Today’s NSDL experts:

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Dr. Cathy Ezrailson, Assistant Professor of Science Education University of South Dakota

http://www.thephysicsfront.org

http://nsdl.org
To begin our celebration of the International Year of Astronomy 2009, let’s investigate:

- Star birth and formation
- Stellar classification
- Star spectra
- Planet formation
- When stars die
- More resources

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Which do you think is the most common element (by mass) found in stars?

A. Helium  
B. Hydrogen  
C. Carbon  
D. Silicon

Sagittarius Star Cloud,  
Center of the Milky Way Galaxy

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Stars are made of:

- (by mass)
- 70-80 % Hydrogen
- 20-30% Helium
- 1-2% Metals (everything else - C, N, O, Si, Ca, Fe, Zn)
Stars are massive, hot, glowing balls of gas that produce their energy via nuclear fusion in their cores. Their lifestyles are determined by the struggle for equilibrium between gravity and pressure, which affects their mass and energy output.
Star Nurseries …
a star is born in the Orion Nebula

Hayden Planetarium, American Museum of Natural History
http://haydenplanetarium.org/movies/ava/S0801starform.mpg

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What physical factors do YOU think most influence how stars are formed?

Consider:

• Mass of the initial gas cloud
• Temperature of the gas
• Speed of cloud rotation
• Other factors…

Type your responses in the chat

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The most important factor in how a star evolves and eventually dies is its initial mass.

A massive cloud can form thousands of stars ranging in mass from about 100 x the mass of the sun to about 1/100th of a solar mass.

- Smaller individual clumps may form single stars, binary stars, multiple star systems, planetary systems

- A star’s life and death depend on:
  - how much fuel (mass) they have available
  - how quickly they expend their energy

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A star is born…

From collapsing cold clouds of interstellar gas and dust… clouds rotate as they collapse … conserving angular momentum … forming the smaller clumps that will become stars

Orion Nebula

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A star’s initial mass determines its life

High Mass Stars
- Bright
- Burn “fuel” rapidly (hundreds of millions of years)
- Have very short lives
- Example: Rigel in the Orion Constellation

Low Mass Stars
- Less bright
- “Burn” for billions of years
- Have very long lives
- Examples: Sun, brown dwarfs

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Let’s pause for questions from the audience....
Classifying stars

We classify stars based on their spectra, which provide us with information on:
- Temperature
- Composition
- Brightness
- (and in some cases, Distance, but that’s another story)
About light and energy

- Light is a particle and Light is a wave.
- A photon’s energy is proportional to its frequency $E = h\nu$ or inversely proportional to its wavelength, $E = hc/\lambda$. ($h$ is the Planck’s constant).

- Electrons in atoms and molecules
  - Absorb light when they jump from lower to higher energy levels.
  - Emit light when they jump from higher to lower energy levels.
About light and energy and stars
About light and stars

• Atoms and molecules in the cooler outer layers absorb light - so we observe an ABSORPTION spectrum.

• Atoms and molecules in the hotter corona (as in the sun) emit light - so we observe an EMISSION spectrum.

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### Surface Temperature Spectral lines from:

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>T &gt; 10,000 K</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>8,000 K – 10,000 K</td>
<td>Hydrogen and helium</td>
</tr>
<tr>
<td>T &lt; 8,000 K</td>
<td>Hydrogen, helium oxygen, iron, silicon, nitrogen, calcium</td>
</tr>
<tr>
<td>Coolest stars</td>
<td>Molecules</td>
</tr>
</tbody>
</table>
The distribution of energy emitted by a star produces a spectrum. (SED = spectral energy distribution)

Light from the core produces a continuous spectrum.

The elements in the cooler layers absorb light, producing the absorption spectrum.
Which elements are present in the mystery star represented by the spectrum below? Stamp your answer(s)

<table>
<thead>
<tr>
<th>Calcium</th>
<th>Hydrogen</th>
<th>Iron</th>
<th>Magnesium</th>
</tr>
</thead>
</table>

Calcium  
Hydrogen  
Iron  
Magnesium  
Mystery Star

Bonus: What is the mystery star’s spectral type?
Mystery Star
Plotting temperature against brightness, gives us an organizing diagram - The Hertzprung-Russell Diagram.

This diagram is to astronomy as the periodic table is to chemistry.

Interactive quiz:  http://aspire.cosmic-ray.org/labs/star_life/support/HR_static.swf
Simulated life cycle of a 1 solar mass star

http://aspire.cosmic-ray.org/labs/star_life/support/HR_animated.swf
Let’s pause for questions from the audience....
How do **planets** form around stars?

Planets form around stars from accretion of smaller bits *(planetesimals)* after the central star forms, or from a clump orbiting the main star *(jupiters)*.

http://atropos.as.arizona.edu/aiz/teaching/a204/images/planetesimals.mov

http://atropos.as.arizona.edu/aiz/teaching/a204/images/ring_formation.mov

http://nsdl.org
When Stars Die

Very massive (> 10 Msun) stars die in energetic explosions - supernovae - producing black holes or neutron stars and release almost all their atmosphere into the interstellar medium.

When Stars Die

Medium sized (1-8 Msun) stars swell up, possibly engulfing planets, releasing outer layers into interstellar medium, the core becomes a white dwarf.

We think Low mass (< 1 Msun) stars also puff out, and eventually become white dwarfs. We do know they are very long lived -- longer than the universe is old.
Astronomy is a dynamic science. New discoveries add to our knowledge of the universe and our own solar system.

- New images brought to use by the Hubble Space Telescope show that star formation is more complex and violent than anyone had believed.
- Supersonic jets of particles and dense clots of dust warp glowing gas into a variety of fantastic shapes.
More about stars can be found at…

The Astronomy Center
http://www.compadre.org/Astronomy

Hubble Space Telescope
http://hubblesite.org

International Year of Astronomy 2009
http://astronomy2009.us
http://astronomy2009.org
More about stars can also be found at:

http://www.thephysicsfront.org

Let’s interact with a final simulation from The Physics Front:
http://www.fourmilab.ch/yoursky

For further discussion, go to our blog at:
http://southdakotascienceeducation.blogspot.com
THANK YOU!

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http://www.thephysicsfront.org

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Learn about new tools and resources, discuss issues related to science education, find out about ways to enhance your teaching at:

http://expertvoices.nsdl.org/learningdigitalK12

Go to http://nsdl.org and click on the K-12 audience page to:
• Download our Seminar Resource List
• Find resources from archived seminars
http://www.elluminate.com
National Science Teachers Association
Dr. Francis Q. Eberle, Executive Director
Frank Owens, Associate Executive Director
Conferences and Programs
Al Byers, Assistant Executive Director e-Learning

NSTA Web Seminars
Flavio Mendez, Senior Director
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