


## The Farnese Atlas

Ancient Roman Sculpture
Records the lost star atlas of Hipparchus ( 125 BC )

Bradley Schaffer, LSU

This globe records 41 constellations accurately placed against a grid of reference circles, including the equator, tropics, Arctic circle, and Antarctic circle. As the constellation positions shift over time (due to precession as discovered by Hipparchus), the position of the constellations on the Titan's globe reveal the date of observations used by the sculptor.


The Alexandria - Syene Baseline used to measure the solar system in antiquity


## Lunar Eclipses

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- A lunar eclipse occurs when the Earth passes between the Sun and Moon, with the Earth casting its shadow on the Moon giving it a dull red color


## Recent and Upcoming Solar Eclipses

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## Solar Eclipse from Space



How fast does that shadow move?




|  | Sidereal period (yr) | Synodic period (yr) | Synodic period (d) |
| :--- | :---: | :--- | :--- |
| Solar surface | $0.069^{[1]}(25.3$ days) | 0.074 | 27.3 |
| Mercury | 0.240846 (87.9691 days) | 0.317 | 115.88 |
| Venus | 0.615 (225 days) | 1.599 | 583.9 |
| Earth | 1 (365.25636 solar days) | - | - |
| Moon | 0.0748 | 0.0809 | 29.5306 |
| Apophis (near-Earth asteroid) | 0.886 | 7.769 | $2,837.6$ |
| Mars | 1.881 | 2.135 | 779.9 |
| 4 Vesta | 3.629 | 1.380 | 504.0 |
| 1 Ceres | 4.600 | 1.278 | 466.7 |
| 10 Hygiea | 5.557 | 1.219 | 445.4 |
| Jupiter | 11.86 | 1.092 | 398.9 |
| Saturn | 29.46 | 1.035 | 378.1 |
| Uranus | 84.32 | 1.012 | 369.7 |
| Neptune | 164.8 | 1.006 | 367.5 |
| 134340 Pluto | 248.1 | 1.004 | 366.7 |
| 136199 Eris | 557 | 1.002 | 365.9 |
| 90377 Sedna | 12050 | 365.1 |  |
|  |  |  |  |
|  |  |  |  |

Until Herschel, Bessel and others in the 18 th C succeeded in detecting stellar parallax, its non-detection was held up as major evidence of the Earth's place at the immovable center of the universe.

## The Distance to Sirius

- Measured parallax angle for Sirius is 0.377 arc second
- From the formula,

$$
\begin{aligned}
d_{p c} & =1 / 0.377 \\
& =2.65 \text { parsecs } \\
& =8.6 \text { light-years }
\end{aligned}
$$



The Hipparcos satellite measured parallaxes for $\sim 1$ million stars
Range is limited by positional error (about 1-3 mas) -> 300 pc

## gaia

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## Missions

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## Mission Operations

Mission Operations

Gaia is an ambitious mission to chart a three-dimensional map of our Galaxy, the Milky Way, in the process revealing the composition, formation and evolution of the Galaxy. Gaia will provide unprecedented positional and radial velocity measurements with the accuracies needed to produce a stereoscopic and kinematic census of about one billion stars in our Galaxy and throughout the Local Group. This amounts to about 1 per cent of the Galactic stellar population.

## LATEST NEWS



## Europe bids Gaia a safe journey

27 June 2013 ESA's billion-star surveyor, Gaia, has completed final preparations in Europe and is ready to depart for its launch site in French Guiana, set to embark on a five-year mission to map the stars with unprecedented precision. Read more

News archive

COUNTDOWN TO LAUNCH - THE GAIA BLOG

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Gaia has arrived in French Guiana

Unfolding Gaia

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## GAIA Probe



## Lissijou figure Orbit around solar L2 1.5 million km from Earth



For How many Stars can we use parallax to measure distance?
From ground, $e_{p}(\min ) \approx 0.3^{\prime \prime}$ at best. So the further star we could even hope to measure is at distance $\frac{1}{0.3^{\prime \prime}}=3 \cdot 3 p c \quad\left(\right.$ even $\left.0 \cdot 1^{\prime \prime} \rightarrow 10 p c\right)$ There are not many stars that close. of the 20 nearest stars, all are within $3.5 p c$. So, only $\approx 20$ stars toul! From space the Hiparcos satellite with $\Delta \theta_{p} \approx 1 \mathrm{mas}\left(10^{-3}\right.$ ")

$$
\begin{aligned}
& \text { The Hiparcos Satellite } \\
& D_{\text {max }} \cong \frac{1}{10^{-3}}=1000 \mathrm{pc}(\mathrm{kpc}) \text {, but with error } \pm 1000 \mathrm{pc} \text { ! }
\end{aligned}
$$

But, requiring a good measurement implies perhaps $\frac{\theta_{p}}{\Delta \theta_{p}} \geqslant 3$
So that $\theta_{p}(\min ) \rightarrow \frac{1}{3 \times 10^{-3}}=333 p c$.
For the purposes of perspective,
The Sun lies 8.5 kpc from
Center of our galaxy. $\rightarrow$ So even in Space, we
 can meas re distances to stars only $\frac{1}{25}$ th of the way the GC! (Tiny!) TO GO further $\rightarrow$ Calibuite "Std Candles !"

## Geometry of the Tidal Force Vector Components



Earth

$$
\begin{aligned}
& F_{P, x}=\frac{G M m}{s^{2}} \cos \phi \\
& F_{P, y}=\frac{G M m}{s^{2}} \sin \phi \\
& \Delta F \approx \frac{G M m R}{r^{3}}(2 \cos \theta-\sin \theta)
\end{aligned}
$$

## Resultant Tidal force vectors


(a)

Gravitational force of the Moon on the Earth

(b)

Differential Gravitational force on Earth, relative to its center.


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