance Period:** 15-Apr-2017

**End Performance Period:** 14-Apr-2019

**Report Term:** 0-Other

Submitted By: David DeMille

Email: ddemille@uchicago.edu

Phone: (203) 376-1619

**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

## STEM Degrees:

## STEM Participants:

**Major Goals:** The goal of this grant is to acquire equipment needed to produce the first-ever Bose-Einstein condensate (BEC) of polar molecules, specifically SrF molecules. The proposed equipment would be integrated into an existing system where SrF molecules have been laser cooled and magneto-optically trapped. The specific new subsystems will consist of additional ultra-high vacuum chambers, a magnetic guide for SrF, various optics and equipment to produce co-located magneto-optical and magnetic traps of these species, a high-power laser to provide optical-dipole trapping of both species, an absorption imaging camera to measure the temperature and density of each species, and a new laser needed to more efficiently load SrF into our traps.

These new subsystems will be used to transfer SrF molecules into conservative magnetic and optical traps, and to co-trap them with ultracold Rb atoms to investigate the possibility to use Rb atoms to sympathetically cool SrF to form a BEC.

**Accomplishments:** We successfully acquired and installed equipment needed to produce a Bose-Einstein condensate of polar SrF molecules. In particular:

1. We acquired and installed electronic equipment (some custom-built for our needs), additional optics, new data acquisition and control systems, a new camera and imaging optics, and new vacuum parts, as needed to create a conservative magnetic trap and load it from our existing magneto-optical trap (MOT) of SrF.
2. We acquired and installed all necessary equipment (vacuum parts, atom sources, lasers and optics, electronics, custom mounting fixtures, etc.) to produce a 2D MOT that can be used to deliver slow Rb atoms to the SrF trapping region, where they can be co-trapped.
3. We acquired necessary vacuum parts to integrate the Rb 2D MOT with the SrF trapping apparatus, and acquired and installed new optics for creating overlapping traps of both species.
4. We acquired and installed a new laser system to form a conservative optical trap for both SrF and Rb.
5. We acquired a new high power RF amplifier to enable tighter compression of molecules in our magneto-optic trap.

Some new developments in the field shifted our approach to certain scientific goals slightly, but our spending matched very closely with the original budget.

These new systems enabled us to demonstrate conservative magnetic trapping and compression of ultracold SrF molecules, and paved the way for further advances in these techniques over the coming years.

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**Training Opportunities:** This grant was entirely for equipment acquisition and did not directly provide opportunities for training.

However, the equipment was used in concurrent projects by 3 Ph.D. students and 1 postdoctoral associate in physics. This sort of research exposes young researchers to a vast array of scientific methods and concepts. They develop extensive skills and experience in areas such as instrumentation design and assembly; numerical simulation and analysis; electronics design, construction and testing; computer-based data acquisition and analysis; laser, optical, and electro-optical operation and design; microwave and RF techniques; vacuum, gas handling and cryogenics; etc.

**Results Dissemination:** Because this was purely a grant for equipment acquisition, no dissemination of results was appropriate.

However, the results from concurrent projects enabled by this equipment were reported in one peer-reviewed article in Physical Review Letters, 3 contributed posters at APS DAMOP and Gordon Conference on Atomic Physics, and many invited talks by the PI and postdoc at 2 major conferences and 3 departmental colloquia and seminars.

**Honors and Awards:** Nothing to Report

**Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

### **PARTICIPANTS:**

**Participant Type:** PD/PI

**Participant:** David DeMille

**Person Months Worked:** 2.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Partners**

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as of 08-Aug-2022

I certify that the information in the report is complete and accurate:

Signature: David DeMille

Signature Date: 8/4/22 3:58PM

Nothing to report in the uploaded pdf (see accomplishments).