ORIENTATION AND ALIGNMENT VELOCITY-CHANGE SPECTRA OBTAINED BY DIRECT INVERSION OF TIME DOMAIN STIMULATED ECHO DATA

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Using photon echo techniques we have measured the collisional relaxation of isolated orientation (ρ^1) and alignment (ρ^2) multipoles in the $^3P_1$ excited-state Zeeman manifold of ^{174}Yb vapor perturbed by He and Ar buffer gases. The data presented provide the first comparison of alignment and orientation decay rates sensitive to the effects of depolarizing and velocity-changing collisions. These measurements have the highest velocity resolution of any magnetic-state scattering measurements to date [1], and by direct inversion of our echo data we have obtained the first model-independent velocity-change spectra (collision kernels) for these processes.

In our experiment, three polarized, colinear light pulses resonant with $^1S_0$ - $^3P_1$, λ = 556nm transition of Yb, induce a stimulated echo. Depending on their polarization, the first two laser pulses introduce a q = 0 (2) component of orientation (alignment) into the $^3P_1$ Zeeman manifold with an amplitude that is modulated as a function of axial velocity with period $v_{mod} = \lambda/t_{21}$, here t_{ij} represents the time interval between pulse i and j. The echo is generated as a result of the interaction of the third laser pulse with the velocity modulation in these quantities.

During t_{32}, collisions with buffer gas atoms depolarize and/or velocity thermalize the ordered Yb atoms (Yb*). These collisions reduce the echo amplitude [1], at a rate proportional to a t_{21}-dependent effective cross-section, $\sigma_{eff}(t_{21})$. Significantly, $\sigma_{eff}(t_{21})$ can be related via Fourier transformation to a collision kernel, $W(\Delta v)$, that represents the probability density per unit velocity that a single polarization preserving collision induces an axial velocity change Δv.

Model-independent collision kernels were derived from our measured values of $\sigma_{eff}(t_{21})$ by direct Fourier transformation. The data and derived kernels are shown in figure 1a and 1b. The Ar-Yb* kernel exhibits a pronounced two-component structure with a narrow central component associated with diffractive collisions, and broad van der Waals induced structure in the wings associated with small angle classical scattering [2]. The complex nature of these kernels differs dramatically from the

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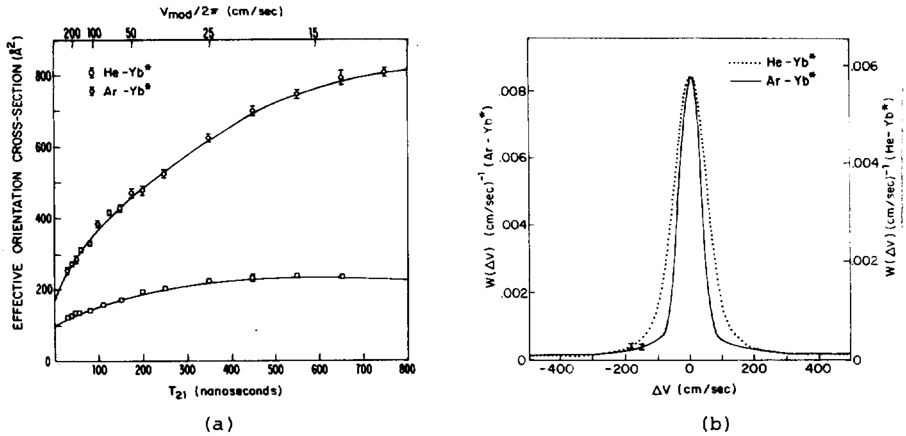

Figure 1: (a) Measured values of $\sigma_{eff}(t_{21})$ as a function of t_{21}. The data are orientation cross-sections for He- and Ar-Yb* collisions. Each point represents an average of 6-16 separate measurements. (b) Velocity-changing collision kernels derived via Fourier transformation from the $\sigma_{eff}(t_{21})$ data in (a) and previously measured values of $\sigma_{eff}(0)$ [1]. In order to compare the relative shapes of these kernels we have adjusted the vertical axis corresponding to each kernel so that their maxima coincide. The error bars in the figure represent the full range of deviation that our data exhibit and will be discussed.

single-component forms commonly used or assumed. These kernels, as well as observed differences in alignment and orientation collisional relaxation rates, will be described.

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