



<u>The Farnese Atlas</u> 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

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Solar Eclipse from Space

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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	1.00001	365.1

Parallax

Until Herschel, Bessel and others in the 18th 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,

 $d_{pc} = 1/0.377$ = 2.65 parsecs = 8.6 light-years



The Hipparcos satellite measured parallaxes for ~1 million stars Range is limited by positional error (about 1-3 mas) -> 300 pc Planned GAIA mission will measure 1 billion gaia

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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.

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Science@ESA: Episode 6: Charting the Galaxy



· Gaia has arrived in

French Guiana

Unfolding Gaia

GAIA Probe



Lissijou figure Orbit around solar L2 1.5 million km from Earth



For the purposes of perspective,
to the since
$$\frac{\partial Stars}{\partial Stars}$$
 can use use parallax to
Meetine $\frac{\partial Stars}{\partial Stars}$?
From ground, $\frac{\partial G_{P}(mn)}{\partial x O 3}$ at best. So the furthed star we could
even hope to measure is at distance $\frac{1}{O 3''} = 3\cdot 3pe$ (even $0\cdot 1'' \rightarrow 10p$)
There are not many stars that close.
of the 20 nearest stars, all are unitin $3\cdot 5pc$. So, $0ndy \approx 20$ stars tabl!
From space the thipscass satellate with $\Delta Op \approx 1mar$ ($10^{3''}$)
 $D_{max} \approx \frac{1}{10^3} = 1000 pc$ ($1kpc$), but with error $\pm 1000 pc$!
But, requiring a good measurement implies perhaps $\frac{Op}{\Delta Op} \ge 3$
For the purposes of perspective,
the Sun likes $8\cdot 5kpc$ from
 $Can measure distances to Stars
 $only = \frac{1}{25}th$ of the way to the GC! (Tiny.)
 $The Go further perhaps to the GC! (Tiny.)
 $The Go further perhaps to the GC! (Tiny.)$$$

Geometry of the Tidal Force Vector Components



Resultant Tidal force vectors



Gravitational force of the Moon on the Earth

Differential Gravitational force on Earth, relative to its center.



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