The James Webb Space Telescope's Near-Infrared Camera: Making Models, Building Understanding

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The Astronomy Camp for Girl Scout Leaders is a science education program offered by the near-infrared camera (NIRCam) team for NASA's next large space telescope: the 6.5-meter James Webb Space Telescope (JWST). Since 2003, our team has hosted "Train the Trainer" workshops with adult leaders from all Councils of the Girl Scouts of the USA (GSUSA). These workshops directly benefit thousands of young girls of all ages, not only in general science education but also specifically in astronomical and technological concepts relating to JWST. Training includes topics in basic astronomy (night sky, phases of the Moon, the scale of the solar system and beyond, stars, galaxies, telescopes, etc.) as well as JWST-specific research areas in extra-solar planetary systems and cosmology, to pave the way for girls and women to understand the first images from JWST.

A New E/PO approach

In its proposal to NASA to build the near-infrared camera for JWST, the science team adopted an unusual approach for education and public outreach (E/PO). Instead of waiting until JWST's launch, we decided to begin spending our resources immediately to impact the education and attitudes of girls and young women towards subjects involving science, technology, engineering, and math (STEM). Our project, led by a prominent woman astronomer (Dr. Marcia Rieke), especially targets K-14 girls to combat the misconceptions that women can't do or enjoy physical science.

We began partnering with the Sahuaro Girl Scout Council (Tucson, Arizona) to train and equip adult Girl Scout leaders so they could, in turn, host astronomy-related activities at the troop level and teach young women essential concepts in astronomy, i.e., the night sky environment. To date, our E/PO team of faculty, post-docs, and graduate students has trained more than 160 leaders from 24 states, Washington D.C., Guam, and Japan. A byproduct of our workshops is the revision of the "Sky Search" badge material that impacts many thousands of Junior girls (ages 8-11). Together, all of us form a growing team that works to promote the excitement of JWST. Through the GSUSA's extensive infrastructure, we will help explain the exciting scientific results from JWST when it launches in 2014.

Understanding Images of the First Stars Ever Formed

The primary scientific goal for JWST is to discover, image, and study the first material objects that ever formed. These so-called "First Light" objects are predicted to be unusually massive stars that may have led to the formation of supermassive black holes at the centers of today's galaxies. Although these images will be profound because they represent our origins, they may be mere smudges, and explaining them to the public is a challenge requiring several levels of abstraction including concepts such as infrared light, redshift, expanding universe, Big Bang, stars, black holes, etc.

Unfortunately, many of our GSUSA trainers have a difficult time visualizing basic astronomical concepts that are normally taught in elementary and middle school — rotation and revolution, the yearly motions of the planets, the scale of the solar system, and phases of the Moon, for example. In order to foster girls' interest and creativity in STEM subjects, it is crucial that all of us create an environment that not only encourages their interests early in their lives, but also creates a safe place for girls to try and fail, and then try again and succeed. Therefore, a major part of our effort is to allow participants to discover the night sky by making observations via both the naked eye and with a variety of portable telescopes. The Camp culminates with a night on the Kuiper 61-inch telescope on nearby Mt. Bigelow.

Overall, we model what astronomers do by engaging people in hands-on processes of scientific inquiry, and we equip leaders to

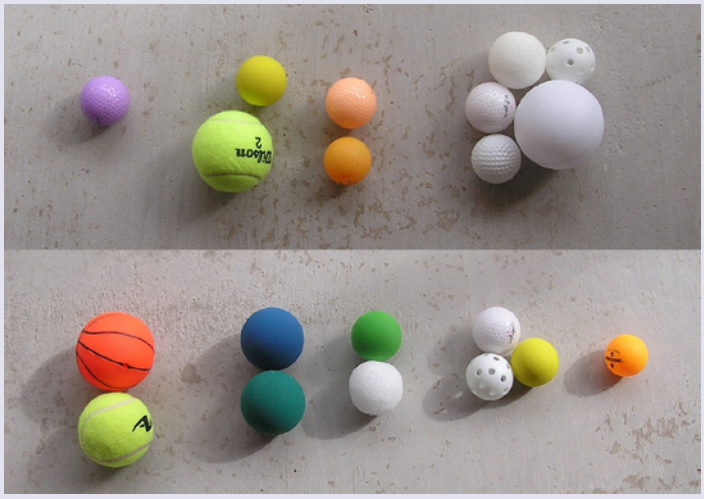
***Learning to Use a Planisphere*. On the first of three evenings, before observing the night sky, our GSUSA leaders are taught how to navigate the sky with a planisphere and find satellites using basic coordinate systems. Throughout each night we involve them in kinesthetic models to explain what they observe in the sky, such as the rising and setting of constellations, seasonal differences in constellations, motions of the Moon and planets, etc.**

host astronomy-related activities at the troop level. In other words, we merge the separate STEM letters into a single thought process.

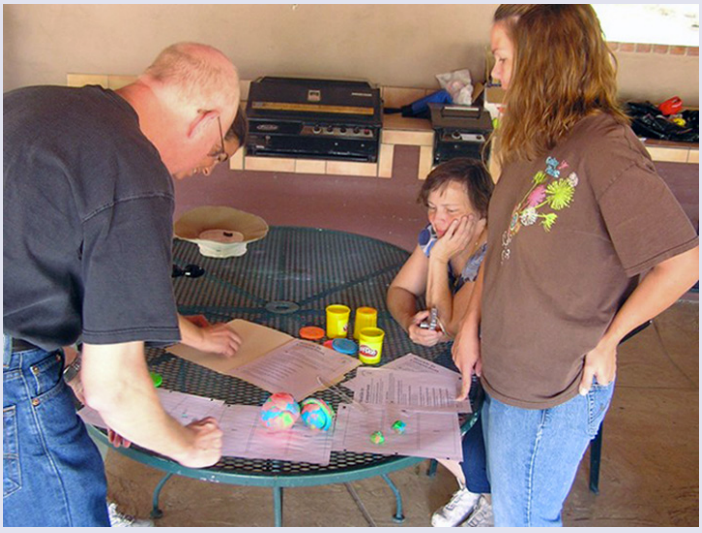
While many of the Camp's activities relate to the "First Light" theme, others relate to additional science themes of JWST and NIRCam — "Birth of Stars and Protoplanetary Systems" and "Planetary Systems and the Origin of Life." The latter includes our own solar system.

The series of images in this poster paper (all courtesy of the University of Arizona NIRCam Team) highlight several of the activities we conduct during a typical three-day long workshop.

Galaxy Classification and Hubble Deep Field Images. **Through the use of colored images of prominent galaxies and interacting pairs, teams of leaders first develop their own classification system. Then we progress to learn about galaxy evolution, the scale of the universe, the Hubble Deep Field images, and so on.**



Categorizing Planets. **Participants are shown how people, as well as scientists, group or categorize things such as plants and animals, cats and dogs, etc. In small groups, the participants group and categorize 10 spheres based on their properties and characteristics (color, size, etc.). Similarly, astronomers categorize objects in the solar system, and there may be more than one "right" answer!**



Relative Sizes, Planetary Diameters. **The relative sizes of the planets are modeled using clay, beads, and Styrofoam balls.**

Lunar Phases. **The Earth-Moon system can be modeled by combining a tennis ball and penny separated by ten Earth circumferences. This combination can also be used in daylight to understand the concept of phases.**

Acknowledgements

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Macramé Solar System Distance Model. **The relative distances of the planets from the Sun are modeled to scale, and in the correct relative orientation, using macramé.**

Human Orrery. **This model is based on the Human Orrery at the Armagh Observatory in Northern Ireland. Participants can model day and night, the motion of the planets in their orbits around the Sun, and the positions of the planets in the sky from the perspective of the Earth. There are also plates to show the positions of the 13 zodiacal constellations. A more detailed description of the orrery's construction, as well as its use for STEM education, will be available (in 2011) in the ASP's Boulder meeting Conference Series book.**

Comparing JWST/NIRCam With a Disposable Kodak Camera. **The opto-mechanical and electrical components of a used, Kodak disposable camera provide an excellent analogue for experiencing the design of the NIRCam instrument. Girl Scout leaders dissect a disposable camera in order to discover the various subsystems and how they work together.**

My! What Big Eyes You Have, JWST. **Using counting disks and circles of various sizes, the Girl Scout leaders visualize the arithmetic associated with light-collecting area and are able to "see" how much more light JWST will gather relative to the human eye and why bigger is better.**

Constellation and Planet-Sorting Cards. **Leaders participate in two separate activities — classification of stars, and the classification of the objects in our solar system (and extra-solar planets). Constellation Sorting Cards enable participants to sort according to various stellar parameters such as luminosity, temperature, apparent brightness, diameter, distance, etc. A more advanced set includes absolute magnitudes, types, and spectral classes. Planet Sorting Cards show information about the planets, dwarf planets, asteroids, comets, and satellites. Their orbits are also shown. There are two card sets with grade-appropriate information. The more advanced set includes several extra-solar planets.**

Lookback Time in Our Daily Lives. **JWST and NIRCam will provide the longest lookback time yet achieved for stars and galaxies in the universe. To convey this fundamental concept, we use familiar phenomena such as thunder, lightning, and fireworks to introduce the concept of the finite speed of light. We then extend this concept beyond Earth to discuss communication with the rovers on Mars and other distant spacecraft. Finally, we use the "Photon Conveyor Belt" activity created by former graduate student, Dr. Jennifer Donley, to involve our leaders in concepts relating to galaxy formation versus redshift.**

Hubble's Law. **To the general public the expansion of the universe is often a confusing, and potentially threatening, concept. However, this concept is essential to understanding the mission and science from JWST. To teach this concept, we engage our leaders in measuring motions of familiar objects like cars and Slinkys, as well as simulated galaxies in an overlapping set of overhead transparencies produced at different levels of enlargement.**

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