The Impact of Large-Scale Surveys on Pulsating Star Research
ASP Conference Series, Vol. 203, 2000
L. Szabados & D. W. Kurtz, eds.

The MOA Project Data Reduction Pipeline and Database

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Abstract. The MOA Project is a collaboration of Japanese and New Zealand (NZ) astronomers and physicists undertaking a survey of stellar variability in the direction of the Galactic bulge and Magellanic Clouds. The primary motivation of the project is detection and monitoring of gravitational microlensing events although a large amount of data is also collected on stellar variability. Surveying the number of stars required to detect gravitational microlensing events is an operation of some magnitude and requires sophisticated data processing software.

1. Introduction

Gravitational microlensing surveys such as the MOA Project (Abe et al. 1997) routinely observe millions of stars because the probability of microlensing for any given star is very low (Griest 1991). Such massive observational programs also produce a wealth of data on variable stars of all types. The MOA Project has developed some highly automated software to reduce CCD images of star fields into light curves of the constituent stars. MOA aims to be able to produce near-real time analysis of time-critical astrophysical phenomena (such as gravitational microlensing and optical counterparts to gamma ray bursts) in order to alert other collaborations for follow-up observations.

The MOA data reduction software (the 'data pipeline') is broadly similar to the equivalent software produced by other microlensing teams. However, the MOA database system differs from the MACHO database (Axelrod et al. 1995), which breaks star fields into arbitrary 'chunks', as the MOA database deals with each star field as a whole. Also, the MOA database system attempts to be compatible with any kind of CCD camera and filter system, rather than be a software system useful for only one observational set-up.

2. The MOA Data Reduction Pipeline

The purpose of an astronomical data reduction pipeline is to convert astronomical observations into meaningful quantities. Due to the high rate of data collection ($\sim$5 Gb night^{-1}) the MOA Project has the additional requirements that its data pipeline be fast, highly automated, and robust. The approach taken for MOA software was to build a suite of collaborative programs in which each

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program does a single task well. The pipeline was intended to be as efficient and portable as possible, so it is mostly implemented in C++. The DoPHOT image reduction code (Schechter, Mateo, & Saha 1993) is used and was ported from FORTRAN into ANSI C. Perl scripts were used to bind the programs together.

The management of image reduction is performed by a MOA program called Autophot. Autophot can call DoPHOT to reduce many images in parallel, the degree of parallelism being adjustable by the user, and has successfully run on both uni- and multi-processor systems. The installation by MOA of a SUN e450 with four Ultrasparc II CPUs at Mount John Observatory and the parallel processing capability of Autophot greatly increase pipeline throughput.

3. The MOA Database

A database is a program that is designed to store and retrieve data. An object-oriented database, called StarBase, was implemented in C++ to time-optimise the operations required for a variable star survey. StarBase is designed to handle several years of MOA observations on many million-star fields. StarBase is portable and the database files written on one computer can be read by any other platform without translation. StarBase was also designed to store data from an arbitrary number of CCD chips and any kind of filter, which has allowed it to archive data from different CCD camera systems. Frame position registration and photometric zero point correction algorithms are also built into StarBase.

The underlying physical implementation of StarBase is a linked-list on disk, suited to the typical data access patterns of a photometric survey. A detailed description of StarBase architecture and performance is given by Reid (2000).

4. Future Plans

An implementation of the Optimal Image Subtraction (OIS) technique (Alard 1999, 2000) is nearing completion and will supplement the DoPHOT stage of the pipeline. A Common Object Request Broker (CORBA) interface may be added to StarBase to allow remote queries to be made across the Internet. The MOA pipeline should be ready to issue gravitational microlensing alerts in the 2000 Galactic bulge observing season.

References

Abe, F., Allen, W., Banks, T., et al. 1997, in IAP Conf. 12, Variable Stars and the Astrophysical Returns of Microlensing Surveys, ed. R. Ferlet, J.-P. Maillard, & B. Raban (Gif-sur-Yvette: Editions Frontières), 75

Alard, C. 1999, astro-ph/9903111

Alard, C. 2000, in these proceedings, p. 50

Axelrod, T., Allsman, R. A., Quinn, P. J., et al. 1995, BAAS, 27, 1390

Griest, K. 1991, ApJ, 366, 412

Reid, M. L. 2000, Ph.D. thesis, Victoria University of Wellington, in preparation

Schechter, P., Mateo, M., & Saha, A. 1993, PASP, 105, 1342