COMMENTS AND ADDENDA

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Depolarization Cross Sections for the Metastable Noble Gases by Optical Pumping

L. D. Schearer
Texas Instruments Incorporated, Dallas, Texas 75222
(Received 7 July 1969)

The relaxation times of optically oriented metastable atoms of Ne, Ar, and Xe in buffers of noble gases have been measured, and depolarization cross sections obtained. The cross sections range from 0.43×10^{-16} cm^2 for Ne^m-He collisions to 190×10^{-16} cm^2 for Xe^m-Xe.

The metastable $^3P_2$ atoms of Ne, Ar, and Xe have recently been oriented by optical pumping. A detailed account of optical pumping in Ne and the measurement of depolarization cross sections for collisions with $^1S_0$ He and $^1S_0$ Ne atoms has been published,[1] and a brief description of optical pumping in Ar and Xe has appeared.[2] The purpose of this addendum is to report the results of measurements of depolarization cross sections obtained for collisions of Ar and Xe metastable $^3P_2$ atoms with the ground-state atoms of the other noble gases.

The depolarization cross sections are obtained by measuring the magnetic-resonance linewidth as a function of pressure of the ground-state buffer gas. The experimental procedure followed for linewidth and pressure measurements is described in Ref. 1. The measured linewidth as a function of Ar pressure for $^3P_2$ Ar atoms is shown in Fig. 1. Similar curves are obtained for various mixtures of noble gases.

The error bars shown in Fig. 1 represent the maximum uncertainty in the determination of the linewidth. The solid line shown is obtained with a depolarization cross section $\sigma = 100\times10^{-16}$ cm^2 and a field inhomogeneity corresponding to 9.0 kHz. At low pressures the deviation from the solid line indicates contributions to the spin relaxation due to quenching of the metastable atoms at the container walls. The largest source of error arises from the determination of the pressure in the absorption cell. This error is taken to be 5%.

The measured depolarization cross sections are shown in Table I. The cross section for Ar^m-Xe

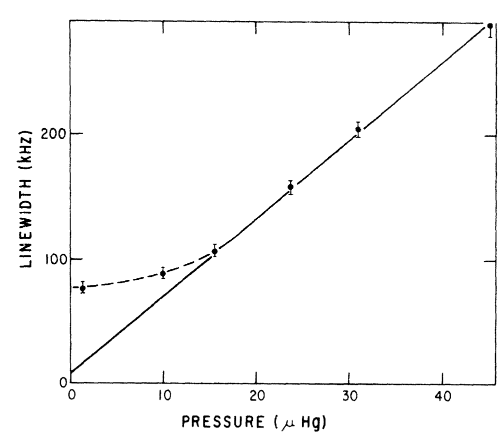

FIG. 1. Argon metastable magnetic-resonance linewidth as a function of argon pressure.

TABLE I. Depolarization cross sections.

(10^{-16} cm^2)	
$\sigma(\mathrm{Ne}^m\text{-He}) = 0.430$	± 0.022
$\sigma(\mathrm{Ne}^m\text{-He}) = 16.6$	± 0.8
$\sigma(\mathrm{Ar}^m\text{-He}) = 6.2$	± 0.4
$\sigma(\mathrm{Ar}^m\text{-Ne}) = 26$	± 2
$\sigma(\mathrm{Ar}^m\text{-Ar}) = 100$	± 7
$\sigma(\mathrm{Ar}^m\text{-Xe})^{\mathrm{a}} \sim 127$	
$\sigma(\mathrm{Xe}^m\text{-He}) = 15$	± 1
$\sigma(\mathrm{Xe}^m\text{-Ne}) = 38$	± 2
$\sigma(\mathrm{Xe}^m\text{-Ar}) = 61$	± 4
$\sigma(\mathrm{Xe}^m\text{-Xe}) = 190$	± 16

[a] There is considerable uncertainty in this value (see text).

collisions is shown without error limits. In practice, we found that with the addition of even small amounts of Xe (~10 μ) to the Ar discharge, the Ar metastable density was too low to yield acceptable optical pumping signals. The cross section shown is the result of a single measurement at low pressures, and is to be taken as suggestive only.

We also point out that the cross section for Xe^m-Xe collisions may contain the effects of metastability exchange. Hadeishi and Liu have reported the observation of exchange collisions between metastable Xe^{131} and Xe^{131} ground-state atoms.[3] Our samples contained natural Xe. We were unsuccessful in our attempts to observe a nuclear polarization of the odd Xe isotopes. Linewidth measurements at $g_j = 2$, due to the even isotopes of metastable Xe, and at $g_F = 1.2$, due to the $F = \frac{3}{2}$ levels in Xe^{131} and the $F = \frac{5}{2}$ levels in Xe^{129}, yielded similar values for the spin-relaxation time. This would tend to suggest that under the conditions of our experiment, metastability exchange collisions do not contribute to the reported linewidth.

Notable by its absence are measurements with Kr. We have no reason to expect that Kr metastable atoms could not also be optically pumped in a similar fashion. It was simply not among the gases in our stockroom.

I would like to acknowledge the capable assistance of F. D. Sinclair.

[1] L. D. Schearer, Phys. Rev. 180, 83 (1969).
[2] L. D. Schearer, Phys. Letters 28A, 660 (1969).
[3] Tetsuo Hadeishi and Chung-Heng Liu, Phys. Rev. Letters 19, 211 (1967).

PHYSICAL REVIEW VOLUME 188, NUMBER 1 5 DECEMBER 1969

Acoustic Instability in Weakly Ionized Gases

P. Kaw
Plasma Physics Laboratory, Princeton University, Princeton, New Jersey 08540
(Received 9 July 1969)

It is shown, in contrast with earlier work, that energy transfer between hot electrons and neutrals in a weakly ionized gas does not lead to an acoustic instability, if proper care is taken to account for the nonstationary nature of the neutral equilibrium.

It has been recently suggested[1-3] that acoustic waves in a weakly ionized plasma may be driven unstable under certain conditions, if the electrons are maintained at a higher temperature than the neutrals. The energy source of the instability is the energy transferred from the electrons to neutrals by elastic collisions. The mechanism of amplification is related to the fact that a perturbation in the gas density due to the sound wave leads to a perturbation in the electron density, which, in turn, modifies the energy transfer between electrons and neutrals in a manner that favors the growth of the wave. In these investigations,[1-3] the time dependence of the equilibrium temperature of the neutrals has been ignored. A careful study of the results reveals, however, that the growth rate of the instability has a magnitude comparable to the rate of change of the equilibrium neutral temperature; under these conditions it is improper to neglect this latter time dependence. In this paper, we show that if this nonstationary nature of the equilibrium temperature of neutrals