SUMMARY OF Ph.D. DISSERTATION

School Fundamental Science and Technology	Student Identification Number	SURNAME, First name ANZAI, Kenji

Title

Development of a sensitive high-resolution spectrometer in the 3.4 μm wavelength region

Abstract

Most molecules have intense absorption transitions of fundamental vibrational bands in the mid-infrared region. Therefore, mid-infrared spectroscopy has contributed to various fields of molecular science. Employing lasers as light sources, sensitivity and spectral resolution are greatly enhanced. However, laser spectroscopy in the mid-infrared region has been relatively undeveloped because of the lack of widely tunable coherent light sources.

In the present research, we have developed a coherent light source with a tunable range of 91 cm^{-1} and a spectral linewidth of 0.06 MHz (HWHM) in the 3.4 μm region. We have applied it to sub-Doppler-resolution spectroscopy and isotope abundance measurements of methane.

In Chapter 1, history of mid-infrared spectroscopy and current situations of the light sources are surveyed.

In Chapter 2, the theoretical background of saturated absorption spectroscopy attaining sub-Doppler-resolution is described.

In Chapter 3, difference frequency generation and a developed light source are discussed.

In Chapter 4, an application to sub-Doppler-resolution spectroscopy is described. Because the power level of a few microwatts from the light source is not high enough to induce nonlinear effects, we use a Fabry-Perot cavity as an absorption cell to enhance the optical field strength, which has allowed us to observe a Lamb dip of the ν_3 band of $^{12}CH_4$. The spectral linewidth of the Lamb dip is 0.33 MHz (HWHM), which is narrower than the previous observations using the similar method. Because the cavity cell also extends the effective absorption length, saturation spectrum is successfully recorded even for less abundant $^{13}CH_4$.

In Chapter 5, an application to isotope abundance ratio measurement of methane is described. Isotope abundance ratio provides information of material circulation in atmosphere. We found the best pair of the $^{12}CH_4$ and $^{13}CH_4$ transitions that satisfies various conditions at the same time, and actually observed it within the tunable range of the developed light source. Intensity ratio of the pair has been repeatedly measured, and the absorption coefficient ratio is determined with a precision of 3 ‰, which is better than most of the previous spectroscopic measurements.

In Chapter 6, conclusion and a view for the future are given.