

NEAR INFRARED CAMERA (NIRCAM): MAKING MODELS, BUILDING UNDERSTANDING. L. A. Lebofsky¹, D. W. McCarthy¹, M. L. Higgins², and N. R. Lebofsky³, ¹Steward Observatory, University of Arizona, Tucson, AZ 85721 (lebofsky@lpl.arizona.edu), ²Sahuaro Girl Scout Council, 4300 E. Broadway, Tucson, AZ 85711, ³Retired

Introduction: The Astronomy Camp for Girl Scout Leaders is a science education program sponsored by NASA's next large space telescope: The James Webb Space Telescope (JWST). We seek to develop a long-term relationship with adult trainers from all Girl Scouts of the USA (GSUSA) Councils that directly benefits troops of all ages, not only in general science education but also specifically in the astronomical and technology concepts relating to JWST. Since 2003, the E/PO team for JWST's Near Infrared Camera (NIRCam), in collaboration with the Sahuaro Girl Scout Council, has been training and equipping adult Girl Scout leaders so they can in turn teach young women essential concepts in astronomy, i.e., the night sky environment. We model what astronomers do by engaging people in the process of scientific inquiry, and we equip leaders to host astronomy-related activities at the troop level. It is GSUSA's goal to foster girls' interest and creativity in Science, Technology, Engineering, and Math (STEM); it is crucial to 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. We have trained nearly 150 leaders in 11 camps since 2004.

While one of the major themes for NIRCam is "The End of the Dark Ages: First Light and Reionization," and we are training our leaders with this theme in mind, a major part of our E/PO effort is to allow the leaders to discover the night sky by making naked-eye and telescope observations. However, many of the leaders have a difficult time visualizing basic astronomical concepts, 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, diurnal motion, phases of the Moon, seasons, and seasonal constellations, for example. Our 20 years of experience working with children and adults in McCarthy's Astronomy Camp, the hundreds of elementary and middle school teachers that have attended our professional development workshops (e.g., L. and N. Lebofsky's ARTIST, ORION, and STORI), as well as thousands of students in our General Education science classes, have taught us the value of getting people to participate in the learning experience.

Camp Activities: While many of the camp activities are related to the "First Light" theme, many of the background activities relate to two of the other JWST and NIRCam themes: "Birth of Stars and Protoplaneta-

ry Systems" and "Planetary Systems and the Origin of Life." The latter includes our own Solar System. A few of our activities are highlighted below:

1. *Earth and Moon: Day and Night; Rotation and Revolution.* We model the rotation of the Earth, demonstrating the difference between the Earth's rotation rate and its 24-hour day/night cycle. We also model the rotation and revolution of the Moon, the phases of the Moon, and the fact that the Moon does rotate on its axis, which is why we see only one side of the Moon.
2. *Earth/Moon Comparisons.* The relative diameters of the Earth and Moon, the distances between them, and their relative volumes are modeled. This is done with a series of activities, using paper circles, Styrofoam balls on a string, and balls of clay for comparing the relative sizes of the Earth and the Moon and the distance to the Moon relative to the diameter of the Earth (see upper left and upper right figures on next page).
3. *Size Model: The Diameters of the Planets.* The relative sizes of the planets are modeled using beads and Styrofoam balls (see upper right figure on next page).
4. *Macramé Planetary (Solar) Distance Model.* The relative distances between the planets are modeled using macramé (see upper right and lower left figures on next page).
5. *Lookback Time in Our Daily Lives.* Using familiar phenomena such as thunder and lightning and fireworks, we introduce the concept of the finite speed of light. We then take this beyond the Earth to discuss communication with the rovers on Mars and other distant spacecraft. Finally, we talk about "lookback," the concept that when we see the light from a distant star or a distant galaxy, we are actually seeing the object in the past, when the light first left the object on its journey to Earth. This activity can be used in conjunction with the macramé model.
6. *Planet Sorting Cards.* The classification of the properties of the objects in our Solar System and the extra-solar planets is introduced. Classification 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.

7. *Human Orrery*. This model is based on the Human Orrery at the Armagh Observatory in Northern Ireland. The Human Orrery is our latest activity. Participants can model day and night, the motion of the planets in their orbits around the Sun, as well as the positions of the planets in the sky from the perspective of the Earth. Finally, when we do our night time observing, they can see, for themselves, the placement of the planets in the night sky and compare what they see in the sky with the model they created with the Human Orrery. There are also plates to show the positions of the 13 zodiacal constellations. We have created a test/portable version of the orrery that was used in our fall camp (see lower right figure below). We will be hosting a Girl Scout overnight in February where scouts will help in the labeling and decorating of the individual plates for the permanent model. Girls will understand the concepts modeled by the human orrery, participate in its construction, and prepare presentation modules to facilitate at three other Girl Scout STEM events in Yuma, Nogales, and Safford.

Beyond the Camp: While the Astronomy Camp for Girl Scout Leaders goes beyond the Solar System, the activities that we have created have gone beyond the camps. Since time is limited (2.5 days), we have activities that have been developed but have yet to be presented at the camps. A number of these activities have been used at McCarthy's adult Astronomy Camp and at Sahuaro Girl Scout events.



Solar System scale models. Upper left: Earth-Moon relative sizes using clay balls. Upper right: A display at a Sahuaro Girl Scout Council event showing a variety of models including the relative sizes of the planets (back left), relative distances of the planets using macramé (middle), Earth-Moon relative sizes using clay balls (front right), and Earth-Moon relative distances using Styrofoam balls (across the back and right side). Lower left: relative distances of the inner planets with the macramé model. Lower right: "Portable" version of the Human Orrery.

The NIRCam E/PO website can be found at:

<http://zeus.as.arizona.edu/~dmccarthy/GSUSA>



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