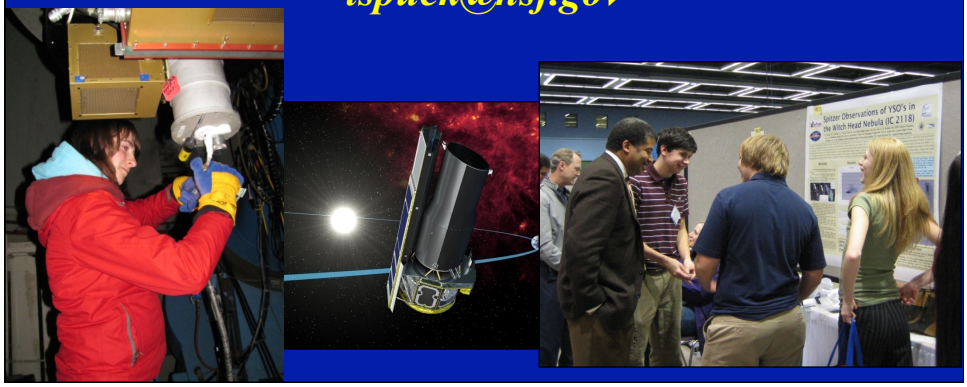
Science Benefits when we Engage Students in Authentic Research

Tim Spuck – Oil City High School

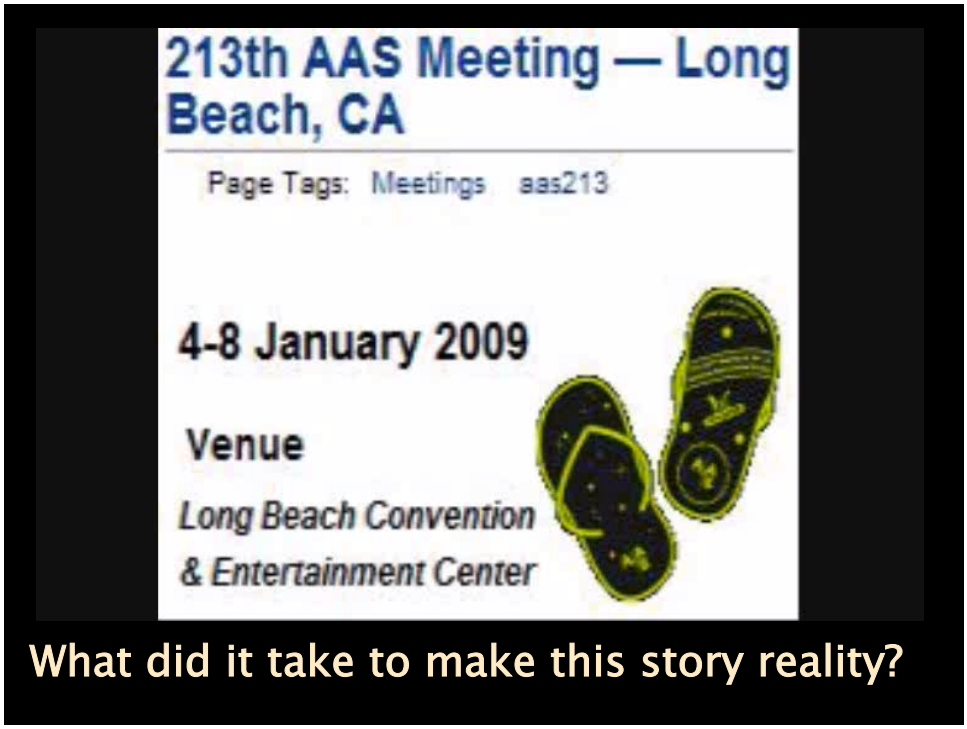
tspuck@nsf.gov



Tyson on John Stewart

Oil City – Pennsylvania

Population: 10,000 and one of the 10 poorest schools in PA

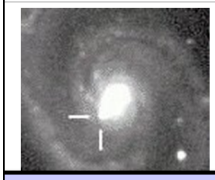


What did it take to make this story reality?

In the summer of 1992 I attended a 2-week institute at the National Radio Astronomy Observatory in Green Bank, WV.

The program was funded by the National Science Foundation.

Supernova: SN1994I



March 1994 - Oil City Students Heather Tartara and Melody Spence take first light image of SN 1994I providing professional astronomers with some of the earliest supernovae light curve data on record.

ads — The Smithsonian/NASA Astrophysics Data System — NASA

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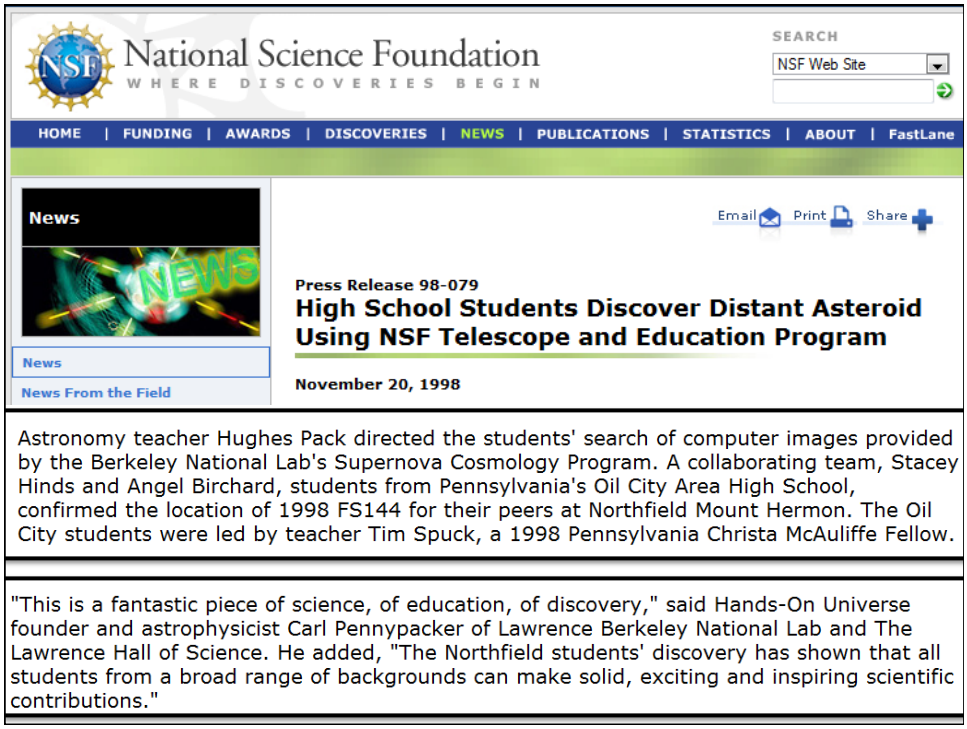
Successful Operation of Remote Telescopes for Education and Research

- Fulltext Article not available
- Find Similar Articles
- Full record info

Pennypacker, C.; Deustua, S.; Perlmutter, S.; Goldhaber, G.; Arsem, E.

American Astronomical Society, 185th AAS Meeting, #69.05; Bulletin of the American Astronomical Society, Vol. 26, p.1423

Since 1986, we have found over 20 nearby supernovae with the U.C. Leuschner Observatory's 30" automated telescope. This pilot search demonstrated that supernovae can be found reliably using automated search techniques, and we discovered a high rate of Type Ibc supernovae. In addition, we have successfully piloted a high school education project - "The Hands-On Universe Project." In this program high school students become proficient with modern CCD-based astronomical imaging, even undertaking real research. An example of the latter was the acquisition of the earliest images of SN1994I by two students from Oil City Pennsylvania. We have had remarkable success in changing students' attitudes about science, scientists, and education. We are in the final stages of completing the automation of a new 30" telescope to be operated robotically in a good, remote site. This telescope will be functioning by spring of 1995. It will serve the Supernova Search and the Hands-On Universe programs.



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News

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News From the Field

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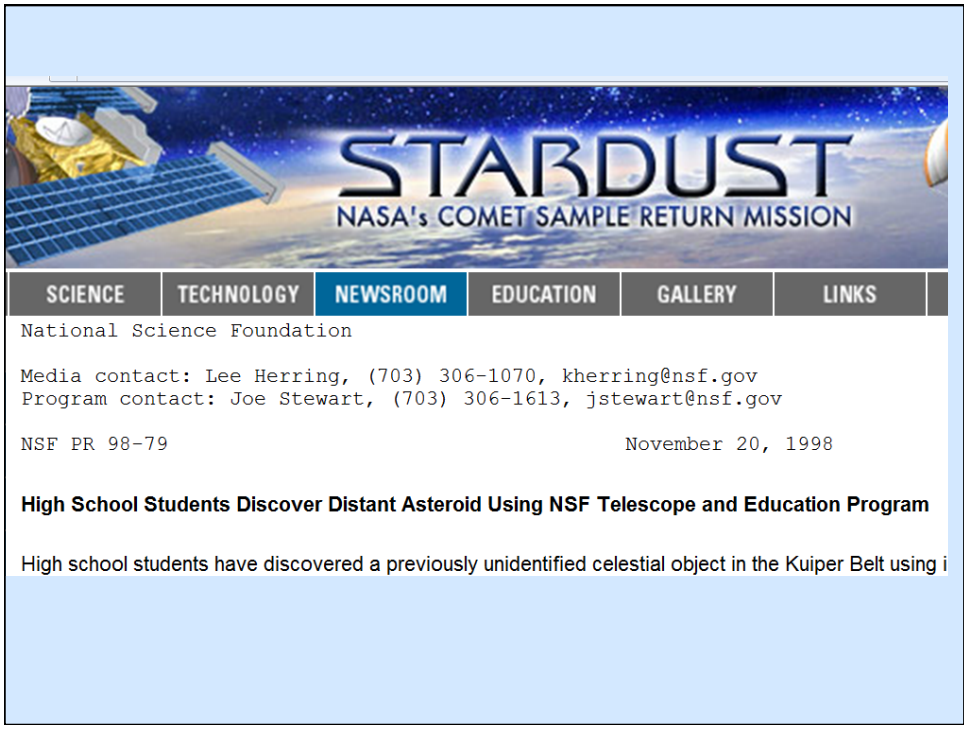
Press Release 98-079

High School Students Discover Distant Asteroid Using NSF Telescope and Education Program

November 20, 1998

Astronomy teacher Hughes Pack directed the students' search of computer images provided by the Berkeley National Lab's Supernova Cosmology Program. A collaborating team, Stacey Hinds and Angel Birchard, students from Pennsylvania's Oil City Area High School, confirmed the location of 1998 FS144 for their peers at Northfield Mount Hermon. The Oil City students were led by teacher Tim Spuck, a 1998 Pennsylvania Christa McAuliffe Fellow.

"This is a fantastic piece of science, of education, of discovery," said Hands-On Universe founder and astrophysicist Carl Pennypacker of Lawrence Berkeley National Lab and The Lawrence Hall of Science. He added, "The Northfield students' discovery has shown that all students from a broad range of backgrounds can make solid, exciting and inspiring scientific contributions."



STARDUST
NASA's COMET SAMPLE RETURN MISSION

SCIENCE | TECHNOLOGY | NEWSROOM | EDUCATION | GALLERY | LINKS

National Science Foundation

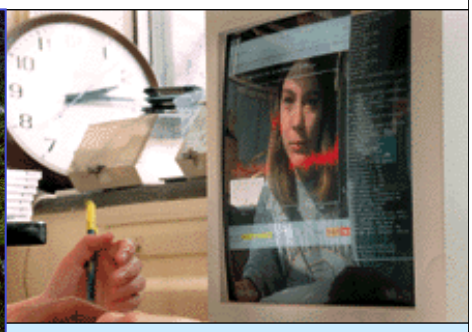
Media contact: Lee Herring, (703) 306-1070, kherring@nsf.gov
Program contact: Joe Stewart, (703) 306-1613, jstewart@nsf.gov

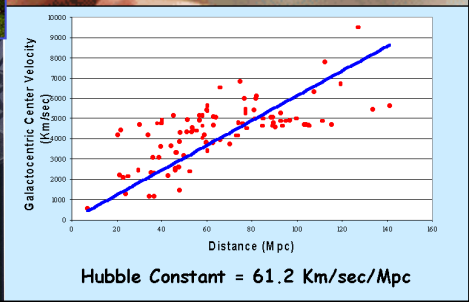
NSF PR 98-79 November 20, 1998

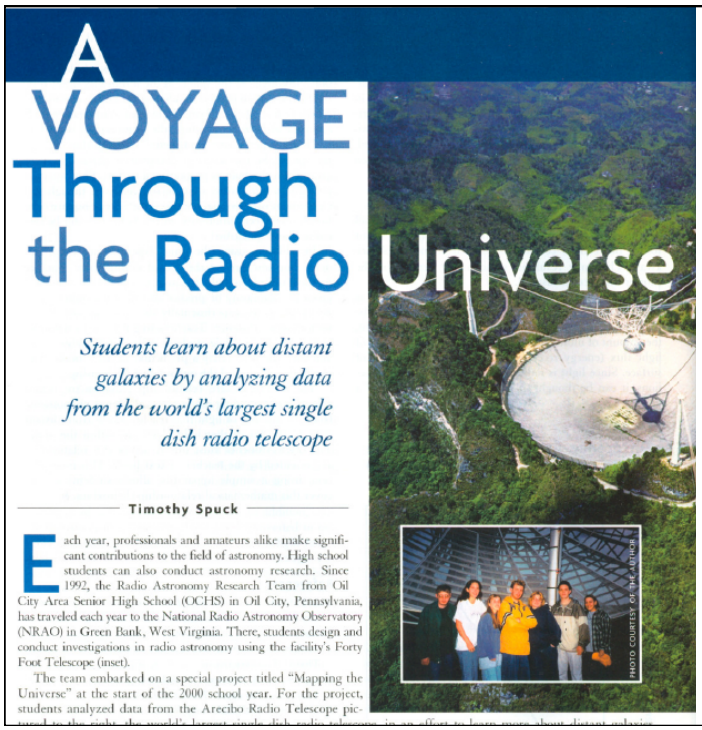
High School Students Discover Distant Asteroid Using NSF Telescope and Education Program

High school students have discovered a previously unidentified celestial object in the Kuiper Belt using i

2002 - Thanks to an NSF funded RET experience my students and I designed a project to measure the expansion rate of the universe.

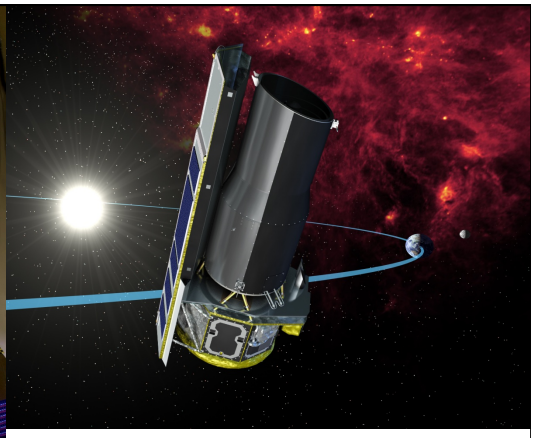






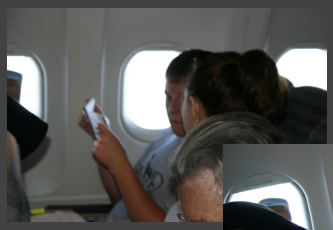
October 2004

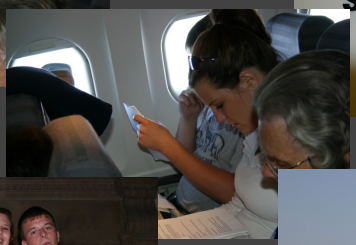
The Science Teacher



Spitzer Space Telescope Research Program for Teachers and Students Impact

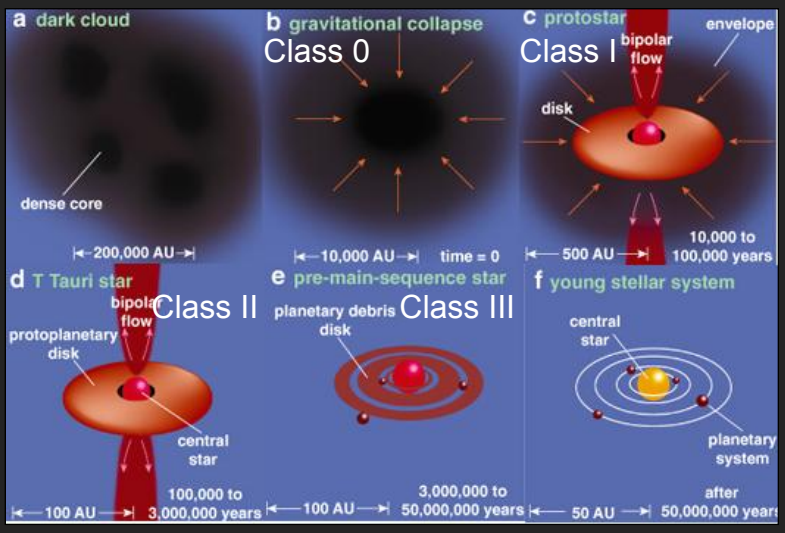
2005 - The Spitzer Space Telescope Research Program for Students and Teachers





A CRASH COURSE . . .

The Science of Low Mass Stars



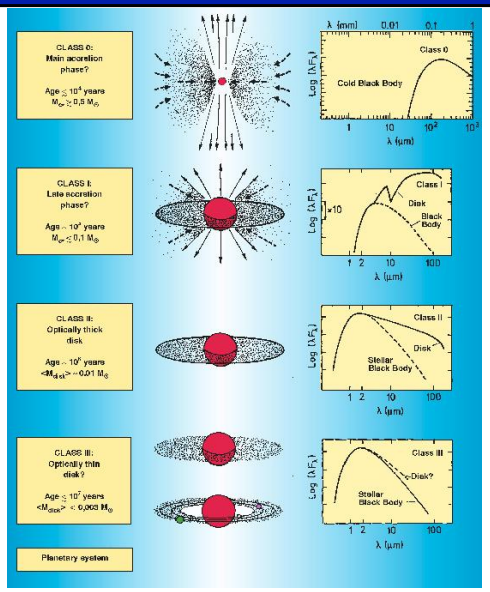
Class and Spectral Energy Distribution (SED)

Class 0
Main accretion phase?
M_{env}>~0.5 Msun
<~10^4 years

Class I
Late accretion phase?
M_{env}<~0.1 Msun
~10^5 years

Class II
Optically thick disk
Avg M_{disk}~0.01 Msun
~10^6 years

Class III
Optically thin disk
Avg M_{disk}<~0.003 Msun
~10^7 years



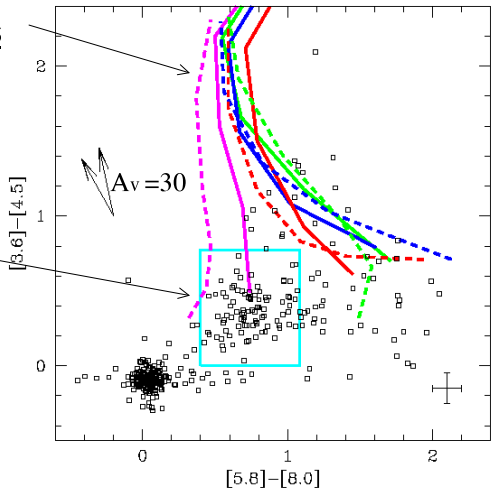
IRAC Color-Color Diagrams

Class I (envelope) models

log ρ = -14 to -12.5 g/cm³
L = 0.1, 1, 10, 100 Lsun
inclination = 60 deg

Class II (disk) models

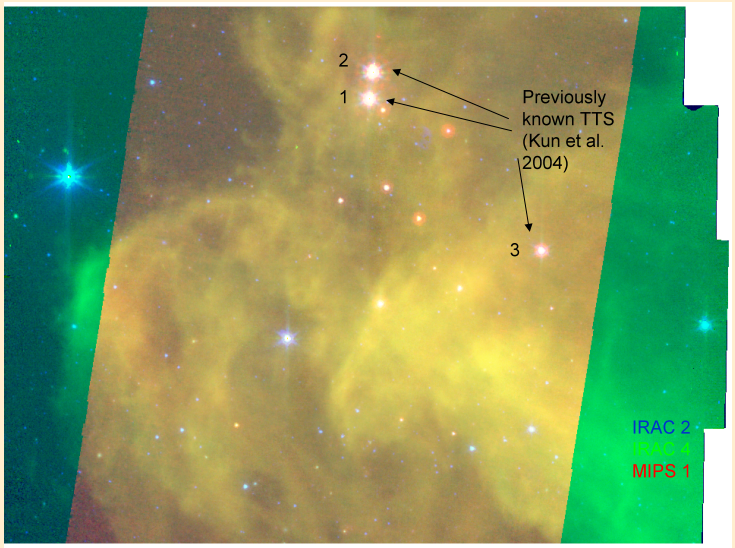
stellar Teff = 4000 K
Mdot = -9 to -6 Msun/yr
inclination = 30, 60 deg

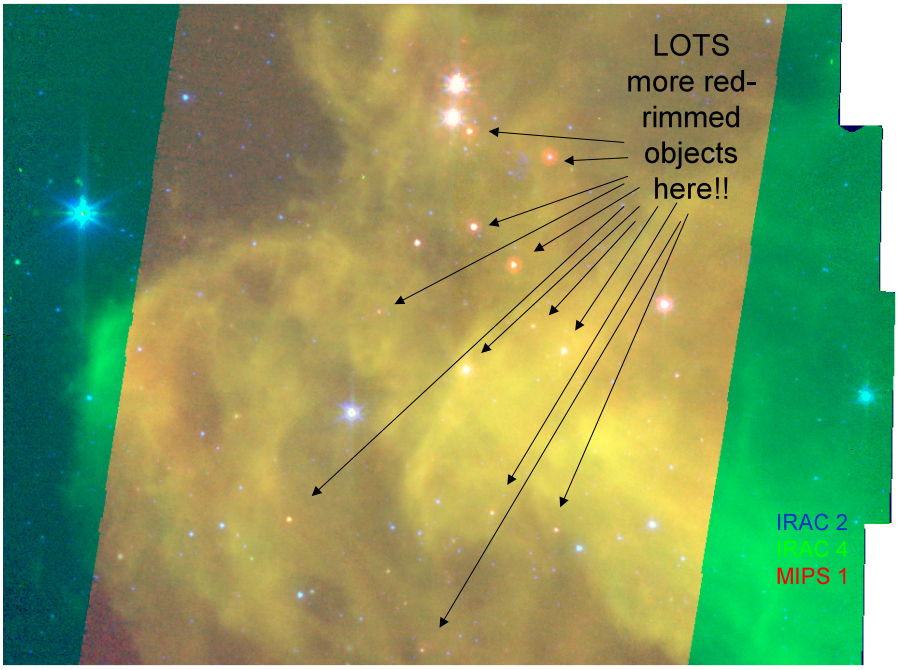


Allen et al. 2004

Literature Search

What do we currently know about IC2118?



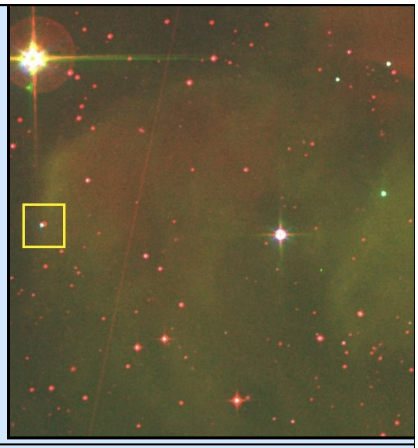


Using Adobe Photoshop and FITS Liberator

ABOVE: A four-color composite image of the region observed by Spitzer. Adobe PhotoShop and FITS Liberator were used to generate the composite image using IRAC 3.6 (blue), 4.5 (green), 5.8 (yellow), and 8 (red) micron data.

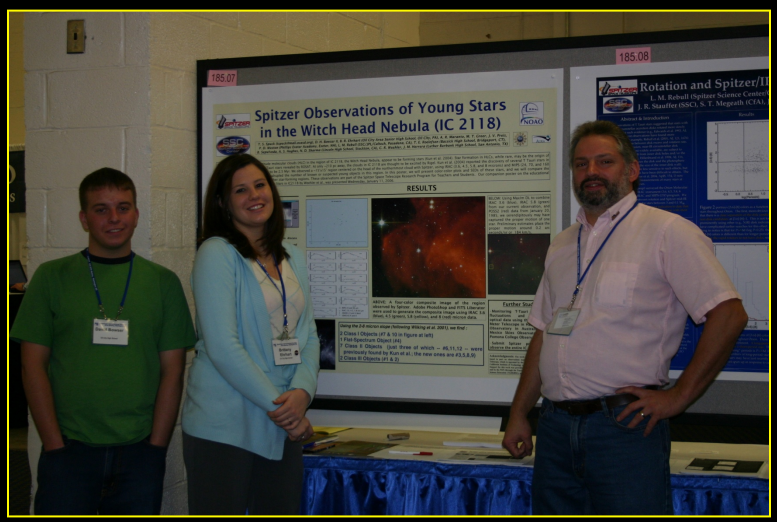
Brittany Ehrhart produced the image to the left. In the photo above she gets some pointers at the 2006 AAS meeting from one of the best astronomy image producers, Astronomer Travis Rector.

Sometimes you find things you never expected … those serendipitous discoveries!

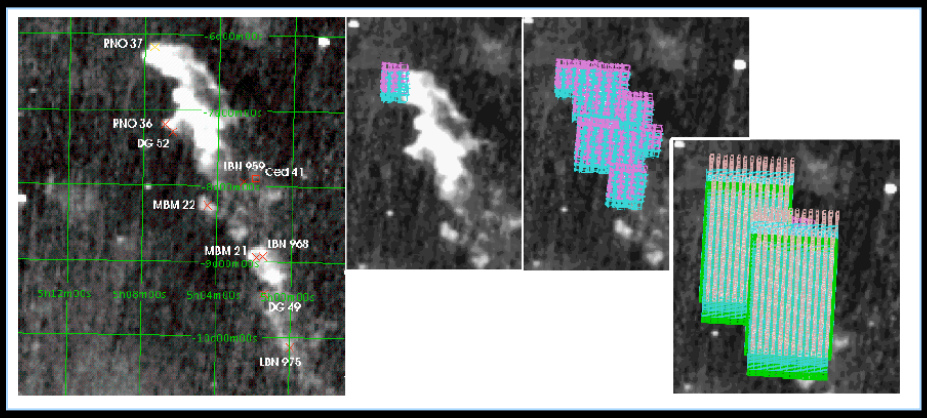


ABOVE: Using MaxIm DL to combine IRAC 3.6 (blue), IRAC 5.8 (green) from our current observation, and POSS2 (red) data from January 20, 1985, we serendipitously may have captured the proper motion of one star. Preliminary estimates place the proper motion around 0.2 arc seconds/ yr or 184 km/s if we assume a distance of 210 pc … the distance to IC 2118. **(Follow-up findings 20 - 70 pc)**

Presentation of findings at the American Astronomical Society Meeting January 12, 2006.



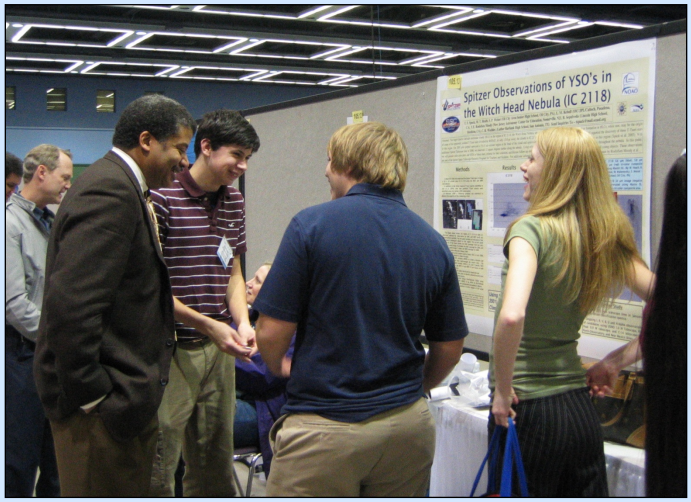
Follow up proposal submitted in February was awarded an additional 12 hours to complete the survey of the cloud.



Observations were completed at the end of March 2006!

Again in the Summer of 2006

January 2007 AAS Conference – Poster Presentation

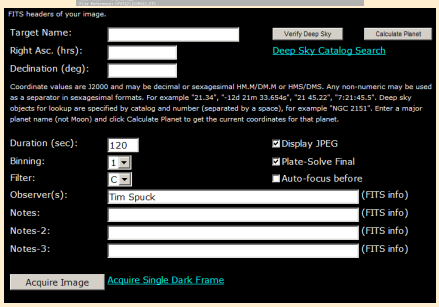


Oil City students Matt Walentosky, Nick Kelley, Paige Morton discuss their research with renowned astrophysicist Neil deGrasse Tyson.

Getting H-alpha Data
Kitt Peak Observatory
January 2007

Perth Observatory – C14 Robotic Telescope . . .

Oil City Students used a remote telescope at Perth Observatory to monitor several of the T-Tauri candidates in IC 2118 for variability.



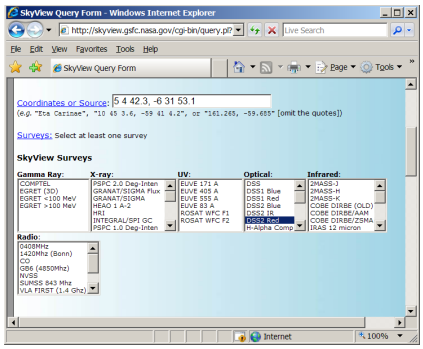
•The IC2118 Team was awarded time on the Palomar 200-inch telescope to obtain follow-up spectroscopy of our YSO candidates in January 2007. **(Strong winds … poor weather)**

•UVRI images were also obtained using the USNO 40-inch telescope from Nov 2006 – Jan 2007.

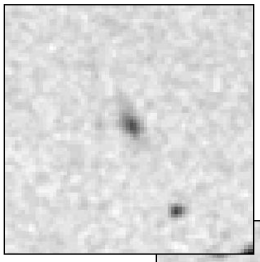
Students worked to Eliminate Obvious Galaxies . . .

Over 400 targets were analyzed using POSS images.

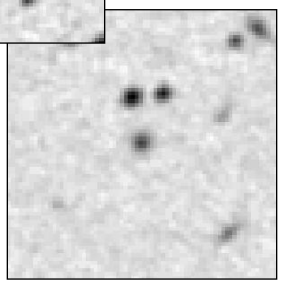
SkyView
The Internet's Virtual Telescope



F	G	H	I	J	K	L
5	41.9	-6	28	15.8	17.8	S
4	42.3	-6	31	53.1	17.8	G



Galaxy

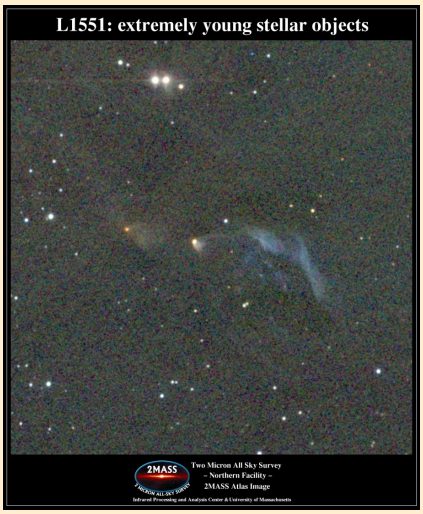


Star

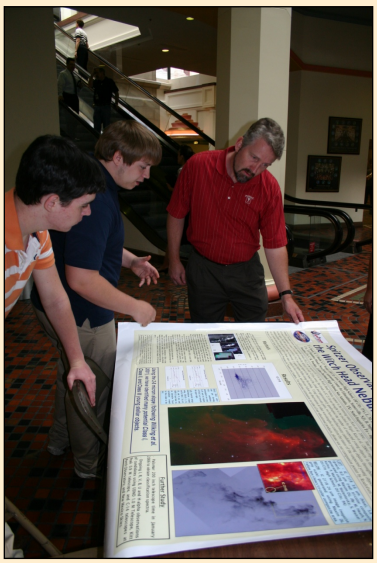
Students also looked for evidence of outflows.

- *only present for the very youngest objects, Class Os and Is*

None found in IC2118.

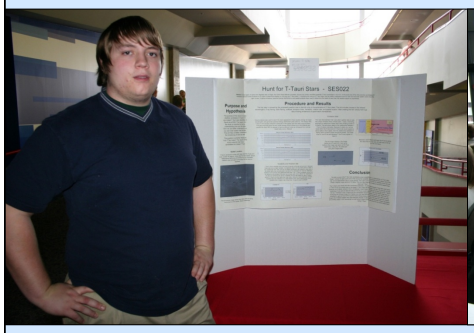


Science In Motion Capital Day – Harrisburg PA



May 2007 - Oil City students present their Spitzer Research to State Officials at the State Capital.

Oil City junior Nick Kelley takes **1st Place Senior Division Earth/Space/Environment and Best of Science Fair Award** at the 2008 Pittsburgh Regional Science & Engineering Fair for his in-depth analysis of two YSO candidates in IC2118. (April 2008)



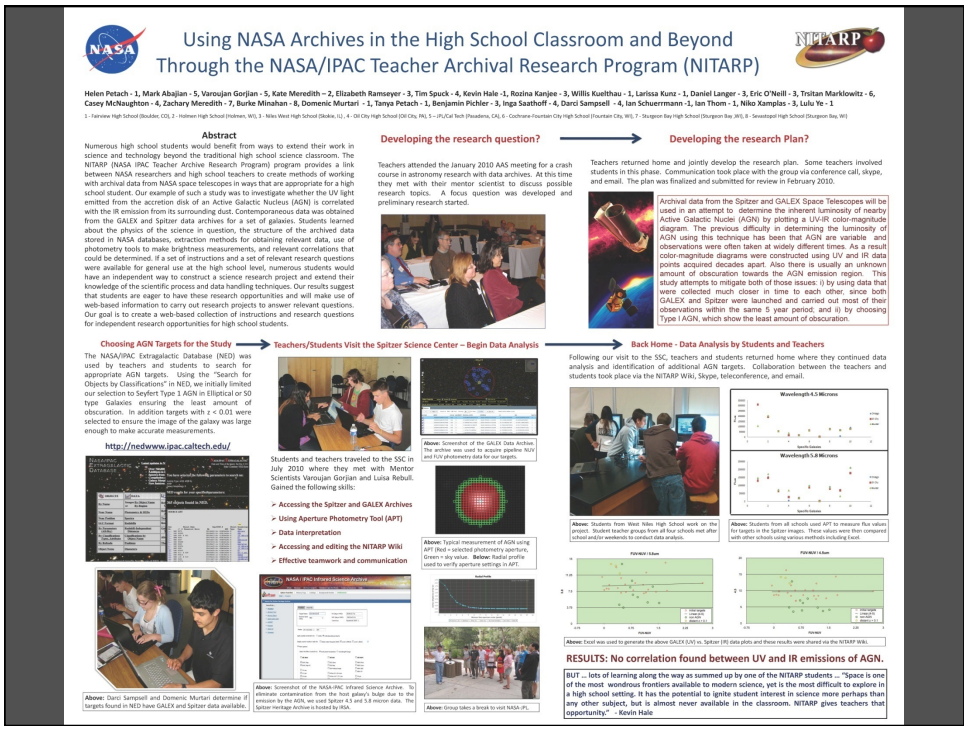
And Matt Walentosky goes on to International Science Fair and wins a 2nd Place for his research on the cataclysmic variable star WzSge!

•Rachel and Jennifer awarded time on the Kitt Peak 0.9 M telescope for research testing new method of identifying T-Tauri stars. (November 2008)

•Jennifer wins **1st place at Pittsburgh Regional Science & Engineering Fair and a 4th Place at the International Science & Engineering Fair** in Reno, NV. (May 2009)

All bringing us to the January 2009 AAS Meeting in Long Beach and an interview with Dr. Neil deGrasse Tyson.

Oil City Students Compete at the 2010 Pittsburgh Regional Science & Engineering Fair – Inga Saathoff wins 1st Place and moves on to the International Science Fair where she was awarded a $50,000 scholarship to Florida Institute of Technology.



Using NASA Archives in the High School Classroom and Beyond
Through the NASA/IPAC Teacher Archival Research Program (NITARP)

Helen Petach - 1, Mark Abajian - 5, Varoujan Gorjian - 5, Kate Meredith – 2, Elizabeth Ramseyer - 3, Tim Spuck - 4, Kevin Hale -1, Rozina Kanjee - 3, Willis Kuelthau - 1, Larissa Kunz - 1, Daniel Langer - 3, Eric O'Neill - 3, Tristan Marklowitz - 6, Casey McNaughton - 4, Zachary Meredith - 7, Burke Minahan - 8, Domenic Murtari - 1, Tanya Petach - 1, Benjamin Pichler - 3, Inga Saathoff - 4, Darci Sampsell - 4, Ian Schuerrmann -1, Ian Thom - 1, Niko Xamplas - 3, Lulu Ye - 1

1 - Fairview High School (Boulder, CO), 2 - Holmen High School (Holmen, WI), 3 - Niles West High School (Skokie, IL) , 4 - Oil City High School (Oil City, PA), 5 – JPL/Cal Tech (Pasadena, CA), 6 - Cochrane-Fountain City High School (Fountain City, WI), 7 - Sturgeon Bay High School (Sturgeon Bay, WI), 8 - Sevastopol High School (Sturgeon Bay, WI)

Abstract

Numerous high school students would benefit from ways to extend their work in science and technology beyond the traditional high school science classroom. The NITARP (NASA IPAC Teacher Archive Research Program) program provides a link between NASA researchers and high school teachers to create methods of working with archival data from NASA space telescopes in ways that are appropriate for a high school student. Our example of such a study was to investigate whether the UV light emitted from the accretion disk of an Active Galactic Nucleus (AGN) is correlated with the IR emission from its surrounding dust. Contemporaneous data was obtained from the GALEX and Spitzer data archives for a set of galaxies. Students learned about the physics of the science in question, the structure of the archived data stored in NASA databases, extraction methods for obtaining relevant data, use of photometry tools to make brightness measurements, and relevant correlations that could be determined. If a set of instructions and a set of relevant research questions were available for general use at the high school level, numerous students would have an independent way to construct a science research project and extend their knowledge of the scientific process and data handling techniques. Our results suggest that students are eager to have these research opportunities and will make use of web-based information to carry out research projects to answer relevant questions. Our goal is to create a web-based collection of instructions and research questions for independent research opportunities for high school students.

Developing the research question? → **Developing the research Plan?**

Teachers attended the January 2010 AAS meeting for a crash course in astronomy research with data archives. At this time they met with their mentor scientist to discuss possible research topics. A focus question was developed and preliminary research started.

Teachers returned home and jointly develop the research plan. Some teachers involved students in this phase. Communication took place with the group via conference call, skype, and email. The plan was finalized and submitted for review in February 2010.

Archival data from the Spitzer and GALEX Space Telescopes will be used in an attempt to determine the inherent luminosity of nearby Active Galactic Nuclei (AGN) by plotting a UV-IR color-magnitude diagram. The previous difficulty in determining the luminosity of AGN using this technique has been that AGN are variable and observations were often taken at widely different times. As a result color-magnitude diagrams were constructed using UV and IR data points acquired decades apart. Also there is usually an unknown amount of obscuration towards the AGN emission region. This study attempts to mitigate both of those issues: i) by using data that were collected much closer in time to each other, since both GALEX and Spitzer were launched and carried out most of their observations within the same 5 year period, and ii) by choosing Type I AGN, which show the least amount of obscuration.

Choosing AGN Targets for the Study → **Teachers/Students Visit the Spitzer Science Center – Begin Data Analysis** → **Back Home - Data Analysis by Students and Teachers**

The NASA/IPAC Extragalactic Database (NED) was used by teachers and students to search for appropriate AGN targets. Using the "Search for Objects by Classifications" in NED, we initially limited our selection to Seyfert Type 1 AGN in Elliptical or S0 type Galaxies ensuring the least amount of obscuration. In addition targets with $z < 0.01$ were selected to ensure the image of the galaxy was large enough to make accurate measurements.

http://nedwww.ipac.caltech.edu/

Students and teachers traveled to the SSC in July 2010 where they met with Mentor Scientists Varoujan Gorjian and Luisa Rebull. Gained the following skills:

- Accessing the Spitzer and GALEX Archives
- Using Aperture Photometry Tool (APT)
- Data interpretation
- Accessing and editing the NITARP Wiki
- Effective teamwork and communication

Above: Screenshot of the GALEX Data Archive. The archive was used to acquire pipeline NUV and FUV photometry data for our targets.

Above: Typical measurement of AGN using APT (Red = selected photometry aperture, Green = sky value. Below: Radial profile used to verify aperture settings in APT.

Above: Screenshot of the NASA-IPAC Infrared Science Archive. To eliminate contamination from the host galaxy's bulge due to the emission by the AGN, we used Spitzer 4.5 and 5.8 micron data. The Spitzer Heritage Archive is hosted by IRSA.

Above: Group takes a break to visit NASA-JPL.

Following our visit to the SSC, teachers and students returned home where they continued data analysis and identification of additional AGN targets. Collaboration between the teachers and students took place via the NITARP Wiki, Skype, teleconference, and email.

Above: Students from West Niles High School work on the project. Student teacher groups from all four schools met after school and/or weekends to conduct data analysis.

Above: Students from all schools used APT to measure flux values for targets in the Spitzer images. These values were then compared with other schools using various methods including Excel.

Above: Excel was used to generate the above GALEX (UV) vs. Spitzer (IR) data plots and these results were shared via the NITARP Wiki.

Above: Darci Sampsell and Domenic Murtari determine if targets found in NED have GALEX and Spitzer data available.

RESULTS: No correlation found between UV and IR emissions of AGN.

BUT ... lots of learning along the way as summed up by one of the NITARP students ... "Space is one of the most wondrous frontiers available to modern science, yet is the most difficult to explore in a high school setting. It has the potential to ignite student interest in science more perhaps than any other subject, but is almost never available in the classroom. NITARP gives teachers that opportunity." - Kevin Hale

Assessing the Hα Survey Method to Recognize T Tauri Stars (HαSMRTS)

- Inga Saathoff
- Oil City Senior High School / Kennedy Catholic High School

T Tauri Stars

Characteristics:

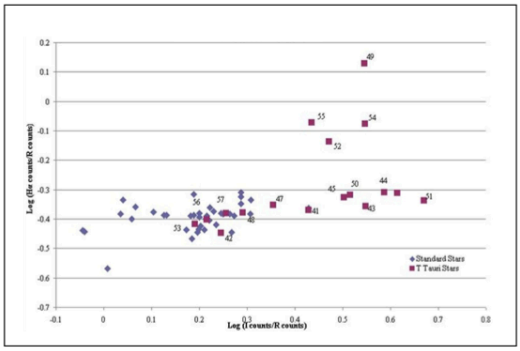
- ⋆ Strong Hα emission line because of high activity
- ⋆ Low mass stars have more IR light relative to R light when compared to standard stars

Identification:

- ⋆ Traditionally identified using expensive spectroscopy and Space Telescopes
- ⋆ New method used simple R, I, Hα count ratios and 2MASS data.

HαSMRTS Method

Log(Hα/R)



Log(I/R)

Identifying T Tauri Stars using Small Scale Optical Telescopes

Inga Saathoff – Oil City High School, **Timothy Spuck** – Oil City High School, **Dr. Luisa Rebull** – Spitzer Science Center (Contact Tim Spuck at tspuck@hotmail.com for more information.)

Abstract

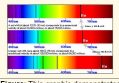
Understanding T Tauri stars is essential if we are to more fully understand our own Solar System. Because T Tauri stars are young versions of our Sun, we can better understand our own history by studying these young stellar objects (YSOs). Hα Survey Method to Recognize T Tauri Stars (HαSMRTS), previously known as the Spuck-Butchart-Optical Survey Method, is a simplified method of identifying T Tauri stars using small-scale optical telescopes. However, to date the method has only been used in an attempt to distinguish T Tauri stars from standard stars. Active Galactic Nuclei (AGN) and active M dwarf (dMe) stars emit excess in both infrared and Hα, similar to T Tauri stars, making it likely that objects such as these may contaminate any T Tauri selection method based on infrared and Hα. This study uses observations from the Kitt Peak National Observatory 0.9 meter telescope to further investigate HαSMRTS and its true ability to accurately distinguish T Tauri stars from other objects in space. Contamination by dMe stars is significant; however, a statistical analysis using Precision and Recall indicates a peak accuracy of 90.8% with a Matthews correlation coefficient of +0.74. These results indicate HαSMRTS shows great promise for both professional and amateur astronomers in identifying YSOs, and perhaps could one day lead to a fast and inexpensive all-sky survey and T Tauri star monitoring program.

Introduction

HαSMRTS– (*Butchart 2009*)

- Successful in distinguishing T Tauri stars from standard stars using simple ratios of Hα, R and I intensity counts
- Based on information that T Tauri stars have significant H-alpha emission
- Target selection could have been improved
- Neither dMe stars nor AGN were included in the study

Both dMe's and AGN have characteristics similar to those of the T Tarui stars which makes significant contamination probable



Top Figure: This graphic demonstrates how the Hα line will shift as the recessional velocity of the object increases. (image from Red Orbit, 2002)

T Tauri stars – Characteristics

- Young sun like star in the early stages of development
- Large accretion disks
- Bipolar outflow caused by material falling onto the star from the disk
- →Strong Hα emission line
- G, K, or M class star
- →Greater emission at longer λ

Hypothesis

★ Even though dMe stars display a Hα line, these emissions should be significantly stronger in the T Tauri stars as compared to dMe stars.

★ Further, AGN should be distinguishable from T Tauri stars based on their significant cosmological redshift. The Hα line in AGN should be shifted out of the range of the narrowband Hα filter used on the 0.9 meter telescope.

Procedures

- ★ Targets including AGN, dMe stars, T Tauri stars and standard stars were selected from various publications
- ★ R exposure time was based on published R or V magnitudes
- ★ I exposure time was 2 x $R_{exp\ time}$, H-alpha exposure was 10 x $R_{exp\ time}$
- ★ January 30 through February 2, 2010 observing run
- ★ Equipment used: WIYN 0.9 M Telescope at KPNO in Tucson, Arizona
- ★ Used the I-Harris, R-Harris and H-alpha filters
- ★ Data reduction was completed with MaxIm DL and Pinpoint Astrometry
- ★ Used the aperture tool in MaxIm DL to measure R, I, and Hα Intensity values
- ★ Scatter plots were generated in MS Excel
- ★ Statistical analysis was conducted using Precision and Recall methodology
- ★ Test image sets were selected and analyzed using the HαSMRTS

Above: View from KPNO 0.9 M Telescope where data was collected for this study.

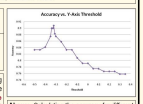
Above: The image displays the aperture tool in MaxIm DL, and the photometry measurements for dMe star *HIP 81417-2m* the R, I and Hα filters.

$$MCC = \frac{TP \times TN - FP \times FN}{\sqrt{(TP+FP)(TP+FN)(TN+FP)(TN+FN)}}$$

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN}$$

TP – true positive
TN – true negative
FP – false positive
FN – false negative

Above: A statistical analysis was conducted using Precision and Recall methodology to determine Accuracy. Targets are classified as a **true positive (TP) - a confirmed T Tauri star that falls within a set of parameters**, a true negative (TN) - a confirmed non-T Tauri object (e.g. AGN, standard star, dMe star) that falls outside the set of parameters, a false negative (FN) - a confirmed T Tauri star that falls outside the set of parameters, or a false positive (FP) - a confirmed non-T Tauri object (e.g. AGN, standard star, dMe star) that falls inside the set of parameters. The Matthews-correlation coefficient (MCC) is an indicator of prediction capability.

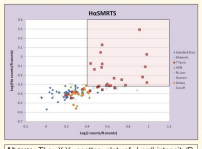


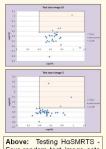
Above: Calculating the accuracy for different threshold values determined the thresholds. An Accuracy vs. X-Axis plot was the basis for holding the x-axis (Log (I counts/R counts)) threshold at 0.4. The accuracy vs. Y-axis Threshold plot above displays a maximum accuracy of 90.8% at a the Y-axis threshold (Log (H counts/ R counts) of -0.32. For this threshold the MCC is 0.74, which emphasizes that the HαSMRTS can be used as a relatively accurate predictor in identifying T Tauri stars.

Results

ID	Type	R Intensity counts	I Intensity counts	Hα Intensity counts	Log (I/R)	(Log H/R)
3C 120	AGN	7503	14342	3246	0.281	-0.364
IRAS 04210+0400	AGN	1922	3364	908	0.243	-0.325
MCG +08.15.009	AGN	2223	4961	909	0.349	-0.388

Above: The table was generated in Microsoft Excel and displays a small sample of objects observed in this study and their corresponding intensities in R, I and Hα and the calculated Log ratio values.



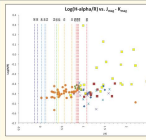


Above: The X-Y scatter plot of Log(I-intensity/R-intensity) vs. Log(H-alpha-intensity/R-intensity) displays all targets in the current study including dMe stars, AGN, BL Lacs, Quasars, Galaxies, standard stars and T Tauri stars as well as those standard stars and T Tauri stars from the Butchart study (2009). There is significant contamination from dMe stars, however, at a cut-off of Log(H/R) > -0.32 and Log(I/R) > 0.4, 65.5% of previously known T Tauri stars would have been correctly identified using this method.

Above: Testing HαSMRTS - Four random test image sets with known T Tauri stars were selected. Point sources were identified by visual inspection of the Hα image. Corresponding targets in the I and R images were measured and data plotted. 93% of known YSO's in the test images were correctly identified.

Conclusions

Based on the evidence in this study, 65.5% of T Tauri stars can be identified using the HαSMRTS with an Accuracy of 90.8%. The Matthews-correlation coefficient of 0.74 indicates a strong correlation between this method and its ability to correctly identify T Tauri candidates. Although there is no single method that can conclusively identify all T Tauri stars, there is strong evidence that supports using the HαSMRTS as a cost-effective tool to initially identify T Tauri star candidates. Observations using additional instrumentation and long-term monitoring programs by the professional and amateur communities could follow to confirm/refute the YSO status of objects discovered using this method.

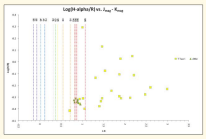


Future Studies

★ **Left and Right:** Even without the 2MASS data the method works. However J,H,and K data may help to distinguish T Tauri stars from dMe stars, as will the WISE catalogue when available.

★ The INT/WFC Photometric Hα Survey (IPHAS) of the northern Galactic plane has identified 4853 point sources that exhibit strong photometric evidence for Hα emission. This may be a source of data to compare our results to. (Witham et al – 2008)

★ Considering the fact that T Tauri stars have a significantly stronger Ca II line in emission, the contamination of dMe stars may be able to be mitigated by taking a simple ratio of intensities using Ca II and U band filters. Additional observational evidence in Ca II and U is required.



HαSMRT Procedure

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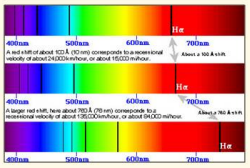
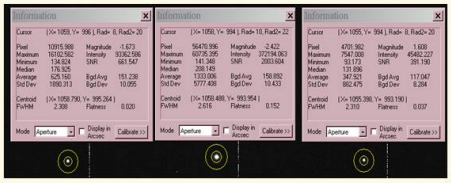


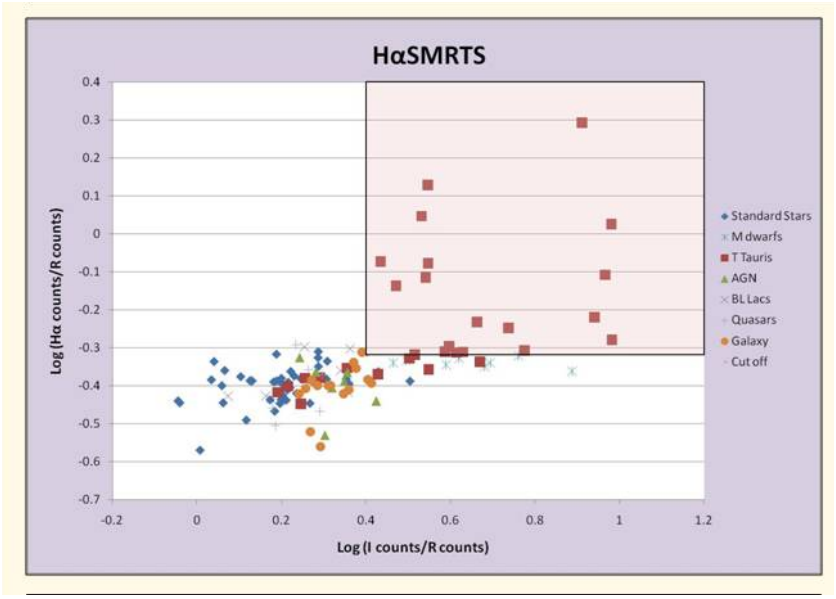
Top Figure: This graphic demonstrates how the Hα line will shift as the recessional velocity of the object increases. (image from Red Orbit, 2002)

Above: View from KPNO 0.9 M Telescope where data was collected for this study.

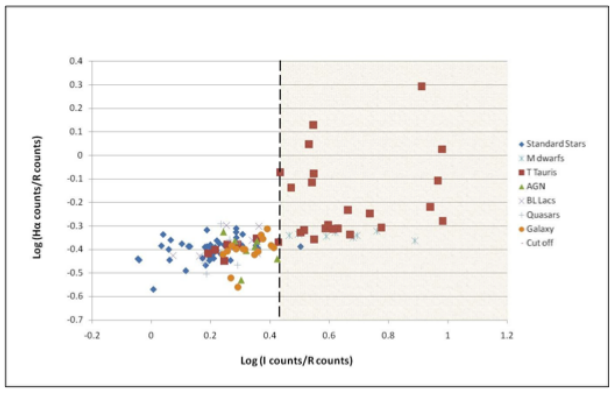
R filter | I filter | Hα filter



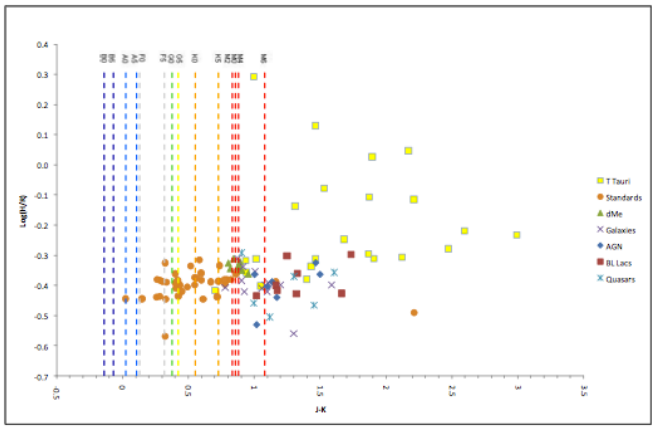
Above: The image displays the aperture tool in MaxIm DL, and the photometry measurements for dMe star *HIP 61413* in the R, I and Hα filters.



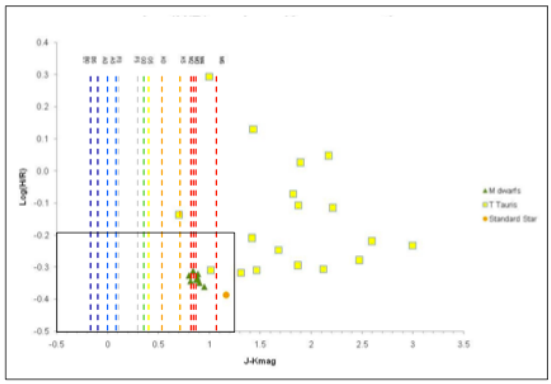
Galaxies and Standard Stars as they Compare to dMe's and T Tauri Stars

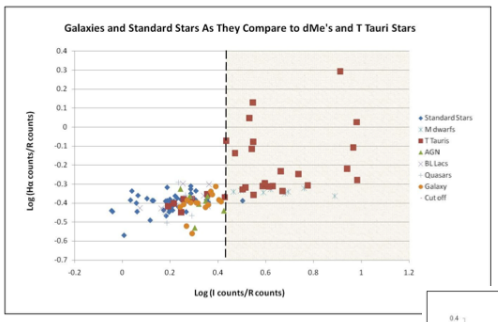


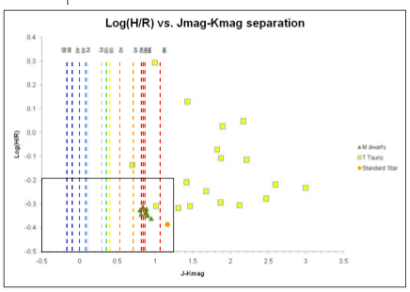
Log (Hα/R) vs. J_{mag} - K_{mag}



Log (Hα/R) vs. J_{mag} - K_{mag} Separation







Results

- Even with an initial contamination of dMe stars, the results show evidence that the method can be used to identify these young sun-like stars in their early stages of development:
  - Accuracy: 90%
  - Precision: ~100%
- Only equipped with small scale telescopes and by using archival data, amateur astronomers can go out and initially identify possible T Tauri star candidates.

Future Studies ?

- using further telescopes to apply the method, e.g.
  - 0.9 meter at Cerro Tololo Observatory, Chile combined with the
  - 14 inch robotic telescope in Perth, Australia
- the above telescopes are both in the southern hemisphere; same objects can be observed
- the results can be compared
- **A primary goal is to make the method more accessible to amateur astronomers!**

What did it take to make this story reality?

1. **Funding agencies with the forward vision to see merit**
2. **Scientists that were willing to step outside the box and truly value education, educators, and students**
3. **Sustained teacher development and support**
4. **A teacher with a desire and motivation to learn, and a "*learned*" level of confidence**
5. **Students with interest and motivation**
6. **Time … lots of it!**
7. **And Pizza … lots of it too!**

Why are partnerships between scientists, educators, and students in authentic research so VERY important?

1. Students can make discoveries and contributions to science.
2. We improve our own knowledge by educating others.
3. Authentic science experiences help develop critical thinking skills.
4. Authentic science experiences can help eliminate misperceptions about science and the scientist.
5. As we consider the terabytes of scientific data available now and in the future, students and teachers can play a significant role in the data analysis process.
6. The experience can be mutually beneficial … a win-win for everyone involved!
7. Our children are our best science ambassadors to the general public
8. These types of experiences can significantly impact the future of scientific endeavors, both nationally and internationally.

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Does Doing Scientific Research in High School Correlate with Students Staying in Science? A Half-Century Retrospective Study

Lesley F. Roberts • Richard J. Wassersug

hands-on research experience once in university. Our data indicate that students who are interested in science and have an opportunity to participate in original scientific research while in high school are significantly more likely ($p<.005$) to both enter *and* maintain a career in science compared to students whose first research experience didn't occur until university. Our data suggest that more hands-on high school science research programs could help increase the number of students entering and maintaining scientific careers, relieving the growing concern that North America is losing its leadership status in the international scientific community.

Acknowledgments:

SSC Spitzer Science Center
SPITZER SPACE TELESCOPE
NSF
NASA
AURA
U.S. DEPARTMENT OF ENERGY
NRAO
NOAO

One of the most important things I've learned about science research . . .