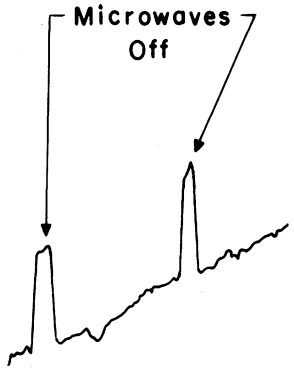

FIG. 3. Recorder tracing of a microwave-induced change of transmitted R_2 light polarized with its electric vector perpendicular to the optic axis.

$m = \pm \frac{1}{2}$ levels of the ground state and should change the R absorption, provided that the rate of optical transitions from the $m = \pm \frac{1}{2}$ levels differs from that of the $m = \pm \frac{3}{2}$ levels. This was actually found to be the case, as can be seen in Fig. 3. The intensity of transmitted R_2 light was displayed on a recorder, and the microwaves were manually turned on and off. The signal corresponds to about a one percent change in transmitted light for complete microwave saturation. The sloping background is due to a drift in the detection apparatus. Signals from R_2 light polarized with its electric vector parallel or perpendicular to the optic axis showed increasing or decreasing light transmission, respectively. This is in qualitative agreement with the transition probabilities shown in Fig. 1. A preliminary study of the amplitudes and signs of the signals indicates that the intensity distribution of light in the source is also contributing to the signal. This may be partially due to a slight frequency shift between the source emission line and the sample absorption line.[11] With the difference in rates of optical absorption now established, it may be possible to enhance this effect and to detect optical pumping directly. These points are being pursued further and will be reported on later.

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FORMATION OF NEGATIVE IONS IN CO BY ELECTRON CAPTURE FROM FAST HYDROGEN ATOMS

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A recent precise measurement of the total cross section for electron loss by a hydrogen atom in collision with a hydrogen molecule has revealed structure in that cross section.[1] A proposal has been made, very tentatively, that enhancement of the cross section occurs at certain energies because at such energies the atomic electron may be captured by the target molecule as well as go into an unbound state. On the basis of the very sketchy evidence available a mechanism for this process was also developed. It was proposed that in collisions leading to the formation of $H^- + H$ the electron first makes a transition into the continuum as the hydrogen atom approaches the molecule, and attains about 0.25 ev of kinetic energy in the proton-electron center-of-mass system. The angular distribution is to be peaked strongly forward. To the molecule then this electron is seen as a free electron which can be captured into a state of

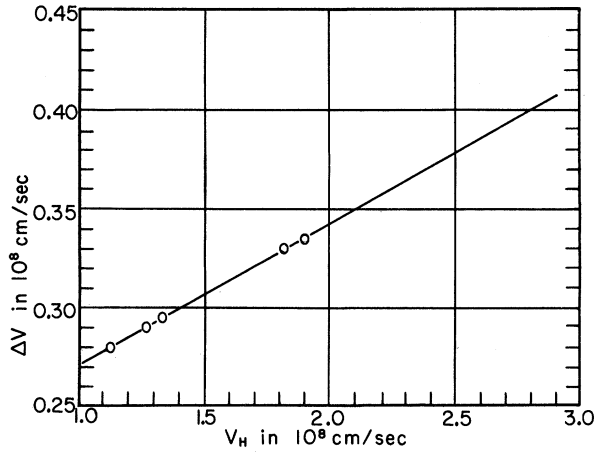

FIG. 1. Velocity of the free electron in the hydrogen atom system as a function of the hydrogen atom velocity in the laboratory. The points are taken from $H+H_2$ data.

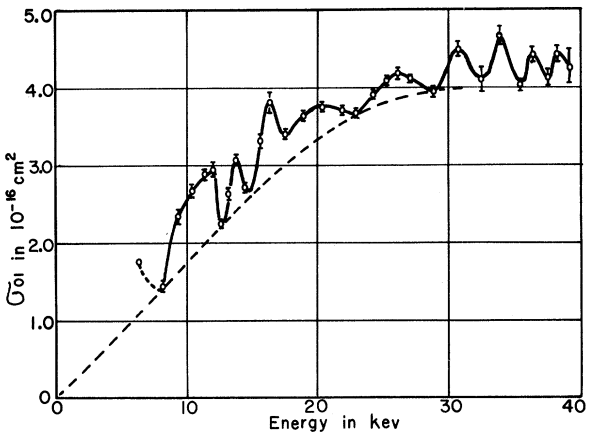

FIG. 2. Electron loss cross section for hydrogen atoms in CO. At the lowest energy a measurement of $\sigma_{01}+\sigma_{0-1}$, but not $\sigma_{01}-\sigma_{0-1}$, is available.

H_2^- in accordance with the Franck-Condon principle provided that its energy in the lab system, $E_e = mV_e^2/2$, is proper. On the basis of this picture it was found necessary to assume that the velocity the electron acquires in the H atom system, ΔV, is a slowly varying function of the velocity of the atom, V_H (Fig. 1). Thus, if

$$V_e = V_H + \Delta V, \tag{1}$$

ΔV is found to be linear with V_H. In that case the energy at threshold of the electrons stripped from H,

$$E_e = (m/M)E_H + E_0 + 2[(m/M)E_0E_H]^{1/2}, \tag{2}$$

coincides with the thresholds found by Schulz[2] and by Khvostenko and Dukel'skii[3] for free electrons in H_2. Here E_H is the kinetic energy of the atoms in the lab system and E_0 is the kinetic energy of the electron in the moving atomic system after it has been stripped.

To test these ideas we have measured the loss cross section for hydrogen in argon and in carbon monoxide. In the first case we find a smooth cross section with no evidence of structure. In the second we have found a multitude of very large peaks reaching more than 10^{-16} cm^2 above the smooth background (Fig. 2). If we treat the thresholds again exactly as the H_2 case, in fact take the increments ΔV directly from Fig. 1, we

Table I. Comparison of electron energies and appearance potentials.

H energy kev	Electron energy ev	Appearance potentials ev	
8.10	6.59		
12.55	9.71	9.66	$C(^3P)+O^-$
14.45	11.03	10.92	$C(^1D)+O^-$
16.6	12.5	12.34	$C(^1S)+O^-$
23.50	17.15	17.11	C^*+O^-
28.77	20.65	20.93	$C^+(^2P)+O^-+e$
32.4	23.30	23.40[a], 23.63[b]	C^-+O^++e
35.40	25.25		
36.9	26.12	26.26	$C^+(^4P)+O^-+e$

[a]Petrocelli, reference 6.
[b]Lagegren, reference 5.

find a very close agreement between the resulting electron energies and the expected appearance potentials of O^- and C^-. In Table I we have listed these energies and the appearance potentials for negative ions derived from CO if the dissociation energy of CO is taken as 11.11 ev and the affinity of O as 1.45 ev.[4] For $C^- + O^+$ we have listed values taken from the theses of Lagegren[5] and Petrocelli[6] separately. In CO, as in H_2, we find at least one very broad peak below the first one that appears from free electron capture. In the present case the ion formed would have to be CO^- if our ideas are correct. A mass spectrographic analysis is under way to elucidate these processes further.

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DIPOLE STATE IN NUCLEI*

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In order to explain the unexpectedly high (γ, p) cross section in heavy nuclei, various authors[1,2] have proposed that these protons arise mainly from a direct process. The close relationship of this process to the shell model and optical model has been elucidated by Wilkinson,[3] who points out that the initial state of the nucleus is quite well described by the shell model. The proton involved in the direct process can then be considered as being initially in an eigenstate in the shell-model well. Upon absorption of the dipole gamma ray, the proton makes a transition to either a bound level in the well or one in the continuum. Because this state is not stationary, it is given a width $\Gamma + 2W$, where W is the absorption in the optical-model well at the relevant excitation and describes the absorption of the single-particle excitation into compound states and Γ is the width for escape. The proportion of fast protons that escapes is then $\Gamma/(\Gamma + 2W)$. The picture is very appealing, in that it produces the observed order of magnitude of fast particles, which is several orders of magnitude greater than the statistical description predicts. The relation of this description to one in terms of compound states of the system has been given in detail.[4] In reference 4 it is made clear that the highly excited levels discussed by Wilkinson are really combinations of thousands or millions of compound states which, however, act coherently as a single-particle state for some processes. We will refer to these groups of compound states as single-particle excitations.

The positions of the single-particle excitations can be found directly through other processes. Recently, (d, p) experiments using poor resolution[5,6] have determined the positions of single-particle excitations lying between zero bombarding energy and the binding energy of the last neutron. The spacings of these excitations seem to be in sharp conflict with those required by Wilkinson. For example, in Ti^{49}, the $f_{7/2}$ and $g_{9/2}$ levels are only about 4 Mev apart. However, just the transition between these two levels is an appreciable part of the giant dipole resonance in this nucleus, which comes at an energy of about 15 Mev. It is true, of course, that one must add a pairing energy to the 4 Mev before making the comparison, because in the absorption of the gamma ray a pair is generally broken. However, this is only one or two Mev. It seems, therefore, that the transition between single-particle excitations should occur at an energy of only about half that of the giant dipole resonance.

We should like to point out in this note that these two energies cannot be compared directly, since, in the dipole absorption, a hole is formed in the nucleus. Since the process is a dipole one, the excited particle and hole are strongly correlated in angle; i.e., their angular momen-