CHASE
CHilean Automatic Supernova sEarch

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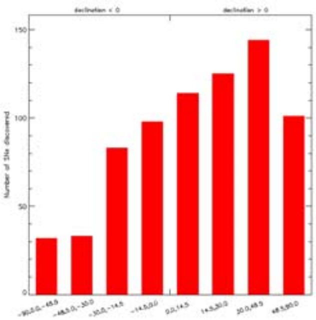
The goal of the CHASE project is to discover young southern supernovae

Why we need a southern supernova search



The Millennium Center for Supernova Studies (MCSS) is obtaining systematic photometric, spectroscopic and polarimetric observations of nearby SNe to study their physics and improve their use as cosmological probes. The SNe discovery bias against the southern hemisphere (see Fig. 1), was limiting the number of targets observables by the MCSS facilities. In particular, it was reducing the number of SNe for which the MCSS follow-up starts at very early epochs which is crucial for understanding their progenitors and explosion mechanisms.

Fig. 1: Declination distribution of the SNe brighter than 18.0 discovered between 2002 and 2007. Each bin in the histogram covers the same area in the sky, therefore the number of discovered SNe should be equal.

Data acquisition and reduction

To carry out the CHASE survey, we are using the 10% Chilean time on four of the six Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes (PROMPT) located at CTIO (Fig. 2 and Fig. 3). Every day a code up-loads in the various telescopes queues a sample of galaxies, based on the characteristics of each facility, the observations carried out the previous nights, the target visibility and our priority scale. As soon as the images are acquired by the instruments and archived, they are automatically downloaded on our reduction machines at Cerro Calán. Currently the data are processed in two double processor dual core machines that allows us to full reduce the data usually before noon of the following day. For the data reduction we developed a modified version of the pipeline used by the ESSENCE survey. In short, the data reduction flow consists of: 1) dark subtraction and flat field correction, 2) images astrometrization, 3) image registration, 4) image combination, if more than one image per field have been taken, 5) objects detection and zero point calibration, 6) template subtraction, 7) candidates selection, 8) candidates web page 9) visual inspection

Diameter = 40 cm
Pixel scale = 0.6 "/pix
FoV = 10´x10´
Read out time = 9 sec

With a 40 second exposures the limiting magnitude is ~ 18.0

Fig.3: PROMPTs domes at CTIO

Fig.2: PROMPT telescope

Survey strategy

Our relatively shallow limiting magnitude reduces considerably the space volume in which we can detect very young SNe. The galaxies with radial velocity < 3000 km s^{-1} thus constitute the sample within which we search for these young objects. Through montecarlo simulations we have estimated that an observational cadence of 3-4 days is the best strategy for the purpose. In addition to this golden sample of very nearby galaxies we have a more extended sample which radial velocity is in general < 8000 km s^{-1}. Those galaxies are our backup targets to fill visibility gaps during the night and through the year. They are observed with a cadence which could vary from five days to more than a month. On average we observe ~ 250 galaxies per night. However, since our priority in the PROMPT scale is low, this number is highly variable form night to night, significantly decreasing during dark time. Indeed we have little control on which galaxies are observed during a given night and this do not allow us to fully implement our search strategy. Nevertheless, for every night we carefully keep track of what was observed and under which conditions.

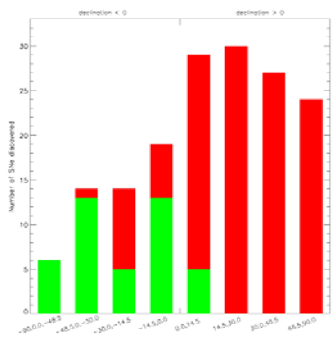


Fig. 4: Declination distribution of the SNe brighter than 18.0 discovered between May 2008 and May 2009. The SNe discovered by CHASE are reported in green and are 73% of the total discovered in the southern hemisphere.

Follow up program

In addition to the SN search, we are following bright SNe in the BVRIu'g'r'i'z' filters (Fig. 6). Our fully automated data reduction procedure, allow us to follow the evolution of the light curve in real time, triggering further observations if something potentially interesting is detected.

The Future

Optical search:
In spite of the excellent results obtained with the PROMPTs, the observations scheduling does not allow us to fully implement our search strategy and therefore completely achieve our goals. For this reason at the beginning of 2010 we will enhance the CHASE search and follow-up capabilities with our own 50-cm telescope (Fig. 7) where we will have full control on the scheduling.

Near infrared search:
The University of Tokyo plans to operate an astronomical observatory on the top of Cerro Chajnantor at 5600m. A 1-m pilot telescope optimized for infrared observations should start to operate at the beginning of 2010. The superb infrared sky transparency of this high altitude site makes this facility an ideal tool to carry out a near infrared SN search with the aim of discovering extinguished SNe.

Results

After a difficult start on March 2007 when only two of the four PROMPTs were simultaneously in operation, since October 2007 all four facilities have been operating. On the same month the PROMPT team also managed to considerably improve the telescopes pointing greatly increasing the overlap between images obtained at different epochs. Under these better operational conditions on November 2007 we discovered our first two SNe. In 2008 we have discovered other 31 SNe with an average of more than 2.5 SNe per month. Finally in 2009, so far, we have discovered 31 SNe that means ~ one per week. These numbers make CHASE the most successful nearby SN survey operating in the southern hemisphere. To test our ability in finding young objects, we used the classification spectrum to set the phase of our discoveries. Regarding Type Ia SNe, ~45% were detected before maximum light (Fig. 5). In the case of Type II, ~60% were discovered within a week after the explosion. In particular the Type Ia SN 2008hv was discovered fifteen days before maximum and the Type Ib/c SN 2009bb ~ two days after the explosion.

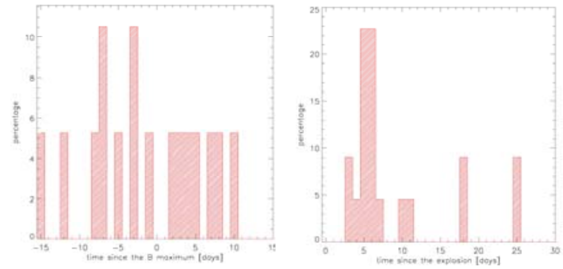


Fig 5; Phase distribution of Type Ia (left) and Type II (right) SNe discovered by CHASE

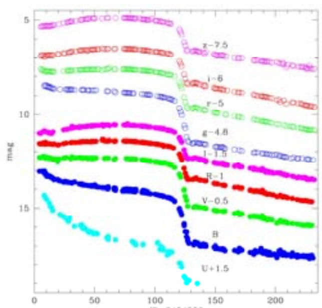


Fig 6: Example of the CHASE intensive follow up of the Type II plateau SN2008bk

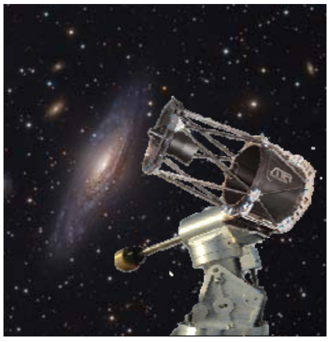


Fig 7: Future CHASE 50-cm telescope