Research Based Astronomy in the Secondary Classroom

Lessons Developed For Investigating YSOs Using APT, Excel, MaxImDL, and MOPEX

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ABSTRACT

We present several learning approaches that were performed to explore YSOs within LDN 425 and LDN 981. Classroom instruction on the characteristics of YSOs was supplemented with hands-on learning of software needed to search Spitzer mosaics for YSO candidates. Structured activities were used to teach the intricacies of MOPEX, APT, MaxImDL, and Excel. Excel worksheets were developed to help students convert flux densities into magnitudes and vice versa. We created Spectral Energy Distributions (SED), plotting the energy against the wavelength for each candidate YSO. This research was made possible through the Spitzer Space Telescope Research Program for Teachers and Students and was funded by the Spitzer Science Center (SSC) and the National Optical Astronomy Observatory (NOAO). Please see our companion education poster by McDonald et al. titled "Spitzer - Hot and Colorful Student Activities" and our research poster by Johnson et al. entitled " Star Formation in Lynds Dark Nebulae."

Teacher Outreach – Programs and Presentations

Teachers implemented the Spitzer data in the classrooms and to their peers at local and national conferences.

Some of the specifics:

Pete Guastella (Manhasset High School) has 10 students in his research program that have developed research projects directly or indirectly from the Spitzer project. He has presented talks at the NCSSMST and the International Science and Engineering Fair on the use of Astronomy in Research Based Science Education.

John Schaefers (Ingomar Middle School) has developed new lessons to teach the concepts of infrared to his students. He was a recipient of the First Energy Mathematics, Science,& Technology Grant with a program called "Hearing Infrared Light: Implementing the IR package with some new things to do, try and experiment with." First Energy is an electric company provider

Cris DeWolf (Chippewa Hills High School) has presented at the Michigan Earth Science Teacher's Association Conference a session entitled "Infrared Astronomy: Seeing the Invisible." He will also present at the Michigan Science Teachers Association in 2009

Program Development at the Schools

Manhasset High School,Manhasset, NY
Students have developed several research projects based on their Spitzer skills. The core group has used Spot, Leopard, APT and Excel to generate color composite images, select candidate YSOs and analyze spectral energy distributions (SEDs). A spin off group is examing Spitzer data of selected AGNs and comparing it to GAV RadioTelescope data as they investingate the possible correlation between AGN intensity and Black Hole mass.

Oil City Area Sr. High School, Oil City, PA
Students have been using MOPEX, MaxIm DL, and FITS Liberator/ Photoshop to generate color composite images of LDN 981 and LDN 425. Using MaxIm DL and Excel, they have generated spectral energy distributions (SEDs) and color-color diagrams in an effort to identify potential YSOs. Future students will be monitoring potential YSOs at optical wavelengths using small ground-based telescopes in an effort to generate lights curves needed to determine variability and rotation rates. In November 2008, students Jennifer Butchart and Rachele Siegel were awarded time on the Kitt Peak 0.9 Meter Telescope to conduct follow up optical observations of LDN 981 and a potentially new large-scale survey method of identifying YSOs.

Chippewa Hills High School, Remus, MI
Astronomy students have used Spot to generate 3-color composites of LDN 981 and selected candidate YSOs. Spitzer team members have worked with these lists and used APT and Excel to determine magnitudes and create SEDs and color magnitude diagrams for the potential YSOs. Comparisons were made to shared data on the wiki site.

Sidney High School, Sidney MT
The physics class first looked at IR radiation by experimenting with the Leslie cube, and determined that there is IR using an update of Newton's experiment. We used an IR temperature probe to find IR sources in the world around us. We used Spitzer Pride programs to make false-color images. Currently the students are working on learning how to analyze the Lynds cloud data.

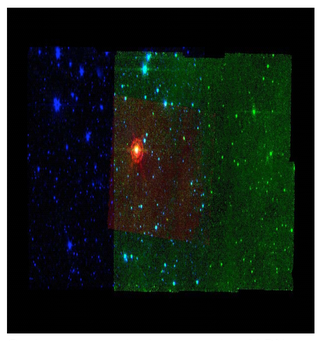
Breck School, Minneapolis, MN
Students are learning about Spitzer in a special Saturday program.

Even middle schools students enjoyed learning to work with Spitzer Pride tools

Below is a section of a take home assignment given to **Ingomar Middle School** students

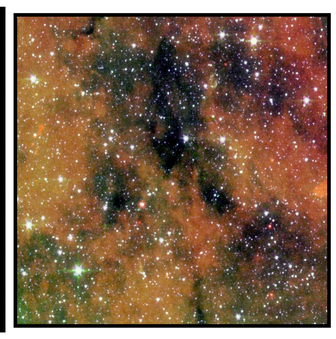
Spitzer: Leopard: INSTALL AT HOME:
http://ssc.spitzer.caltech.edu/propkit/spot/
***Query/Target Name (LND881 , LND 425 or LND981)/**
click on : Simbad (not NED)/
Resolve Name/
Select/ OKAY/
Select (on right side chose wavelength)
See Base Image controls on right
See Controls on Left
Try: top bar image selections

Students are all smiles at Ingomar MS as they enjoy Spitzer lessons developed by Mr. Schaefer



Student-generated color composite of LDN 425

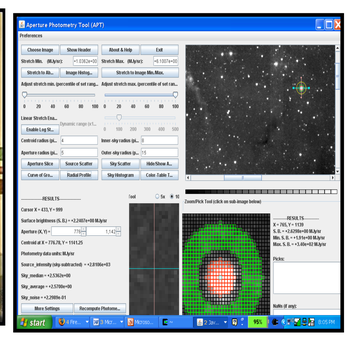
Image developed by Rose Haber, Manhasset, NY



Student-generated color composite of LDN 981 using FITS Liberator

Image developed by **Jennifer Butchart, Oil City, PA**

Manhasset students say hello to the Oil City counterparts during a Skype Conference in early December



Students developed the skills to use complex software such as APT.

Technology Transfer

Hands on Learning
Communication = Education
Communication through Various Modalities

Group photo taken at Spitzer Science Center during the 4-day Summer Conference, June 2008

LDN 425 MIPS 1						
RA	DEC	Intensity	Mag	SNR	Flux	Notes
17 46 39.86	-04 34 06.0	0	0	0	0.00E+00	Not in channel
17 46 43.92	-04 37 50.9	0	0	0	0.00E+00	Not in channel
17 46 45.5	-04 34 41.8	0	0	0	0.00E+00	clear sky
17 46 45.21	-04 36 00.1	0.435	14.06	1.396	1.69E-05	couldn't see
17 46 50.35	-04 38 22.7	15.331	10.317	19.127	5.33E-04	
17 46 50.75	-04 34 32.2	11467.22	3.13	5202.986	3.99E-01	
17 47 03.22	-04 33 26.8	0.61	13.818	1.276	2.12E-05	couldn't see

Student-developed candidate YSO lists from LDN 425 data

Jennifer Butchart and Rachele Siegel conduct follow-up optical observations of LDN 981 at Kitt Peak (Nov. 08)

--JenniferButchart 06:58, 3 December 2008 (PST) I'm back again... I looked at what Luisa thought were interesting targets, and I found that some of ours correspond with hers. They aren't exact, but they're pretty close. They are:
Ra/Dec
20 59 33.1/50 12 02.4
21 00 17.27/50 19 40.6
21 00 37.16/50 21 02.6
21 00 49.26/50 15 44
21 00 49.27/50 15 45.7

Student interaction on the Wiki-- active, timely discussions of student and mentor work

TELECONFERENCE

Teachers met regularly to discuss fundamental techniques prior to data acquisition.
Teachers discussed school progress and problems.
Handled housekeeping.

WIKI

The Wiki is a dynamic environment for the participants (teachers, scientists, and students) to interact as their research projects evolve over time.
It affords the users a simple way to transfer large amounts of data over the internet. (Files too big to email!)
https://coolwiki.ipac.caltech.edu

SKYPE

Maximizing web technology.

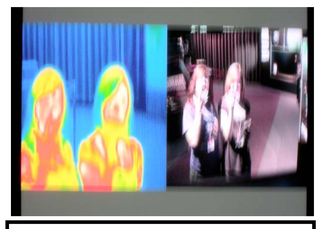
Just a fun way for students to interact at first. This tool grew to be an excellent instrument for students to discuss project goals and review findings.

Face to Face

Spitzer Teachers
First meeting at January 2008 AAS (Austin Texas).
Received basic training in infrared technology.
Met with Dr. Rebull – Discussed possible study.
Developed criteria for Lynd Cloud selection.
Assigned tasks.

Spitzer Teachers and Students
4-day conference at
Spitzer Science Center June 2008
Lectures :
YSO selection techniques
Magnitude and Flux Density
Use of available software: Spot, Leopard, MOPEX, APT and Excel Spreadsheet

Hands On Learning and Practice



Students explore the world of infrared imaging at JPL in June 08

JenniferButchart 10:49, 29 October 2008 (PDT) I got on ADS today and found the same article (by Quanz, S. P.; Apai, D.; Henning, Th.) titled Dust Rings and Filaments around the Isolated Young Star V1331 Cygni. It is the same one as Shana found. I do believe these are the points they identified:

--Sandy 13:22, 30 October 2008 (PDT) This is sandy's test comment.

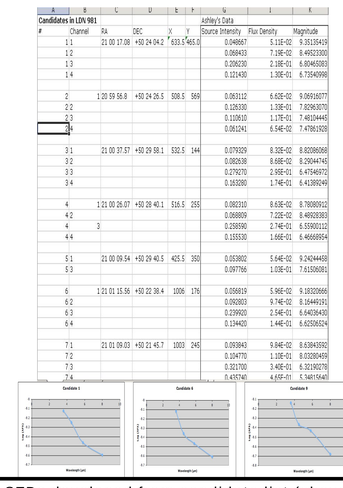
--JenniferButchart 05:29, 31 October 2008 (PDT) I just read that entire article on astro-ph (found here: astro-ph) and it says V1331 Cygni is, mostly likely, the only star that has formed in LDN 981 (it formed in isolation). However, they stated that stars may form along the filaments of the cloud since it it undergoing a gravitational collapse.

Student interaction on the Wiki.

Learning By Doing

As students practiced with software like APT, they shared their ideas via the Wiki, e-mail, and Skype web conferencing.
Students developed a list of possible YSO candidates, converted counts to magnitudes in 5 channels and produced spectral energy distributions (SED).

An excerpt from the Wiki
Ashley Peter – Nov 08
Of the 14 candidates above, we found references for 6 candidates: candidates 1, 3, 6, 7, 11, and 13.
We followed Mr. Spuck's directions and came up with an overlay of 3 wavelengths: MIPS 24 in red, IRAC 8 in green, and IRAC 4.5 in blue.
We located the stars that appeared to have a red ring and added them to our list of candidates.
Here is the list of candidates we found using this method of overlaying:



SEDs developed from candidate list (above)

Summary

•Students And Teachers Learned
- The instrumentation used in infrared astronomy and the necessity of space-based telescopes.
- The physical properties of light, such as wavelength and flux and about emission and absorption.
- How stars form.

•Students And Teachers Became Hands-On Learners:
- Compared the images obtained by IRAC and MIPS.
- Produced false-color images that enhance the features of young stellar objects and the interstellar cloud.
- Extracted data tables of sources and fluxes at each wavelength.
- Using authentic data, students were able to generate color plots.

•State/National Science And Technology Standards.
- The national science standards addressed in this project are the structure and properties of matter, interactions of energy and matter, the origin and evolution of the Earth system, and the abilities of technological design.

•In the Future
- The false-color images that this group produced will be useful in future public presentations.
- Dramatic illustrations of YSOs and star-forming regions will be shared with other teachers via workshops and presentations.
- Students will be able to access the data sets in the *Spitzer* archive.
- Lessons that address STEM skills and concepts will be developed by this *Spitzer* teacher group and disseminated to teachers nationwide.

Conclusion

- Students assumed an active role in the process of project development, teamwork, data collection and analysis, interpretation of results, and formal scientific presentations.
- These workshops, forms of communication, and lessons promoted an inquiry-based learning experience which inspired interest in science, technology, and space research.