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Parallax Park - A Bilingual, Outdoor, Interactive Family Exhibit

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Abstract. Parallax Park will be an outdoor, interactive family exhibit for McDonald Observatory. It will bring the quest for extra-solar planets and the astronomical distance scale down to Earth for the more than 100,000 visitors who come to the Observatory each year. The Park will teach visitors the basic principles of astrometry. It will concentrate on distance determination and extrasolar planet detection, and emphasize the advantages of space-based astrometry measurements. Visitors will experience parallax by traveling a path around a representation of the Sun, mimicking Earth's orbit, while viewing representations of stars at various distances and in various directions. Concepts include parallax, Cepheids as standard candles, the inverse square law, and motion around a center of mass. The exhibit includes interactive components suitable for children's use. Text labels and printed guides, in English and Spanish, will explain how to use the Park to explore the uses of astrometry in modern science. In addition auxiliary educational materials that align with the National Science Education Standards will be produced.

1. Introduction

Astrometry has enjoyed many recent triumphs, ranging from the results of the Hipparcos mission, producing high-precision parallaxes for tens of thousands of stars (Perryman *et al.* 1997) through very high-precision parallaxes from Hubble Space Telescope (e.g. Benedict *et al.* 2003) and the USNO program (e.g. Dahn *et al.* 2002). Modulo funding exigencies, the future looks equally bright. The Space Interferometry Mission (Unwin & Shao 2000) should produce astrometry with a precision of a few microseconds of arc for tens of thousands of stars. GAIA should obtain 20 microsecond of arc precision for hundreds of millions of stars (Perryman 2003). The improvements in astrophysics and galactic structure promised by such missions makes them an 'easy sell' to our professional colleagues. But what about the taxpayers who support such efforts? Parallax Park addresses them directly.

The Parallax Park design team consists of individuals from a number of organizations. Sandi Preston, Brad Armosky, Frank Cianciollo, and Marc Wetzel of McDonald Observatory Education and Outreach contribute overall management and education/public outreach expertise. Mary Kay Hemenway of the University of Texas Department of Astronomy provides astronomical education expertise. Ruth Freeman of Blue Sky Designs, Alan Ransenberg of Alchemy of Design, and Tip Wilson of 1+2 Inc provide museum-quality exhibit content and design expertise. Jim Rhotenberry provides architectural expertise. Together we have nearly completed the final design of Parallax Park. With a final design in hand, we will raise the funding required to build Parallax Park at a site next to the

Figure 1. **Entrance to Parallax Park**

existing McDonald Observatory Visitors Center. An exhibit like this requires line of sight to quite distant objects. West Texas provides this opportunity.

Two questions articulate our major themes: "How far away is that star?" "How do you find planets orbiting other stars?". We will be happy if the visitor walks away knowing how parallax works and that stars and planets orbit a common center of mass. We will be ecstatic if the visitor walks away with an appreciation for the inverse square law and how 'standard candles' give us the distances to everything else in the universe. Additional educational materials such as guide books for the general public and teacher guides for visiting classes will be provided. Through these we can explore any aspect of astronomy, from planetary exploration to cosmology. Of course our education goals follow the suggestions of the National Science Education Standards (NAS 1996).

A few disclaimers: the figures are presented in greyscale. The originals are in color. At this stage in the design process the Spanish has been translated from the original English by a computer program, not a bilingual astronomer.

We will now take you for a walk through Parallax Park and provide examples of a few of its already designed elements.

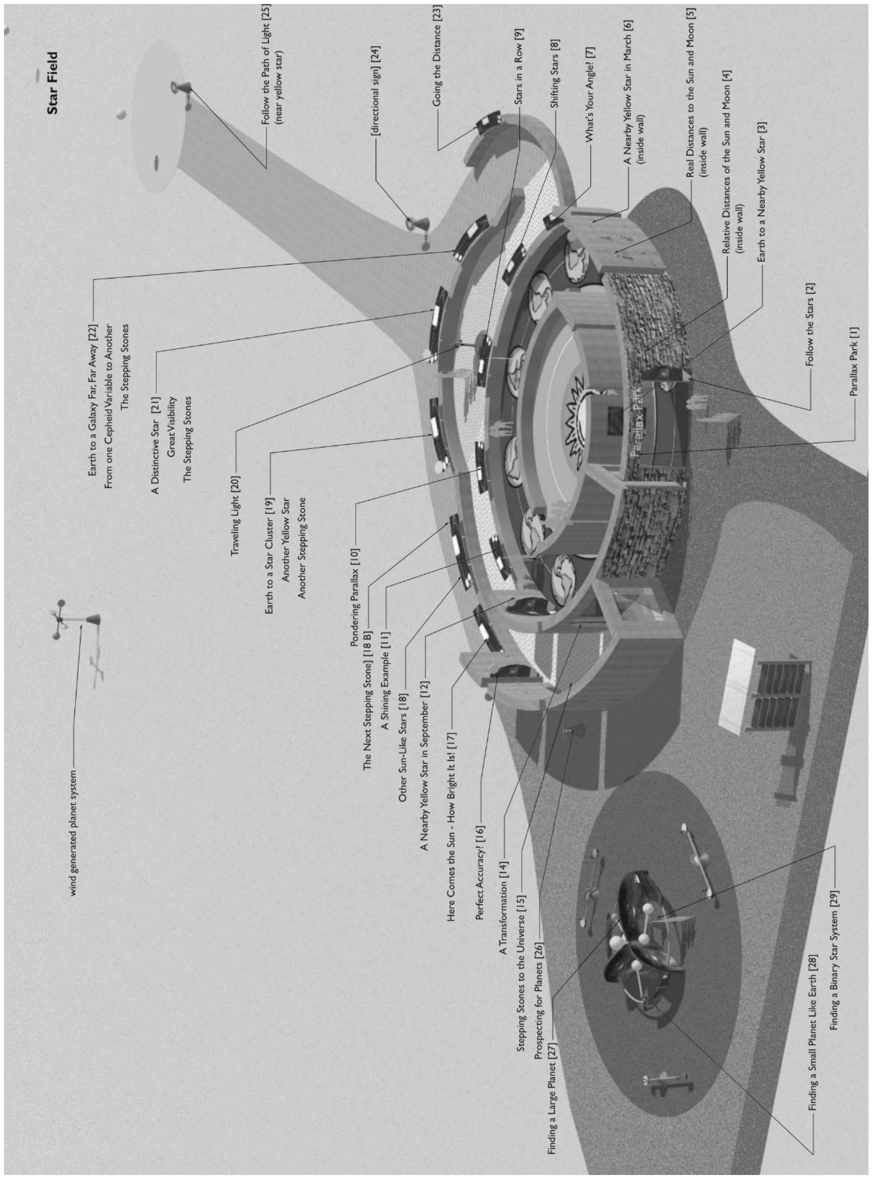

Figure 2. **A perspective view of the main section of Parallax Park. The outer wall of the inner circle is 60 feet in diameter.**

2. A Walk in the Park

Figure 1 presents an artist's rendition of the main entrance to Parallax Park. The playground area devoted to finding planets is at the left of the figure.

Figure 2 shows a perspective view of the main section of Parallax Park. We enter Parallax Park in 'January' at the bottom of the figure. For scale, the inner circle has a diameter of about 60 feet. Information panels will be attached both to the walls and displayed horizontally. The present design has about thirty of these panels. The first three introduce the Park and give an overview of the activities we will experience.

The third information panel (Figure 3) is encountered at January and is entitled "Earth to a Nearby Yellow Star". This panel introduces our guides, Stella and her Dad. Figures 4, 5, and 6 show details of this panel and give a flavor of the level of exposition and artistic style.

Figure 3. **General introduction to the first thematic area, measuring the parallax of a nearby star.**

By the time we pass through February we will have an appreciation of distances in the Solar System and an introduction to the history of the quest for parallax.

Figure 4. **Introducing Stella, a visitor to Parallax Park, where all children are above average.**

Figure 5. **Introduced Dad and a triangle.**

2.1. Measuring Relative Parallax

Continuing to walk the Earth's orbit, we reach March. Here we make our first parallax measurement. About 200 feet away we see a yellow 'star' and a white star (both globes on poles). Using finger widths, we measure the separation between the white star and the yellow star (at this point seen to the left of the white star). Proceeding along the orbit we have an opportunity to learn more about parallax and be gently directed to pay attention to the shifting position of the yellow versus the white star. We learn about Copernicus and the assertion that motion around the Sun should cause the stars to exhibit parallax. We learn of Bessel's success, and find out why it took so long. The parallactic shift of 61 Cyg is compared to the size of a grain of salt sitting up on the Hobby•Eberly Telescope dome.

At last we reach September and make our second measurement of the separation between the white star and the yellow star, at this point seen to the right of the white star. We now know the yellow star is closer to us than the white star. With this knowledge available for many thousands of stars, the night sky becomes three dimensional. We peer through 3-D glasses at the 61 Cyg star field represented as an anaglyph. 61 Cyg floats in front of the stars in the field, some of which are so far away they show no parallax. We see Stella and Dad leaping from the first to the second stepping stone, stones that represent the many intermediate steps required to establish the distance scale of the Universe by linking nearby to more distant objects.

2.2. Measuring Absolute Parallax

But wait! We saw both the yellow AND white stars exhibit parallax. How do we determine the true distance to the yellow star? By measuring the parallax angle from stars that exhibit no parallax, stars 90 degrees away from the yellow star. We experience for ourselves the difficulty of such a measurement using finger widths. We find out that space is the best place for such measurements and learn of the spacecraft Hipparcos and the Space Interferometry Mission. Once through September we leave the orbit of the Earth and move outward towards new stepping stones.

3. Standard Candles and the Inverse Square Law

First we watch Stella and her Dad interact with everyday ordinary candles. They remind us that a distant candle appears fainter than one nearby. We then make the leap to stars. Are some stars the same, like many candles are the same? Yes. Stella shows us two stellar spectra, one the Sun, the other a sun-like star. (Here we shamelessly plug the existing McDonald Observatory Visitors Center which has an entire exhibit dedicated to spectroscopy.) Here is the next stepping stone. Comparing the brightness of the Sun to other sun-like stars can provide their distance.

3.1. A Cluster of Stars

We immediately apply this technique to a star cluster seen out in the field, much further away than the yellow and white stars with which we just interacted. The cluster contains a yellow sun-like star. We therefore know its distance, if we understand and use the inverse-square law. The next few panels introduce that concept with diagrams. In Parallax Park the yellow star in the cluster is nine times fainter than the nearby yellow star. Thus it is three times further away. We then encounter a device permitting us to demonstrate this concept for ourselves. By moving a screen with an impressed grid pattern closer to and further from a point source of light, we see that doubling the distance decreases the light intensity in each section of the grid by a factor of four.

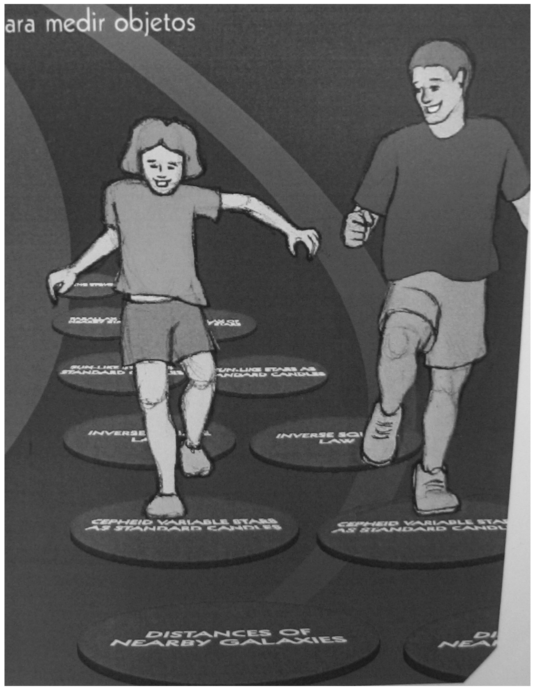

Figure 6. **Leaping to the last distance determination stepping stone. From back to front the stepping stone labels are: Stepping Stones; Parallax of Nearby Stars; Sun-like Stars as Standard Candles; Inverse Square Law; Cepheid Variable Stars as Standard Candles; Distances of Nearby Galaxies**

3.2. The Great Leap Outward - Cepheid Variables

As luck would have it, our star cluster contains a Cepheid variable star. Out there in the field, that star is in fact changing its brightness. Instead of a 10 day long cycle, ours has a thirty second cycle. We find out that Cepheids are easy to spot because they vary in brightness. We spin a zoetrope and watch a Cepheid expand and contract, becoming fainter and brighter as it does. We are told that the more intrinsically bright the Cepheid, the longer its cycle. We find out that they are very valuable standard candles because they are intrinsically bright and can be seen at great distances.

We now lift our eyes up to the ridge road connecting the HET and Mt. Locke and see a fainter Cepheid varying its brightness at the same rate as the Cepheid in the cluster. Because they vary with the same cycle time, we know they have the same intrinsic brightness. Because the other one is fainter, it is further away. At Parallax Park this distant Cepheid lies in an external galaxy. We have made the final leap to the last stepping stone discussed on panels in our exhibit (Figure 6).

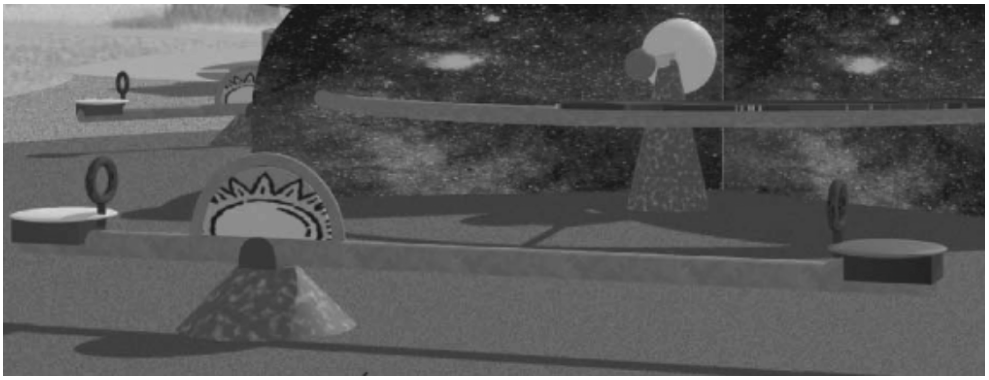

Figure 7. **Center of mass demonstration devices.**

Walking through Parallax Park we have measured distances of stars that could in reality range from 4 light years to over 15 million light years away. The Hubble velocity-distance relationship will be discussed in the supporting optional materials.

Our final (and optional) trek for this section of Parallax Park takes us out to the nearby yellow star, the one whose distance we measured using the white star as a reference point. On the ground around the yellow star will be another visual reinforcement of the inverse square law. As we walk on the path to the nearby yellow star, we see visible indications of intensity of light in relation to our proximity to the star. We see why the star's light looks less bright as we move away from the star. Here is another demonstration that light from stars radiates in all directions. The greater the distance the light travels, the less bright it appears because the same amount of light is spread further apart as it travels away from the star.

4. Prospecting for Extrasolar Planets

We now mosey on over to the Planet Playground. Here we find out that we cannot easily see planets orbiting around stars outside our solar system, because the star is always far brighter than the planet. However astronomers can find these planets by detecting a telltale "wobble" in the light coming from some stars. From our position on Earth we can detect an invisible planet by changes in the position of the light from the star (the wobble), as it completes each regular cycle of movement around a common center of mass. We observe the light from the star wobble from side to side. Astronomers also measure the change in velocity of a star to find otherwise unseen companions. We can get more information about this method over at the Spectroscopy exhibit.

4.1. Spin Cycle

By interacting with three 'systems' we now experience directly the concept that stars and stars - and stars and planets - orbit a common center of mass. These systems look like old-fashioned barbells, bars with balls on either end. Big yellow balls are stars. Smaller balls represent planets. We can spin all three systems around and see that each balances across the fulcrum. Planets cause smaller wobbles than do stars. The smallest planets cause the smallest wobbles of all. We are urged to look out at the star field and see one star wobbling back and forth almost imperceptibly. This is a wind-driven version of the star-smallest planet system

4.2. Teetering Towards Understanding

As a final demonstration of center of mass we get to play on teeter-totters. The seesaw is balanced when the mass at each end corresponds to the Star and the planet like Earth. The fulcrum represents the common center of mass. When the mass of the objects at each end of the seesaw differs, the position of the common center of mass changes. At this writing, the details of this interactive are not yet established, as we deal with liability issues. Figure 7 shows our most recent idea, but still lacks some safety features mandated by state and federal guidelines.

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