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CROSSED MOLECULAR BEAM STUDY ROTATIONAL EXCITATION OF HD(J=O->1) IN COLLISIONS WITH He

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Crossed Molecular Beam Study
Rotational Excitation of HD(J=0→1) in Collisions with He

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The study of rotationally and vibrationally inelastic scattering has received significant attention in recent years[1] and the He-H_2 system has served as a model system for many studies. Most experimental studies on this system have been concerned with spectroscopic line broadening, nuclear spin relaxation, and ultrasonic dispersion and a variety of calculations have been performed on this system to explain these data in terms of an interaction potential. The isotopically substituted systems He-D_2, He-HT, and He-HD have also received attention, the latter two systems with regard to the role of electronic anisotropy vs. mass asymmetry in inducing rotational transitions.[3] The He-HD system has been the focus of a number of theoretical studies[4,5] and the importance of the mass asymmetry in rotationally inelastic scattering has been established.

We wish to report the observation of rotationally inelastic scattering in the He + HD system in a crossed molecular beam experiment conducted at a collision energy of 19.3 meV, low enough such that only the J=0→J=1 rotational excitation occurs. The crossed molecular beam apparatus has been described in detail[6] and the experiments were conducted by crossing two liquid nitrogen cooled supersonic nozzle beams of He and HD at 90° in a vacuum chamber held at 10^{-7} torr by an oil diffusion pump. The scattered HD signal was detected with a quadrupole mass spectrometer detector which rotates about the collision center in the plane of the beams. The velocity distribution of the scattered HD molecules is measured by the time of flight (TOF) technique. The TOF chopper consists of 8 slots of width 1 mm equally spaced on the circumference of an aluminum disc of radius 8.5 cm. The chopper is rotated at 400 Hz and a reference lamp - photo-FET arrangement initiates data collection by a 40 channel multiscaler controlled by a minicomputer. The data are collected and stored in synchronization with modulation of the He beam at 150 Hz by a tuning fork chopper. TOF spectra are recorded as a function of laboratory scattering angle with data collection times on the order of 5 to 6 hours per laboratory angle. For normalization and determination of the spherical part of the interaction potential, we have measured the angular distribution of scattered HD with the TOF wheel removed. These data are shown in the upper panel of Figure 1 along with the Newton diagram portraying the kinematics of the elastic and inelastic transitions. TOF data at selected laboratory angles are shown in the lower panel of Figure 1. The prominent peaks in the data arise from elastic scattering and the small shoulder at longer flight times results from the inelastically scattered HD. We have chosen to show data which correspond to HD scattered inelastically in the backward hemisphere, theory indicating that the inelastic cross section should peak at θ c.m. = 180°. In order to provide some theoretical insight into our observations we have performed close-coupling calculations of the differential cross section for $J=0\rightarrow1$ scattering using the He-H_2 potential of Shafer and Gordon[2] and shifting the center of mass of the molecular partner as required for HD; the results of these calculations are also shown in Fig. 1. The center of mass shift is the primary source of the rotational inelasticity in the He-HD system and consequently the data provide additional information on the spherical part of the interaction potential with only a minor role played by the electronic anisotropy. More detailed calculations to refine the interaction potential are currently underway.

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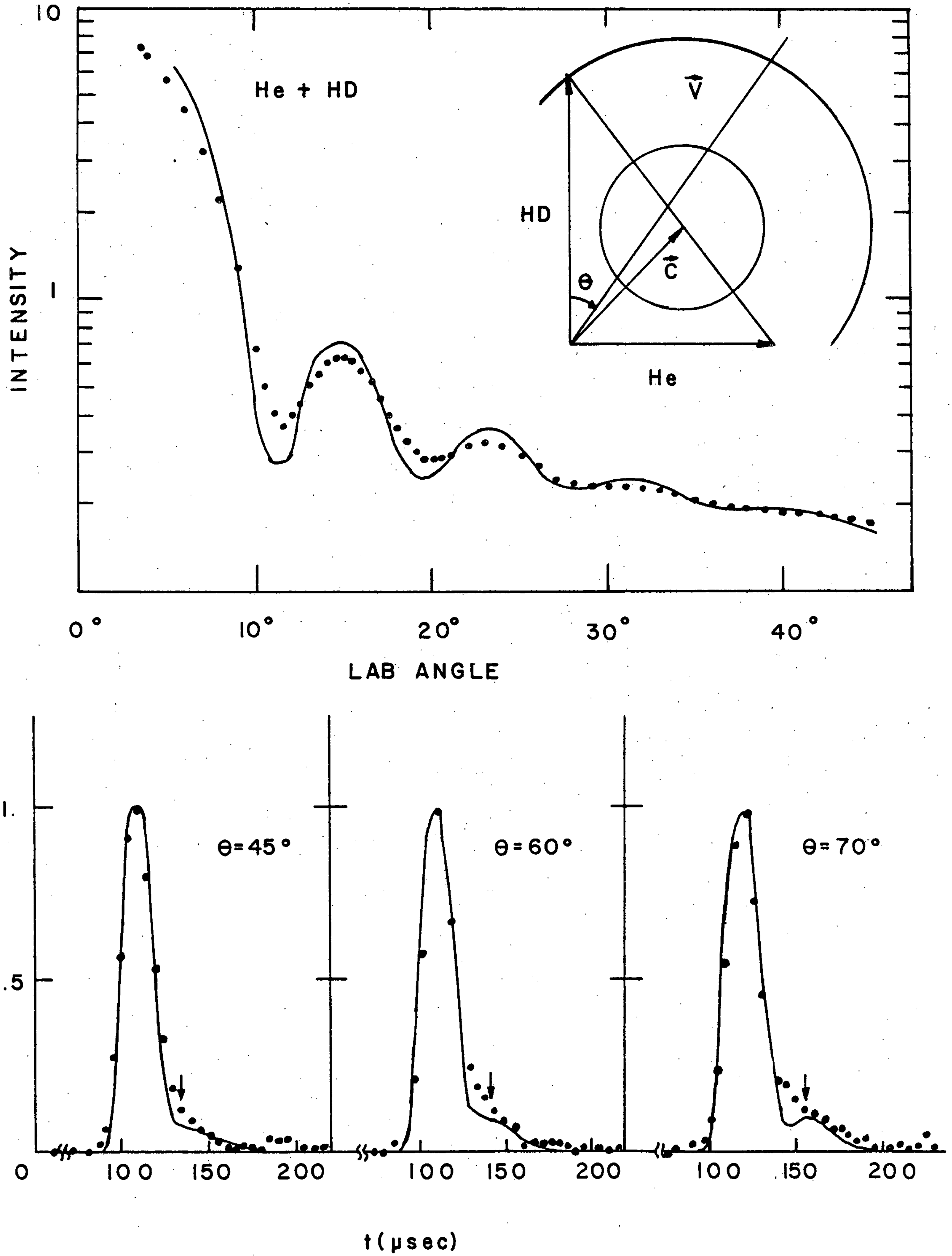
Figure Caption

Figure 1: Upper panel - Lab angular distribution of scattered HD in He + HD collisions. Solid line is a calculation based on the potential of Ref. 2. The Newton diagram showing the circles for elastic ($J=0\to0$) and inelastic ($J=0\to1$) is shown.

Lower panel - TOF data at $\Theta = 45°, 60°, 70°$.

Solid line - The results of cross sections computed with Shafer-Gordon potential. Arrow marks location of the maximum in the inelastic HD intensity.



10
1
INTENSITY
He + HD
HD
He
θ
0°
10°
20°
30°
40°
LAB ANGLE
1.
.5
θ=45°
θ=60°
θ=70°
0
100
150
200
t(μsec)

Fig. 1

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