Homogeneous Perturbation Between the \( c'_{\Sigma}^{1} \Sigma_{u}^{+}(v' = 0) \) and \( b'_{\Sigma}^{1} \Sigma_{u}^{+}(v' = 1) \) Rotational States of \( N_2 \)

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Introduction

Many measurements and accurate theoretical calculations have been reported about the \( c'_{\Sigma}^{1} \Sigma_{u}^{+} \) and \( b'_{\Sigma}^{1} \Sigma_{u}^{+} \) states. Yoshino et al[1] reported homogeneous perturbation between the \( c'_{\Sigma}^{1} \Sigma_{u}^{+}(v' = 0) \) and \( b'_{\Sigma}^{1} \Sigma_{u}^{+}(v' = 1) \) states with absorption spectrum. Their perturbation theoretical calculations agree with experimental data.

In this study rotational resolved emission spectra of the \( c'_{\Sigma}^{1} \Sigma_{u}^{+}(v' = 0) \) and \( b'_{\Sigma}^{1} \Sigma_{u}^{+}(v' = 1) \) states were observed. Lifetime measurements about the rotational levels were performed using single bunch mode.

Experiment

The experiments were performed on beam line 20A. The synchrotron radiation was monochromized by 3-m normal incidence Eagle mounted scanning monochromator with a 2,400 line/mm grating which has resolution \((E/\Delta E)\) of about 60,000 with 10µm exit/entrance slit widths.

We used two detectors on this experiment. One is MCP (Microchannel plate) and the other is PMT (Photomultiplier tube) with MgF₂ window. Since each detector has different wavelength sensitivity, upper level \( \rightarrow \) ground state \( X'_{\Pi} \Sigma_{g}^{+} \) transition is observed by MCP, and upper level : \( a'_{\Pi} \Sigma_{g}^{+} \) transition is observed by PMT.

Results and Discussion

Observed spectra using MCP and PMT are shown in Fig.1(a) and Fig.1(b), respectively. Since the \( c'_{\Sigma}(0) \) and \( b'(1) \) states have the same symmetry, rotational levels which have the same rotational quantum number \( J' \), occur homogeneous perturbation[2]. The influence of the perturbation irregularity is confirmed from interval of rotational lines. In Fig.1(a), the \( b'(1) \) band overlapped the \( c'_{\Sigma}(0) \) band. Since the \( c'_{\Sigma}(0) \) states internuclear distance is near that of the ground state. Therefore, it seems that the \( c'_{\Sigma}(0) \) states have large emission intensity by the Frank-Condon principle. As seen in Fig.1(b) rotational levels which are largely perturbed, have intensities much larger than those of the other rotational levels. It is noted that upper level \( \rightarrow \ a'_{\Pi} \Sigma_{g}^{+} \) transitions are increased by homogeneous perturbation.

Fig.2 represent the lifetimes of rotational lines of the \( c'_{\Sigma}(0) \) and \( b'(1) \) states. Rotational levels of \( c'_{\Sigma}(0) \) have lifetimes 0.59~1.16 nsec and those of \( b'(1) \) have lifetimes 0.71~1.59 nsec.

References


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