

# VYSOS and Mini-VYSOS: Preparing to Survey Star Forming Regions

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## **Abstract**

The Variable Young Stellar Object Survey, or VYSOS, will be a long term monitoring survey of star forming regions across the entire Galactic plane. VYSOS, along with its smaller counterpart, mini-VYSOS, will provide the first comprehensive and systematic record of early stellar evolution, and will allow for the identification of rare phenomena that occur during early stellar evolution. The focus of this REU project was the creation of a database to provide information about the targeted regions of VYSOS and mini-VYSOS. A model dome for mini-VYSOS was also constructed in preparation for an installation of a remotely operated dome, and the mechanical integrity of VYSOS was analysed, following a recent earthquake on the Big Island of Hawaii.

## **Introduction**

From observations of young stellar objects, it has been well established that the majority of stars are born in giant molecular clouds. In the simplest case, once a molecular cloud becomes bound by its own gravity, it collapses to form a stellar embryo with an infalling envelope. The stellar embryo continues to accrete mass from the surrounding disk, and the core temperature rises rapidly, eventually forming a protostar.

In the earliest stages, this process can only be detected in the sub-millimeter range. As the material surrounding the nascent star heats up, it can be detected in the far and mid infrared. As the envelope of the protostar begins to deplete, the process can be detected in the near infrared, and finally, the optical. Yet, often before these processes are optically visible, the existence of a young star is revealed by Herbig-Haro objects, or similar dynamic phenomena that occur in star forming regions.

Because many of the details of early star formation are unclear, a long-term optical survey of star forming regions is needed. Such a survey will not only provide insight into the earliest stages of stellar evolution that are optically visible, but it may also provide important information about the origin of Herbig-Haro objects, and similar rare outflows from young stars.

## **Background**

### *VYSOS*

The Variable Young Stellar Objects Survey, or VYSOS, is comprised of two twin 16.25 inch telescopes, each equipped with a wide angle CCD camera. The field of view is 27 by 41 arc minutes. VYSOS North is currently located at the Mauna Loa Observatory, and VYSOS South is located at Cerro Armazones, in Chile. Each telescope will have a complete range of broadband filters, but will concentrate mostly on the R band.

The function of these two telescopes is to provide long-term monitoring of star forming regions. Between VYSOS North and South, it will be possible to monitor star forming regions across the entire Galactic plane. The result will be a database providing the first systematic record of early stellar evolution. This record will provide information about the earliest stages of stellar evolution and the time-dependent and rare phenomena that occur as young stars evolve.

The Big Island of Hawaii experienced an earthquake in October of 2006 that may have damaged VYSOS North. The effects of this earthquake upon the telescope have not yet been fully determined.

### *Mini-VYSOS*

Mini-VYSOS will be a 135 mm Stellarvue apochromatic astrograph, equipped with the same filters as VYSOS. It will have a custom made field flattener, which will produce a 2.9 by 2.9 degree field of view. It will be located near VYSOS, at the Mauna Loa Observatory. Its primary function will be to monitor star forming regions along the Galactic plane. The result will be a 8.7 degree wide, 360 degree view of the Galactic plane. Mini-VYSOS will also monitor larger star forming regions that do not lie along the Galactic plane, and are not easily covered with the smaller field of view of VYSOS.

The enclosure for Mini-VYSOS will be constructed at the Institute for Astronomy. Because Mini-VYSOS will be remotely operated, it was desired that the dome for Mini-VYSOS be able to be remotely removed, regardless of the position of the telescope.

### *Halpna Emission Stars*

One of the most easily accessible tracers of star formation is the Halpna emission line, indicating the excitation of Hydrogen gas. For this reason, an analysis of stellar spectra has proven successful in the search for new members of star forming regions.

## **Methods**

### *Database Creation*

A MySQL database was created, and it contains two tables: one for VYSOS and one for Mini-VYSOS. The fields of the VYSOS table include coordinates of the center of the field of view, comments and references concerning the region, a path to a JPEG and FITS image of the field of view, the date the field was entered into the database, the viewing priority of the field, and the number of times the object has been observed. If the region is part of a larger mosaic, there is a field with a path to a schematic of the mosaic layout. The Mini-VYSOS table is set up similarly, with a few minor differences.

HTML, PHP, and Java were used to display these tables on the public wiki, at [www.vysos.ifa.hawaii.edu](http://www.vysos.ifa.hawaii.edu). The information for each of the fields of view can be viewed, and when logged in, the user is able to edit and add to the list of fields.

The fields that comprise the VYSOS table represent star forming regions of various size and activity. In some cases, such as T Tauri, the desired target was a single, isolated star. In these cases, the object was placed in the middle of the field of view. In other cases, such as Lynds 1551 in Taurus, the targeted region was relatively small, but contained many scattered, interesting objects. In this situation, the field of view had to be selectively positioned in order to view the majority of interesting objects. For more extensive regions, such as Ophiuchus, a multi-field mosaic was created. The goal in these regions was to cover the majority of interesting targets in the fewest fields of view. Finally, for very large regions, such as Cygnus, a combination of mosaics and single fields of view were used. In such extensive regions, the only option was to be very selective in the targets chosen for monitoring.

In order to ensure maximum efficiency, a script was written to tell the user if a new potential target is contained within an existing field of view. If so, the user is told which field of view contains the new object. Otherwise, the object can be added to the database.

#### *VYSOS Inspection*

Following the earthquake in October of 2006, Bo Reipurth was unsure if VYSOS had sustained damage. One of the most important inspections that had to be performed was an analysis of the polar alignment. Currently, the polar alignment cannot be attained to better than a few arc minutes. It was unknown whether this was a consequence of a mechanical or an optical issue. A dial indicator was placed in many positions on the equatorial fork of VYSOS, and the behavior of the base was monitored as the telescope was slewed and moved in various manners.

#### *Mini-VYSOS Dome Modeling*

For various reasons, it was decided to build an enclosure for Mini-VYSOS, rather than use a commercial structure. A simple, square, steel structure was constructed for the housing. It was desired that the dome be designed in such a manner to ensure that it could be remotely opened regardless of the position of the telescope. Therefore, it was necessary to ensure that the transit of the dome during removal would clear the telescope in all possible positions.

Two different moving models of a dome were constructed out of wood. The first model used one pivot point, and two pivot arms, such that the dome was lifted from the housing as it folded towards the side of the housing. Though this design was successfully modeled and met the desired specifications, a simpler model was chosen. The second, and more simple, model used one pivot point and one pivot arm, folding the dome to the side of the telescope housing.

Once this design was constructed out of wood, the exact curvature of the dome was determined. This involved measuring the approximate height of the telescope when positioned at different angles, then determining the proper position of the pivot point, such that the dome could be semicircular.

### *HalpHa Emission Stars*

A systematic search was begun for new HalpHa emission stars using objective prism plates. The plates show a spectrum of the stars between 630nm and 680nm, where HalpHa emission is at 656.3nm. A microscope was used to search for emission lines on the prism plates. When HalpHa emission stars were found, their position on the objective prism plate was marked. Then, Palomar sky maps and digitized sky surveys were used to determine the coordinate of the emitter. This position was compared to published HalpHa emission stars to determine if the new star had previously been published.

## **Results and Future Work**

### *VYSOS and Mini-VYSOS Database*

Currently, the tables within the MySQL database for both VYSOS and Mini-VYSOS contain over 400 fields of view. The information for each of these fields is displayed on the public wiki. These tables will continue to grow as the VYSOS and Mini-VYSOS project advances.

In the future, the scheduling program will be interfaced with the database, and the priority field will dictate which fields are viewed by the telescope on a given night. The user will be able to set this priority to view regions on a regular schedule, and may also set precedence on an important region. A future addition to the database and wiki could include uploading images taken by the telescope or information extracted from these images via the IPP Pipeline.

### *VYSOS Base*

The dial indicator did not show movement that can be considered significant for any of the positions on the equatorial fork. From this analysis, the mechanical integrity of the base of VYSOS was confirmed. The next step in this analysis will include a complete inspection of the optics of the telescope.

### *Mini-VYSOS Dome*

The final structure for Mini-VYSOS will be a square, steel housing, which will be anchored into Mauna Loa at the four corners. Four threaded steel rods were cemented into the ground, and the housing was mounted on top of these rods. The housing was then leveled and stationed using nuts threaded onto the rods.

The pivot point and curvature of the dome were determined, and a successful wooden model of the dome was constructed and tested. The dome is ready to be constructed in steel. After this is completed, Mini-VYSOS will be ready to be completely installed on Mauna Loa.

### *HalpHa Emission Stars*

Approximately 15 HalpHa emission stars were found in the region of RNO40. It was determined that most of these stars had been previously identified and published as young stars. This is an ongoing search. New HalpHa emission stars and new star forming regions will provide new areas to be monitored by VYSOS and Mini-VYSOS.

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**References**

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