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学位論文題目　　Development of an Astronomical Data Archive System

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論文内容の要旨

We have developed a data archive system for the optical telescopes of Okayama Astrophysical Observatory and Kiso Observatory. The system, called MOKA (Mitaka Okayama Kiso Archive system), is not only the first network-accessible astronomical archive system in Japan but also the prototype of the data archive system of Subaru Telescope.

Archival data contain much information besides that the observer intends to extract. It is often that an important object is found into the image, or an unimaginable phenomenon is caught in the image by chance. It is certain that comparing data obtained in various wavelength regions presents new prospects of the object. Archival data of Subaru Telescope, which mounts the wide-field imaging camera and other characteristic instruments, are expected to bring many fruitful results for us.

The archives for space mission data exist since 1970's, but it is in recent years that the construction of archives for ground-based telescopes has begun. The most crucial reason is the difficulty in reuse of the data, which is caused by the non-uniformity of the data quality. The observing procedure of ground-based observations is not definite but is freely determined by each observer, and the configuration of observational instruments is often changed. Moreover, atmospheric environment, such as weather condition, seeing, etc., also influences the quality of ground-based observational data very much. Hence, in order to retrieve valuable data quickly and to analyze them with high precision, it is essential to evaluate the data quality and to examine the environment of the observation.

There exist several archive systems which provide the shrunk preview images of the CCD frames and the atmospheric parameters at the observation, but the functions are insufficient for evaluating the data quality or for examining the observational environment. In order to inspect an imaging frame in detail, it is desired to show the image with various tonal ranges. Also, for the examination of a spectroscopic frame, the function of extracting the spectrum from the frame is essential. For the environmental information, an archival user needs the time variation of meteorological parameters rather than the parameters at a point in time. The above functions are indispensable for ground-based data archives to make its scientific productivity maximum. That is why we have developed a new data archive system.

The functions of MOKA are provided by the user interface, which allows users to have access to MOKA from various computer platforms through the WWW (World Wide Web). Using the user interface with a WWW browser, archival users can access data objects of MOKA, which are a header information database, header information (HDI) files, quicklook image (QLI) files, and weather/sky-monitor databases, etc.

The most characteristic feature of MOKA is the highly functional user interface for evaluating the data quality and examining the observational environment. The QLI viewer shows the quick-look image of a CCD frame with the user-adjustable tonal range and with the profile along an arbitrary row or column. Those functions are helpful for inspecting details of the images and the spectra, and indispensable for evaluating the data quality and for picking up data for request. The QLI viewer is a Java applet, so that it needs no installation onto any client computers and runs on most of WWW browsers that support Java. The QLI viewer is the only previewer of the archive systems in the world which

realizes the above-mentioned functions on any computer platforms.

The meteorological data viewer and the night-sky image viewer are invoked from each CCD frame in the result list of the search and are used to examine the observational environment. The meteorological data viewer displays the data of six hours around the observation time of the frame, and the night-sky image viewer shows the image at the closest time of the observation. Since the atmospheric conditions affects observational data very much, the examination of the atmospheric variation around the time of the observation is essential to evaluating the data quality. MOKA is the only data archive system in the world which integrates the environmental data with the observational data.

The Java technology is adopted not only for the above three viewers but also for the most part of the user interface of MOKA. Java realizes interoperability beyond the difference of computer platforms, and reduces redundant network traffic.

There are several multi-mode, multi-spectral instruments planned for Subaru Telescope. Though the identification and the retrieval of calibration frames are the very essential procedure for an archival user, the relation of the calibration frames with the object frames between the observational modes is very complex for multi-mode instruments, since the calibration frames are often used in common beyond the observational mode. We have studied the archive system for OOPS (Okayama Optical Polarimetry and Spectroscopy System), a multi-mode, multi-spectral instrument of Okayama Astrophysical Observatory. The table structure of the database is made use of by STARS (Subaru Telescope ARchive System) for the same type of instruments of Subaru Telescope. The most of the user interface of STARS is also made on the basis of MOKA. MOKA has greatly contributed to the rapid construction of STARS, which can start its operation from the beginning of the observation. The development of STARS, such as of preview system, is still continued on the basis of the experience of MOKA.

As for the contributions to astronomical researches, there have been several papers on galactic astronomy that utilize MOKA. The header information database is also used by the German NEO (Near Earth Objects) survey project, DANEOPS, whose research is in progress. Moreover, there are many accesses in the season when the observatories call for proposals, since many astronomers examine the feasibility of their observation plan by the use of MOKA.

The development of MOKA with the actual data of Okayama and Kiso observatories has revealed various important matters for constructing data archives. One is the header description of observational data, and we have determined the standard of the description of FITS keywords in cooperation with the FITS committee of Japan. The data headers of SNG and 1K CCD imager have been revised and unified. The new instruments of both observatories are also being developed based on the standard. The dictionary of the header keywords has also been prepared and used for the observational instruments of Subaru Telescope. We have further discussion on the quick-look images and the environmental data for the future development of the ground-based data archives, which will certainly broaden the horizon of new observational astronomy.

論文の審査結果の要旨

　本論文は、地上光学観測を主とする天文観測データのアーカイブシステムに関して、申請者が開発した三鷹・岡山・木曾データアーカイブシステム（略称ＭＯＫＡ）を例にとり、観測データの質的評価など従来の同種のシステムでは困難だった点に関し、新しい概念の提案および新機能・インターフェースの実装により、これを解決したものである。

　論文では、第１章で天文観測データ・アーカイブシステムの歴史と必要性をコンパクトにまとめ、スペース観測と地上観測の２大分野における現状とＭＯＫＡシステムの開発の動機を述べている。次に、第２章でＭＯＫＡシステムの開発経緯と同システムの大まかな構造および諸要素を概観し、特に制御・観測・記録プログラムシステムが個別ばらばらに存在する地上光学観測データの統一的扱いに関する困難さと、新しい概念の提案を含むその解決法が述べられている。そして、第３章では、ＭＯＫＡシステムの具体的な構成と実装が、特に上記解決法の具体的な現われとなるデータ早見機能、観測環境データビュアーなどの新機能およびインターフェースに力点をおいて詳述されている。さらに、第４章では、ＭＯＫＡシステムの利用によるデータベース天文学研究の成果例が、同システムがすばる望遠鏡データアーカイブシステム（略称ＳＴＡＲＳ）の設計および実装に多大な影響を与えた点と共に述べられている。最後に、第５章ではＭＯＫＡシステムの限界と問題点が、新システムに対する提案と共に述べられている。なお本研究内容の大部分は、既に学術雑誌に発表済みである。

　論文にも述べられているとおり、ＭＯＫＡシステムは、地上光学観測データに対する日本の天文学史上初めての本格的なデータアーカイブシステムである。もちろん、ＭＯＫＡシステムの開発は多くの研究者の共同作業の結果であるが、同システムの基本構造の設計および上記の新機能の提案・実装は、申請者個人の貢献であり、また、本システムの開発リーダーとしての申請者の貢献は非常に大きい。さらに申請者が自ら提案し、設計から実装までを行った種々の新機能については、利用者から好評を持って迎えられているばかりでなく、その長所がＳＴＡＲＳに数多く継承された点において、波及効果が大であるといわざるを得ない。また、論文の質、体裁、英語表現なども申し分がない。

　このように申請者の研究は、日本におけるデータベース天文学のパイオニア的研究として、その天文学的意義が高いばかりでなく、データ早見機能の高度化や観測環境データビュアーなど、従来の同種システムにみられなかった数々の新機能の提案と実装例を具体的に示している点で、情報工学的にも非常に価値ある研究であることを、委員全員が一致して確認した。

　以上の判断に基づき、博士論文審査委員会は、全員一致で、申請者の論文が学位（学術）を受けるにふさわしいと判定した。