



## The UCI COSMOS Astronomy & Astrophysics Program for Talented High School Students

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Figure 1. Students & Teaching Assistants in the COSMOS Class of 2009



Figure 2. UCI 24" Telescope

### Abstract

The COSMOS program is a month-long, residential, summer program for talented high school students held at four University of California campus (Davis, Irvine, Santa Cruz, and San Diego). Since the program's inception in 2000, we have offered the Astronomy & Astrophysics Cluster in the UCI COSMOS program. Our high school students take classes and laboratories in astronomy & astrophysics and complete a research projects in small groups under the supervision of faculty and teaching assistants. Students take data for their research projects with telescopes at the UCI Observatory or use existing data taken in the course of our own research. Here we discuss the curriculum, research projects, highlight the newest lab we developed involving galaxy rotation curves and dark matter, and discuss student evaluation of the program and lessons we have learned over the past 10 years.

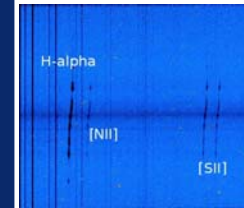


Figure 3. Long-slit spectrum of UGC 477. The students measure the wavelength of the H $\alpha$  emission line.

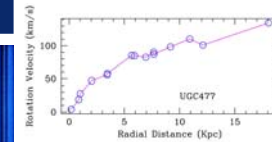


Figure 4. H $\alpha$  rotation curve of UGC 477 as measured by 2009 UCI COSMOS students.

### Motivation

The COSMOS summer program was designed to give California high school students who are exceptionally talented in math and science an opportunity to learn about a field of science or mathematics that they would not normally be available in their high school curriculum, to expose them to research, and to motivate them to pursue careers in scientific research.

### Course Description

Our 4 week-long course includes:

- Lectures on astronomy & astrophysics using an introductory astronomy textbook, *21st Century Astronomy* (J. Hester et al., 2006)
- CLEA lab exercises (Marschall, et al. ) performed in the computer lab under the direction of a TA
- Research Project done by groups of 2 to 3 students led by a faculty member or graduate student TA

### Research Projects

Some research projects performed by the students with data taken using UCI Observatory telescopes, CCD cameras and spectrograph include:

- Imaging Jupiter with an 8" telescope to measure the orbital properties of the 4 Galilean moons and derive Jupiter's mass
- Imaging an open or globular star cluster with the 24" telescope and deriving its distance and age using isochrone fitting
- Imaging an eclipsing binary star system & determining the stars' temperatures, radii and masses
- Obtaining spectra of stars, determining the star's spectra types and estimating their masses

### Galaxy Rotation Curve & Dark Matter Project

In this project, students measure the mass in dark matter in nearby spiral galaxies using optical long-slit spectra obtained with the Kitt Peak National Observatory 4-meter telescope by Rachel Kuzio de Naray. Some of the skills and topics they learn are:

- Introduction to LINUX command line-based computing
- IRAF data reduction
- Basics of emission line spectroscopy
- Doppler shift
- How to measure and plot a galaxy rotation curve
- How to calculate the dynamical mass of a galaxy based on the measured rotation curve
- How to calculate the visible mass (stars + gas) of a galaxy
- How to determine the amount of dark matter in a galaxy by comparing the dynamical and visible masses
- Why astronomers have ruled out objects like planets and faint stars as dark matter

### Lessons Learned

Some important lessons learned in our 10 years:

1. The high school students in the class are extremely motivated and enthusiastic. It is truly a pleasure to teach them, and both faculty and TAs find their teaching experience extremely rewarding.
2. These high school students are very capable of working on basic astronomy research under the guidance of graduate student TAs.
3. The Astronomy & Astrophysics Class has consistently been the most popular of the 7 to 8 COSMOS courses offered each year.

### Student Evaluations

We recently surveyed the 21 students in the 2005 COSMOS class. We received 7 responses with a 29% response rate. All of the respondents are now sophomores to seniors in college; 4 of 7 attend UC campuses. Their majors include physics, aerospace eng., mechanical eng., electrical eng., and pre-medicine.

Survey Results:

1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, and 5 = Strongly Disagree

	Avg	Median	StdDev
• COSMOS showed me that research was something I could do.	1.6	1.0	0.8
• COSMOS had a positive influence on my choice of major in college.	1.6	1.0	0.8
• I would recommend COSMOS to other high school students.	1.0	1.0	0.0

### References

Hester, J., et al. 2006, *21st Century Astronomy*, ( WW Norton & Company: New York)  
Marschall, L., et al., <http://www3.gettysburg.edu/~marschal/clea/cleahome.html>

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