

THE INSIDE ORBIT VOLUME 46, ISSUE 2

September—November, 2011

THE QUARTERLY NEWSLETTER OF
THE GRAND RAPIDS AMATEUR
ASTRONOMICAL ASSOCIATION

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"The long sobs

Of the violins of autumn

Wound my heart

With a monotonous languor."

Perhaps Verlaine was a bit melodramatic describing the changing season but his words do convey the melancholy of saying farewell to yet another summer. Winter approaches but not before the gaiety of autumnal color and crisp fall skies are given their due. The astronomer's disquiet about the coming cold is offset by new opportunities in the clear evening skies, free of murky humidity and whining mosquitoes, not to mention earlier sunsets to begin an evening's viewings.

Thus we present for our gentle reader the 2011 Fall Inside Orbit. This edition

presents the final installment of Kenneth Dykstra's wonderful series on the Kepler Spacecraft's mission to discover exoplanets, Andrew Fraser's excellent essay on globular clusters, and the usual musings of our organization president. So, haul some firewood indoors, brew a pot of rich Ethiopian Harare, and enjoy this edition of the Inside Orbit.



Constellation of Pegasus, Atlas Coelestis. John Flamsteed, 1729

GRAAA ACTIVITIES FOR SEPTEMBER—NOVEMBER 2010

| | |
|--|--|
| October Public Nights at the James C. Veen Observatory | Oct. 8th and 29th |
| ArtPrize Sidewalk Astronomy. From 7.30pm until 9.30pm | Oct. 4th — 7th |
| October Monthly meeting "The Structure of Matter & Dark Matter - Does It Matter?" presented by Dr. Jacob Bourjaily, Harvard University | Schuler Books and Music, 2660 28 th St, SE Oct. 15th 7:00pm. |
| November Monthly meeting "The Golden Age of Discovery" presented by Dave DeBruyn | Schuler Books and Music, 2660 28 th St, SE |

The GRAAA is a 501(C3) non-profit educational and scientific organization dedicated to advancing the study of astronomy and promoting astronomy and science education to the community.

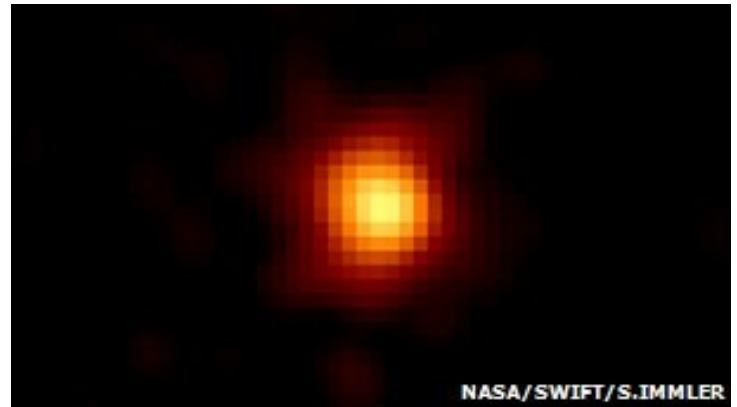
ASTRONOMY & SPACE NEWS

Cosmic distance record 'broken'

A gamma ray burst from a huge star near the edge of the observable Universe may have set the record for the most distant single object detected.

The GRB was detected by Nasa's Swift space observatory, and occurred a mere 520 million years after the Big Bang which translates into a distance of 13.14 billion years from Earth.

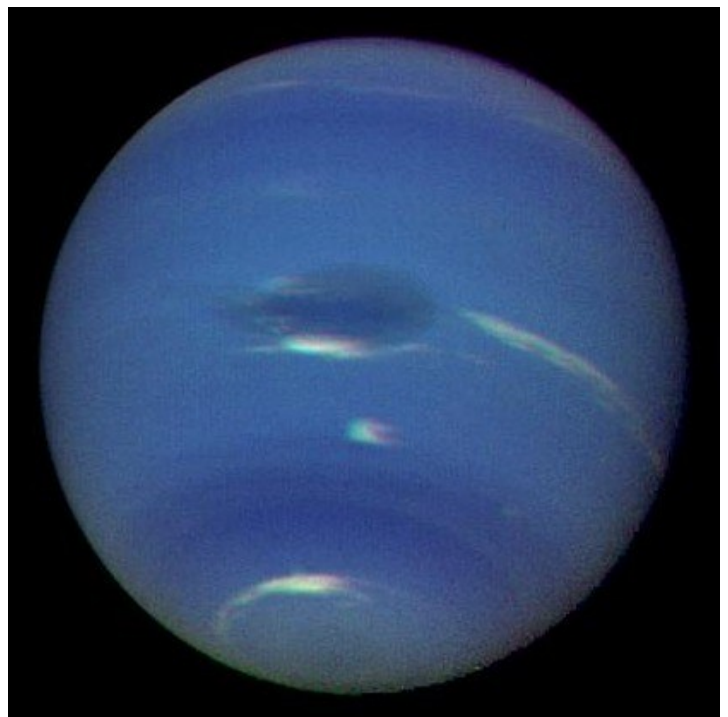
"It would have been a huge star, perhaps 30 times the mass of our Sun," said lead researcher Dr Antonino Cucchiara from the University of California, Berkeley.



Observations made at longer wavelengths - as in this infrared image of GRB 090429B taken by the Gemini North Telescope - are used to work out the distance

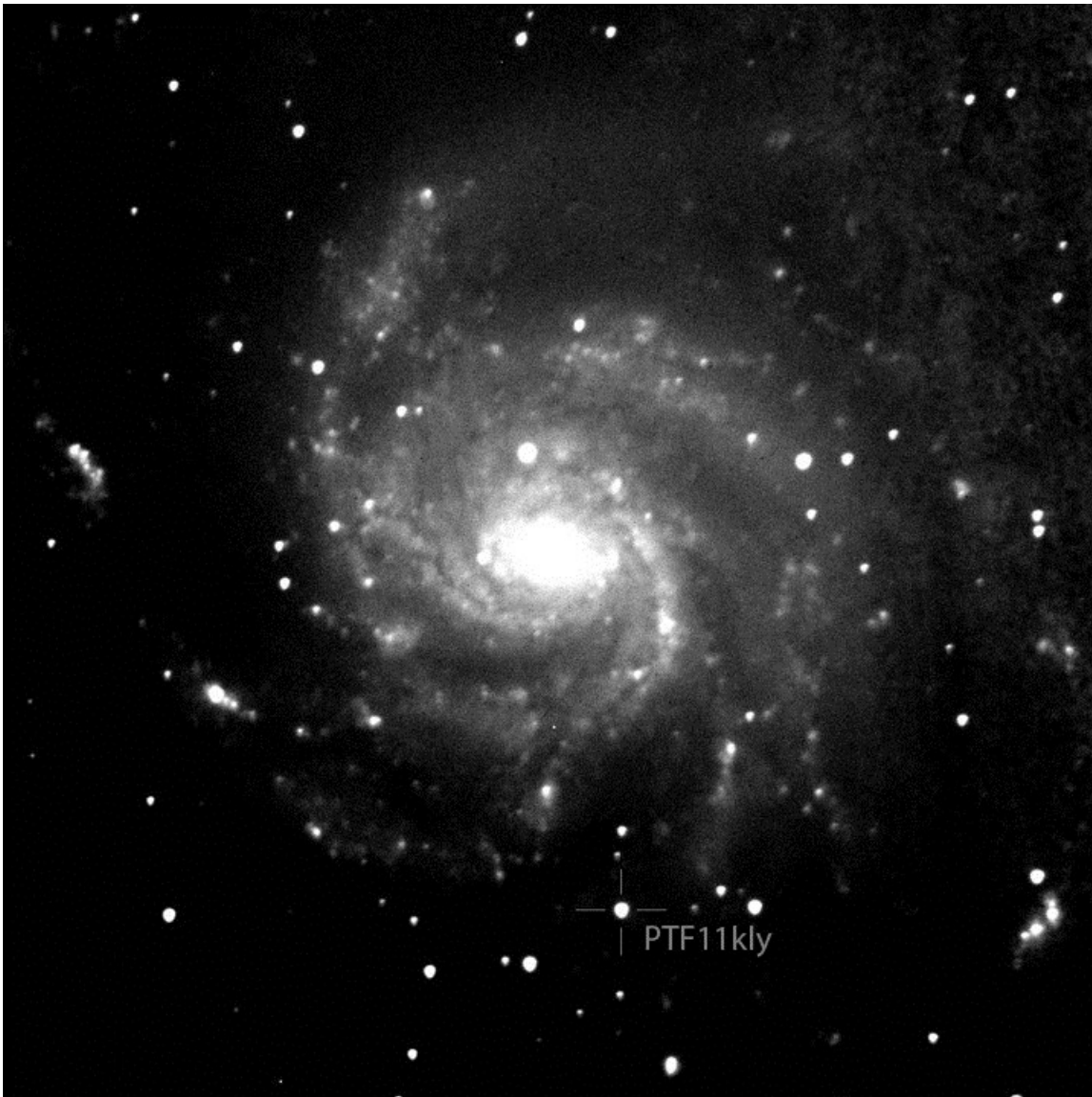
Blelated birthday wishes.

On 12 July, [Neptune](#) will celebrated its very first birthday because exactly one Neptunian year — or 164.79 Earth years — passed since its discovery.



RESEARCH AT THE VEEN

To those who've been following astronomy news this past summer, two supernovae have been observable from our Grand Rapids skies and their presence has not gone unnoticed by members of the GRAAA. In our last issue, as you may recall, club members Jose Borrero and Jeff Dickerman reported observations of the SN in M-51 (Inside Orbit, Vol.46, No.1). With the appearance of a another SN in M101, long time member Dr. Thomas Haynes began not only observing the nova but commenced collecting light curve data using the Marron Research Telescope. We'll all be encouraging Tom to present his results at a future astronomy club meeting.



Type 1A Supernova SN 2011fe in M 101

Photo Courtesy of Dr. Thomas Haynes

MILKY WAY GLOBULAR CLUSTERS

ANDREW FRASER

Introduction

Globular Clusters (GCs) of the Milky Way are huge gravitationally bound stellar systems and the oldest structures of our Galaxy. Comprised of hundreds of thousands of stars, these vast star clusters present a dazzling visual sight under telescopic examination. In the early 20th century study of these objects played a pivotal role in determining the scale and structure of the Milky Way. Continued observational and theoretical research on the intertwined factors of spatial distribution, kinematics, stellar dynamics, metallicity and age has provided insight into their make up, dynamic processes, and the structure and evolution of the Milky Way. The scope of this paper will highlight the properties of these objects in a historical context and the impact their study has on our understanding of the Milky Way.

Historical Observation

The first discovery of a GC is generally attributed to Abraham Ihle in 1665, with the observation of what today is known as M22 in Sagittarius (Jones 1968). Subsequent discoveries during the 18th century are credited to renown observers including Halley, Lacaille, De Chéseaux, Maraldi, and Messier. Messier was the first to resolve a globular cluster into individual stars during observations of M4, but failed to recognize other “round nebulae” as similar clusters. Thirty-three had been discovered prior to William Herschel’s observations which added 37 the list, and he resolved virtually all of the then known clusters. Herschel is also credited with first using the term “globular” to define this class of star cluster (SedWeb1). Today the list of known Milky Way GCs is generally recognized to include 158 objects (SedWeb2).

Spatial Distribution

Globular clusters are recognized as gravitationally bound systems with stars of the same age and similar chemical composition, generally situated in a halo surrounding the galaxy core. It was not until the early 1900’s however, that this distribution of the GCs was recognized. The majority of GCs are situated in the direction of the sky toward the galactic center. This fact was appreciated by Bohlin, in his 1909 proposal that the center of the galaxy lay at a considerable distance from the sun in the direction of Sagittarius (Hoskin 1999). His speculations were not widely accepted however, and it would remain for Harlow Shapley in 1920, building on the period-luminosity relationship for Cepheid variable stars, to determine the distances to a number of globular clusters and their relative position in the structure of the Milky Way. Using observations of Cepheid light curves in the GCs, extrapolating relative brightnesses of luminous stars, and the apparent sizes of the clusters, Shapley determined that GCs were arranged in a halo centered on the core of the Milky Way, which relegated the Sun to a relatively inconspicuous off-center position in the galaxy (Freedman & Kaufmann 2008).



Figure 1. Globular Cluster M13

Photo Credit: TCWebb

An aspect of relying upon the Cepheid period-luminosity relationship that had not been fully appreciated at that time was the differentiation between Population I or Classical Cepheids and Population II or Type II (W Virginis) Cepheid variables. Although the periods of both types of Cepheid variable are very similar, the Population II Cepheids have an intrinsic brightness about two magnitudes greater than the Population I Cepheid (AstrocomWeb). In determining the distances to GCs Shapley assumed the Cepheids he observed in GCs obeyed a period-luminosity relationship consistent with the Cepheids more locally situated in the galaxy. He also confused shorter period variables known as RR Lyrae type, or “cluster variables” evident in GCs, with Cepheids. (Belkora 2003). These factors contributed to Shapley’s distance estimates and therefore his scale of the Milky Way galaxy being too large by a factor of two.

Motions in the Galaxy

Limitations of instrumentation and observational time span requirements

precluded effective measurement of proper motions for GCs until the most recent couple of decades. Nonetheless, radial velocity studies yielded much about their motions in space. Most GCs are constituents of the *halo class* and traverse eccentric orbits highly inclined to the galactic plane independent of the galactic disc. Eccentricities range from about 0.3 to perhaps as high as 0.9 for members joining the galaxy. Perigalactic distances are greater than 1 kpc and apogalactic distances may range to greater than 100 kpc, however most

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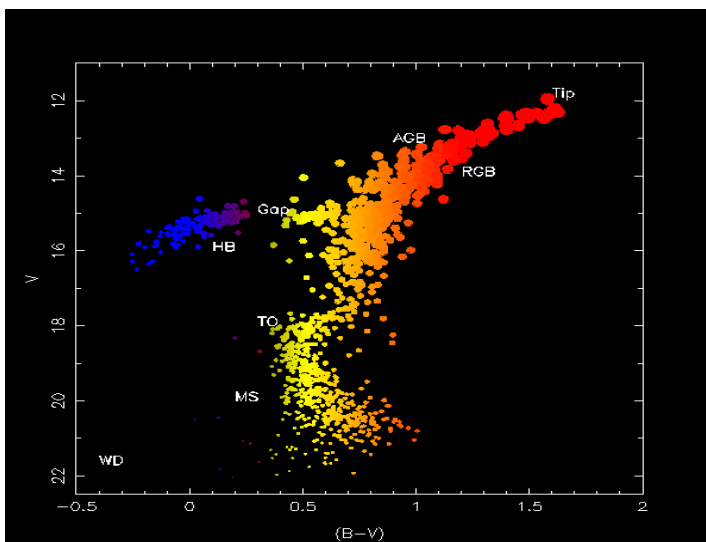
do not extend to more than 25 kpc (Ninkovic 1983). About 30 low metallicity GCs exhibit retrograde motion about the galactic center (Rodgers & Paltoglou 1984), suggesting a separate source of origin for this subset. About 20% of GCs are found within 1 or 2kpc of the galactic plane and make up the *thick disk* population. The orbits of these objects tend to be more nearly circular and oriented near the galactic plane (CaltechWeb3).

Composition and Metallicity

Globular clusters are relatively devoid of gas and dust, and spectroscopic studies of their stars indicate that they have much lower metal abundances than stars in the galactic disk. An HR diagram for GC stars (Figure 2.) displays a truncated main sequence, prominent giant populations, and a horizontal branch which evidence the advanced age of these objects. These are old low metallicity Population II stars which formed from the primordial matter which constituted the Milky Way.

While metal content of these stars are relatively low compared to stars of the galactic disc, studies in the mid-1900's showed that a variation in metallicities exists among the GCs (Morgan 1959).

Figure 2. HR Diagram for Globular Cluster M5; Main Sequence (MS); Turn off (TO); Red Giant Branch (RGB); Helium flash (Tip); Horizontal Branch (HB); Schwarzschild gap in the HB (Gap); Asymptotic Giant Branch (AGB); White Dwarfs (WD)



Spectroscopic studies through the 1980's confirmed a dichotomy between the positions and kinematics of relatively metal-rich and metal-poor GCs. Metallicity expressed as the log ratio $[Fe/H]$ compared to the Sun is a discriminator for the two groups at $[Fe/H] = -0.8$. (Zinn 1985, Armandroff 1989). Again, as differentiated by their orbital motions, two populations exist: those of the thick disc, or *intermediate Population II*, comprised of relatively high metallicity stars and those of the halo class or extreme Population II, with comparatively lower metallicity.

In 1939 Pieter Oosterhoff discovered GCs rich in RR Lyrae stars could be segregated into two groups based on the periods of these variable stars, with a significant gap at 0.6 days. The differences in periods for these groups correlate well with differences in metallicity. Shorter periods trend toward increasing metallicity; Oosterhoff type I clusters are comparatively more metal rich and Oosterhoff type II clusters are relatively more metal poor. The "Oosterhoff Dichotomy" does not appear to be present for globular clusters of dwarf satellite galaxies of the Milky Way. The presence of the Oosterhoff dichotomy among GCs of the Milky Way, with a few exceptions, argues for the halo population of GCs not having been built by accretion processes from dwarf galactic systems (Smith et al. 2006), however this view is negated by consideration of age-metallicity data which will be described later.

Dynamical Processes, Exotic Bodies, and Evolution

The morphology of GCs is a subject of considerable and continuing question. From an examination of the HR turn-off points among a number of clusters it is remarkable that there are only subtle differences in ages among Milky Way GCs, with most generally around 12-13 Gyr and a portion somewhat younger. Throughout the long lives of these clusters a number of internal and external processes act upon them to produce the objects we observe today.

The stars that initially comprise a GC interact with one another gravitationally, gradually modifying their original vectors. Over a period of approximately 100 Myr a given cluster star will typically lose all memory of its original orbit (CalTechWeb), referred to as *relaxation time*. Through continued interactions, a process referred to as *mass segregation* occurs, in which more massive stars lose kinetic energy. This results in more massive stars becoming concentrated toward the center of the cluster and a dramatic increase in central density referred to as *core collapse*. This phenomenon is evidenced by continuously increasing luminosity toward the core of the cluster, and is apparent in about 10-20% percent of GCs (Cal Tech Web, Hut & Djorgovski 1992).. This process may also lead to the formation of an anomalous evolutionary class of main sequence stars termed *Blue Stragglers*, which are situated above the turn off point (TO) on the HR diagram (Figure 2.). The increased central density enables a rejuvenation of stellar material through direct collisions and increased perturbations in binary systems in the core (STWeb).

The detection of X-ray sources in globular clusters date from early 1970's spacecraft observations. The identification of these

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sources was early on correlated with clusters having high central density. The sources are found close to cluster centers (CalTech Web2) and there may be many in a given cluster. Several types of binary systems are proposed to account for the observed luminosities of sources including luminous and low-luminosity low-mass x-ray binaries (LMXB/fLMXB), cataclysmic variables (CV), pulsars (PSR) and magnetically active binaries (BY Dra/RS CVn) as outlined in Figure 3.

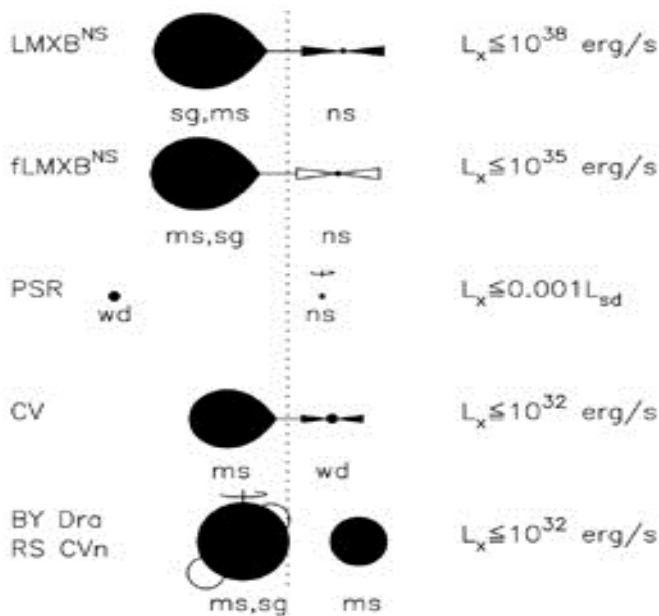


Figure 3. Models of GC X-ray Sources and Maximum Luminosities
ns=neutron star, sg=subgiant, ms=mainsequence star, wd=white dwarf

Credit: CalTechWeb2

The cores of GCs have also been considered candidates for harboring intermediate mass black holes (IMBH). Observation of stellar motions near the core of some clusters, such as M 15 and G1 (Andromeda) has suggested the existence of an IMBH (STSCIWeb), however, the evidence gathered to date is not conclusive (Chanamé, et. al. 2009).

As has already been suggested, the presence of binary systems plays a significant role in GC evolution. Theoretical dynamic studies show that single star cluster constructs are unstable against core collapse, whereas the presence of binaries can significantly impact the velocity of single stars by shrinking the binary's orbit. These systems then become a source of energy capable of stabilizing

and even reversing core collapse. Encounters between single or binary systems and other binary systems also have the potential to eject stars to the outer halo of the cluster or expel them completely (CalTechWeb2). Estimates of the evaporation and destruction rate for ~ 12 Gyr suggest that a significant portion of the original complement of globular clusters have perished through the combined effects of evaporation and tidal shocking with the galactic disc and bulge (Hut & Djorgovski 1992).

Revealing the Galaxy

GCs reveal much about the early galactic evolution. Older, lower metallicity clusters generally situated in the outer halo, and somewhat younger, higher metallicity clusters associated with the galactic bulge, support the long-held theory that the galaxy evolved from a huge primordial gas cloud. In that evolutionary scheme, the older GCs formed first as part of the initial galactic structure, and were left behind in a halo as the galaxy contracted to later form its core and disc (Inglis 1961). Observations of GCs in the outer halo and thick disk have suggested only slight age differences between the groups however, which implies relatively rapid evolution of the Galaxy from the original spherical cloud to the formation of the thick disk.

On-going galactic evolutionary processes are evidenced through the observation of tidal interactions between GCs and the Galaxy. Continued refinement of composition, spatial distribution, kinematics, and ages of GCs, particularly in the outer halo suggest that accretion is an important contributor to the Galaxy's population of GCs. Dwarf spheroidal galaxies (dSph) and GCs are denizens of the galactic halo and distinction between a GC and a dSph itself may be ambiguous. Differences between these two type of objects have been drawn based on mass, luminosity, size, mass-to-light ratio and spread in metallicity. Additionally, greater flattening of the dSph may help differentiate (van den Bergh 2008). The Sagittarius dSph (Sgr), is the nearest neighbor of the Milky Way and is being tidally disrupted. Anomalous chemical signatures of Sgr giant stars are consistent with GC Palomar 12 indicating it has been accreted from this satellite galaxy (Sbordone et. al. 2006). Additional clusters associated with Sgr include M54, which is likely the former dwarf galaxy nucleus, and several others (Mottini, et. al. 2008, Carraro 2009). Other nuclear remnants likely include NGC 2808, which originated in the Canis Major Dwarf (CMa), and Omega Centauri. The recent work of Forbes and Bridges (2010) which included age-metallicity analysis, revealed two distinct GC groups: one at near uniform 12.8Gyr age over a wide range of metallicities, and another isolated at younger ages and intermediate metallicities. This dichotomy indicates that about one-fourth of the total GCs may have been accreted from six to eight dwarf galaxies.

Just as the spatial distribution of GCs revealed the location of the galactic core to Harlow Shapley nearly a century ago, GC's continue to reveal the unseen structure of the Galaxy today. Since extreme halo GCs are the most distant objects associated with the Galaxy, their motions reflect the gravitational effects of the entire Milky Way. Recent GC velocity observations have yielded some of the best

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estimates for the mass of the Milky Way. The resulting value of about 500 billion solar masses (CaltechWeb3), is far in excess of the mass accounted for from directly observable stars and nebulae, and therefore constitute part of the evidence for unseen *dark matter*.

Conclusion

In conclusion, while the GCs are the oldest structures of the Milky Way they can hardly be considered staid elders in the galactic family. Dynamic processes abound both internally and with their host galaxy(s) to provide interesting research subjects and fruitful ground for expanding our knowledge of the Milky Way.

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NASA'S KEPLER MISSION—PART 3

KENNETH P. DYKSTRA



All truths are easy to understand once they are discovered; the point is to discover them.

Galileo Galilei
(1564 – 1642)

51 Pegasi

Our view of those lonely pin-points of light in the night sky changed when, Michel Mayor and Didier Queloz published in 1995 their discovery of the first planet orbiting a main sequence star fifty light years away ¹. To give you an idea of distance, if you could cruise at the speed of light, 186,000 miles per second, it would take fifty years to get there but currently, our spacecrafts are nowhere close to such speeds. For example, the Kepler Spacecraft would take around seventy thousand years to get there and our fastest spaceship, New Horizons, with its Ion Pulse engine racing the ship to Pluto would still take tens of thousands of years – and this is one of our closer neighborhood stars.

We call this star 51 Pegasi since it appears to us in the constellation Pegasus. Wait for Fall and face the southern horizon and look up about half-way, which is about forty-five degrees. You will find a great big square made up of four prominent stars that are the most well known part of the constellation and aptly named, “The Great Square”. On the right-hand side of the square and midway up, on a very clear and dark night, you might be able to see *51 Pegasi* with the naked eye, a small dim light only 5.5 in Magnitude. This anti-climatic star shows a wobble and rhythmic dip in brightness when measured with precision instruments. Mayor and Queloz confirmed that an object orbiting this star is tugging on it, further studies by other ground based telescopes ruled out other possibilities to explain this star's odd behavior ². The very first planet around another star was discovered.

Bellerophon

And on that day a new space race was launched. With the discovery of a world designated *51 Pegasi b*, being the reason for these wobbles and dips, a new word was formed: *Exoplanets*.

Along with this word came a new frontier for astronomers around the world: *Planet Hunting*. And most profound, is the challenge of a new perspective for humans to grasp—no longer do we just see pinpoints of light when we look up at the stars—but Suns of other Earths.

The nick-name given to this exoplanet is *Bellerophon*, which is the name of the mythological Greek hero who captured the famous winged-horse Pegasus. To describe what Bellerophon generally looks like, have you ever looked at Jupiter in the night sky? Very easy to find on any clear night of the year with your naked eye. It is one of the brightest “stars” in the night sky. Like Jupiter, this newly discovered planet is also a behemoth gas planet; but unlike Jupiter's twelve year orbit, this exoplanet only takes about four Earth days to complete one orbit around its star. Its orbit is so tight, astrophysicists calculate it to be tidally locked, meaning that the planet always shows the same side to its star, just like our Moon does to Earth, we never see the dark side of the moon ³. Because of this, it is calculated that Bellerophon's temperature is approximately eighteen hundred degrees Fahrenheit on the daylight side. Aluminum, for example, melts into molten liquid at twelve hundred degrees Fahrenheit. Although this super heated Jupiter-size planet is far from being another “Earth”, its discovery causes one to wonder: Are there other Earths out there?

Let's study the science of wobbles and dips, known as Spectral Analysis, to find out how the star's Kepler flags will be scrutinized by a host of ground-based telescopes on the ready to answer on of humanities age-old questions: Are there other Earths out there?

Spectral Analysis

Although the Kepler spacecraft is designed to pick up transits, *i.e. dips in a star's brightness*, spectral analysis is what will be used to scour those flagged stars and their peculiar dips in order to understand what is causing their dips in brightness: Planets? Brown Dwarfs? Dimmer Binary's? Space Bugs? Spectral Analysis ⁴ arguably began in Sir Isaac Newton's chambers in 1666 when he studied the rainbow made from sunlight, presenting his findings to the Royal Society six years later, he writes,

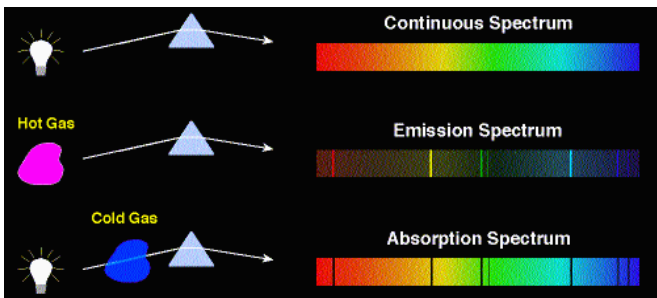
NASA'S KEPLER MISSION—PART 3

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I procured me a Triangular glass-Prisme, to try therewith the celebrated Phenomena of Colours. And in order having darkened my chamber, and made a small hole in my window-shuts, to let in a convenient quantity of the Suns light, I placed my Prisme at this entrance, that it might thereby be refracted to the opposite wall...Comparing the length of this coloured spectrum with its breadth, I found it about five times greater; a disproportion so extravagant, that it excited me to a more than ordinary curiosity of examining, from whence it might proceed⁵.

Over one hundred and forty years would pass from these rudimentary beginnings before an international race to master spectral analysis was sparked across Europe to America in the 1800s. The new discipline was at full-speed with such well known names as John Herschel, Joseph Fraunhofer, and many others forging the way. On the shoulders of these pioneers comes Gustav Kirchoff and Robert Bunsen (yes, of the famous Bunsen Burner used in all chemistry labs around the world today) these men ushered in modern spectral analysis so critical to astronomy today⁶. They honed the skill of reading light, like a laser reading a DVD, it as an ideal information carrier, since photons do not rust, slow down, or degrade.

Rainbows & Spectral Analysis



I would say a rainbow is God's example of spectral analysis for all mankind to enjoy. When Sun light passes through a raindrop, the light is bent due to the non-uniform shape of the raindrop acting like a prism. According to Judeo-Christian mythology, the rebellious human race had never seen a rainbow or rain, nor a boat so the story goes in Genesis, which is why they ridiculed Noah and his sons so ruthlessly... until the deluge! After the flood, Spectral Analysis forever became a symbol, to Christians, of God's promise to never allow such a deluge again. But that is just one of three form of spectral analysis. There are three types of spectra that can be observed when light is refracted into a rainbow: Continuous Spectrum, Emission Spectrum, and Absorption Spectrum. Star light, including our Sun, reveals a Continuous Spectrum, a rainbow (see illustration). An Emission Spectrum is caused by excited gas molecules emitting photons of light, a good example of this is a neon light or fluorescent light, and in the case of astronomy, a beautiful nebula. Planet hunters do not use Emis-

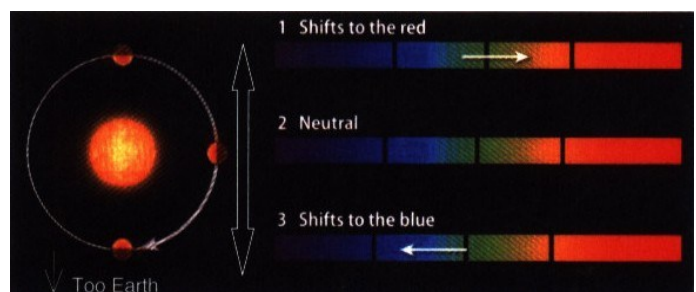
sion Spectrums. Absorption Spectrums are ideal for planet hunters, revealing what most thought impossible for centuries. If star light has traveled through the atmosphere of a planet on its way to Earth, the rainbow spectrum we see will show black lines in it, causing the original Continuous Spectrum to change into an Absorption Spectrum (see illustration). The black lines are where some of the light waves were absorbed by the gases in the planet's atmosphere. Each color in a spectrum represent wavelengths and where the black lines appear are the wavelengths absorbed by the planet's atmosphere. Those black lines tell astronomers what gases exist in the atmosphere of that alien world.

Shifting Spectrum

Edwin Hubble, whom the Hubble Space Telescope is named after, shocked the world in the 1920s revealing how our galaxy isn't the only galaxy and how the universe isn't fixed but expanding, and doing so at great speed. Think of the expansion of universe like a balloon being blown up and our universe is the skin. This discovery even shocked Albert Einstein whom later confessed his "greatest blunder" was in thinking the universe doesn't change⁷. Using the Mt. Wilson Observatory just outside Los Angeles, Hubble made this history-making discovery by employing Spectral Analysis. Mt. Wilson is a now a national historic landmark available for public viewing. My two attempts to see the spectrometer and Hale telescope at Mt. Wilson were thwarted by brush fires one year and mud slides two years later. Using Mt. Wilson's spectrometer, Hubble measured the color shifts in various stars within our galaxy against the color shifts from odd and fuzzy "stars" assumed to be within our galaxy. Those odd and fuzzy objects revealed a Doppler Shift to be far more extreme than those stars within our Milky Way, proving there are whole other galaxies beyond ours.

An easy way to understand Doppler Shift and Spectral Analysis used by planet hunters today is to think of lightwaves like ripples in a river after you throw a stone in it; the ripples represent wavelengths of light (color) that you see with Spectral Analysis. If the waves made from the stone are travelling against the flow of the river, they will look compressed; while ripples going with the flow look stretched. The same is true with lightwaves, if a star or galaxy is speeding away from us, their lightwaves travelling back to us look elongated causing the rainbow to shift to the longer wavelengths, which is the color red. If the star or galaxy is hurt-

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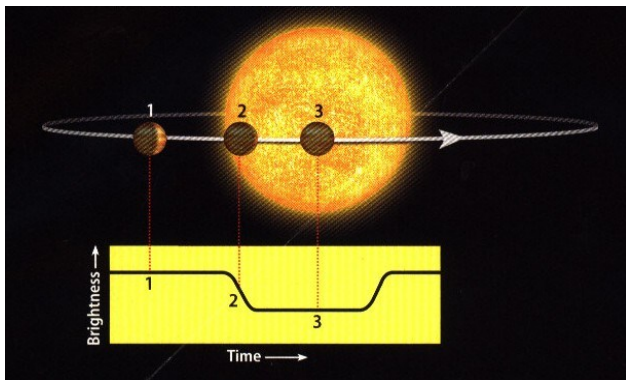


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ling toward us, their lightwaves are compressed causing the rainbow to shift into shorter wavelengths, which are blue. This is a Doppler Shift. A good example of blue shifted light is the Andromeda Galaxy, its rainbow spectrum is shifted to the blue because this massive galaxy is hurtling toward us on a collision course. A good example of a red shift is 51 Pegasi, it is speeding away from us, but then every 4.2 Earth days the red-shift lessens for a short period then increases again to its original length⁸. In other words, it wobbles. Our own Sun wobbles. What we know of our own solar



system is that depending on the alignment of the planets, their combined gravity induces greater pull on our Sun, sort of like the wobble in an unbalanced washing machine tub during the spin cycle.

Kepler's Specialty

Transits occur when a planet eclipses the light of its star as it passes in front of it from our perspective on Earth. By studying one hundred and fifty six thousand stars, NASA believes as many as twelve hundred will just so happen to be have this edge-on view for Kepler to pick up the eclipse. NASA calculates that a planet the size of Earth orbiting a star the size of our Sun at a distance as far away as the Northern Cross region will only dip in brightness about one-hundredth of a percent (.01%). This is equivalent to a pin passing in front of a 100 Watt light bulb and the dip in brightness being noticed about 300 miles away. To make sure it is a true dip in brightness and not some "space bug" in front of Kepler's lens; Kepler must stare at these same hundred thousand stars for the next four years to confirm regular cycles of dips. These dips in brightness might occur every week, every month, once a year or more depending on how often the object makes one revolution around its star. NASA's spacecraft then flags each star that had a transit, transmitting this data to Earth each month for the Kepler science team to analyze and determine which transits are objects of interest, the team designates these as KOI (Kepler Objects of Interest). These KOI's are then sent to a battery of ground-based telescopes on-the-ready around the world to check for wobbles using spectral analysis. NASA mandated a four year mission (2009 - 2013) for the express purpose of identifying planets that eclipse their star once an Earth year and since they require three

confirmed dips in brightness, locating Earth's twin will require three years minimum.

It is ironic how spectral analysis dominates astronomy today and plays such a critical role in the understanding of our universe, yet famous French philosopher, August Comte, declared to his students and peers in 1835:

*We understand the possibility for determining their shapes, their distances, their sizes and their movements; whereas we would never know how to study by any means their chemical composition...I persist in the opinion that every notion of the true mean temperatures of the stars will necessarily always be concealed from us.*⁹

Not only can we now measure the temperature and composition of every star but that of their invisible orbiting counterparts. So with the known brightness of the star, size and color of the star, its dip in brightness, the length of time between dips, the degree of wobble, the degree of red shift, the absorption spectrum; NASA's team of scientist and international team of ground-based telescopes are able to deduce the critical characteristics of the exoplanet orbiting it. Characteristics like: planet density, planet size, gas planet, rocky planet, and most intriguingly, if it is habitable - where rivers and lakes and oceans of liquid water run. The Kepler Mission is no less than epic. It is a Christopher Columbus of events. Over 1200 new worlds have already been found, and of them, Fifty-four potential habitable planets are now be studied with ground based telescopes around the world for the goldilocks zone hope and two super earths have just been announced. Over the next two years, the news I believe NASA's Kepler team announces to the world will change humanities perception of the heavens profoundly. No longer will those lonely pin points of light we see at night be thought of as stars...but as suns of other worlds. It will also change how humanity views our own pale blue dot in this expansive created order we call home.

Next Article Series:

Other Earths/Other Life? Yes. Intelligent Life? No.

Notes:

1. Powell, Corey. "Unlikely Places." *Scientific American* 266, March 1992: 22. Print. To be technically accurate, in 1992, Alexander Wolszczan identified an exoplanet but it isn't orbiting an active star; but a dead star known as a pulsar (a star that went Super nova long ago).
2. Binary stars are two stars orbiting each other. Brown Dwarfs

(Continued on page 11)

NASA'S KEPLER MISSION—PART 3

KENNETH P. DYKSTRA

(Continued from page 10)

are star 'wannabes' but too small to reach critical mass for nuclear fusion. Nuclear fusion is the engine of a star.

3. There actually is no dark side to the Moon. We never see the other side of the Moon but as the Moon orbits Earth and Earth the Sun, the Sun does indeed shine on all sides of the Moon.
4. Spectral Analysis is a facet of spectroscopy used by astronomers.
5. Hearnshaw, J.B. *The Analysis of Starlight: One Hundred and Fifty Years of Astronomical Spectroscopy*. Cambridge University Press Syndicate: New York, 1986. Print (p.20)
6. *ibid.*; Robinson, Keith. *Spectroscopy: The Key to the Stars*. Springer-Verlag: London, 2007. Print. (p.1)
7. Hawking, Stephen. *A Brief History of Time*. A Bantam Book: New York, 1996. Print.



Ken Dykstra obtained his MA Systematic Theology from Grand Rapids Theological Seminary and is currently working on a book of NASA's Kepler spacecraft. You can learn more about Ken at his website:

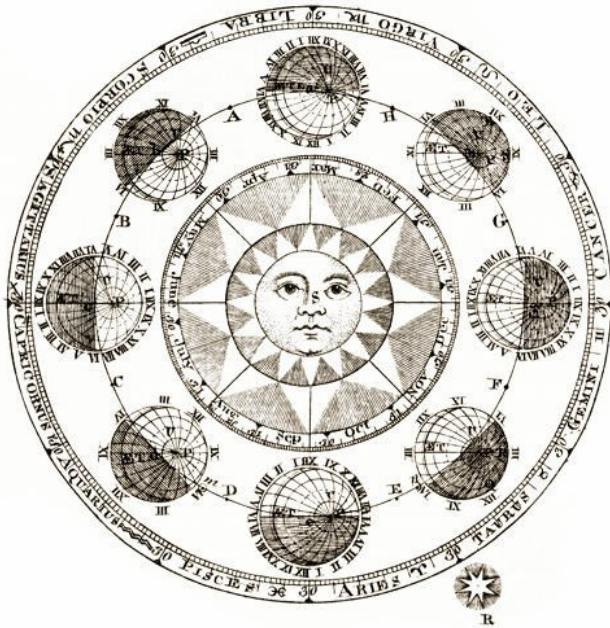
www.otherearths2013.com



Alex Cherney
www.terraastro.com/

DAVE'S FOCAL POINT

DAVE DEBRUYN



Autumnal Equinox greetings to all GRAAA friends. The nice crisp evenings and earlier sunsets provide excellent observing opportunities at this time of year. Be sure to get in touch with Tom Haynes, Kevin Jung, or me if you want to learn how to use the Borr 16 inch reflector at Veen Observatory for personal observations. I recently used it to seek out elusive planetary nebulas, and must say it is a powerful and user friendly asset, well maintained by Jeff Dickerman and the technical crew.

Our Public Visitors Nights so far this season have been a mixed bag, with a number of cancellations due to cloudiness, but those few that have been clear have been very well attended – and profitable! With a turnout of typically more than 100 people, we really appreciate the dedication of GRAAA members who have been showing up regularly with portable telescopes and to help with visitor logistics. Special thanks to Mark Steiner, Gary Segorski, and Tom Good for being willing to regularly handle the difficult job of managing the parking lot, and to Kevin Jung for so effectively using various electronic media to get our messages out. Through quizzing arriving guests, I find that almost two thirds learn about our Visitor Nights events from the web, WZZM weather personnel, or social media. We miss one of the Visitor Night regulars, Larry Campbell, who is hobbled up after corrective knee surgery, but in a recent phone call, I found him as cheery as ever and on the mend. We hope you are back soon Larry.

October will bring with it a packed schedule of GRAAA activities. First up will be a field trip September 30th or October 1st

(depending on sky conditions) to the Wessling Observatory, where our original 12 inch reflector at Veen probes a dark sky accompanied by a large Dobsonian. We will be car pooling from the Alpine Meijer parking lot at 6 p.m., returning around midnight.

Those with telescopes who are interested in taking astronomy to the masses can join us at various downtown locations Tuesday through Friday, October 4th through 7th, when sidewalks will be packed with Art Prize visitors. When the sky is clear, we will be offering appreciative passersby views of the gibbous moon and Jupiter. Please get in touch with me to get an assigned location and further details about this outreach event.

The unquestionable highlight of the month will be a special presentation by Dr. Jacob Bourjaily at our October 15th general meeting at Schuler's. It is hard to know where to begin in describing this ambitious guy. Jake was a junior leader in GRAAA as the new millennium began, designing and installing with his dad and brothers the road lighting system at the observatory as an Eagle Scout project, and speaking at the 30th anniversary Veen Observatory observance. He produced laser light shows at the planetarium while taking advanced placement college classes prior to enrollment in the University of Michigan after winning the prestigious Roger B. Chaffee scholarship. Then it was on to Princeton, where he had an office at the Institute for Advanced Studies while working on his PhD, obtained last spring. Recently, the ever personable Jake moved to Boston to begin a three year appointment as a post doctoral fellow at Harvard. Don't miss his October 15th illustrated presentation *The Structure of Matter and Dark Matter – It Does Matter*.

Thanks to those who helped us with maintenance and improvement projects at the observatory over this past year. The Marron robotic telescope is in full operation thanks to persistence by the tech guys, the decorative gargoyles will soon be back up following construction of striking new mounts by Jon Erwood, and the front of the building has been repainted. Still to come is repainting of the entry doors courtesy of Gary Ross, further electrical wiring upgrades, and continuation of the east dome revamping by master craftsman Jerry Willette. These are great days in our vibrant organization.

CLASSIFIEDS

To have ads placed in the Inside Orbit please contact Dell Paielli : paiellid@gvsu.edu

For ad placement on the GRAAA website contact Kevin Jung graaa@graaa.org

For Sale: Meade 12" LX200GPS w/UHTC coating and Auto-Star II GoTo controller
#771 eye pc case with 8 eye ps's 6.4mm to 40mm
Meade Super Wedge
#905 variable polarizer
#911 nebular filter
#1A rear cell sky filter
#62 T-adapter
Canon FD ring
#612 dew hood
#547 AC adapter
12mm illuminated eye pc
F6.3 focal reducer
Full aperture Solar Filter
#777 off axis guider body
Mobile cart with wheels that the tripod sits on. Rolls on any hard surface.

#07492 Accessory shelf

Items like the Super Wedge can be sold individually

Many of the items are still in their original packages. The scope has been used maybe 8 times.

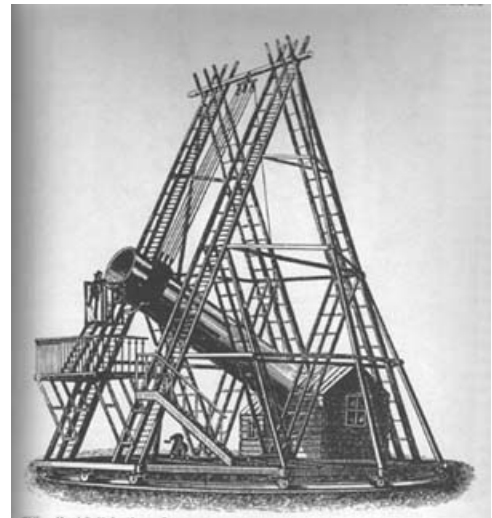
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3308 Kissing Rock Ave SE
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