Adapted From AAC Newsletter FirstLight (2009 Jan/Feb)

[Note: The proposed asteroid garden had never been built due to lack of funds.]

An "Asteroid Garden" for the Gainesville Solar Walk And an Asteroid Primer

By Howard L. Cohen

A new feature for the Gainesville Solar Walk, an asteroid belt or "garden," remains unfunded including a low-cost design that will still retain both the science and art of this unique Gainesville landmark. Article also includes a brief primer on asteroids

Introduction

ost residents of the Gainesville area know that N.W. 8th Avenue between N.W. 34 Street and N.W. 23rd Street houses a unique landmark—a four billion to one scale model of the Solar System (Figure 1). Stretching almost a mile along this popular and heavily-



author.



Fig. 2. Comet Halley Sculptures. Two sculptures represent the aphelion (I.) and perihelion (r.) positions of this famous comet in the Gainesville Solar Walk. The perihelion sculpture sports a tail, common with comets when in the inner solar system. Photo by author.

traveled street, people can walk, bike or drive and marvel at the vast distances between ten foot high sculptures representing the Sun and its nine planets. (Yes, Pluto is still number nine!) While many other scale models exist, the Gainesville Solar Walk has both a scale and linearity that best helps visualize and appreciate the scale of planetary orbits.

Our Solar Walk is also a unique blend of science and art with its ten, imposing sculptures representing the Sun and its horde of planets.

Conceived in 1998 and initially constructed in 2002, Fig. 1. The Gainesville Solar Walk. A scale model of this "solar walk" was a joint project of the Alachua the Solar System, scaled four billion to one, stretches Astronomy Club, Inc. (AAC), the Division of Cultural nearly one mile along NW 8th Avenue in Gainesville. Affairs of the City of Gainesville and Tarpon Springs Florida from NW 23rd Street to NW 34 Street. Photo by artist, Elizabeth Indianos. Funds, materials and labor to construct the Gainesville Solar Walk came primarily from donations by members of the AAC, the

City of Gainesville, community members, businesses, and the artist.

(Lists of major donors can be found on bronze plaques mounted on the back sides of the Sun and Pluto sculptures. Also, see www.floridastars.org/solarwalk/ssdonors.html for a list of donors.)

Later enhancements by the artist include two "star benches" and a pair of two interpretive signs (2006) designed and created by the author, the artist, graphic designer Saydi Kaufman and the Art in Public Places Trust (APPT), which oversees the purchase of public art for the City. Recently(2008) the City added two small sculptures by the artist (Figure 2) representing the near and far points of Comet Halley (*perihelion* and *aphelion* respectively). This feature allows one to "walk" the walk while gaining an appreciation for the enormous range in distance this most famous comet travels toward and away from the Sun.

Additional enhancements have been suggested but not constructed due to lack of funds. For example, a proposed, addition is a garden. This garden is not necessarily filled with plants but with rocks or their representations to illustrate an important feature of our solar system—a vast belt of *asteroids* that populates part of the wide region between the last inner planet Mars and the first outer planet Jupiter.

Last year the AAC submitted a \$25,000 capital grant proposal to the city's Tourist and Development Center to fund the asteroid belt for the Solar Walk based on a design by Elizabeth Indianos. This feature consisted of a series randomly placed, silicon carbide dust, oblong concrete "asteroids." Sizes would have ranged from 18 - 38 inches, with the majority being midrange and smaller. The placement was to begin 65 feet from the Mars sculpture and end 150 foot farther out, illustrating where most asteroids orbit.

Unfortunately, the Tourist and Development Center proposal chose not to fund this project. However, the APPT still wishes to add this meaningful enhancement and is currently seeking alternative ideas for a less expensive design.

New Ideas Are Welcome and Encouraged

Readers are encouraged to forward practical, low-cost ideas and designs for construction of an "asteroid garden." Plans must be commensurate with the science and art inherent in the Gainesville Solar Walk and fit naturally into the existing project. You can be as detailed as you wish. No budget is yet established but it is likely that the APPT will need a model that they can implement at a total cost of less than \$5,000. Be creative. For example, the "garden" itself need not consist of separate asteroids but could be a stylistic "wall" symbolizing the distribution of asteroids in the main belt.

Therefore, to execute a design for the "garden" that expresses both science and art, one needs basic knowledge of the asteroid belt. Since the asteroid feature should communicate accurate information about the asteroids and the asteroid belt while keeping an artistic flavor, designers should be familiar with basic attributes of asteroids. The remainder of this article is a brief primer about asteroids that may help. This primer is not intended to be a complete discourse on all features of asteroids (e.g., history, nomenclature, origin, evolution, etc.). Instead, the next sections give relevant information important for planning an asteroid feature for the Gainesville Solar Walk.

Send your ideas to the author at 8952 S.W. 92 Lane, Gainesville, FL 32608 or by e-mail (cohen@astro.ufl.edu). Questions? Call (352-495-1811) or use e-mail.

A Brief Asteroid Primer

Asteroid Orbits

Asteroids, sometimes known as *minor planets*, are small chunks of rock and metal orbiting the Sun. The *main asteroid belt* is between Mars and Jupiter where probably 95% of the asteroids roam (Figure 3).



Fig. 3. Main Asteroid Belt and Trojan Asteroids. Diagram looks down on Earth's orbit 2006 August 14. The Main Belt stretches from about 2.1 to 3.3 AUs from the Sun. (An AU or astronomical unit is Earth's mean distance from Sun.) Two large asteroid families ("Trojans") also precede and follow Jupiter by 60° where two gravitational stability zones occur (*Lagrangian Points L4 and L5*). Another family ("Hildas") orbits between 3.5 and 4.2 Aus. Diagram based on data in JPL DE-405 ephemeris and Minor Planet Center database of asteroids (2006 July 6).Rendered by custom software written for Wikipedia. Diagram redrawn by author using Wikipedia image.

However, some asteroids wander within the orbit of Earth or even closer to the Sun than the innermost planet Mercury, while others precede and follow Jupiter (labeled "Trojans" or "Greeks" in Figure 3).

In addition, most main belt asteroids orbit at preferred distances from the Sun so that the distribution of asteroid orbits shows gaps or dips where fewer asteroids are found. These locations result from resonances with Jupiter's orbit period around the Sun. Periodic gravitational interactions between Jupiter and the asteroids result in unstable orbits at distances from the Sun where their orbital periods are related by small integers. See Figure 4.

For example, few asteroids orbit the Sun at a distance of 2.50 astronomical units corresponding to an orbital period of 3.95 years, which is one-third of Jupiter's 11.86 year orbital period. These "gaps" were first identified by Indiana University astronomer Daniel Kirkwood in 1857 and bear his name.

Note: An *astronomical unit* or **AU** is the Earth's mean distance from the Sun, or about 93 million miles, a distance of 123 feet in the Gainesville Solar Walk (scaled four billion to one).

Inspection of Figure 4 shows the vast majority of the asteroids have orbits from about to 2.1 to 3.3 AUs from the Sun. This corresponds to a main belt about 150 feet wide in the Gainesville Solar Walk starting about 65 feet beyond Mars and ending about 215 past the red planet (Figure 5).

Many orbit diagrams of the asteroid belt appear to show the asteroid belt



Fig. 4. Main Asteroid Belt Distribution: Kirkwood Gaps. Resonances with Jupiter's orbit period influences the distribution of asteroid orbits leaving gaps in the belt where fewer asteroids orbit. Several resonances are labeled in the figure. Diagram by author using histogram from Wikipedia (created by NASA).



very cluttered with asteroids (e.g., see Figure 3). Also many movies (especially science fiction) emphasize this feature by showing space ships trying to avoid imminent collisions with these "space rocks." This is misleading. The actual space between Mars and Jupiter is about 340 million miles. The corresponding distance between Mars and Jupiter in the Gainesville Solar Walk is

are probably *miles* or several feet in the Solar Walk. In addition. most

Fig. 5. Location of the Main Belt Asteroids in Gainesville Solar Walk. Inset about 450 feet. However, the shows position of main belt in Solar System. The main belt's position scaled to the average spacings between dimensions of the Solar Walk is shown in the main diagram. The main belt would asteroids begin approximately 65 feet beyond Mars and extend 150 feet ending about 215 feet several million farther out. Diagram by author.

asteroids are very small and would have scaled dimensions much less than 0.01 inches in the Solar Walk. (See next section on asteroid dimensions.) Consequently, illustrating the actual dimensions in the scaled solar system is a challenge!

So, the asteroid belt is guite empty with the distances between asteroids very large. In fact, spacecraft flying through the asteroid belt would probably never encounter or see an asteroid. Indeed, collisions between asteroids are now rare and a spacecraft passing through the asteroid belt has little chance of colliding with one. (Asteroids may have formed from planetary accretion in the early Solar System with subsequent collisional fragmentation of larger objects when the density of objects was very high.)

Asteroid Dimensions

More than 100,000 asteroids have now been observed but they could number in the millions. Estimates of asteroid numbers and dimensions show that all asteroid material would make up an object less than half the diameter of our Moon.

Asteroids range in size from several very large ones as 1 Ceres (largest with a diameter just less than 600 miles) to many smaller ones less than a mile wide, even down to small stones. (Asteroids are numbered and often named.) For comparison, the Moon and Earth are about 2,160 and 7,920 miles across respectively. Ceres, scaled to the dimensions of the Gainesville Solar Walk would be less than 0.01 inches across! (Note: Some astronomers now consider Ceres large enough to be called a *dwarf planet*.) Clearly dimensions of asteroids in the Solar Walk cannot be easily represented by their true scaled sizes.

About twenty-six known asteroids are larger than 125 miles across. Many are in the six to 60 mile range. We do not know much about the smaller ones but there may be more than a million onemile sized asteroids or smaller (tiny as pebbles). See Figure 6.

Only the largest asteroids are likely to be approximately round, most are probably irregular in shape. (Strong gravity is needed to pull objects into a round shape.) Some shapes may have resulted from occasional asteroid collisions, especially in the early solar system. Impact craters are also common on asteroids suggesting violent past encounters with other solar system bodies (Figure 6).

Asteroid Reflectivity and Composition

Most asteroids are quite dark. About 75% probably reflect only about 3% of the light shining on them although some have reflectivities of about 15% to 25% (called the *albedo*).



Fig. 6. Mosaic of Three Large Main Belt Asteroids. Images from spacecraft. The two known Martian satellites are shown for comparison since these satellites are probably asteroids captured by Mars.(Few asteroids have been imaged close up.) Images scaled to one another with arrow indicating about 10 miles. Photo Credits NASA. Mosaic created by author.

Asteroid 4 Vesta, second largest asteroid with a diameter of about 320 miles, may be among the lightest, with a reflectivity of perhaps about 40%. Asteroid 253 Mathilde, an irregular 40x30 mile asteroid, is more typical and probably reflects only about 3% of the light on the average. An intermediate case is 11x7 mile asteroid 951 Gaspra, possibly reflecting about 20% of the light shining on it.

Many asteroids are believed to contain iron and nickel but most are probably more "stony." Three main categories include the following:

C-Type or carbonaceous asteroids are most common (about 75%), especially in the outer part of the asteroid belt. They containing silicates, oxides, sulfides and volatile organic (carbon) compounds plus water-containing minerals. They are very dark (reflectivity about 3–9%). Their composition is probably similar to the original solar nebula out of which the Solar System condensed but have less hydrogen and helium.

S-Type or silicaceous or stony asteroids are less common (about 15%) and are found mostly in the inner asteroid belt. These asteroids tend toward grey with intermediate or moderate reflectivity (about 0–22%). They contain mostly silicaceous material (metallic iron mixed plus iron-silicates and magnesium-silicates forming silicate minerals as olivine and pyroxene), and are commonly known as "stony asteroids."

M-Type or metallic asteroids are least common (about 10%) and have moderate reflectivity (about 10–18%) and many are rich in iron and nickel with possibly small amounts of stone.

Other minor groups exist such as composite asteroids, a mix of more than one type and result from coalescence or collision.

References

Arnett, B. 2008, *Asteroids* from "The Nine Planets" (www.nineplanets.org/asteroids.html). Cunningham, C. J. 1988, *Introduction to Asteroids* (Willmann-Bell, Inc., Richmond). Gehrels, T., Ed. 1979, *Asteroids* (University of Arizona Press, Tucson).

National Space Science Data Center 2008, *Asteroids* in "Lunar and Planetary Science," (nssdc.gsfc.nasa.gov/planetary/planets/asteroidpage.html).

Wikipedia 2008, Asteroid (en.wikipedia.org/wiki/Asteroid).

Wikipedia 2008, Kirkwood gap (en.wikipedia.org/wiki/Kirkwood_gaps).

Howard L. Cohen is an emeritus professor in the University of Florida's Department of Astronomy, a founding member of the Alachua Astronomy Club, Inc., and a current member the club's executive board. The AAC appointed Dr. Cohen to represent the AAC at APPT meetings in matters relating to the Gainesville Solar Walk.