

M13 Globular Cluster - Beauty and Mystery

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- Hubble Photo. History. Description.
- Orbit. Formation. Fast Pulsars Anomaly.
- Opportunities for Up-and-Coming Scientists.

M13 Globular Cluster - Hubble Photo

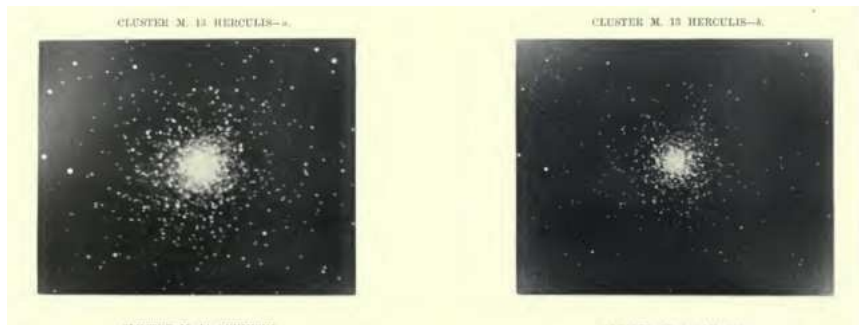


- M13 Globular Cluster in Hercules Constellation.
- Image taken by the Hubble Space Telescope.

M13 Globular Cluster History

- Messier M13 = NGC 6205 Hercules Globular Cluster
 - 1714 – Discovery by Edmond Halley.
 - 1764 – Messier adds M13 to his non-comet list.
 - 1779 – M13 Single stars visually resolved.
 - 1895 – Decent M13 astrophotos using 20-inch reflector.
 - 1914 – First M13 Spectral Stats (39 stars avg F0).
 - 1931 – Accurate M13 Star Position Measurements.
 - 1997 – Hubble UV Spectra of M13 and M3 Cores.
 - 2002 – Another M13 Orbit Calculation.
 - 2009 – Not Enough M13 Millisecond Pulsars.
 - 2023 – Baumgardt GC parameters catalog (v4).
 - 2026-June – Another GC Formation Model.
- Resources:
 - Excellent catalog of GC info. Click on NGC-6205.
<https://people.smp.uq.edu.au/HolgerBaumgardt/globular/>
Version 4 is dated March-2023.
 - Wiki article "Globular clusters"
well-written, coherent, explanatory, many refs.

Early Astrophotos of M13 (NGC 6205) - 1 of 2



- Right image is 60-min exposure with 20-inch reflector. Left image is 5-min exposure, same scope, of core.
- Source: Vol.2, pp 173-174, and plate preceding pg 173, "Photographs of Stars, Star-Clusters and Nebulae", by Isaac Roberts, 1899. Avail at archive.org.

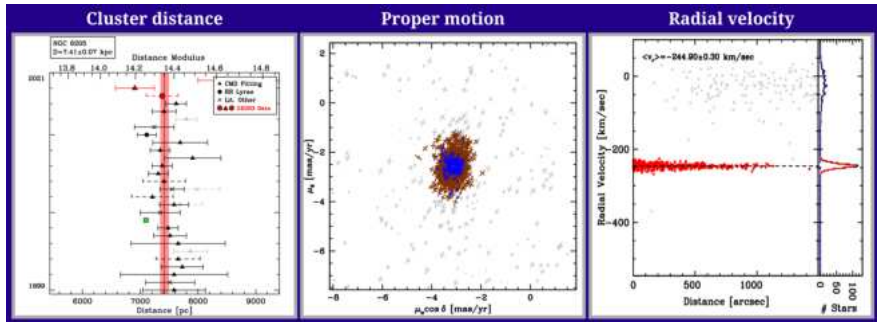
Early Astrophotos of M13 (NGC 6205) - 2 of 2

- Comments by observer were written (1899) when the Milky Way was considered to be the Universe. Andromeda and other galaxies believed "like-sized" to globular clusters.
 - "The general configuration of the stars [of M13] are suggestive of their development from a spiral nebula."
 - "The forms of the convolutions still remain visible in the arrangement of the stars, while the nebulous matter appears to have been absorbed, and the nuclear condensations at their centres account for the dense aggregations of stars."
 - "Central nebulosity in the great nebula in Andromeda, and in some of the other spiral nebulae, would furnish ample materials for the formation of such clusters as [M33, M14, and M2]."
- His observations re streamers around globular clusters may be worth investigation. Could arm gaps in galaxies relate to mass loss via spinoffs of angular momentum?

M13 Description

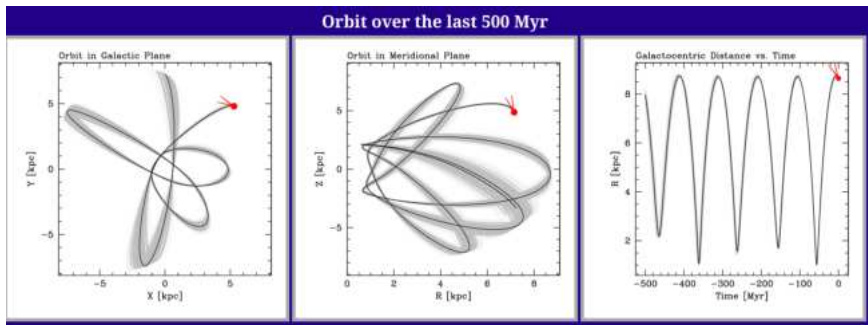
- Messier M13 = NGC 6205 Hercules Globular Cluster
 - Distance from Sun 24.1 Mly = 7.4 Kpc.
 - Observing Coords: RA 250.421814, DEC +36.459862.
 - Mass 484,000 solar masses.
 - Half-mass radius: 5.21 pc = 17 Lyr.
 - Apparent visual diameter about 20 arcmin.
That is, diameter 43 pc or 140 Lyr.
 - Half-mass radius is one-quarter of visual radius.
 - Galactic Coords:
 - x = 5.29 Kpc, velocity u = 30.36 km/sec.
 - y = 4.81 Kpc, velocity v = -14.96 km/sec.
 - z = 4.86 Kpc, velocity w = -77.75 km/sec.
 - Speed wrt galaxy about 86 km/sec or Mach 250.
 - Passes thru galactic plane about every 100 Myr.
 - Age of M13 about 12 Gyr (11.65 Gyr?).
Maybe 100-120 passages thru galactic plane?
Astonishing stability vs tidal disruption.

M13 Position and Velocity wrt Sun



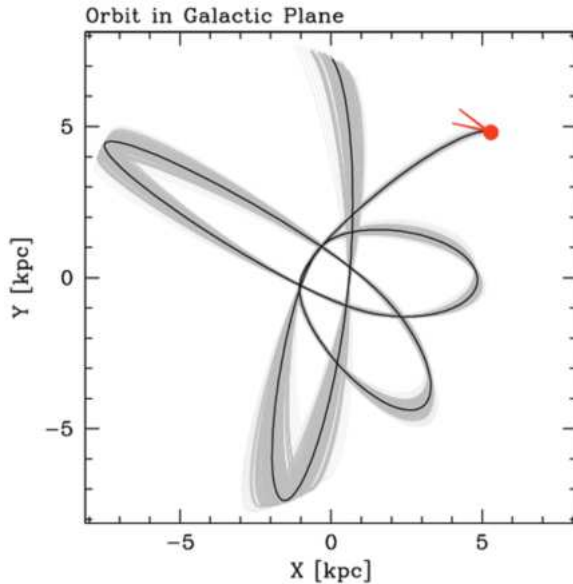
- Info from Baumgardt Catalog for NGC 6205.
 - Left: Cluster distance from Sun. Red band indicates distance is about 7420 pc.
 - Center: Proper motions of stars in cluster. Blue region indicates RA and DEC change rates milli-arcsec/year.
 - Right: Radial velocity towards Sun. Red histogram indicates radial velocity -245 km/sec.

M13 Recent Orbit wrt Milky Way - Overview

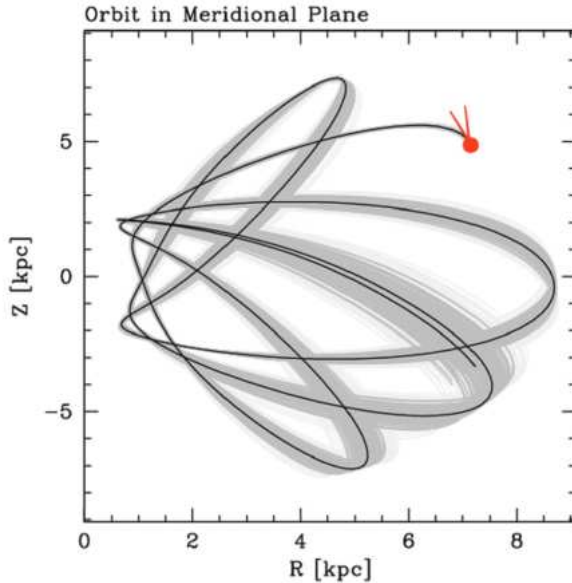


- Recent Past 500 Myr Estimate via Baumgardt Catalog.
 - Left: Orbit projected on X-Y galactic plane.
 - Center: Orbit projected on R-Z meridional plane. Symmetry of distance R creates bounce illusion.
 - Right: Distance R to MW center vs past Time.
- These will be shown in detail next 3 slides.

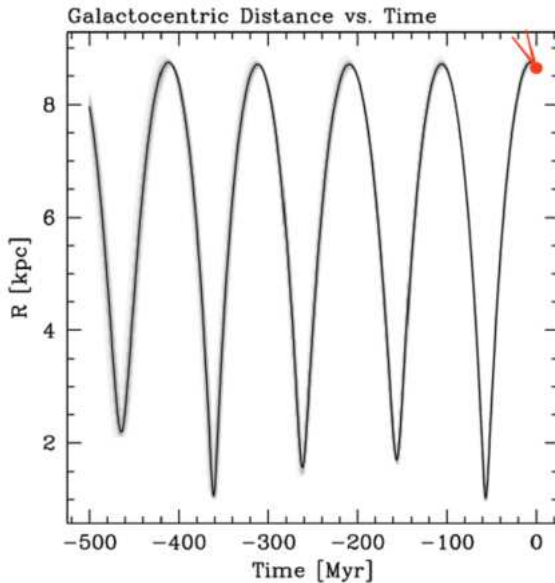
M13 Past 500 Myr Orbit in X-Y Plane



M13 Past 500 Myr Orbit in R-Z Plane



M13 Past 500 Myr Orbit R vs Time



- How Were Globular Clusters Formed?
 - GCs are very old, order of 10 Gyr.
"Population II" stars, low metallicity. Recall the astronomical terminology: Elements heavier than H or He are "Metals".
 - Recent (June-2026) paper reports on simulations of galaxy disk formation at redshift 7.6, that is, 13.8 Gyr ago.
 - Quick version: In early galactic disks, low-density, weakly-rotating, gas-rich clusters born from cosmic filaments seem to survive. The distribution of their stellar kinematic properties seem to coincide with some properties of modern globular clusters.
 - Source: Arxiv 2606.27426, "Cosmic Wallflowers".
 - Source: Physics.org 2026-07, "Cosmic Wallflowers".

- Hypothetical Simplified Sketch:
 - Early galactic disks fragment. Especially in gas-rich turbulent systems, or due to galaxy interactions or dense outflows. Filaments form outside of the galaxy.
 - Filaments contract gravitationally towards clusters. They lose angular momentum through two-body and tidal interactions. Hot, pressure-supported clusters survive whereas cold clusters are likely to be tidally disrupted.
- Hence longevity of GCs from proto-clusters which are:
 - Low-density (fewer two-body interactions).
 - Weakly rotating (less angular momentum).
 - Gas-rich (burn hotter, can transition to being pressure-supported).

Not Enough Millisecond Pulsars in M13?

- How many Millisecond Pulsars should be in M13?
 - Paper 2009 by Jogler, et al, "MAGIC observation of Globular Cluster M13 and its millisecond pulsars", Arxiv 0907.0987v1.
 - Estimates M13 should have about 100 fast pulsars, but only five have been found, with periods 2-10 msec.
 - I have NOT made a detailed study of this topic, but maybe worth checking for papers re fast/all pulsars in GCs.
- Possible interesting approach:
 - EM/plasma damping in GCs may cause faster than usual spindown of all pulsars, change pulsar population stats.
 - Maybe also lower frequency of glitches (sudden increases in spin).
 - Isolated pulsars vs pulsars in GCs different contexts. Look for contrasts. Entropic interpretations perhaps.

Opportunities for Up-and-Coming Scientists

- Globular Cluster studies offer unlimited opportunity.
 - Oldest well-structured stable objects in cosmos, near enough to be observed in detail, encoding history of past environments in structure and spectra.
 - Many great scientists developed via careful, thoughtful study of details of Nature: Newton, Archimedes, Darwin, Feynman, Fourier, Faraday are a few familiar names.
- Some Fields and Topic Areas:
 - Astronomy: Instruments, Models, Lensing.
 - Physics: Mechanics, Plasmas, Thermodynamics.
 - Chemistry: Spectra, Streamers, Molecules.
 - Biology: Homeostasis, Evolution, Feeding.
 - Math and Stats: Models, How we Know.
 - Compute and ArtInt: Are GCs Eigenvectors?

Merci, et Bon Chance !