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論文内容の要旨

We have devised a novel type multi-channel Fourier transform spectrometer (MCFTS) incorporating an Wollaston prism polarizing interferometer combined with two Savart plates and a phase retarding plate. This original MCFTS produces a number of lines of folded interferograms recorded with a two dimensional imaging detector such as CCD detector. These interferograms comprise pairs of in-phase and anti-phase interferograms separated by the Savart plates and given shifted path differences with respect to each other owing to the phase retarding plate.

By subtracting the anti-phase interferograms from the in-phase interferograms, one can double the amplitude of the interferograms and reduce non-interfering components and noises due to the defects on the optical components such as scratches and dusts. In this way, it is possible to enhance the signal to noise ratio by more than a factor of $\sqrt{2}$.

The enhancement of the resolving power is also expected by connecting the interferograms with a newly developed method. The technique of Fourier transform is applied to align the phase of the interferograms. The resolving power of the spectrum reproduced from the connected interferogram is enhanced roughly in proportion to the number of interferograms connected.

In the present novel type MCFTS, the total incident light is available except for a small amount of reflection loss. The main factor for the light loss of the present MCFTS is the Fresnel reflections at the boundary of each optical component in the absence of the absorption of the optical materials. This reflection loss can be dramatically reduced by coating the anti-reflection films at the boundary of the optical components or by cementing the components together.

We manufactured a prototype spectrometer implementing the concept of the novel MCFTS. In this prototype MCFTS, two pairs of interferograms, namely four lines of folded interferograms, are detected with a CCD detector. The spectrum of the manufactured MCFTS was reproduced by performing the Fourier transform of two pairs of connected interferograms. It was confirmed that the resolving power of the spectrum was enhanced by approximately a factor of two compared with that of the spectrum reproduced from one line of interferogram.

The spectral calibration of the MCFTS was performed by using mercury, cadmium and sodium emission lamps. The spectral calibration was performed by fitting the spectra for these lamps with a dispersion curve calculated from the refractive indices of the WP. The results indicate that the optical performance of

the Savart plates, the phase retarding plate and the Wollaston prism is as designed. By using these curves, the spectrum of the Jupiter was calibrated.

The doublet spectrum of mercury emission lines at 577 and 579nm can be separated by a spectrometer with a resolving power exceeding 289. The spectrum regenerated from a single line of the interferogram, which gives a resolving power of 345 at 578nm, shows the doublet spectrum barely separated. On the other hand, the spectrum obtained by connecting two interferograms, which gives a resolving power of 668 at 578nm, shows the doublet spectrum clearly separated. This result confirms that the resolving power is actually enhanced by the implementation of the novel type MCFTS of our design. It also means that the phase adjustment by the developed method successfully functioned at the connected portion of the interferograms.

For astronomical observations, objectives often usually require spectral information with wide band coverage, high resolving power, spatial information with high resolution and wide field of view. As a result, a spectrometer for astronomical observation requires high performance realizing high SNR, high resolving power, broad wavelength coverage, high spatial resolution and wide field of view.

The present MCFTS has no mechanical driving part and is assembled very compactly for its potential high resolution. Therefore, the system should be inherently stable against vibrations and easy to handle. In contrast, a scanning Fourier transform spectrometer requires a high accuracy in fabrication and high stability in driving the moving mirror and it is not easy to construct such a spectrometer useful for visible region or for shorter wavelength region. On the other hand, the present type of MCFTS will easily produce the interferogram even in the ultraviolet region.

One of the advantages of the present MCFTS over scanning type FTS is that the SNR does not depend upon atmospheric scintillation for astronomical observations. However, since the influence of the background noise from the sky reduces the merit of FTSs, there are not so many objects for which the present MCFTS can exhibit its usefulness for ground based astronomical observation. The real merits of the present MCFTS will be demonstrated for astronomical observations from aircraft, balloons, rockets, and satellites rather than for ground based observations, since the background noise is smaller for those applications from space than for the ground observations and the spectral resolution required is usually not very high and adequate for the present MCFTS. Moreover, it will be possible to develop various scientific applications such as a spectroscopy for fluorescence, plasma-emission, bio-luminescence, cathode-luminescence and so on, since the MCFTS has a high throughput. Practical use of the present MCFTS for various other fields such as fiber scope diagnostics for medical examination or meteorological spectroscopic observation may be also worth farther investigation.

論文審査結果の要旨

本論文は、従来から応用されてきた天文用分光器とは異なり、広視野に対応でき、駆動部を必要としないなどの優れた特徴を持った、新しいタイプの分光器（ＭＣＦＴＳ）の天文観測への応用を念頭において開発研究を行った結果をまとめたものであり、全体で５章から構成される。第一章では、従来型の分光器との比較およびＭＣＦＴＳの一般的特徴が解説され、第二章では、従来型のＭＣＦＴＳの二つの欠点を補うために新たに筆者が考案した方式の原理が述べられ、第三章ではこの原理に基づき試作した分光器の実際の設計および実験結果が述べられている。第四章ではこの分光器の方式の性能評価がまとめられ、第五章で天文学への応用に関する考察が示されている。

観測天文学で通常用いられている回折格子などの分散素子とＣＣＤ検出器を組み合わせたマルチチャンネル分光法は、全波長域を同時に観測するため天候変化の影響を受けにくいという利点と機械的駆動部を持たず安定であるという利点がある一方、入射部にスリットを用いるため光の利用効率が100%に達しないという欠点を持っている。　これに対し、フーリエ分光法はスリットを必要としないため光の利用効率が高い反面、従来のフーリエ分光器ではシングルチャンネル検出器でフリンジ計測を行うため機械的駆動を必要とし、天候変化の影響を受け易いという欠点があった。　論文提出者は分散型マルチチャンネル分光法とフーリエ分光法の両者の利点を併せ持つ分光法であるマルチチャンネルフーリエ（ＭＣＦＴＳ）の分光法に着目し、これを更に改善する新しい光学系を考案した。

本論文の核心は、サバール板、ウォストンプリズムなどの複屈折偏光光学素子を巧みに組み合わせて用いることによって、従来型の複屈折偏光ＭＣＦＴＳに比べて、（１）光の利用率を約四倍向上させ、（２）波長分解能を約２倍向上させる、ことができることを示したものである。

波長分解能を２倍向上させるのに用いたフリンジ接続法は、さらに拡張することが可能であり、ＣＣＤの画素数で決まる高い波長分解能（分解能５万以上）を、実現することも原理的には可能であることを示した。

これらは論文提出社の独自の考案によるものであり、試作器を実現することによりこの分光法の有効性を立証したことは、論文提出者の光学理論と実験の力を証明する優れた業績である。

なお、本論文は共同研究の結果を記述したものであるが、全章にわたって論文提出者が主体となって進められたもので、論文提出者の寄与が充分であると判断され、公開発表会を含む最終審査において、本論文が博士（学術）の学位を受けるにふさわしいものと判断し、審査員全員で合格と判定した。