

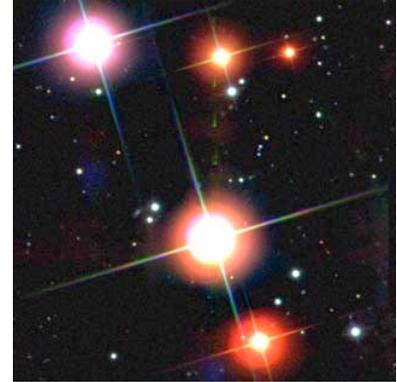


What Are Stars Made Of?

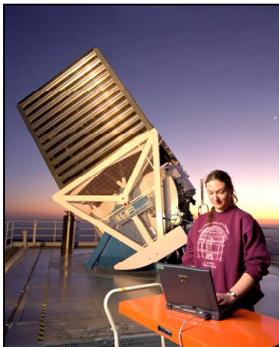


Welcome to Yerkes Observatory and the
**2004 Kavli Institute of Cosmological
Physics (KICP) Yerkes Summer Institute!**

Tonight you will begin an exciting week starting with a star party on the South Lawn with the Milwaukee Astronomical Society (MAS). This event will be followed by a week investigating *what stars are made of*. Throughout the week you will explore spectroscopy. You will discover, among many things, how astrophysicists use the properties of light to investigate distant objects, such as stars, that they can never travel to. The week will end with you making a presentation to your family and fellow students about this enlightening topic. Don't worry, by the end of the week you will be amazed at what you have learned.



During the day on Sunday, Monday and Tuesday, you will be divided into three groups (**POLARIS**, **ARCTURUS**, and **VEGA**) and will rotate through three all-day laboratories that will help you learn about the techniques of spectroscopy and how it can be used to study stars, liquids, and glowing hot gases. In the middle of the week you will be "*mixed-up*" into new groups where you will become experts in one of the daytime laboratories. Later in the week we will have a "*Jigsaw*" session where a few people from each mixed-up group will present the laboratory about which they became an expert to the rest of the students. Each evening you will do a night laboratory/activity that will help you better understand how we use spectroscopy to figure out what stars are made of. The nighttime laboratories depend on clear skies and so their schedule is less fixed.



Here's to a great week of investigation – we can hardly wait to listen to your ideas about how we can study stars & what they are made of!

2004 Yerkes Summer Institute Format

- Day Laboratories*** There are three in-depth day-long investigations. Each of you will be assigned to one of three groups (POLARIS, ARCTURUS, or VEGA), and with that group will have the opportunity to explore each daytime laboratory. Please use your schedules (beginning on page vi) to identify where you should report.
- Night Laboratories*** The night laboratories take advantage of the fact that we are at a world-class observatory, but depend on clear skies. The nighttime plans will be decided each day and must remain flexible.
- Mixed-up Group*** Each of the three groups will be reorganized ("mixed-up") to recap and explore one daytime lab in more depth. This is time to clarify concepts, solidify your understanding and become an expert on the topics of a particular lab. *This group will also present the lab they explore to the parents and other visitors at the end of the institute.* Please use your schedules to identify in which mixed-up group you will be. The group assignments can be found on page viii.
- Jigsaw Session*** After your *mixed-up group* has come to some preliminary conclusions about the data you have collected, you will have a chance to share those findings with half of your peers. Your mixed-up group will be divided into a #1 group and a #2 group that will then meet with other 1's or 2's. Each of you will share with those students the results that your mixed-up group has examined and any conclusions that you have come to based on those results. Other members of your jigsaw group will listen to you and ask questions, make comments, or suggest possible errors. You will do the same for them when they share their group's findings. Please use your schedules to identify of which Jigsaw group you will be a member. The Jigsaw schedule can be found on page viii.
- NOTE: YOU SHOULD NOT ENTER ANY PERSONAL CRITICISM OF INDIVIDUAL PRESENTATIONS. IN OTHER WORDS, YOU SHOULD NOT SAY THAT SOMEONE WAS TOO QUIET, OR SOMEONE TALKED TOO SOFTLY, OR SOMEONE TALKED TOO MUCH. COMMENT ONLY CONSTRUCTIVELY ON THE CONTENT.
- Parent Investigations*** On Thursday evening your parents and other visitors will participate in an open house. This is your chance to get together with your parents and share what you learned during one of the labs. Think about how to get your parents involved in one part of the lab. Your group presentation should give the visitors an overview of your experiment, and allow them to experience first hand as much of your investigation as possible. Mixed-up groups will work together for the presentations.



Night Laboratory-1

Seeing is Believing (Sarah Hansen & Erin Sheldon)

The purpose of this lab is to look at the spectrum of stars by eye using a telescope. In the day labs you will learn that the light emitted and transmitted by objects and materials (e.g. spectra) can reveal a lot about the makeup of an object. Spectra can also be used to learn about the composition of distant objects such as stars and galaxies. Although the other night lab will use a CCD camera and be more quantitative, this is a chance to see with your own eyes that the light from stars can be split into a rainbow and to see features in that rainbow that have an understandable physical origin.



Night Laboratory-2

Celestial Detectives (Chris Greer, Vivian Hoette & Andy Puckett)

Have you ever seen a rainbow of colors when you shine white light through a crystal or prism? The white light is split up into a continuous spectrum of colors, with a million shades from red to violet. In this lab, we will use a telescope-mounted prism to take digital images of the spectra of astronomical objects. These images will be in black and white, so we won't be able to see the colors for ourselves, but we can use a computer to graph the brightness at each wavelength (color) of light. We will find that each rainbow of color isn't continuous! There will be some wavelengths of light that are relatively faint, while others will be enhanced in brightness. We will use these celestial fingerprints to determine the properties of stars and nebulae over great distances in space. Is this star hotter than that one? Is there some element in that nebula that isn't in this other one? Let's find out!



Night Laboratory-3

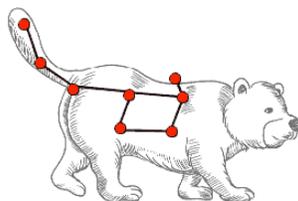
Flame Tests (Eileen Sheu)

You may wonder what spectroscopy has to do with fireworks, but in this night lab we will see how the two are related. One of the oldest ways to determine what elements are in something is to burn it. It turns out that certain elements give off very distinct colors when put in a flame, under the right conditions. This behavior makes it easy to identify these elements. In this lab you explore what colors correspond to what elements, which is what firework manufacturers need to know in order to make the pyrotechnic shows that people love to see.

Group Names Background

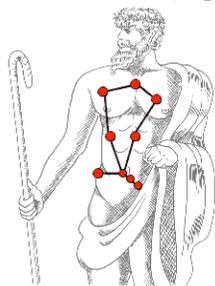
(text adapted from Jim Kaler's
<http://www.astro.uiuc.edu/~kaler/sow/spectra.html>)

POLARIS (Alpha Ursae Minoris). Polaris, the North Star, marks the unchanging North Celestial Pole. Polaris also marks the end of the handle of the Little Dipper, the prominent figure of Ursa Minor, the Smaller Bear. Much fainter than its "Big" counterpart, the Big Dipper, the Little Dipper is hard to find in a bright sky. Polaris has the common reputation of being the brightest star in the sky but it comes in at about number 40. Its lower rank, however, is largely determined by its great distance of 430 light years. The star is an evolved yellow supergiant 2200 times more luminous than our Sun. Hydrogen fusion has stopped in the star's core, and it is now passing through a phase of instability wherein it pulsates over a period of about four days, and hence is a "Cepheid" variable star. Cepheids are paramount distance indicators in astronomy, as their true brightnesses are revealed by their periods of oscillation. Polaris is particularly interesting as the pulsations have nearly, but not quite, ceased. Just as a violin string has a "fundamental" tone that gives its pitch, it also vibrates in higher-frequency overtones. Comparison with other Cepheids shows that Polaris is pulsating not with its natural fundamental period, but in its first overtone.



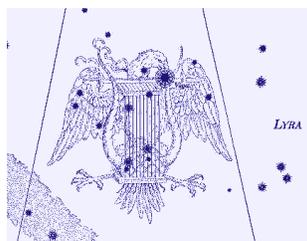
(image from <http://www.classicalmythology.org/maps>)

ARCTURUS (Alpha Bootis). Among the very brightest of stars, shining with a soft orange light, Arcturus lights northern spring skies. It is one of three luminaries that partition the northern sky into very rough thirds, the others being summer's Vega and winter's Capella. Of the three, Arcturus, the Alpha star of the constellation Bootes, the Herdsman, is slightly the brighter, making it the brightest star of the northern hemisphere and the fourth brightest star of the entire sky. Arcturus, the "Bear Watcher," follows Ursa Major, the Great Bear, around the pole, "arktos" being the Greek name for "bear," from which our word "arctic" is derived by reference with the constellation of the Greater Bear. Arcturus is located at a distance of 37 light years, and became famous when its light was used to open the 1933 world's fair in Chicago, as that light had left the star at about the time of the previous Chicago fair in 1893.



(image from <http://www.classicalmythology.org/maps>)

VEGA (Alpha Lyrae). One of the most famed stars of the sky, Vega is the luminary of the dim but exquisite constellation Lyra, the Lyre, which represents the harp of the great mythical musician Orpheus. Its name derives from an Arabic phrase that means "the swooping eagle." Vega is one of three brilliant stars that divide the northern heavens into thirds, the others Arcturus and Capella, and with Altair and Deneb forms the great Summer Triangle, lying at its northwestern apex. At magnitude zero, it is the sky's fifth brightest star, falling just behind Arcturus and just ahead of Capella. It is also one of the closer stars to the Earth, lying just 25 light years away. Though its proximity helps make it bright in our skies, it is also inherently luminous, 54 times brighter than our Sun. Vega is a classic white main sequence star, like the Sun quietly running off the nuclear fusion of hydrogen deep in its core, with a surface temperature of 9600 degrees Kelvin.



(image source <http://www.cyberwitch.com/wychwood/Observatory/introNightSky2.htm>)

SCHEDULES
2004 KICP Space Explorers Yerkes Summer Institute
Saturday, August 7 – Friday, August 13



Instructor	Day Lab	Night Lab	Location
Charles Brass			
Kyle Cudworth			
Carlos Cunha	You Are the Spectrometer (ext.)		Battleship Lab
Bill Fisher	What's in the Mix?		South Building
Robert Friedman	You Are the Spectrometer		Battleship Lab
Chris Greer		Celestial Detectives	24-Inch Telescope
Sarah Hansen	Fingerprinting the Stars	Seeing is Believing	Basement Lab/12"
Vivian Hoette		Celestial Detectives	24-Inch Telescope
Rick Kessler			
Rich Kron			
Randy Landsberg	What's in the Mix?		South Building
Thushara Perera			
Andy Puckett		Celestial Detectives (prep)	
Douglas Rudd	Fingerprinting the Stars (ext.)		Basement Lab
Matthew Sharp	You Are the Spectrometer		Battleship Lab
Erin Sheldon		Seeing is Believing	12-Inch Telescope
Eileen Sheu		Flame Tests	South Lawn
Monica Valluri	Fingerprinting the Stars		Basement Lab
Phil Wisecup			
Brian Wilhite			

Schedule Overview

	Saturday August 7	Sunday August 8	Monday August 9	Tuesday August 10	Wednesday August 11 (Analysis & Jigsaw)	Thursday August 12 (Analysis & Jigsaw)	Friday August 13
9-11AM		Day Labs	Day Labs	Day Labs	Mixed-up Group Work	Mixed-up Group Work	Clean-up
11:45-1PM	LUNCH						
1:30-5PM		Day Labs continued	Day Labs continued	Day Labs continued	1:30-2:30PM Mixed-up Group Work 3pm-5pm Jigsaw Session	Prepare for Parent Investigation in Mixed-up Group	
5:00-5:30PM	Staff Meeting						
Dinner 5:15-6:30PM							
7:30-10:30PM	7:30 Leadership Meeting 8PM Welcome 8:15-10:30PM STAR PARTY	PM Labs	PM Labs	PM Labs	Mixed-up Group Work	7:30-10PM Parent Investigations	

DAY Lab Rotations	You Are the Spectrometer	Fingerprinting the Stars	What's in the Mix?
Sunday	POLARIS	VEGA	ARCTURUS
Monday	ARCTURUS	POLARIS	VEGA
Tuesday	VEGA	ARCTURUS	POLARIS



Celestial Codes

POLARIS

Christopher Smith*	12
Danielle Larkin*	12
Monashae Brownlee	11
Mark Dewberry	10
Devin Barnes	11
Kallie Jones	10
Iris Muhammad	8
Brittany Lockhart	9
Stacy Stewart	7
Joshua Johnson	12

ARCTURUS

Jimmie Price*	11
Christine Carter*	11
Mia Dunlap	11
Derrick Clay	12
Jovan Gathings	10
Serrater Chapman	10
Asia Ingram	7
Kristopher Nance	9
Brittany Davis	7
Paula Montgomery	8

VEGA

Timotheus Gordon*	11
Elizabeth Nyikako*	11
Ashley Hall	11
Julia Bowman	9
Cameron Edwards	10
Javal Howard	10
Taylor Major	6
Aminat Onisemoh	7
Jessica Ball	11

MIXED-UP LAB ASSIGNMENTS

<i>You Are the Spectrometer</i>	<i>Fingerprinting the Stars</i>	<i>What's in the Mix?</i>
Christopher Smith*	Danielle Larkin*	Jimmie Price*
Christine Carter*	Timotheus Gordon*	Elizabeth Nyikako*
Devin Barnes	Jessica Ball	Julia Bowman
Derrick Clay	Mark Dewberry	Monashae Brownlee
Ashley Hall	Mia Dunlap	Serrater Chapman
Kallie Jones	Cameron Edwards	Brittany Davis
Asia Ingram	Jovan Gathings	Kristopher Nance
Taylor Major	Javal Howard	Brittany Lockhart
Stacy Stewart	Paula Montgomery	Aminat Onisemoh
	Iris Muhammad	Joshua Johnson

(* = Group Leader)

JIGSAW 1	JIGSAW 2
A. Christopher Smith*	A. Christine Carter*
A. Ashley Hall	A. Taylor Major
A. Devin Barnes	A. Kallie Jones
A. Asia Ingram	A. Stacy Stewart
A. Derrick Clay	B. Mia Dunlap
B. Timotheus Gordon*	B. Javal Howard
B. Jovan Gathings	B. Iris Muhammad
B. Cameron Edwards	B. Kristopher Nance
B. Paula Montgomery	B. Danielle Larkin*
B. Mark Dewberry	C. Jason Pruitt
B. Jessica Ball	C. Brittany Lockhart
C. Julia Bowman	C. Earle Lawrence
C. Monashae Brownlee	C. Jimmie Price*
C. Aminat Onisemoh	C. Britany Davis
C. Elizabeth Nyikako*	C. Joshua Johnson
C. Serrater Chapman	

Mixed-up assignments: A = You are the Spectrometer, B = Fingerprinting the Stars, C = What's in the Mix?

POLARIS

Christopher Smith* (12)
Danielle Larkin* (12)
 Monashae Brownlee (11)
 Mark Dewberry (10)
 Devin Barnes (11)
 Kallie Jones (10)
 Iris Muhammad (8)
 Brittany Lockhart (9)
 Stacy Stewart (7)
 Joshua Johnson (12)

POLARIS Lab Rotation (Sunday, Monday, Tuesday)

When	What	Where	Who
Sunday Aug. 8			
Day Lab	You Are the Spectrometer	Battleship Lab	Robert Friedman Matthew Kyle Sharp
Night Lab 7:30-10:30	To be determined		
Monday Aug. 9			
Day Lab	Fingerprinting the Stars	Basement	Sarah Hansen Monica Valluri Doug Rudd
Night Lab 7:30-10:30	To be determined		
Tuesday Aug. 10			
Day Lab	What's in the Mix?	South Building	Randy Landsberg Bill Fisher
Night Lab 7:30-10:30	To be determined		

ARCTURUS

Jimmie Price* (11)
Christine Carter* (11)
 Mia Dunlap (11)
 Derrick Clay (12)
 Jovan Gathings (10)
 Serrater Chapman (10)
 Asia Ingram (7)
 Kristopher Nance (9)
 Brittany Davis (7)
 Paula Montgomery (8)

ARCTURUS Lab Rotation (Sunday, Monday, Tuesday)

When	What	Where	Who
Sunday Aug. 8			
Day Lab	What's in the Mix?	South Building	Randy Landsberg Bill Fisher
Night Lab 7:30-10:30	To be determined		
Monday Aug. 9			
Day Lab	You Are the Spectrometer	Battleship Lab	Robert Friedman Matthew Kyle Sharp
Night Lab 7:30-10:30	To be determined		
Tuesday Aug. 10			
Day Lab	Fingerprinting the Stars	Basement	Sarah Hansen Monica Valluri Doug Rudd
Night Lab 7:30-10:30	To be determined		

VEGA

Timotheus Gordon* (11)
Elizabeth Nyikako* (11)
 Ashley Hall (11)
 Julia Bowman (9)
 Cameron Edwards (10)
 Javal Howard (10)
 Taylor Major (6)
 Aminat Onisemoh (7)
 Jessica Ball (11)

VEGA Lab Rotation (Sunday, Monday, Tuesday)

When	What	Where	Who
Sunday Aug. 8			
Day Lab	Fingerprinting the Stars	Basement	Sarah Hansen Monica Valluri Doug Rudd
Night Lab 7:30-10:30	To be determined		
Monday Aug. 9			
Day Lab	What's in the Mix?	South Building	Randy Landsberg Bill Fisher
Night Lab 7:30-10:30	To be determined		
Tuesday Aug. 10			
Day Lab	You Are the Spectrometer	Battleship Lab	Robert Friedman Matthew Kyle Sharp
Night Lab 7:30-10:30	To be determined		