

Hyperfine interaction in molecular iodine between the 0_g^+ , 1_u and 0_u^- states correlating with the $I(^2P_{1/2}) + I(^2P_{1/2})$ dissociation limit

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Abstract

The three-step three-color laser population of the $I_2(\beta 1_g, \nu_\beta, J_\beta)$ and $DO_u^+(\nu_D, J_D)$ rovibronic states via those of the BO_u^+ and $1_u, 0_g^+(bb)$ states, correlating with the second and third dissociation limits of the valence states, has been used for the study of mechanisms of optical transitions involved in the population of the $\beta 1_g, \nu_\beta, J_\beta$ rovibronic states. It has been shown that the $1_u(bb) \leftarrow BO_u^+$ transition is allowed due to hyperfine interactions of the $1_u(bb), \nu_{1u}, J_{1u}$ and $0_g^+(bb), \nu_0, J_0$ rovibronic states, though energy gaps between these pairs of the states are huge, greater than 0.7 cm^{-1} . The $\Delta J = \pm 2$ lines observed in the $\beta 1_g - 1_u(bb)$ transition are also due to hyperfine interaction of the $1_u(bb), \nu_{1u}, J_{1u}$ and $0_u^-(bb), \nu_0, J_0$ rovibronic states. It has been also shown that the $1_u(bb) \leftarrow BO_u^+$ transition cannot be attributed either to magnetic dipole or to electric quadrupole transitions. Contributions from the Stark effect in a strong laser field and from possible production of the $I_2(X) \dots I_2(B)$ colliding pairs to mechanism of the $1_u(bb) - BO_u^+$ transition are negligible.

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1. Introduction

Optical transitions which are forbidden in the electric dipole approximation are the subject of numerous studies (see [1–10] and references therein). In the homonuclear diatomic molecules, the $g \leftrightarrow u$ selection rule for electric dipole transitions is very strong. It precludes optical transitions between electronic states of the same parity with respect to permutation of identical nuclei [1]. However, in some cases the above selection rule can be violated, and the transitions can be observed, although with much smaller intensity. These cases are as follows:

1. The transitions are allowed in the magnetic dipole or electric quadrupole approximation [1, 4–6].
2. A strong static electric field, or intensive laser radiation which mixes the parities of molecular rovibronic states due to the Stark effect is applied (see [11–14] and references therein).
3. The selection rule $g \leftrightarrow u$ is cancelled since transitions occur in the colliding pairs or van der Waals (vdW) complexes [15–20].
4. The molecular rovibronic states have a mixed g, u symmetry due to the hyperfine interaction [7–10, 21–24].