氏名	森　野　　勇
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学位論文題目	Far-Infrared and Infrared Spectroscopy of Transient Molecules of Astronomical Interest
論文審査委員	主　査　教　授　海　部　宣　男 教　授　稲　谷　順　司 助教授　梶　野　敏　貴 助教授　川　口　建太郎 助教授　金　森　英　人 （東京工業大学） 助教授　山　本　　智（東京大学）

論文内容の要旨

Since molecular observations in interstellar space have very important role to understand physical conditions - density and temperature - and production mechanisms of molecules, many molecules are studied in laboratory and in astronomical observation. A lot of information in interstellar space has been mainly obtained by millimeter-wave astronomical observations, but in millimeter wave region relatively heavy molecules have their rotational transitions. Observations of small molecules such as hydrides are limited, although they are important to understand the production mechanism related hydrogen compounds. Most of hydrides have rotational transitions in submillimeter-wave or far-infrared region. Recently, the astronomical observation techniques in submillimeter-wave, far-infrared, and infrared regions are greatly developed, and the observations in these regions become possible. However, there are a few laboratory data for molecules in these regions. In the present study, far-infrared and infrared Fourier transform spectroscopy was applied to measure transient molecules of astronomical interest in laboratory and the results were applied to astronomically observed data.

The dc discharge cell with multi-reflection system was constructed for far-infrared absorption measurement. The author applied to observe the pure rotational spectra of the SH, NH_2, NHD, and ND_2 radicals and the vibration rotation spectrum of NH_2OH. The measurement of SH was the first application of far-infrared Fourier transform spectroscopy to transient molecules, and detection limit of this measurement system was estimated. About 600 rotational lines of NH_2, NHD, ND_2 and about 5000 rovibrational lines of NH_2OH were observed in high-resolution and wide frequency coverage. By the analysis of the observed spectra, precise molecular parameters were obtained. The information obtained by these measurements is very useful for sub-millimeter and far-infrared astronomical observation.

The positive column discharge cell was constructed for infrared emission observation. The author applied to measure the vibration rotational spectra of the CD and ^{18}OH radicals. By analysis, precise molecular constants in the vibrationally excited

states were obtained. From intensity analysis using Herman-Wallis effect, the vibration transition moment of CH was determined, and applied to determination of column density in infrared astronomical observation. The observed intensity of ^{18}OH was discussed.

Some result of laboratory spectroscopy were applied to astronomical observational results. The upper limit of column density of SH was estimated from the submillimeter-wave emission spectrum in Orion-KL. For clarifying the production mechanism of SH_n, it is clear that more deep search for SH is necessary. Using the transition moment of CH in this study, the column density of CH was determined from infrared absorption spectrum in late-type star TX Psc. The author found that the column density in envelope of C-type late star was almost same as diffuse cloud. The rotational spectrum of NHD was not found in the published millimeter and submillimeter line survey data in Orion-KL and Sgr B2.

論文の審査結果の要旨

本学位論文は、フーリエ分光計を用いて不安定生分子の高分散測定を行い、天文学的に興味が持たれる不安低分子の定数等を高精度で決定したものである。低温・希薄な宇宙空間においては、イオン分子反応を主体とした化学反応により地上においては不安定な分子が多数生成されることが知られている。

申請者は、分光学的な知見が充分でなくしかも宇宙空間での生成が知られまたは予想されているＣＨ、ＳＨなど水素を含む小型ラジカルを中心に、サブミリ波から赤外線までをカバーする高分散フーリエ分光計を用いてそれらを精度良く測定し天文学的な観測に応用することを目標に、実験装置の改良を行いつつ本研究に取り組んだ。

得られた結果は次のとおりである。

(1)不安定分子への赤外線フーリエ分光の初めての応用として、ＳＨ分子の純回転遷移を測定し、これにもとづいてＯri-ＫＬなどの天体における電波の観測データを解析して、宇宙におけるＳＨ分子の存在量の上限を得た。

(2)NH_2、ＮＨＤ、ND_2の純回転遷移およびNH_2OHの振動回転遷移多数を測定して、それぞれの分子定数を精度良く決定した。これにもとづいてＮＨＤのスペクトルを天体のデータから探したが、見いだせなかった。

(3)ＣＨラジカルの振動遷移モーメントを、Hermann-Wallis効果を考慮した詳しい解析によって決定し、この値を用いて晩期型星ＴＸ　Ｐsc外層大気のＣＨのコラム密度を決定した。

(4)ＣＤおよび^{18}OHラジカルの振動回転遷移を測定し、それぞれの振動状態の分子定数を正確に求めた。

本審査委員会は、赤外線フーリエ分光のラジカルへの初めての応用、ＣＨの強度解析など新しい知見を含む優れた分光実験の成果を得た研究として、本論文を高く評価し、博士論文として十分な内容を備えたものであると判断した。