

**Bar Detection in Spiral Galaxies with Neural Networks**  
**Tim Weinzirl**  
**Mentor: Steve Odewahn**

**Student Summary:**

Bar Detection in Spiral Galaxies with Neural Networks

Tim Weinzirl

**Introduction:**

Relevant to the development of galaxy formation theory is the distribution of barred and unbarred spiral galaxies at high ( $z > 1$ ) and low ( $z < 1$ ) redshifts. Unfortunately, factors like low S/N and poor resolution in high-redshift galaxy images hinders one's ability to subjectively identify bars. This complicates the process of comparing and contrasting the distribution of barred galaxies at high and low redshifts.

A quantitative methodology is a superior means of detecting barred galaxies. The higher-spatial-frequency bars and spiral arms of a spiral galaxy can be modeled with a Fourier series. Since the relative amplitude and phase angle of peak signal for particular terms in the Fourier series are sensitive to the presence of bars, an artificial neural network can be trained to recognize bars based on the Fourier model. The application of quantitative bar detection via an artificial neural network is a promising approach to understanding the universal distribution of barred spiral galaxies.

**Overview of Project:**

With a large set of barred and unbarred spiral galaxies, we intend to train an artificial neural network to quantitatively detect the presence of a bar based on the Fourier model of the high-frequency spatial structure within the galaxies. In order to model with the Fourier series, we must subtract the symmetric bulge and disk components out of the original galaxy images.

The best-fit bulge+disk model for a galaxy is calculated through a luminosity decomposition involving a one-dimensional surface brightness profile. In doing so, a best-fit model is calculated for the surface brightness profile of each galaxy with a maximum-likelihood fitting routine. We model the bulge and disk components of the galaxies with the sum of a de Vaucouleur  $R^{1/4}$  law bulge and an exponential disk, respectively

$$(1) \quad \log(I_{bulge}(r)) = \log(I_e) - 3.3307 \left[ \left( \frac{r}{r_e} \right)^{1/4} - 1 \right]$$

$$(2) \quad \log(I_{disk}(r)) = \log(I_0) - \frac{\log(e)}{h} r$$

The sum of the bulge and disk together is

$$(3) \quad I_{sum}(r) = I_{bulge}(r) + I_{disk}(r)$$

The decomposition ultimately provides the optimum combination of the four parameters  $r_e$ ,  $I_e$ ,  $I_0$ , and  $h$  from equations 1 and 2. With these four values, the sum of the bulge and disk models can be determined.

Once we subtract the bulge and disk, we can model the remaining high-frequency structure using the following Fourier series

$$(4) \quad I(r, \hat{l}_s) = I_0(r) + \sum_m I_{mc}(r) \cos(m\hat{l}_s) + \sum_m I_{ms}(r) \sin(m\hat{l}_s)$$

where

$$(5) \quad I_0(r) = \langle I(r, \hat{l}_s) \rangle$$

$$(6) \quad I_{mc}(r) = 2 \langle I(r, \hat{l}_s) \cos(m\hat{l}_s) \rangle$$

$$(7) \quad I_{ms}(r) = 2 \langle I(r, \hat{l}_s) \sin(m\hat{l}_s) \rangle$$

We then isolate the relative amplitude and phase angle of peak signal for the  $m=2$  and  $m=4$  terms in the Fourier series; these two parameters are respectively defined as

$$(8) \quad A_m(r) = \frac{\sqrt{I_{mc}(r)^2 + I_{ms}(r)^2}}{I_0(r)}$$

$$(9) \quad \hat{l}_{s0} = \left( \frac{1}{m} \right) \tan^{-1} \left( \frac{I_{ms}}{I_{mc}} \right)$$

For the  $m=2$  and  $m=4$  terms, the relative amplitude of a barred galaxy should show a strong spike in the inner region of the galaxy where the bars lie, whereas the relative amplitude for an unbarred spiral galaxy shows no such spike. Furthermore, the phase angle of peak signal for a barred galaxy should be constant over the same interior region of the galaxy; in comparison, the phase angle for an unbarred spiral should change systematically. It is through compiling these parameters for a large number of barred and unbarred spirals that we will be able to construct a training set that can be used to train an artificial neural network to quantitatively detect bars.

### Summary of Progress:

The summer was spent learning about maximum-likelihood fitting routines, galaxy surface brightness profiles, and writing C programs to generate a bulge+disk model from a one-dimensional galaxy surface brightness profile. Two approaches were taken in calculating the sum of the bulge and disk models: a brute-force calculation and an iterative, non-linear fitting algorithm. Both programs found the best-fit model to an input one-dimensional surface brightness profile to the following equation:

$$(10) \quad \log_{10}(I_{\text{sum}}(r)) = \log_{10} \left( 10^{a_1 + a_2 r} + 10^{a_3 + a_4 r^{1/4}} \right)$$

The four bulge-disk parameters needed to recreate the sum of the bulge and disk are easily extracted from  $a_1$ ,  $a_2$ ,  $a_3$ , and  $a_4$  through simple calculations.

Both programs must generate initial guesses for  $a_1$ ,  $a_2$ ,  $a_3$ , and  $a_4$  before calculating the best fit to equation 10. This is done from the independent modeling of the bulge and disk components of the input surface brightness profile. The independent bulge fit is made strictly to the interior region of the profile, and the disk fit strictly

involves the outer region. The independent bulge and disk fits are made, respectively, to

$$(11) \quad \log_{10}(I_{bulge}(r)) = a_1 + a_2 r^{1/4}$$

$$(12) \quad \log_{10}(I_{disk}(r)) = a_3 + a_4 r$$

Given initial guesses for the  $a_1$ ,  $a_2$ ,  $a_3$ , and  $a_4$ , the program implementing the brute-force method will consider every possible value for each of the four parameters to a precision of 0.01 over a limited range. The combination that minimizes the variance between the input profile and the model is selected. Through a trial and error process, the range over which each parameter is varied was gradually expanded to ensure that the best-fit model was not inhibited by allowed range.

The second, and more elegant, approach implemented the Levenberg-Marquardt non-linear fitting algorithm presented in the [Numerical Recipes in C](#) text. The program accepts an initial guess for the parameters  $a_1$ ,  $a_2$ ,  $a_3$ , and  $a_4$ , stores them in the vector  $\mathbf{a}$ , and then proceeds to iteratively calculate the  $\mathbf{a}$  that minimizes  $\chi^2$ , which is defined as

$$(13) \quad \chi^2 = \sum_{i=1}^N \left[ \frac{y_i - y(x_i; \mathbf{a}_i)}{\sigma_i} \right]^2$$

Interestingly, the brute force and nonlinear methods produce almost identical results; for practical purposes, the two programs produce equivalent fits. The nonlinear fitting program has the advantage in execution time, as it produces the results almost instantaneously; the brute force method, in comparison can take around 10-15 minutes for one surface brightness profile.

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## **A Mirror Storage Solution**

**Johnny J. Mendias III**

**Mentor: Paul Peterson, Jerry Martin**

### **Student Summary:**

Johnny J. Mendias III, REU  
Mechanical Engineer, TTU  
McDonald Observatory, Ft. Davis, TX

August 12, 2005

The REU Experience @ McDonald Observatory

The right choice for applied engineers searching for a professional experience in applied sciences and aerospace innovation.

The REU Program at the McDonald Observatory an excellent choice for any applied engineer in the aerospace or astronomical discipline. As a Mechanical Engineer it was an ideal choice for my discipline and passion for astronomy. The McDonald REU program

challenges the engineering student to apply all their potential and collaborate with excellent mentors and advisors to assist the intern as you achieve completion of your specified project.

Upon entering the McDonald REU program, the aspiring engineer has attained the foundation of their education, establishing your excellence in education, present potential knowledge and the fundamentals of applied sciences and mathematics essential to contribute toward the engineering industry. Therefore, college education has paved the path for the engineer's future success in the applied engineering industry. REU programs allow the aspiring engineer to apply their present understanding and prepare the student for establishing their foundation in professional engineering.

The REU program at the McDonald Observatory establishes an experience of professional reality. It takes you upon a new dimension of research and respect to aerospace and astronomical studies. The program lasts up to ten weeks and presents each engineer with a specific project dedicated to their engineering discipline. The REU program for engineers is generally dedicated to establish the framework of project management. Project Management at the McDonald provides the aspiring engineer to use the ethics and discipline of leadership and management roles. Project Management molds the engineer into a dedicated and useful motivator, innovator, and leader for a successful project outcome and solution. I was assigned to work at the HET, the Hobby-Eberly Telescope.

### The Hobby-Eberly Telescope

The HET (Hobby-Eberly Telescope), a 9.8 meter reflecting telescope contains 91 identical, 1 meter hexagonal segments made of Schott "Zerodur". Every viewing night each mirror is calibrated to precision by sensors at each corner of the hexagon to create one single 78 m<sup>2</sup> (839.59 ft<sup>2</sup>) primary mirror. The mirrors create a honey-combed hexagonal-shaped mirror. This primary has a focal length of 13 meters (F 1.3), which reflects toward a secondary mirror that interprets the resolved image to an acquisition camera and fiber optic feeds to the telescope operators and residential astronomers in the HET control room. Since this mirror is open to the atmosphere it collects debris, from dust particles and bat dropping. Hence the mirrors are cleaned with CO<sub>2</sub> foam that washes the minor debris from the surface. At the moment the HET primary is undergoing a face-lift from its present silver coating to being aluminized. Hence as mirrors are collected for aluminizing they must have a place for security and safety from surface contact. In addition, there are five spare mirrors as well that need storage housing. The intended solution is the design and construction of a mirror storage unit. Since each HET mirror weighs about 315 lbs. the rigidity of the structure must be a factor and its overall function to install and remove the mirrors from the storage unit by means of an overhead ceiling hoist. Hence, this was our challenge that intended a functional solution.

### The Mirror Storage Project

For my project I was assigned a mentor, Paul Peterson, a Mechanical Engineer from the HET facility. Mr. Peterson and I discussed all possibilities of potential projects that suited

my particular knowledge and potential. From four project choices, all of which were dedicated to the HET, one was selected as most feasible. This project was the HET Mirror Storage Project. I was assigned to create a storage unit capable of housing seven hexagonal, 1-meter mirrors and two calibration plates. I was to apply the project management scheme set forth by the HET McDonald division to complete this project. In addition, I was to create concepts, design, build, install, and release my storage unit to the client by my completion of my term at the McDonald Observatory.

As I completed my project I would be assisted by my mentor and collaborate with optical and mechanical technicians. While my mentor assisted strengthening my fundamental concepts of mechanics and dynamics, I grew a deeper respect and understanding of the design of my project's potential, testing my design with free body diagrams and applying physics engines to my CAD models. Many technicians, such as machinist Robert Peonisch, contributed ideas and concepts that would make this project sensible to the reality of the facility's capabilities. I also consulted my client, Jerry Martin, optics specialist, to assist me in determining our requirements and factors of safety to take into consideration. In addition, I found financial assistance from an electrical engineer, George Damm, to place PO's and develop my bill of materials. While my sponsor, Bob Calder, gave me advice in preparation of my design, as it went public to the facility and our overseers in Austin. As a result, I attained not only a new level of understanding and respect toward engineering professionalism, but a new level of confidence to apply this experience toward my future goals in engineering.

#### Project Management @ the HET

As I progressed along with my project I learned to apply myself and develop into an engineering profession that elevated my potential. I attained the opportunity to work in an atmosphere immersed with professionalism. My work performance was motivated to work toward my goal. I found that the plan laid out by the Project Management HET staff was beneficial toward my development as an engineer and leadership roles. I not only learned from my colleagues, but found the motivation to contribute my knowledge for a solution. The day-to-day routine of the staff found my curiosity and questions, a time to share their knowledge of their experience and job duties for the HET. At times I got the honored opportunity to assist in the removal and installation of the HET mirrors and optics devices. I not only gained a deeper understanding for their duties, but a new level of respect for the purpose of the duties they were required to accomplish and maintain.

As a new work day dawned, a new challenge awaited me. The Project Management Plan of the HET follows certain guidelines, initially with a concept, where we determine our requirements and contacts. This leads on to a Concept Review, where I presented three potential designs to the facility for the Mirror storage unit. I consider all possibilities, from an in-house design that we would fabricate and construct, to a manufactured unit. Of these choices, my client chooses one that will become our concept. Thus, I enter the Design Stage. During the Design process I test the concept with free-body diagrams and apply Algor Fempro®, a physics engine to test the design to static and dynamic loads.

We complete my CAD using Autodesk Inventor® and create the finished design, which brought my concept to reality.

After I complete my design, I arrange a formal meeting with my client and sponsor to a Design Review. At the design review, I present my analysis and data I have determined for the given loading. I explain the function and how the storage unit will operate, satisfying our given requirements. We discuss any modification and safety factors to consider. And finally, I present a bill of materials and an estimated cost for the project. Eventually, we come to an agreement that the design's potential can indeed become a reality, and we move toward our next phase- Construction.

During the construction phase, I collaborate with my welders, fabricators, and machinist to create my assembly drawings. I create individual components of each piece, and give descriptive instruction of its material composition, dimensions, quantity, and special considerations for fabrication and installation. We purchase our supplies and track our deliverables. As we await our order, we prepare the installation space for construction. Since this project requires mounting to our support beams and foundation, we start the boring and drillings for our anchor bolts. As supplies come in I assist the fabrication of jigs, templates to assist our welders in complex angle welds. Fabrication takes about one week to complete, and our welds take an additional 3 days. Once all components are complete, we machine and sand rough edges for our metallic coating. Once we have a complete shelf, we run a mock load test, to ensure that the shelf can hold the tolerated load we desire. We place 300 lbs of material onto the shelf and measure the deflection and compare that to our analyzed results. Once satisfactory, we are now ready for installation.

As we install the components, I direct the correct installation procedures for the support structure and installation of our shelves, which would be mounted by tapered pillow-block bearings. As we complete installation, we are ready for the release. During the release, I present the unit to my client and give all the necessary information of operating procedures and safety consideration for the storage unit. I also present the potential modifications that can be included, such as a housing for each mirror, a housing for the entire unit, and a locking device to prevent operation by those that may not specialize in optics. After the release, my job is now done and this project has attained all the requirements it set out to satisfy.

Project Management at the HET, follows a guide that not only makes the task easier as a guiding principle, but your appreciation to its completion and understanding of its structure and composition. Professional ethics such as, leadership, time management, critical thinking and organization all apply to a successful project. As my project developed, I developed to understand my capabilities and how my potential could contribute to the project's success. I learned to think critically and find solutions to the project by the fundamentals I applied from my education in statics, dynamics, mechanics, and basic calculus. In addition, technology, by CAD models and physics engines brought my designs to a new perspective of reality. In the end, I found success in a project that helped me mature and develop into my profession. In conclusion, The McDonald REU

prepares the aspiring engineer for the concepts and reality of the professionalism in engineering.

### McDonald REU Summery

The REU program is dedicated to engineers with a potential to contribute to the astronomical and aerospace industry. The program welcomes all engineering disciplines. The program last ten weeks to complete your specified project. There is a stipend of \$325/wk. The Astronomers Lodge (AL) houses the interns during their ten week stay. Food is served at the AL at a faculty discount, with a buffet style. As you complete your project, you are given the opportunity to assist at public Star Parties, visit local Observatories (i.e. VLA, New Mexico), and experience research in a new perspective of science and technology. During my stay I applied my stipend into a college savings that I could apply to my future educational expenses and project developments. The McDonald REU program for engineers is the ideal choice to elevate the aspiring engineer into a professional reality.

The McDonald REU program is coordinated by Matthew Shetrone, (432) 426-4168, shetrone@astro.as.utexas.edu

NOTE: The following is a detailed account of the HET Mirror Storage Project; it follows the HET Project Management scheme and includes detailed analysis and assembly drawings.

### Concept

During the Concept phase we determine an idea for the solution at hand. This idea can be far-fetched, for we are brain-storming all possibilities to solve our problem. We initially identify who is our project sponsor/manager. We meet with our client to determine what requirements we must satisfy. We then take this data and acquire what techniques may need to be applied to the project, i.e.: CAD, Free-body diagrams, construction, fabrication, or welding We then research what existing systems or techniques can be applied to the design. We research the data and concepts that our manufacturers can supply for a solution. After all data is collected, we thus customize all our resources to satisfy the outlining function of the project. Before we start our CAD models, we test our concept with free-body diagrams. We can now determine our Reaction Forces and Moments that may occur during static and dynamics operation. Once we are comfortable with our results, we can create a CAD model of the design. For any project, it is reasonable to come up with three different concepts for the client to choose from, one is usually a manufactured unit, so we can compare our design to that on the market. In addition, an overall concept of how each concept will satisfy the requirement is essential. Be honest and give the pros and cons of each concept to the requirements. And finally, take into account Safety Factors, whether it be function to basic risk assessment of the designs. Now you are prepared to meet with your client and sponsor for a Concept Review and decide which concept satisfies the given requirements.

### Design

After we have determined which concept is satisfactory, we can now get to work detailing our concept, through design. We initially take dimensions of our installation space and modify our concept to represent a fixture of reality. Based on our previous hand calculations we can compare our CAD models through a physics engine, which will test the stress and strain of our design. Algor Fempro is such an analyzer that can be applied to our design, after we indicate the applied loads and constraints design. You must never trust an analyzer until it agrees with the calculated results we determined. Many complications can occur during the analysis that are unseen by the user. This software is used to mimic reality, not become reality. Once we establish our complete detailed design up to scale, we can determine the required materials that need to be purchased, customized, or supplied by our in-house unit or distributor. Research all the necessary information of your components, from composition to tolerances, which are compatible to the design and its function. Once complete, create your Bill of Materials, a list of all required components of the design and purchasing information from contacts, quantity, dimensions, and overall cost. During the Design Review, present the overall function and how this design satisfies the given requirements. Include its safety factors and operational use while in static and dynamic phases. Give the bill of materials to your sponsor to decide if this project has a feasible budget. Once this design attains satisfactory results, allow the project team to understand the construction and installation schedule and when deliverables will be achieved.

### Build

We are one our way in bringing our concept to reality! During the Building phase we can now purchase all required supplies and await their arrival. During this time, prep the installation space for construction. Work collaboratively with your machinist, welders, and fabricators in determining the necessary information they will need in the assembly drawings. Create detailed assembly drawings that specify the dimensions, tolerances, and special requirements that are needed for each component that may need in-house fabrication and welding. Determine the special tools and jigs that may need to be supplied to help speed up the construction process. Once Materials are delivered, begin assembly of the components. After a section of the design can be assembled, plan a test to generate a mock load/operation of the design in the work shop. Test this design by means of loading the device to its maximum potential. Operate the device as it was to function. This test will ensure that our design meets the anticipated requirements, before we install the unit. Finally determine the installation team and date for which the unit will be installed to its destined location.

### Install

If the installation process permits we may have to issue an installation plan that will assist us in the assembly of the unit. Once installed, we set the tolerances of any device that may need to be calibrated. Then we can ensure that the device is fully operational and ready for release.

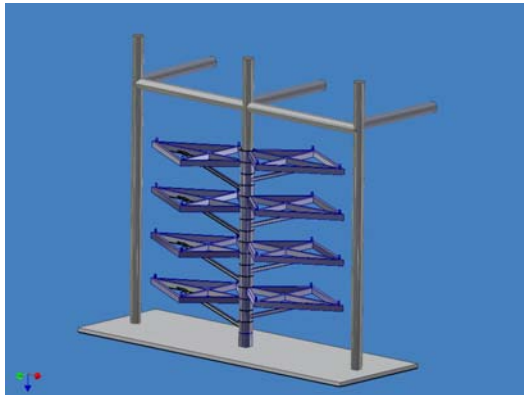
### Release

The Release is the final phase of our project. At this time we present the designed installed unit to the client and operational team that will be operating the unit. We give a



brief demonstration of the unit's operation and function. We assist and train the client as they operate the unit for the first time. We then supply our client with any consideration to take into account, such as future modifications and applications that can help the present design's functionality. We then supply our sponsor with all data, from analysis, assembly drawings and instructions for future reference. Finally, we have met the requirements set forth by the HET Project Management and Development division to ensure a successful solution for our given requirement.

## The Concepts



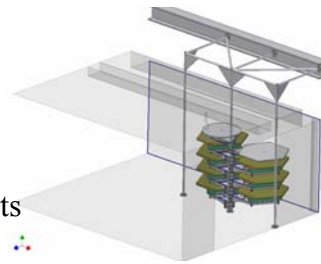
- **Solution A: *The Mirror Tree***
- Rigid construction
- Houses 8 mirrors supported by a single post with bearing supports to each individual shelf.
- Rotational shelves satisfy our desired hoist location and provide min. vibration.
- Loading is distributed to longitudinal axis of post and supports.
- Installation space is kept at minimum requiring only 7.5' of space.
- Swivel arms do not obstruct access to exit, clearing at least 3'
- Installation is rigid and permanent.
- Meets all necessary requirements.
- Recommended Solution.



- **Solution B: *The Mirror Rack***
- Design is compact and rigid.
- Swivel Shelves on either side of parallel poles.
- Internal load is distributed by supports
- Can house only 4 mirrors on each side.
- Must require more installation space (up to 12') and materials.
- Right mirror shelves could possibly obstruct exit.
- Permanent installation.



- **Solution C:** Manufactured Storage Unit
- *Material Handling Sales Inc*, High Density Storage
- Distribution center located in Maine.
- Can hold excessive loads, up to 3000lbs
- Unit may need modifying; drawer-type units are rare.
- 12" Clearance between each shelf
- Temporary unit, may be relocated



### The Design

#### The Mirror Tree

Composed of structural steel alloy supports

Single shaft support of solid 2" steel

Mounted to Dodge Pillow-Block Bearing, w/ Timken tapered bearings, and locking SetLock™ Collar

Mounted Skeleton Shelf Design

Holds up to 7 HET mirrors w/ mounts

Additional shelving for calibration plates

#### The Function

Each mirror will be stored at a 30° from plane of rotation

Establish a 120° rotational displacement for each HET shelf

Shelf rotates out 90° to access hoist location at center of each shelf (approx. 22")

Clearance of 14" between each shelf

Access to top self gives 10" of clearance to hoist

#### The Safety

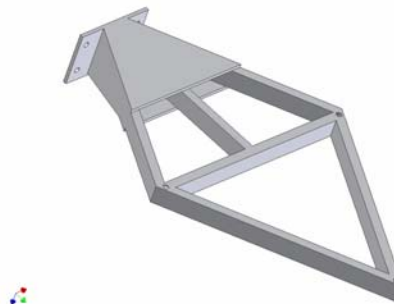
When shelf is in use, clearance of 4' to exit

Steel Retractable Spring Plunger w/ lock down nut will set the rotational displacement in storage and in use.

Locking latch gives stability and security to shelf while in storage.

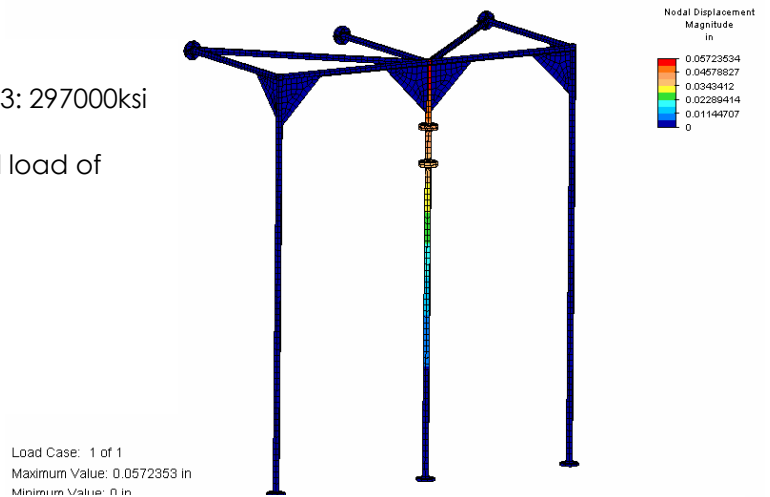
Mounted locating pins on shelf prevent vibration and movement while in motion.

### The HET Mirror Tree



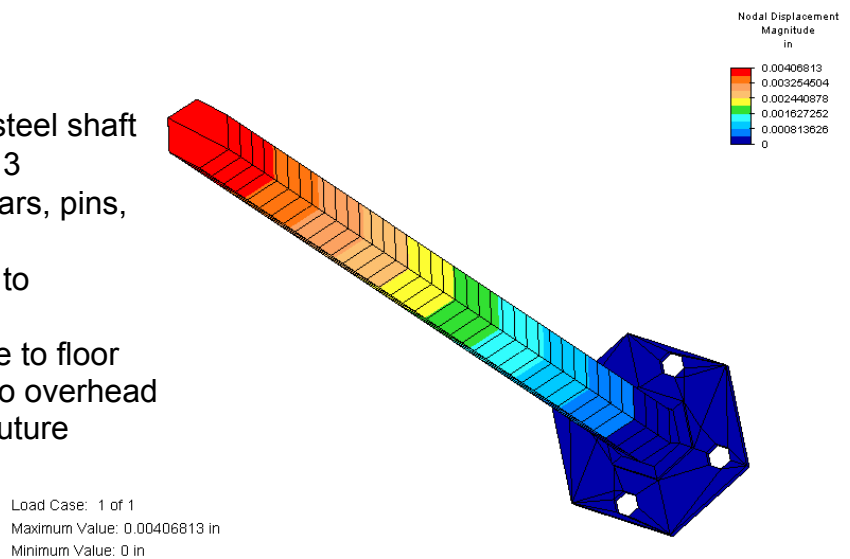
## The Structure

- Overall strain 1345 lbf/in<sup>2</sup>
- Young's Modulus for ASTM A53: 297000ksi
- Thus Strain= .000046 in/in
- Overall displacement with full load of 2300lbf= .057"



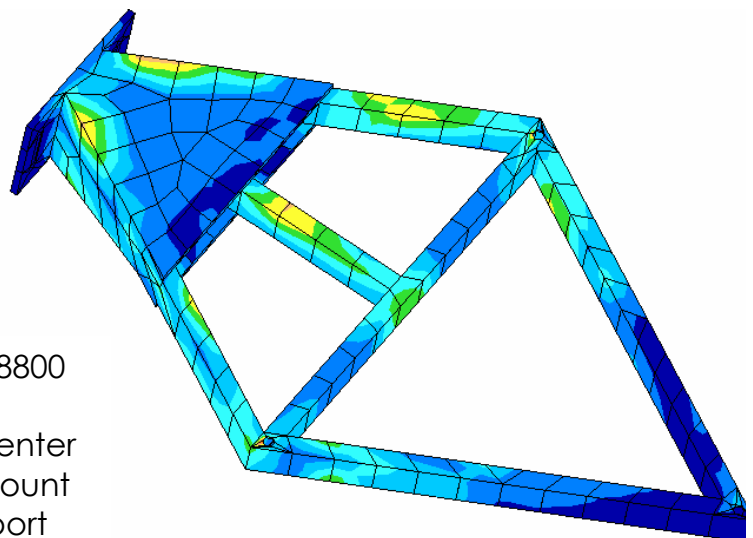
## The Shaft

- Machined to precision steel shaft
- Shaft Tol: .0006 to .0013
- Applications include gears, pins, and shafts
- Low carbon steel, slow to expansion and wear
- Welded in place at base to floor flange and threaded into overhead flange union, allowing future removal of bearings.



## The Shelf

- We have a moment load of 8800 in-lbf
- Stress is distributed back to center supports, thus allowing our mount to distribute our loading support evenly among our two pillow-



## The Bearing

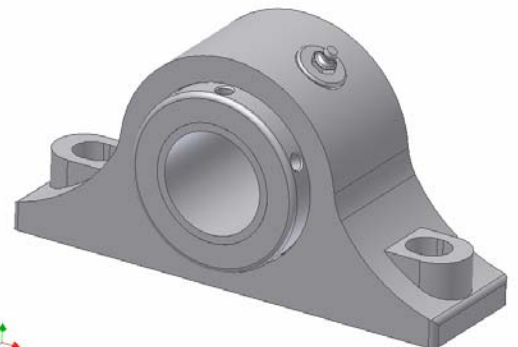
- Dodge Type E-Extra Pillow-Block Bearing with 8" mount.
- Entirely sealed and assembled to mount
- Timken Tapered Bearings, w/ TDI arrangement, inner race movement on shaft
- Supports any to all moment loads
- Our set of 2 TDI's = modified TDO
- Holds trust load of 6908lbf, ours is max of 1500lbf
- Radial load of 16800lbf
- ASTM A48 Cast Iron Housing
- Set Screw Set-LOC™ Collar creates eccentric 360° hold up to 3500 lbf to our shaft
- Two Bearings per shelf will satisfy our loading and prevent misalignment of bearings
- Most economical solution to our loads and reverse engineering application.



## The Flange

### Support flange:

- Will hold 300 psi,
- Total area: 28.27in<sup>2</sup>
- Total loading potential: 8482.30 lbf
- Our foundation will hold up to 150psi = 4240 lbf (see structural design S1 in blueprints)
- Our intended load w/ mirrors = 4046.83 lbf
- Note: This will be welded to our machined shaft and anchored to foundation by WeJ-It anchor bolts



Union flange:

- Will hold 150 psi,
- Total area: 28.27in<sup>2</sup>
- Welded to our steel shafts
- Bolted by 5/8" bolts with lock washers and nuts
- Note: One union flange will be threaded to our machined vertical shaft, for removal of bearings

Credits and collars.

I would like to recognize the following individuals for making this project a success:

Paul Peterson, Mechanical Engineer, HET

Jerry Martin, Optics Technician, HET

Bob Calder, HET Management, HET

George Damm, Electrical Engineer, HET

Robert Peonisch, Technician, HET

Dr. David Corbin, Astronomy and Physics, SRSU

John J. Mendias, Contractor, Triple J Services

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## **Design of a Telescope Control System Interface**

**Tim Hudson**

**Mentor: Jim Fowler**

### **Student Summary:**

Design of a Telescope Control System Interface

T. Hudson

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### **ABSTRACT**

A telescope control system interface provides a means of communication between an astronomer, or telescope operator, and a telescope. This communication loop has historically been unfriendly to the average user, often relying upon text-based screens or very basic graphical user interfaces. In this paper, we present a new standard for the telescope control system interface by utilizing an advanced graphical technology. Specifically, we intend to code an application in C++ that employs the OpenGL API. This allows us to present information in a manner that is concise, flexible, and easy to learn.

### **INTRODUCTION**

I and my mentor, Dr. James Fowler, decided to attempt this project together, with the hopes that we might harness the power of computer graphics and apply it to a field of software in dire need. The explosion of computer graphics technology within the last fifteen years has revolutionized many industries. Computer aided drafting has become an integral part the engineering industry and computer animation has become the new love of the movie industry. The military makes use of realistic computer simulations while hospitals use three-dimensional imaging to analyze a patient. With this paper, we intend to show how computer graphics technology will revolutionize the modern telescope control system interface.

With graphics technology, we can create a visually pleasing system that accomplishes several goals: An interface should be extremely intuitive, so as to minimize the amount of training time needed. A well-designed GUI should require little to no instruction prior to operation. It should also make an efficient use of visual space on the monitor, and cut down the number of total monitors needed for telescope operation. It should be easily customizable for the various types of users. It should be as self-monitoring as possible, requiring the user's attention only when absolutely necessary. It should minimize the amount of user error by requiring as little input as possible.

To make all of these goals attainable, we decided to use a graphical standard known as OpenGL. This API allows us to achieve our goals with graphical operations that would otherwise be very difficult to implement. An added benefit to using OpenGL is hardware support. Most of today's computers have dedicated GPUs that support at least a portion of the OpenGL API in hardware. This allows for added graphical effects without a significant burden being placed on the primary CPU.

## BACKGROUND

In this section, we intend to give some background about our current telescope control system, and the tools we intend to use.

### Current Telescope Control System

The telescope control system we used as a model for a system that needed improvement was at the Hobby-Eberly Telescope (HET) at McDonald Observatory in the Davis Mountains of West Texas. The need for improvement derives from the fact that the current TCS interface was borrowed from that of another telescope. It was not designed with the HET in mind. The main window contains mostly text, the majority of which is not needed. Dr. Jim Fowler suggested a graphical interface that did not include unneeded information.

To accomplish this, we decided that OpenGL was the best choice. Introduced in 1992 by Silicon Graphics Incorporated, it is the API of choice for programmers who want to code graphically intense applications. It is a mature API that is supported by multiple platforms with multiple languages. We also decided to use C++ because it is extremely portable and a language we are both comfortable with.

## DESIGN

In this section, we will discuss the design issues of our graphical telescope control system interface.

### Graphical Features

In order to achieve our design goals, we utilized a variety of graphical features readily available in OpenGL.

### Three-Dimensional Representation

OpenGL has both 2D and 3D applications. The latter, however, is arguably the prime focus of the API. By allowing the programmer to easily construct geometric primitives in memory,

OpenGL facilitates the assembly of entire 3D environments. OpenGL then handles the math associated with transforming the 3D image onto a 2D screen. This would allow any telescope control system to contain a 3D model of the dome and telescope structure. Or perhaps the astronomer would prefer some sort of 3D finding chart. Even the core of the interface could be represented in 3D if desired. In any case, 3D representation often allows for quick visual information retrieval. For example: Instead of finding the dome shutter status in a list of numbers, it is much easier to look at a picture. Not only would you instantly know the status of the shutter, but also the dome's orientation.

#### Rotatable and Scalable Text

While many GUIs may boast text that can be rotated and scaled, they do not do so with the precision and ease of OpenGL. By representing text with geometry, OpenGL can scale and rotate text at infinitely precise increments. This can in turn, make a telescope control system interface infinitely customizable.

#### Pop-ups and Mouse-overs

This feature is not specific to OpenGL, but plays an important role in the efficiency of the GUI. By hiding text information until it is needed, the overall size of the GUI can be reduced. Mouse-overs are important because you can obtain additional information about any object on the screen by simply placing the cursor over the object. Pop-ups can be utilized to warn the telescope operator of errors or other immediately pertinent information. This negates the need for a dedicated error message space.

#### Alpha Channel Blending

For every visual element of an OpenGL program, color information is stored in four discrete channels. These channels are referred to by the acronym RGBA (Red, Green, Blue, and Alpha). The first three channels determine the overall color of the element, while the alpha channel determines the opacity of the element. An object drawn on the screen at only half opacity would reveal any objects drawn below it. This can effectively allow the simultaneous display of two visual elements that happen to occupy the same space.



Figure 1 - A semi-opaque window achieved through alpha blending

This could be applied to messages or windows so that they are drawn over information on the screen without completely obscuring it.

#### Modularity

A major goal of ours was to make a telescope control system interface that could easily be changed to suit a particular observatory and even particular users. By containing each piece of information in a module, and allowing the configuration of each individual module, we can produce an extremely flexible GUI. OpenGL allows for “subwindows” within windows that can be resized and reshaped. Within these subwindows, we can place any kind of information. For example: In one module, we might put temperature information. The text size and colors within that module could be arranged in any fashion. Then the module itself could be dragged to any desired position on the screen. It could be resized to a very small box, so that it did not take much space, or it could be expanded to fill the entire screen. In this manner, any number of modules could be added or removed from the TCS, making it easy to upgrade in the future. For

our telescope control system interface, we added a temperature module, a text module, a history log module, a dome status module, a radar map module, and a tracker module. Given that our telescope control system interface is very simple, it does not include modules for calibration, scheduling, guidance, data information, or maintenance. All of these functions are already managed by other programs at the HET, however they would not be too difficult to add. After arranging modules in a suitable manner, the arrangement can be saved, so as to personalize the TCS for any number of users.

#### Implementation

In this section, we discuss the way our telescope control system interface was implemented.

##### Planning

Dr. James Fowler made the bulk of the decisions concerning the design of the interface. He suggested a circular design to correspond with the degree of motion of the telescope. We also incorporated many elements from the current TCS interface, but attempted to streamline them in the process.

##### Interviewing

To ensure satisfaction by our end-users, the telescope operators, we conducted many interviews. We queried each operator about the feasibility of various design elements. We also obtained many new design elements from the operators themselves. We were also made aware of the various presentation needs of each operator.

##### Programming

In order to take advantage of OpenGL's capabilities without worrying about the intricacies of window-system dependent commands, we employed the help of GLUT, an OpenGL Utility Toolkit written by Mark Kilgard. It allows us to start an OpenGL capable window without regard to a specific operating system. We constructed the bulk of the program with C++ and OpenGL, although we also made use of system calls to a PERL script made to obtain POSS II images from the web. Over the 10-week period, an interface gradually evolved that included most of the aforementioned design elements. Though not fully operational, it was a sufficient mockup to determine the effectiveness of such an interface.

#### CONCLUSION AND FUTURE WORK

Within the given time constraints, we were unable to implement all intended features of the interface or implement connectivity with the TCS server. In the event that we were given more time to complete our project, we would like to implement more advanced features of OpenGL, such as texture-mapping and more 3D features.

We did a few follow-up interviews with telescope operators to get their reaction to the new interface. We were pleasantly surprised by the response we received. The graphical features and practicality of our new interface were very well liked.

We believe that we have uncovered the mere tip of the iceberg of what is possible, and we are excited to see what the future has in store for the modern telescope control system interface.

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## **An Investigation of Blue Straggler Stars in M67**

**Steven Warren**

**Mentor: Matthew Shetrone**

**Student Summary:**



## An Investigation of Blue Straggler Stars in M67

Steven Warren  
San Diego State University

I worked this summer as an intern at the University of Texas at Austin run McDonald Observatory. I worked with Dr. Matthew Shetrone of McDonald Observatory and Dr. Eric Sandquist of San Diego State University on a project that is to become the definitive blue straggler star (BSS) investigation to date.

The purpose of my work was to measure radial and rotational velocities, metal abundances (lithium in particular), check for signs of binarity, and gather all known information about the BSSs across all wavelengths from the literature. In doing so, I could hopefully put constraints on formation mechanisms of each BSS as well as provide the scientific community with a broader knowledge of BSSs and how they work.

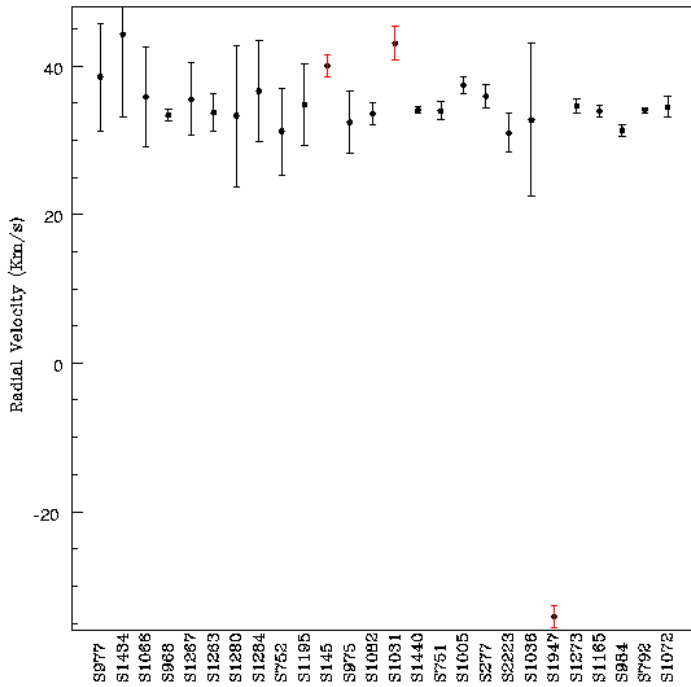
M67 makes the perfect subject for this type of research. It has a distance modulus of about 9.7 (Dinescu et al 1995) which put it about 2800 light years away. Its close proximity allows us to get high resolution spectra of individual stars. It is one of if not the only cluster we are able to do this with. Most other clusters are too far away or too dense (globulars) to separate the individual stars. It is also very well studied which allows us to better detail each star.

The data I worked with was obtained from both McDonald Observatory in Fort Davis, Texas and Mt. Laguna Observatory in San Diego, California. I dealt with two types of data, spectroscopic and photometric. The spectroscopic data was obtained from the Hobby-Eberly 9.2m telescope using the high-resolution spectrograph (HRS) as well as the 2.7m (107") Harlan J. Smith telescope using the coudé spectrometer. My photometric data is CCD photometry and was gathered with the 1m (40") telescope atop Mt. Laguna. It is necessary to use both photometry and spectroscopy in order to fully understand an object. Photometry provides us with the ability to pick out BSSs from a color-magnitude diagram but gives us little other information aside from temperature and light variation. Spectroscopy allows us to dig deeper into the secrets of the star and expose everything from temperature, abundances, periodicity, surface gravity, micro/macroturbulence, and many other properties.

There are two basic ways to form a BSS, direct stellar collision and binary coalescence. The two ways predict very different BSS properties. Direct stellar collision will result in a slower rotating BSS. It also predicts the destruction of an important element, lithium, through mass ejection. Surprisingly enough the lithium isn't burned from the impact itself, but any left over lithium will be destroyed through a brief red giant type phase after the merger. Binary coalescence, however, will result in a faster rotating object (if the pair is of similar mass), and if the merger is slow enough, will allow for lithium to remain in the atmosphere of the newly formed BSS. It was my job to search for this element because it not only allowed us to put a constraint on the formation mechanism but it has also never been detected in a BSS.

My first task was to reduce the raw spectra. I employed IRAF to assist me in this task. The steps included bias and trim subtraction, overscan removal, flat fielding, and spectral line alignment amongst others. Once I had completed this I moved on to the analysis of the spectrum through many different means.

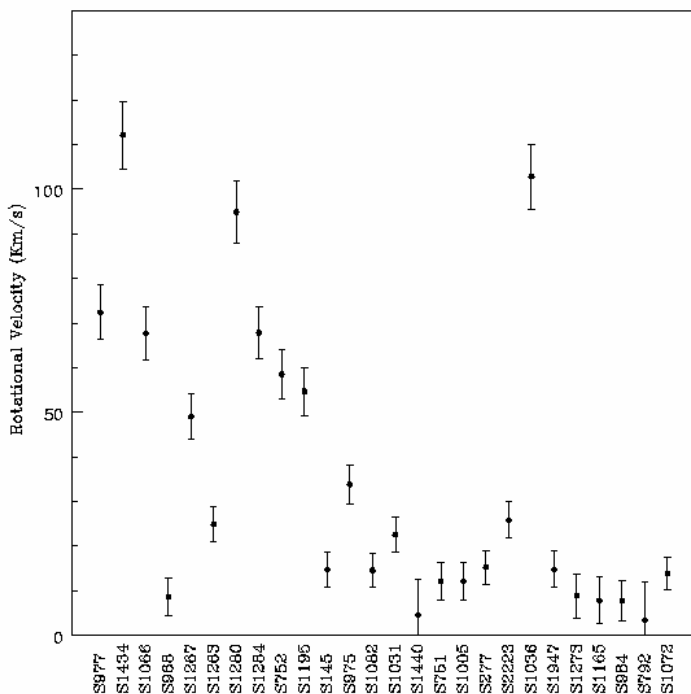
Finding radial and rotation velocities are a very important step in the analysis process. Radial velocities can tell you two important things about a cluster star. The first being if it is a member and the second if it is a binary.



If a star has the same mean velocity as the cluster it has a good chance at being a member. M67's mean radial velocity is about 34 km/s, so it would be expected that the stars you study have the same radial velocities. Looking at the first figure clearly shows a trend at about 34 km/s. There are many binary stars among the BSSs in M67 and at any given time the main component may not have a radial velocity that is similar to that of the cluster, but if you have many observations you can look at its mean velocity to find out if it is a member. The three stars marked with red error bars are

those that show no signs of binarity and have radial velocities much different than that of M67. We have concluded that these are possible non members.

Rotational velocities are another important velocity to try and nail down. The rotational velocity can put a constraint on how the BSS was formed.

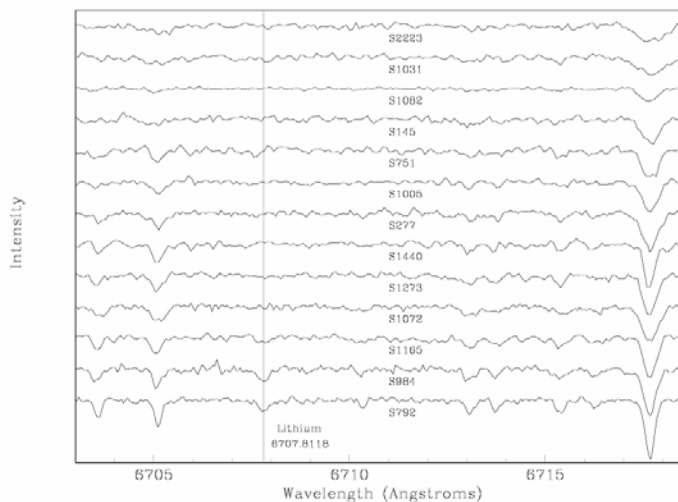
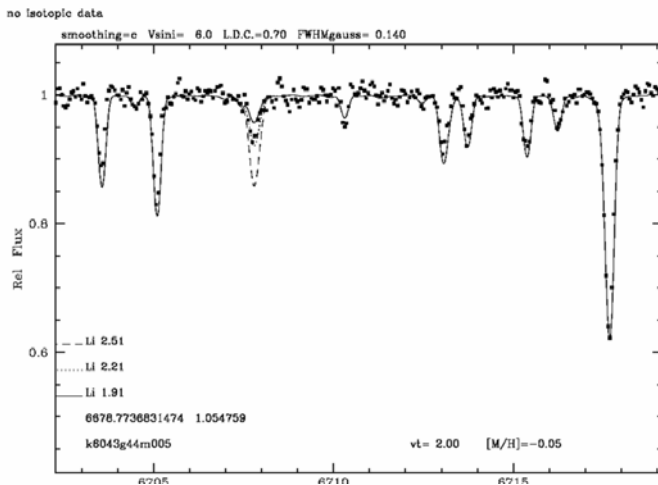


The rotational velocity can put a constraint on how the BSS was formed. Figure two shows rotational velocity vs. star ordered from blue to red in color. There is a clear correlation between the rotational velocity and color. The redder BSSs clearly rotate slower. This would imply more collision formations rather than binary coalescence, but in an open cluster one would assume that stellar collision would be exceedingly rare and would thus be an unlikely explanation for all of them. I am in the process of trying to prove that these can still be binary mergers, but between a high mass and low

mass star as too conserve angular momentum one would not need to spin up the resulting BSS too much. The one high rotation BSS on the red side, S1036, is a known W UMa type contact binary and is in the process of forming a BSS. When it has completed its merger I predict that it will not only spin up a bit more, but will also move to the blue side of this plot.

In order to detect lithium in the atmosphere of a star, the surface temperature has to be low enough depending on the metallicity. Other clusters have shown a lithium ‘dip’ in which the detectable lithium drops significantly at certain surface temperatures. M67’s dip is predicted to be around 6500 K. I chose all the BSSs with surface temperatures at or below this temperature to conduct my search with. My red sample consisted of 12 BSSs. I used the latest version of the LTE spectral analysis package MOOG (Sneden 1973) to conduct my search. This consisted of making a synthetic spectrum and overlaying the observed spectrum to look for lithium line strengths. In order to create the synthetic spectrum we had to have an initial surface temperature estimate. We used the Houdashelt method which involved B, V, I, J, and K colors. The BVI data was obtained from our photometric data while the JK colors were obtained from a GATOR search online.

With the photometric temperatures in hand I made synthetic stellar spectrum using the



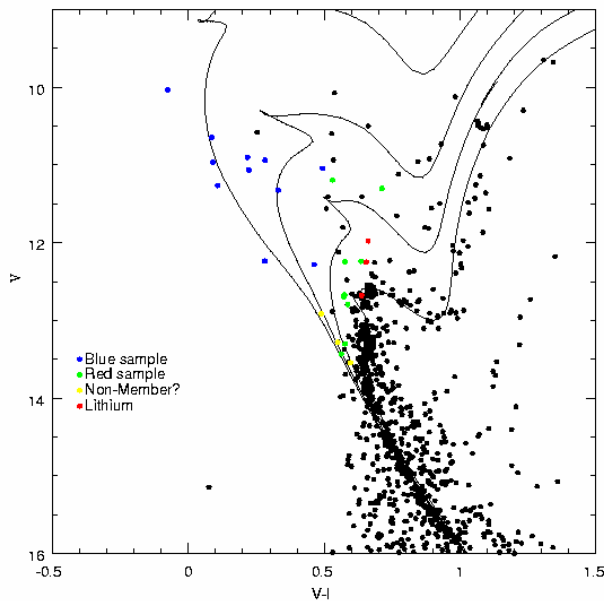
Kurucz grid of ATLAS stellar models. The figure at left shows an example of the MOOG analysis tool. Lithium is the third line from the left with three different line strengths over-plotted. I did this for my entire red sample and plotted them one on top of another. Figure 4 shows my results from the lithium analysis.

We detected Lithium in three stars S792, S984, and S1165. Upon closer analysis we have determined that these three stars are not BSSs. S792 and S984 are most likely binaries containing two turn-off stars or a light blended pair. S1165 based upon its color magnitude diagram position is most likely a turn-off star.

Metal abundances were found using the same MOOG program but with a different parameter file. Abundances were determined by adjusting three

parameters: surface gravity, microturbulence and temperature. The surface gravity was determined by forcing abundance equivalence between the FeI and FeII lines. The microturbulence was found by adjusting its strength until the slope of FeI vs. equivalent width was equal to zero. This was an iterative process done until the above parameters fit within the abundance errors.

One last piece of information I needed to gather was photometric information via color-magnitude diagrams (CMD). Figure 5 is an example of one of the CMDs I made. Plotted onto



of the photometric data are four isochrones. The isochrones predict tracks of stellar evolution at different ages. From left to right the isochrone ages are 0.4 Gyr, 1.0 Gyr, 2.0 Gyr, and 4.0 Gyr. M67's current age is about 4 Gyr and the coinciding isochrone clearly shows an agreement with the stellar evolution. The interesting thing about this plot is the blue star that lies outside of the last isochrone. The 0.4 Gyr isochrone represents the double turn-off mass age, which is the age of the cluster when the turn-off mass was twice that of which it is now (1.4 solar masses). The implications of the outlying star are that it had to have been formed by more than two stars in order for its mass to be greater than 2.8

solar masses.

With all this information at hand we are currently in the process of trying to determine what it all means for each and every star. The most definite conclusion we have determined so far is that lithium is *always* destroyed in the formation of BSSs. So in the future, any BSS candidate with lithium is either in a binary system where the lithium is from a companion or the star is not a BSS, period. The final result of this project will be a ground breaking paper which will hopefully be the place to start for any future BSS research for any research team.

## Line profiles in red giants of NGC 6752

Mary Reiman

Mentors: Carlos Allende-Prieto, Matthew Shetrone

### Student Summary:

Line profiles in red giants of NGC 6752

Mary Reiman

University of Wyoming

REU 2005 at McDonald Observatory, UT

Collaborators:  
Carlos Allende Prieto  
McDonald Observatory and Department of Astronomy  
The University of Texas

Matthew Shetrone  
Research Scientist, McDonald Observatory

Abstract:

This paper will encompass the research work that took place during the summer REU program at McDonald Observatory. The research done was on the atmosphere of red giants by looking and the analyzing of the core line shifts.

Introduction:

The raw data of NGC 6752 was gathered from the VLT (Very Large Telescope) located in Chile. The data came to me as massive tables that held wavelength, flux, and aperture. For each of the given stars, the spectrum was from an echelle spectrograph that first broke the data to the red half and the blue half. With the red half, the spectrum is broken up into 15 apertures; the blue, into 23 apertures. There was some overlapping of wavelengths when going from one aperture to the next so that there were no gaps in the information. This overlapping of information will come into play in a little bit.

So, with these tables of measured wavelength, flux, and aperture, I was able to ‘transform’ this three column table to a ten column table through an idl program given to me by Carlos Allende Prieto with some minor adjustments. The columns created were the following:

Measured wavelength, error on that wavelength, Solar wavelength, error on the Solar wavelength, the Ion of the line, Excitation potential, log (gf) (the oscillator strength), equivalent width, the minimum point of the flux, and aperture

Once the table above is completed, the issue of the repeat lines needed to be addressed. So, by using the following equation, I was able to properly handle the situation.

$$U' = (\Sigma(x_i/\sigma^2) / \Sigma(1/\sigma^2))$$

With this equation, I was able to weight the information so that no data was thrown out or ‘cook’ the data in any way.

The next step was to find rotational velocities for each of the stars. Through the following equation the velocities for each identified line were found.

$$V = ((\text{Measured wavelength} - \text{Solar wavelength}) / (\text{Solar wavelength})) * c$$

With the error calculated by:

$$\sigma_v^2 = (\partial V / \partial m)^2 \sigma_m^2 + (\partial V / \partial s)^2 \sigma_s^2 + (\partial V / \partial c) \sigma_c^2$$

By using iraf, I plotted the velocity versus equivalent widths ended up with two different results, positive slopes and negative slopes as shown in figure 1 and 2. The positively sloping graph is what is more expected when studying red giants, for that means that the star's atmosphere is expanding. With the negatively sloping graph (see figure 2), it more than likely means that the atmosphere is contracting, which may mean that that particular star is going through a period of pulsation. This result is very exciting, for little is known about the exact details of pulsation within red giants.

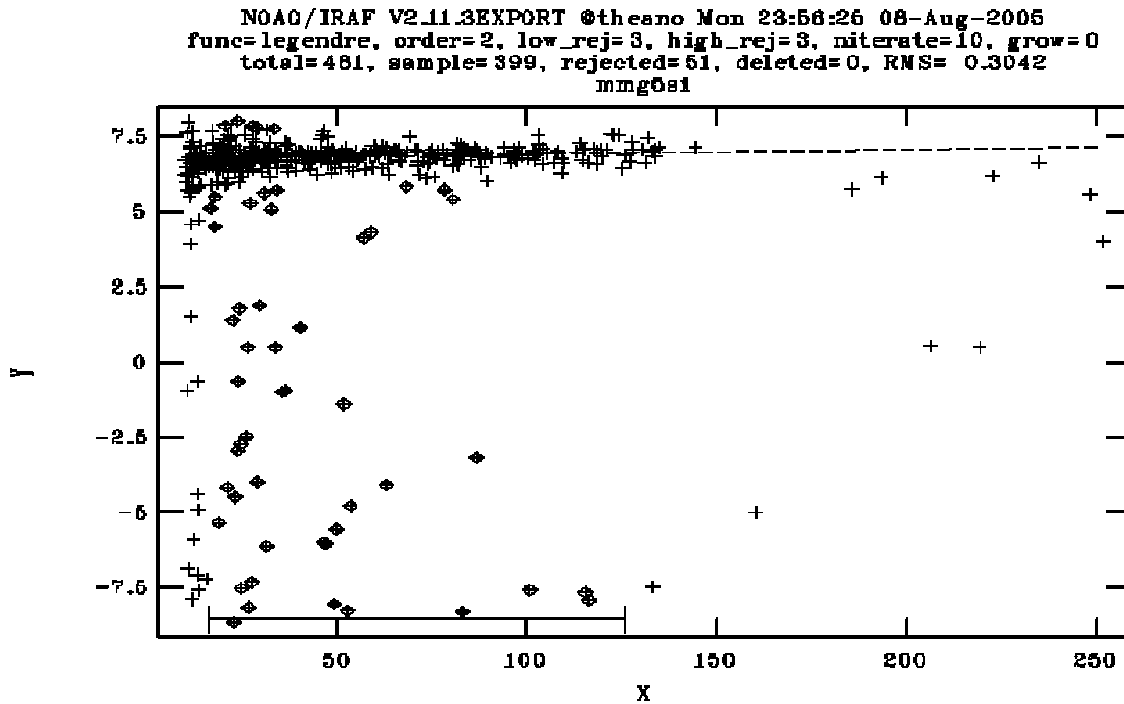


Figure 1 is an example of a resulting positively slope graph from the star mmg5, showing velocity vs. equivalent width.

NOAO/IRAF V8.11.BEXPORT @theano Mon 23:19:28 06-Aug-2006  
 func=legendre. order=2. low\_rej=8. high\_rej=8. niterate=10. grow=0  
 total=551. sample=429. rejected=47. deleted=0. RMS= 0.3975  
 mmgl1

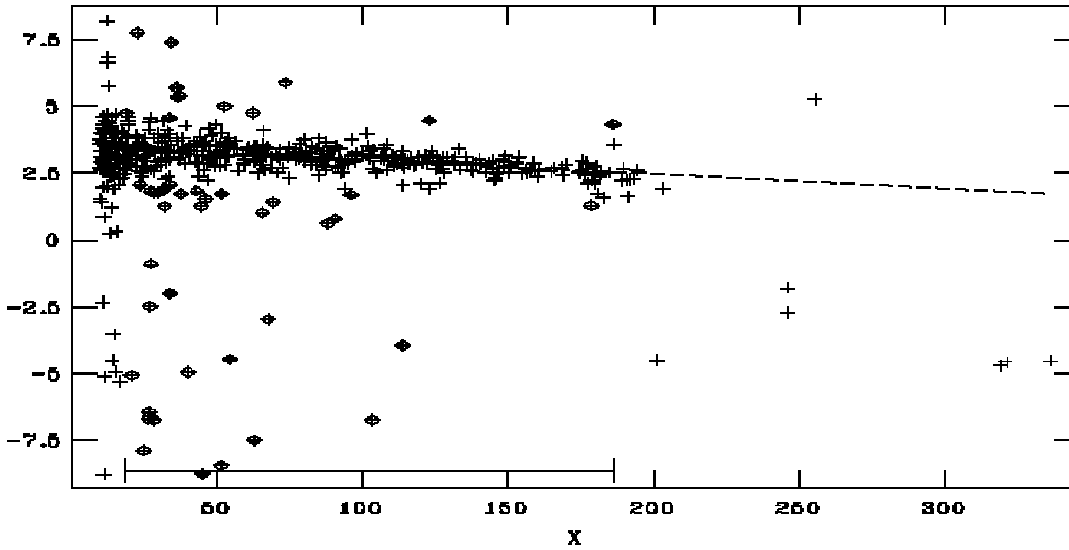


Figure 2 is an example of one of the negatively sloping graphs. This shows star mmgl1's velocity vs. equivalent widths

For each of the stars, two similar plots (like those above) were found and the slope of the fit line was recorded. Making sure that the two fit-line-slopes agreed with the red and blue parts of the spectrum (for the individual stars) before averaging the values was very important to be able to notice any discrepancies. Similar measures were used in comparing the excitation potential to rotational velocity.

In Yong et al. 2003, NGC6752 was studied for different reasons. By combining their work along with mine, I was able to create the table shown on the subsequent page. I did graph the both equivalent width and excitation potential the other columns to see if there was any noticeable relationships. There are definitely correlations between the stage of the red giants and the slope relation of equivalent width/velocity.

The field of red giants has barely been touched, with an insight into one aspect of red giant a wide range of questions and possibilities.

Source:

Yong, Grundahl, Lambert, Nissen, and Shetrone. 2003 A& A 402, 985-1001

Name	Teff (K)	log g (cm s <sup>-2</sup> )	ξ (km s <sup>-1</sup> )	Macro (km s <sup>-1</sup> )	Al	Red slope	Blue slope	Avg Slope	EP Red	EP Blue	EP Avg
mg0	3928	0.26	2.7	5	5.91	2.52E-03	3.64E-03	3.08E-03	-7.90E-04	-9.98E-04	-8.94E-04
mg1	3900	0.24	2.7	4.75	5.65	-5.08E-03	-6.19E-03	-5.63E-03	1.62E-03	2.04E-03	1.83E-03
mg2	3894	0.33	2.5	6	5.6	3.02E-03	2.17E-03	2.60E-03	-1.42E-03	-9.20E-04	-1.17E-03
mg3	4050	0.5	2.2	5.5	5.6	1.21E-03	2.26E-03	1.73E-03	-2.72E-04	-6.96E-04	-4.84E-04
mg4	4065	0.53	2.2	5.5	5.73	-8.31E-04	-1.06E-03	-9.44E-04	3.43E-04	9.44E-05	2.19E-04
mg5	4100	0.68	2.1	5	5.57	1.93E-03	1.89E-03	1.91E-03	-4.83E-04	-5.74E-04	-5.29E-04

mg6	4154	0.8	2.1	4.5	5.4	4.95E-04	1.52E-03	1.01E-03	-5.59E-04	-3.06E-04	-4.33E-04
mg8	4250	0.91	2	5	5.57	3.78E-04	3.77E-03	2.07E-03	3.29E-04	-1.42E-04	9.34E-05
mg9	4288	0.9	1.9	5	5.6	-4.44E-04	2.28E-04	-1.08E-04	-1.04E-04	6.33E-05	-2.05E-05
mg10	4264	0.94	1.8	4.75	5.61	-8.73E-04	1.70E-03	4.11E-04	-1.59E-04	-2.22E-04	-1.90E-04
mg12	4286	1.02	1.8	5.25	4.92	-1.12E-03	7.36E-04	-1.91E-04	-1.06E-04	-4.24E-04	-2.65E-04
mg15	4354	1.11	1.9	5.25	5.55	-1.88E-03	-3.85E-04	-1.13E-03	-3.60E-04	1.84E-04	-8.82E-05
mg18	4398	1.2	1.8	4.75	5.42	-3.24E-04	6.93E-04	1.84E-04	1.84E-04	-2.35E-04	-2.59E-05
mg21	4429	1.2	1.8	5.25	6.01	-7.19E-04	9.27E-04	1.04E-04	-2.35E-04	-2.35E-04	-2.35E-04
mg22	4436	1.31	1.8	5	5.82	-1.84E-03	1.49E-03	-1.75E-04	-4.43E-04	-6.42E-04	-5.42E-04
mg24	4511	1.33	1.9	5	4.95	-3.43E-04	1.38E-03	5.18E-04	-1.74E-04	-5.96E-04	-3.85E-04
mg25	4489	0.5	1.7	5.25	5.34	1.93E-04	1.76E-03	9.77E-04	-3.96E-06	-4.02E-04	-2.03E-04
hd141531	4273	0.8	1.9	5.5	4.74	-1.41E-03	3.54E-04	-5.30E-04	-3.51E-04	-1.83E-04	-2.67E-04
hd103036*	4200	0.1	3.1	7.25	5.08	-1.11E-03	-1.11E-03	-1.11E-03	1.42E-04	1.42E-04	1.42E-04

**A new Query Engine for HET**  
**Amy Westfall**  
**Mentors: Brian Roman, Sergey Rostopchin**

**Student Summary:**

HTOPX II:  
A New Query Engine for HET

Amy Westfall  
Texas Tech University

Over the course of ten weeks at McDonald Observatory, I have created a replacement for the HTOPX (HET Top Priority Targets, Experimental) Program which is used by the resident astronomers at the HET to sort through the long list of targets in the queue of requests from different universities. This program aids in the efficiency of observing.

The HTOPX program consists of a database, and a GUI front-end for analyzing objects in the database. In the old HTOPX, the “database” was an ASCII file called plan.db and the front-end GUI was written in TickleTK. There were several problems with the front-end as well as the ASCII plan.db. First, the front-end had several efficiency issues. For example, setting constraints on the objects retrieved from the database was a matter of checking or unchecking boxes containing values across the spectrum of possible values from the database, including numerical values. Second, the database, as well, had several efficiency issues. In order to change information about one object in the database (for example, incrementing the number of times an object has been observed), would require re-writing the entire plan.db file.

The proposed solution to the HTOPX woes consisted of, first, a MySQL replacement for the plan.db ASCII file, and second, an interface capable of interacting



with a MySQL database and allowing the resident astronomers at HET greater flexibility for deciding which objects to observe when. The chosen method for creating this interface was to implement the capabilities of the world wide web: HTML, PHP, JavaScript, and CSS (Cascading Style Sheets). PHP comes with MySQL functionality, and with the aid of CSS and JavaScript, it has been easy (relatively easy) to create a portable, versatile, and superiorly interactive interface.

The new HTOPX interface has many advantages over the old one. First, a color coding system alerts resident astronomers of the priority and position (relative to the HET track, the line in the sky where the object is within the range of the HET) of the objects which are in their query result list. Second, CSS allows for menus to appear on mouseover events, and this saves window and desktop space because several extra windows to control the database query do not need to be opened, and long lists of criteria in HTML forms do not have to be sifted through to find one variable that needs to be changed. Third, a feature to save and load query settings is also available.

The new HTOPX works largely with PHP's session variables. The program consists of three main web pages in a frames setting. The large window is used to display, in tabular form, the results of queries to the MySQL database, which I will explain later. Within these tables are nested menus, which appear on the mouseover event on the names of each object displayed on the table. The window on the right consists, so far, of five drop-down menus where query settings pertaining to sky conditions, object program (related to the university from where the object was requested), instrument settings, object status (whether or not the object is on hold, for example), and sorting options. The top window consists of other query settings, however these pertain to what the resident astronomers told me were the most important settings, such as priority filtering, and filtering based on sky position relative to the HET track.

Both of these menu pages has its own processing page, which is opened when the forms on these menu pages are submitted. This processing page takes the posted variables and turns them into session variables. These session variables are interpreted by the table page, when it reloads, and are put into a MySQL query, the results of which are displayed in the table.

This new HTOPX effectively replaces the old HTOPX, and provides a much more versatile interface for the resident astronomers at the HET.

### **The new HTOPX (HTOPX II)**

HTOPX II - Mozilla Firefox

http://login.as.utexas.edu/aw/htopxfames3.html

Getting Started Latest Headlines

Time to track  min:0  max:0

Time (left) in track (min):0

Priority (min):0

08/11/2005  
02:54 UTC  
17:17 LST

Top Frame

Object Name	Priority	Time	Location
HR3428	3	08:37:30.0 +19:50:53.0	M05-2-001 LRS_e2_1.0_V_1x1
HR3905	3	09:49:55.4 +26:14:36.0	M05-2-001 LRS_e2_1.0_V_1x1
HR4435	3	11:28:10.4 +48:12:21.0	M05-2-001 LRS_e2_1.0_V_1x1
HD132142	3	14:53:45.6 +53:52:30.0	M05-2-001 LRS_e2_1.0_V_1x1
HR6018	3	16:07:08.5 +36:37:01.0	M05-2-001 LRS_e2_1.0_V_1x1
HR6136	3	16:26:00.9 +00:46:32.0	M05-2-001 LRS_e2_1.0_V_1x1
HR6159	3	16:30:15.8 +11:35:39.0	M05-2-001 LRS_e2_1.0_V_1x1
HD161817	3	17:44:39.1 +25:46:03.0	M05-2-001 LRS_e2_1.0_V_1x1
HR6770	3	19:49:22.4 +52:51:38.0	M05-2-001 LRS_e2_1.0_V_1x1
HR6817	3	19:49:22.4 +52:51:38.0	M05-2-001 LRS_e2_1.0_V_1x1
HR7429	3	19:49:22.4 +52:51:38.0	M05-2-001 LRS_e2_1.0_V_1x1
HR7576	3	19:49:22.4 +52:51:38.0	M05-2-001 LRS_e2_1.0_V_1x1
J0945+4636	1	09:45:42.1 +46:36:50.7	STA05-2-001 LRS_g1_2.0_GG385
J1108+0811	1	11:08:37.5 +08:11:01.7	STA05-2-001 LRS_g1_2.0_GG385
J1219+6344	1	12:19:10.6 +63:44:10.9	STA05-2-001 LRS_g1_2.0_GG385
J1232+4821	1	12:32:34.8 +48:21:33.0	STA05-2-001 LRS_g1_2.0_GG385
J1335+5843	1	13:35:26.0 +58:43:59.6	STA05-2-001 LRS_g1_2.0_GG385
J1539+3104	1	15:39:16.2 +31:04:07.8	STA05-2-001 LRS_g1_2.0_GG385
J1606+3124	1	16:06:08.6 +31:24:46.9	STA05-2-001 LRS_g1_2.0_GG385
J2049+1003	1	20:49:45.9 +10:03:14.4	STA05-2-001 LRS_g1_2.0_GG385
J1735+5049	1	17:35:49.0 +50:49:11.6	STA05-2-001 LRS_g1_2.0_GG385
J2210+2013	1	22:10:51.7 +20:13:24.0	STA05-2-001 LRS_g1_2.0_GG385

Table of query results

Sky Program Instrument Status Sorting

Moon  Model

Less than: 0

Seeing  Greater than: 0

Transmission:  P  S  N

Menu

The names of objects (the first column on the table) are, in fact, menus in themselves.

TYC\_1426\_00662

TYC\_3012\_02527

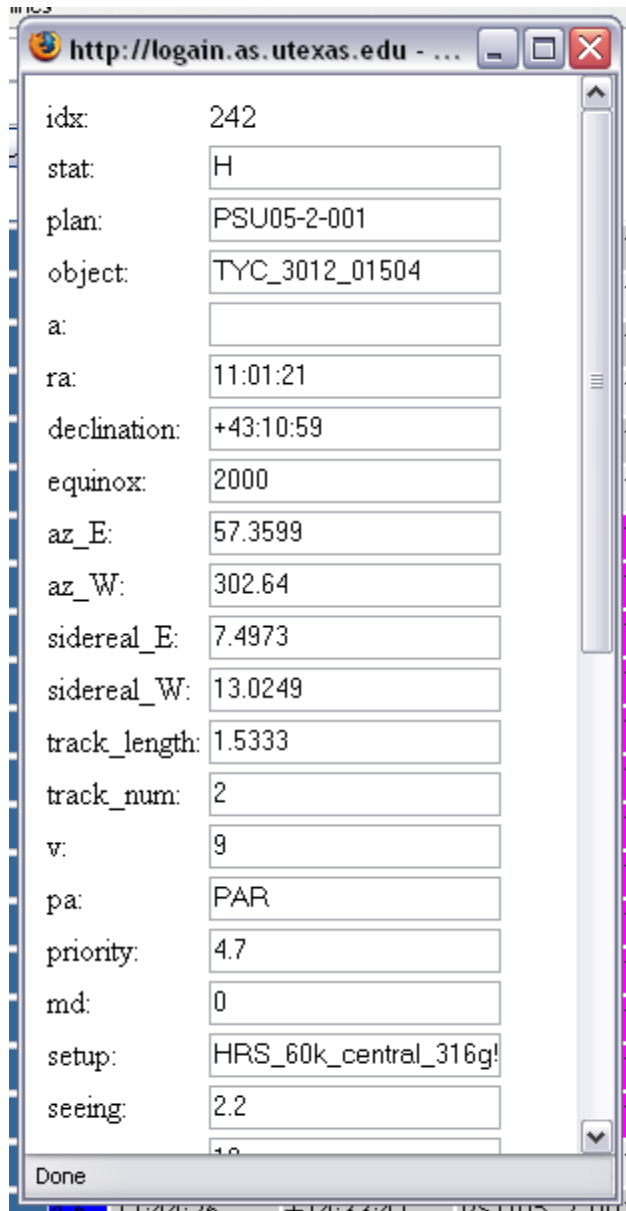
TYC\_3012\_02527

TYC\_3012\_00285

numdone: 0  finish  0

hold  unhold:  object  program

These menus provide a collection the most essential options for updating single objects in the database. In addition, the “Edit DB” button will open up a window in which the user is able to edit any property of the object.



There still remains some work to complete HTOPX II, and to implement it as a replacement for the old HTOPX, however, on the whole, I feel like this project has been a complete success.