# Orientation of atoms during photodissociation of molecules

O. S. Vasyutinskiĭ
*A.F. Ioffe Physicotechnical Institute, USSR Academy of Sciences*

(Submitted 26 February 1980)
Pis'ma Zh. Eksp. Teor. Fiz. **31**, No. 8, 457–460 (20 April 1980)

The orientation of atoms during photodissociation of molecules by circularly polarized light was established. Observation of oriented cesium atoms, produced due to photodissociation of CsI molecules by circularly polarized ultraviolet radiation, is reported.

PACS numbers: 33.80.Gj

The optical orientation of atoms,[1,2] involving a transfer of angular momentum from the light to an ensemble of atoms as a result of interaction of an atomic system with a circularly polarized (CP) resonance radiation, is well known. It has also been established that in an ionization reaction resulting from collisions of hydrogen molecules with optically oriented $2\,^3S_1$ helium atoms the electron angular momentum is transferred from the helium atoms to hydrogen atoms produced in the reaction.[3]

In this paper we show for the first time that there is a completely different mechanism for transfer of angular momentum from the light to the atoms. An oriented ensemble of atoms can be obtained during photodissociation of molecules by a CP light. The angular momentum imparted to the molecular system by a circularly polarized radiation via the unstable, excited states of the molecules must be transferred to the atoms produced as a result of photodissociation. A key factor in this case is that the lifetime of the molecules in an unstable state usually is much smaller than the time characterizing the coupling of the electron momentum of the molecules with their rotation.[4] Therefore, the electron orientation in the excited state of the molecules must be transferred almost without losses to the photodissociation products.

We observed cesium atoms oriented in the ground state, which were produced due to photodissociation of cesium iodide molecules by CP ultraviolet radiation in the reaction:

$$h\nu + \mathrm{CsI} \rightarrow \mathrm{Cs} + \mathrm{I}. \qquad (1)$$

The experiment was as follows (see Fig. 1). An absorption cell (AC), which contained CsI pairs at a pressure of $p \approx 10^{-2}$ Torr and $p \approx 10$ Torr of neon, was placed in a constant magnetic field $H_0 \approx 0.3$ Oe.

The pump radiation, produced by a superhigh-pressure DRSh-1000 mercury tube ($T_1$) and propagated in the direction of the magnetic field, was passed through the circular polarizer (CP) and then focused in the cell. A photodissociation of CsI according to the reaction (1) was accomplished in the cell. To determine the orientation of atoms obtained in this manner, we produced a magnetic resonance of the system of ground-state sublevels of the cesium atoms. This changed the circular dichroism of the

  

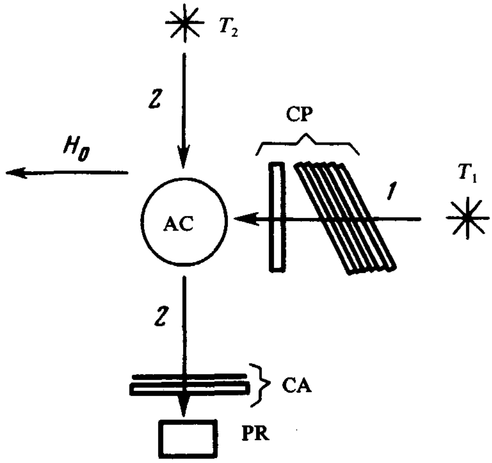


FIG. 1. Experimental setup: $T_1$ DRSh-1000 tube; $T_2$; cesium tube; 1, pump beam; 2, recording beam; CP, circular polarizer; CA, circular analyzer; PR, photoreceiver; AC, absorption cell.

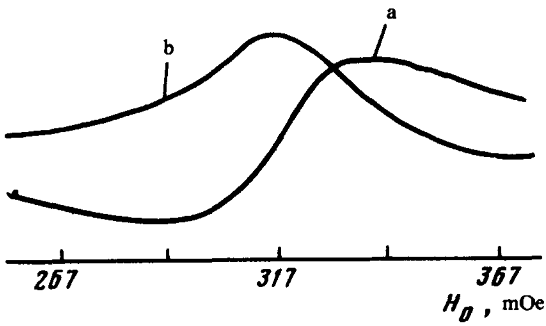


FIG. 2. Magnetic resonance signal in the $6\,^2S_{1/2}$ states of the cesium atoms oriented during photodissociation of CsI molecules by a circularly polarized radiation: (a) in-phase component of the signal; (b) quadrature component of the signal.

cesium vapor, recorded by using an unpolarized resonance light beam from the cesium tube ($T_2$), which was transmitted through the cell in the perpendicular direction to the magnetic field $H_0$ and then focused on the photoreceiver (PR) in front of which a circular analyzer (CA) was placed.[5] The signal from the PR was amplified and then detected by a synchronous detector. The in-phase (a) and the quadrature (b) components of the signal obtained by slowly varying the magnetic field $H_0$ are shown in Fig. 2. The widths of the resonance curves in Fig. 2 are attributable primarily to depolarization of the cesium atoms during collisions with the CsI molecules.

The experiment showed that the oriented atoms are produced in the cell only when the pump radiation is circularly polarized. It was also established that the observed effect is caused only by the short-wave part of the pump radiation, which gives rise to dissociation of the CsI molecules [$\lambda \leqslant 360$ nm (see Ref. 6)]. These facts indicate that the cesium atoms are oriented directly during the reaction (1). To estimate the efficiency of the examined mechanism for the orientation of atoms, we performed an experiment which differed from the one described above in that it used an unpolarized radiation of the DRSh-1000 tube to obtain the cesium atoms in the reaction (1), and the orientation of these atoms was achieved by using an additional CP light beam from the cesium tube. It turned out that the signals obtained in this manner are close to those depicted in Fig. 2. Therefore, the degree of orientation of the atoms attained the dissociation of molecules is close to that attained in the direct interaction of atoms with the CP resonance radiation under the same relaxation conditions.

It should be noted that the production of oriented atoms due to photodissociation of molecules by CP radiation, which was observed in our experiment, apparently has a sufficiently general nature and should be observed in the interaction of CP radiation with different molecules that have absorption bands producing a dissociation.

Thus, the orientation of atoms during photodissociation of molecules by CP radiation was established in this experiment.

The authors thank R.A. Zhitnikov for his interest in this work and for a discussion of the results, E.B. Aleksandrov for consultation in connection with building of the experimental setup, and A.I. Okunevich for useful discussions.

[1]A. Kastler, J. Phys. Radium. **11**, 255 (1950).
[2]W. Hopper, Rev. Mod. Phys. **44**, 169 (1972).
[3]S. P. Dmitriev, R. A. Zhitnikov, V. A. Kartoshkin, G. V. Klement'ev, and A. I. Okunevich, Pis'ma Zh. Eksp. Teor. Fiz. **28**, 442 (1978). [JETP Lett. **28**, 409 (1978)].
[4]G. Gertsberg, Spektry i stroenie dvukhatomnykh molekul (Spectral and Structure of Diatomic Molecules), IIL, 1949.
[5]C. Cohen-Tannoudji and F. Laloe, J. de Phys. **28**, 505, 722 (1967).
[6]P. Davidovits and D. C. Brodhead, J. Chem. Phys. **46**, 2968 (1967).