Final Report

Project No. NR 012-121

ARPA Order No. 125 and 1479

COLLISIONAL AND RADIATIVE PROCESSES IN ATOMS AND MOLECULES AT LOW ENERGIES

L. Krause
University of Windsor

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UNIVERSITY OF WINDSOR

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DEPARTMENT OF PHYSICS

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FINAL REPORT

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Date of Contract: 6-19-67
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TITLE OF PROJECT: Collisional and Radiative Processes in Atoms and Molecules at Low Energies

A. The following is the summary of the activities covered by the contract, during the duration of the contract from September 1, 1967 to August 31, 1969 (extended to December 31, 1969 without increase in cost).

1. The quenching of sodium resonance radiation by inert gases has been investigated. It was found that the upper limit of the quenching cross section equals about 10^{-19} cm^2. This work has been partly supported by a previous A.F.O.S.R. grant. See references below.

2. The quenching of sodium resonance radiation as well as $3^2P_{1/2} - 3^2P_{3/2}$ mixing induced in collisions with nitrogen, hydrogen and a variety of simple polyatomic molecules has been investigated. See references below.

3. The trapping of potassium resonance radiation and its quenching by molecular gases has been investigated. A cursory search for a long-lived collision complex (K^* - inert gas) has been made without producing evidence for its existence. See references below.

4. The disorientation of magnetically aligned potassium atoms in the Zeeman substates of the $4^2P_{1/2}$ and $4^2P_{3/2}$ states, induced in collisions with noble gases, has been investigated. The resulting cross sections which are much larger than theoretically predicted values, have stimulated considerable further theoretical work. See references below.

5. The quenching of cesium resonance radiation and $6^2P_{1/2} - 6^2P_{3/2}$ excitation transfer induced in collisions with nitrogen and hydrogen atoms has been investigated. See references below.

6. Excitation transfer between the $^2P_{1/2}$ and $^2P_{3/2}$ resonance states in potassium and rubidium, induced in collisions between excited potassium and ground state rubidium atoms, has been investigated. See references below.

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7. The quenching of rubidium resonance radiation and $5^2P_{1/2} - 5^2P_{3/2}$ excitation transfer induced in collisions between excited Rb atoms and simple molecules (H_2, HD, D_2, N_2, CH_4, CD_4, C_2H_2, C_2H_4, C_2H_6) has been investigated. A paper is now being written for publication in the Canadian Journal of Physics.

8. The investigation of the isotope effect in the cross sections for $^2P_{1/2} - {}^2P_{3/2}$ mixing in cesium, induced in collisions with isotopic molecules, has not been completed even though a preliminary letter has been published (see reference below).

9. The investigation of $4^2P_{1/2} - 4^2P_{3/2}$ mixing in potassium, induced in collisions with slow electrons, has not been completed although good progress was being made at the time of termination of the contract.

10. The investigation of disorientation of magnetically oriented $6^2P_{1/2}$ cesium atoms, induced in collisions with noble gases, has not been completed, even though good progress was being made at the time of termination of the contract. A contributed paper was presented at the VIth International Conference on the Physics of Electronic and Atomic Collisions (see reference below).

11. The construction of the scanning Fabry-Perot interferometer for the investigation of the details of excitation transfer from excited alkali atoms to molecules, has not been completed at the time of termination of the contract.

B. Papers arising from the research covered by the contract.

-. G. Copley, B. P. Kibble and L. Krause, 'Experimental Evidence for the Absence of Quenching of Sodium Resonance Radiation by Inert Gases', Phys. Rev., 163, 34 (1967).

2. D. A. McGillis and L. Krause, 'Inelastic Collisions Between Excited Alkali Atoms and Molecules: IV Sensitized Fluorescence and Quenching in Mixtures of Cesium with N_2, H_2, HD and D_2', Can. J. Phys., 46, 1051 (1968).

3. L. Krause, 'An Experimental Search for Selection Rules Governing Collisional m_J Mixing in Alkali Atoms', Proceedings of the International Conference on Optical Pumping and Line Shape, Warsaw (1968).

4. M. Stupavsky and L. Krause, 'Inelastic Collisions Between Excited Alkali Atoms and Molecules: V Sensitized Fluorescence in Mixtures of Sodium ith N_2, H_2, HD and D_2', Can. J. Phys., 46, 2127 (1968).

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5. D. A. McGillis and L. Krause, 'An Isotope Effect on $6^2P_{1/2} - 6^2P_{3/2}$ Mixing in Cesium, Induced in Collisions with CH_4 and CD_4', Can. J. Phys., 47, 473 (1969).

6. E. S. Hrycyshyn and L. Krause, 'Sensitized Fluorescence in Vapours of Alkali Metals: XI Energy Transfer in Potassium-Rubidium Collisions', Can. J. Phys., 47, 215 (1969).

7. E. S. Hrycyshyn and L. Krause, 'Sensitized Fluorescence in Vapours of Alkali Metals: XII $4^2P_{1/2} - 4^2P_{3/2}$ Mixing in Potassium, Induced in Collisions with Ground State Rubidium Atoms', Can. J. Phys., 47, 223 (1969).

8. G. Copley and L. Krause, 'The Trapping and Quenching of Potassium Resonance Radiation', Can. J. Phys., 47, 533 (1969).

9. G. Copley and L. Krause, 'Experimental Evidence for the Absence of a Long-Lived K-Xe Complex in $4^2P_{1/2} - 4^2P_{3/2}$ Mixing in Potassium Induced by Collisions with Xenon Atoms', Can. J. Phys., 47, 1881 (1969).

10. M. Stupavsky and L. Krause, 'Inelastic Collisions Between Excited Alkali Atoms and Molecules: VI Sensitized Fluorescence in Mixtures of Sodium with CH_4, CD_4, C_2H_2, C_2H_4 and C_2H_6', Can. J. Phys., 47, 1249 (1969).

11. P. Violino, 'Investigation of the Hyperfine Structure of the $6^2P_{3/2}$ State of ^{133}Cs by a Level-Crossing Method', Can. J. Phys., 47, 2095 (1969).

12. E. S. Hrycyshyn and L. Krause, 'Inelastic Collisions Between Excited Alkali Atoms and Molecules: VII Sensitized Fluorescence and Quenching in Mixtures of Sodium with H_2, HD, D_2, N_2, CH_4, CD_4, C_2H_4 and C_2H_6', Can. J. Phys. (to be published).

C. Papers presented at scientific meetings.

1. The following contributed papers were presented at the meeting of the American Physical Society in New York in February 1969:

   (i) L. Krause and D. A. McGillis, 'An Isotope Effect on $6^2P_{1/2} - 6^2P_{3/2}$ Mixing in Cesium, Induced in Collisions with CH_4 and CD_4'.

   (ii) G. Copley and L. Krause, 'The Trapping and Quenching of Potassium Resonance Radiation'.

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2. The following contributed papers were presented at the VIth International Conference on the Physics of Electronic and Atomic Collisions at the Massachusetts Institute of Technology in July 1969:

(i) G. Copley and L. Krause, 'Experimental Evidence for the Absence of a Long-Lived K - Xe Complex in $4^2P_{1/2}$ - $4^2P_{3/2}$ Mixing in Potassium, Induced by Collisions with Xenon Atoms'.

(ii) J. Guiry and L. Krause, 'Collisional Disorientation of Magnetically Oriented $6^2P_{1/2}$ Cesium Atoms'.

(iii) E. S. Hrycyshyn and L. Krause, '$5^2P_{1/2}$ - $5^2P_{3/2}$ Mixing in Rubidium, Induced in Collisions with Molecules'.

(iv) M. Stupavsky and L. Krause, '$3^2P_{1/2}$ - $3^2P_{3/2}$ Mixing in Sodium, Induced in Collisions with Molecules'.

D. Fiscal Status

The contract monies have been spent and I have instructed our Chief Accountant's Office to issue an invoice for the final installment of the contract, in the amount of $3,500.

L. Krause,
Principal Investigator.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

Quenching and trapping of resonance radiation, excitation transfer between resonance states, and disorientation of magnetically aligned atoms have been studied experimentally in collisions involving alkali metal atoms.

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