The Lick Observatory Supernova Search

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Abstract. We report here the current status of the Lick Observatory Supernova Search (LOSS) with the Katzman Automatic Imaging Telescope (KAIT). The progress on both the hardware and the software of the system is described, and we present a list of recent discoveries. LOSS is the world’s most successful search engine for nearby supernovae.

INTRODUCTION

Located at Lick Observatory atop Mount Hamilton east of San Jose, California, the 0.75-m Katzman Automatic Imaging Telescope (KAIT) is a robotic telescope dedicated to the Lick Observatory Supernova Search (LOSS) and the monitoring of variable celestial objects. It is equipped with a CCD camera and an automatic autoguider (that is, the autoguider is able to find its own guide stars).

KAIT is the third robotic telescope in the Berkeley Automatic Imaging Telescope (BAIT) program. The predecessors to KAIT were two telescopes developed at the Leuschner Observatory, which is located about 10 miles east of the campus of the University of California, Berkeley. KAIT inherits the operational concept and the majority of the software from its two predecessors. More thorough descriptions of the BAIT system can be found in references 1–4.

LOSS discovered its first supernova in 1997 (SN 1997bs in NGC 3627; Treffers et al. 1997 [5]). Its performance improved dramatically in 1998 and 19 supernovae (SNe) were discovered. In 1999, 35 SNe were discovered by mid-December.

Multicolor photometry of SNe is an important scientific goal of KAIT. Because of the early discoveries of most of the LOSS SNe, many good light curves have been obtained.

We report our hardware and software setups for LOSS in Section 2, the SN search in Section 3, and the discoveries and follow-up observations in Section 4.
THE HARDWARE AND SOFTWARE OF LOSS

KAIT has a 30-inch diameter primary with a Ritchey-Chretién mirror set. The focal ratio is \( f/8.2 \) which results in a plate scale of 33.2″ mm\(^{-1}\) at the focal plane. The telescope has a very compact design; it is lightweight and slews fast. An off-axis guider designed by one of us (RRT) enables the telescope to obtain long exposures.

The CCD camera is an Apogee AP7 with a SITe 512×512 pixel back-illuminated chip. It is thermoelectrically cooled to about 60°C below the ambient temperature. The quantum efficiency (QE) is good (peak 60%) and flat from 3000 Å to 8000 Å. The field of view is 6.7′×6.7′ with a scale of 0.8″ pixel\(^{-1}\).

Observations done by KAIT are fully robotic. All hardware (telescope, filters, autoguider, CCD camera, slit, dome, weather station, etc.) are automatically controlled by the software (see Richmond, Treffers, and Filippenko 1993 for details). Dark, bias, and twilight flatfield observations are also done automatically. A focusing routine finds a good focus for the telescope in twilight, then runs every 90 minutes during the night. The images are automatically transferred to the U.C. Berkeley campus to be processed. The appropriate template image is subtracted from each galaxy image, and new objects are detected in the resulting images. The most promising candidates are reobserved during the same night, while others require human evaluation before rescheduling.

THE SUPERNOVA SEARCH

The LOSS galaxy sample includes about 5,000 nearby galaxies. Mosaic images are taken for some large, nearby galaxies. An automatic scheduler selects targets to be observed during the night according to their observation history. Follow-up observations of SNe or routine monitoring of some other objects (active galactic nuclei, variable stars, etc.) are also scheduled at the same time.

We have optimized the system in every possible way to increase the observation efficiency. The search images are taken through a hole in the filter wheel (i.e., no filter is used). This greatly increases the observation efficiency compared to observations through an \( R \)-band filter. The exposure time for the search images is only 25 seconds, but because of the high QE of the CCD camera we still reach a limiting magnitude of \( \sim 19 \) (sometimes deeper). The order of galaxies to be observed is optimized so as to minimize the accumulated movement of the telescope and dome during the night. Currently the observing efficiency is about 75 images per hour. KAIT can obtain more than 1,000 images during a winter night.

Because of our high observing efficiency, all the sample galaxies are observed every 3 to 5 days in periods of good weather. This ensures that most of the LOSS SNe are discovered considerably before their maxima. Follow-up observations of SNe are usually done starting the night after their discovery. A detailed logging system is also designed to keep track of the observation history of every galaxy, which is very useful for statistical studies (e.g., SN rates).
THE LOSS DISCOVERIES IN 1998 AND 1999

1998 discoveries:

Supernovae : 19
Novae : 4
Dwarf novae : 2
Comets : 1

1999 discoveries (through mid-December):

Supernovae : 35
Novae : 7
Dwarf novae : 2
Comets : 1

For a detailed list of the LOSS discoveries, please visit the LOSS Web page at http://astron.berkeley.edu/~bait/kait.html.

Multicolor photometric observations of SNe are always emphasized in LOSS. Our goal is to build up a multicolor database for nearby SNe. So far light curves have been obtained for 11 SNe in 1998 and 12 SNe in 1999. Examples of the LOSS discoveries and their light curves are presented in Figure 1.

Our supernova research at UC Berkeley is supported by NSF grant AST-9417213 and NASA grant GO-7434.

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FIGURE 1. Some of the LOSS SN discoveries and their light curves. Examples shown (top to bottom) are the type Ia SNe 1998es, 1999ac, 1999by, and 1999da. The light curves have been arbitrarily shifted up and down for display purposes.