



Newsletter of the Pomona Valley Amateur Astronomers

Science is a way of thinking
much more than it is a body of knowledge.
Carl Sagan

Volume 36 Number 11

nightwatch

November 2016

President's Message

Did you catch the supermoon this past Monday, November 14? I think the hype around supermoons is a little overblown – the moon is only a few percent bigger than average, and you can't see any more detail – but hey, anything that gets people outside to look at the night sky can't hurt.

Speaking of hype: the December issue of *Sky & Telescope*, which is currently on newsstands, has a feature article I wrote called, "Twelve Steps to Infinity". It's a tour of a dozen objects in the winter sky, arranged from closest to farthest, describing what was happening on Earth at the time that the light we see now left those distant objects. It's an idea I had cooking for a long time – many thanks to fellow PVAA member Steve Sittig for helping me test-drive the list about this time last year.

The club year is winding down – after this week's general meeting, we only have a couple more events before the holidays. We have an outreach scheduled for Thursday, December 8, from 4-6 PM at Oakmont Elementary School, 120 W Green St in Claremont. I live a block and a half away on Olive St, so as long as it's not raining, I'll be there. And our holiday party will be Saturday, December 10, at the IHOP at 80 North Euclid Ave in Upland. The party is always a good time and everyone goes home with something, so come on out and celebrate.

Our speaker this month is Tim Thompson, who will talk about globular star clusters. The meeting is at 7:30 this Friday, November 18, in Shanahan B460 on the Harvey Mudd campus. I hope to see you there.

Matt Wedel

Club Events Calendar

Nov 18, 2016 General Meeting

Nov 30, 2016 Board Meeting

Dec 10, 2016 Xmas Party

Jan 4, 2017 Board Meeting

Jan 13, 2017 General Meeting

Jan 28, 2017 Star Party – Salton Sea, Mecca Beach

Feb 1, 2017 Board Meeting

Feb 10, 2017 General Meeting

Feb 25, 2017 Star Party

March 1, 2017 Board Meeting

March 10, 2017 General Meeting

March 25, 2017 Star Party

Mar 30, 2017 Board Meeting

Apr 7, 2017 General Meeting

Apr 22, 2017 Star Party

May 3, 2017 Board Meeting

May 12, 2017 General Meeting

May 25 - 29, Joint RTMC

May 31, 2017 Board Meeting

June 9, 2017 General Meeting

June 24, 2017 Star Party

PVAA General Meeting 10/14/16

Ron Hoekwater opened the meeting with announcements and then a presentation of a recent visit that he and fellow PVAA member Laura Jaoui made to New York City's American Museum of Natural History. The Hayden Planetarium and the Arthur Ross Hall of Meteorites are part of the museum. The presentation showed several pictures inside the museum and several large meteorites that were on display. Ron wasn't sure if any of the figures came to life at night when the museum was closed.

Mike Carter briefly talked of the Oregon Solar Festival: <http://www.oregonsolarfest.com/> and events at Madras, Oregon. Check out the website for more details. The eclipse is less than a year away! – 8/21/2017

Our speaker for the night was Dr. Michael C. Storrie-Lombardi, M.D. of Harvey Mudd College. The topic was "Searching For Life In The Universe To Detecting Cancer In A Human Being". This started with a project called: Extraterrestrial Vehicle Instrument Laboratory (E.V.I.L.) <http://www.physics.hmc.edu/~lyzenga/wordpress/> which also goes with Laser Induced Fluorescence Emission (L.I.F.E.)

<http://www.physics.hmc.edu/~lyzenga/wordpress/?p=29>

The doctor talked about the differences in wavelengths the 4 great space observatories were built for. Compton 1991-2000 looked at gamma rays in the 30Gev – 20keV range. Chandra 1999-present looks at x-rays in the 10keV - .01keV range. Hubble 1983 – present examines the ultra violet to the near infrared: .115 μ m – 10 μ m range. The Hubble web site states it at: 100nm – 2500nm where nm=nanometers, keV = kiloelectron volts, GeV = Giga-electron volts and μ m = micrometer.

http://hubblesite.org/the_telescope/nuts_and_bolts/wavelengths.php

The last in the series is the Spitzer Observatory that looked at the infrared between the 30 μ m – 180 μ m range. Spitzer was used to get the first direct detection of an exoplanet.

When looking for life in the cosmos, the E.V.I.L. program centered on looking for PAH compounds. PAH stands for Polycyclic Aromatic Hydrocarbon, which are hydrocarbons—organic compounds containing only carbon and hydrogen and are common compounds found in the universe.

https://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbon

They also looked for PNA (Polynuclear aromatic hydrocarbons) compounds, which are a subset of PAH.

A group of students at Harvey Mudd College created a portable Raman spectrograph that they put on a little rover to go into a small tunnel by remote control, and get a spectrograph of the selected areas in the cave. Raman spectroscopy is commonly used in chemistry to provide a fingerprint by which molecules can be identified. The students just miniaturized it. After several design iterations, it will now go on the next NASA Mars rover. The Raman spectrograph can be used in airports to identify explosives and illegal drugs. (Raman is named after the Indian 1930 Nobel Prize winner in physics Sir Chandrasekhara Venkata Raman.)

While this started out as an astronomy project looking for extraterrestrial life, the City of Hope Hospital has taken the student's project and is now currently using the student's Raman spectrograph in clinical trials for breast cancer research. Very, very impressive. An amazing presentation that makes the future look that much brighter.

Gary Thompson



DEVELOPMENT TEAM

HMC Students	Kinohi Institute Clinic 2015-2016	Summer Research 2016	City of Hope Clinic 2016-2017
Alex Alves	Achintaya Bansal	Erica Martelly	Kunal Menda
Apoorva Sharma	Luis Martinez	Jiixin Yu	Willie Zuniga
HMC Faculty Advisors	Phil Cha (Engineering)	Gregory A. Lyzenga (Physics)	Michael C. Storrie-Lombardi (Physics, Kinohi Institute)
			City of Hope Liaisons
			Yuman Fong
			Veronica Jones
			Lily Lia
			Bertram Yuh

ACKNOWLEDGEMENTS
This project would not have been possible without funding, assistance, assistance, and encouragement from the City of Hope, Kinohi Institute, and the Trustees and Board of Directors of Harvey Mudd College.

Spatial Heterodyne Spectrometer (SHS) (Harlander et al. 1992)

Harlander's Goal: Obtain velocity-resolved for UV (135-195 nm) all-sky maps of interstellar line emissions to monitor ISM hot gas distribution and dynamics

- extend into the FUV (1200-2000 angstrom) spectral region the high throughput and high spectral resolution - Fabry-Perot and Michelson interferometers, but with
- compact in size
- field-widened
- no moving parts
- built in all-reflection configuration if needed

Interest in the Interstellar Medium Led to Our Current Work in Cancer Detection

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REASONS FOR USING A RAMAN SYSTEM ... AND THE CORE PROBLEM

We use Raman for the lack of sample preparation and its ability in water. The trick is to deal with the "light-pool" problem.

Going to higher laser power, higher photon energies, and tighter beams all broaden sample.

For a standard dispersive spectrometer the photon-diameter is the slit. Resolution depends directly on the width of the slit.

SPATIAL HETERODYNE (RAMAN) SPECTROMETER

Spatial Heterodyne Spectrometer (SHS) a stationary diffraction grating interferometer (think Michelson interferometer in 2 dimensions)

Core differences from a dispersive spectrometer:

- no moving parts
- all wavelengths are measured simultaneously
- large entrance aperture with a wide acceptance angle (field of view)
- significantly more compact

- For Raman devices the large aperture means we can use a large laser spot on the sample
- SHS is compatible with pulsed laser and gated detectors allowing measurements to be made in ambient light conditions
- Photon throughput ~300x that of dispersive spectrometer

SPATIAL HETERODYNE SPECTROMETER

- Beam splitter sends 50% of photons to each of 2 diffraction gratings.
- Each grating creates a wave-front at a wavenumber-dependent spatial frequency.
- Each wavefront is separated by a wavenumber-dependent angle for each wavenumber in the input beam.
- The two wave-fronts recombine at the detector creating interference fringes (Fizeau fringes).
- The fringes represent the FT of the source's spectrum about the heterodyne wavenumber.
- The heterodyne wavenumber (the "Littrow" wavenumber) is the wavenumber that produces parallel wave-fronts (i.e. the separation angle = 0).
- Gratings create the entire interference pattern and record the interferogram without any moving parts

HMC Spatial Heterodyne Infrared Raman Spectrometer (SHIRS)

2015-2016: Kunal Bhande, Alex Rivkin, Aparna Sharma, Erica Mariani, & Acharya Banerji
 Summer 2016: Luis Martinez, Jason Yu, & Willy Jung
 Project: Raman Spectroscopy and Laser Control
 Implementation on the Heterodyne SHS
 Harvard Medical School, Cambridge, MA
 Harvard West Campus, 300 Brookline Avenue, Cambridge, MA 02115

Fig. 1A The current system is comprised of an excitation path, a Raman collection path and an imaging path.

Fig. 1B A diagram of the NIR spatial heterodyne Raman spectrometer.

785 nm TEC cooled CW laser diode, 40-80 mW delivered to sample, collection times 5-300 ms, beam diameter 1-3 mm.

Breast Cancer - Brozek-Pluska et al. (2012)

Breast Cancer: Discrimination Bands - Depciuch et al.

Or high resolution spectra?

PVAA Officers and Board

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Ron Hoekwater (2017).....	909-391-1943
Cori Charles (2017)	909-646-0275

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Programs	Ron Hoekwater	909-391-1943
Nightwatch	John Stover	909-988-9747

What's Up? - Space Telescopes

Exoplanets were undiscovered until about thirty years ago. An exoplanet is one that orbits a star other than our own Sun. Being relatively small and lost in the glare of their solar primary they're almost impossible to study. But thanks to advanced observational technology they've become a new reality. Starting in about 1992 until the present time, over 3,535 exoplanets in 2,650 solar systems have been discovered. New ones are constantly being found. Earth sized planets in habitable zones are orbiting 1 in 5 Sun type stars. It's estimated that the Milky Way Galaxy has 200 billion stars which could be orbited by 11 billion potentially habitable Earth sized planets. And that doesn't include 50 billion more that could be orbiting infrared red dwarf stars.

Much of this new discovery is due to advanced space telescopes like NASA's orbiting observatory named after Johannes Kepler. It was designed to discover Earth sized planets in other solar systems. This telescope, combined with others, has found that planets orbiting other stars are quite common. But they're so far away we don't really know much about them.

Do they have atmospheres like Earth? Can alien life forms exist in other environments? Do smart aliens have to be sending out messages by radio or can they be intelligent without sending signals across light years of space? So far no radio transmissions have been received from exoplanets.

The first proven exoplanet was discovered in 1995. It was logically a huge planet in a rapid four-day orbit around the nearby G type star 51 Pegasi. This previously unknown star became well known overnight. Huge rapidly orbiting exoplanets close to their primary stars were the first to be detected by modern telescopes. They're called "hot Jupiters" because they're giants heated by their solar closeness. This contradicted theories that giant planets should form much farther out from their suns. But many more hot Jupiters were soon found. Far out planets that take thousands of years to orbit have also been detected. No little exomoons have been located yet.

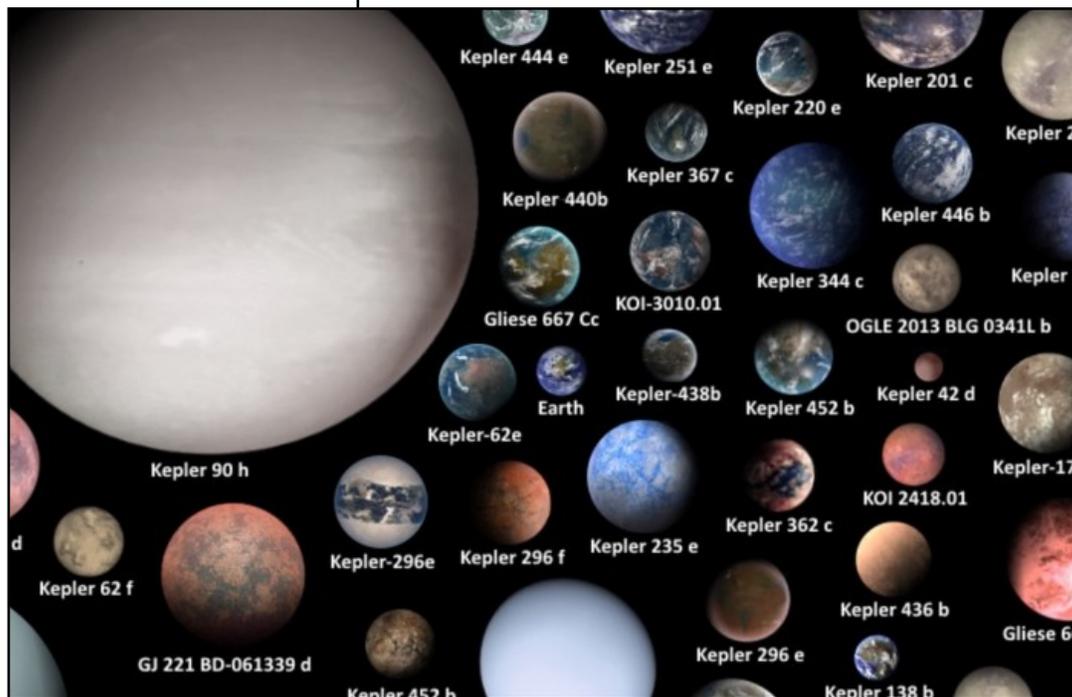
Upsilon Andromedae was the first main sequence star found to have a system of multiple planets. Now many smaller planets have been detected, mostly by the Kepler Space Telescope. They reveal their existence by their transits across the faces of their suns. Evidence has also been found of alien asteroid belts and dusty planet forming discs. Planets have been found orbiting one or more suns in binary star systems.

There appears to be an overall average of about one planet per star. About one in five stars like our Sun have Earth sized planets in the habitable temperature zone. This "goldilocks zone" is not too hot nor too cold. An exoplanet or even an exomoon with seas of liquid water could be home to a lot of life forms.

The nearest exoplanet orbits our closest star Proxima Centauri (a red dwarf only 4.2 light years away). The most massive found is almost 30 times the size of Jupiter. It is so big some astronomers think it might be a type of dim star called a brown dwarf. The smallest detected is been named Draugr and is only twice the mass of our Moon.

Astronomers love to name things discovered, so there is a system used for naming star systems adopted by the International Astronomical Union.

Exoplanets orbiting a single star have names based on taking the name (often a catalogue number) of the primary star and adding a lower case letter. So the small planet named Draugr is also called boringly called PSR B1257+12 b. It was found by



radio telescope 25 years ago. A Draugr is an Icelandic zombie ghost. Only a few exoplanets have exotic descriptive proper names since so little is really known about them.

The color and reflective brightness of some exoplanets has been determined. Such color reflectivity indicates that Kappa Andromeda b would appear reddish like Mars. A magenta color would reflect from GJ 504 b and HD 189733 b would appear a dark blue. One hot Jupiter oddly reflects less than 1% of its star's light. What these exotic detections mean is a deep space mystery. The atmospheric content of warm exoplanets that might be life friendly is still the greatest mystery of all. The search continues. There're a lot of exoplanets out there.

Lee Collins



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Looking to teach kids about exoplanet discovery? NASA Space Place explains stellar wobble and how this phenomenon can help scientists find exoplanets: <http://spaceplace.nasa.gov/barycenter/en/>

Is Proxima Centauri's 'Earth-like' planet actually like Earth at all?

Just 25 years ago, scientists didn't know if any stars—other than our own sun, of course—had planets orbiting around them. Yet they knew with certainty that gravity from massive planets caused the sun to move around our solar system's center of mass. Therefore, they reasoned that other stars would have periodic changes to their motions if they, too, had planets.

This change in motion first led to the detection of planets around pulsars in 1991, thanks to the change in pulsar timing it caused. Then, finally, in 1995 the first exoplanet around a normal star, 51 Pegasi b, was discovered via the “stellar wobble” of its parent star. Since that time, over 3000 exoplanets have been confirmed, most of which were first discovered by NASA's Kepler mission using the transit method. These transits only work if a solar system is fortuitously aligned to our perspective; nevertheless, we now know that planets—even rocky planets at the right distance for liquid water on their surface—are quite common in the Milky Way.

On August 24, 2016, scientists announced that the stellar wobble of Proxima Centauri, the closest star to our sun, indicated the existence of an exoplanet. At just 4.24 light years away, this planet orbits its red dwarf star in just 11 days, with a lower limit to its mass of just 1.3 Earths. If verified, this would bring the number of Earth-like planets found in their star's habitable zones up to 22, with 'Proxima b' being the closest one. Just based on what we've seen so far, if this planet is real and has 130 percent

the mass of Earth, we can already infer the following:

- ◆ It receives 70 percent of the sunlight incident on Earth, giving it the right temperature for liquid water on its surface, assuming an Earth-like atmosphere.
- ◆ It should have a radius approximately 10 percent larger than our own planet's, assuming it is made of similar elements.
- ◆ It is plausible that the planet would be tidally locked to its star, implying a permanent 'light side' and a permanent 'dark side'.
- ◆ And if so, then seasons on this world are determined by the orbit's ellipticity, not by axial tilt.

Yet the unknowns are tremendous. Proxima Centauri emits considerably less ultraviolet light than a star like the sun; can life begin without that? Solar flares and winds are much greater around this world; have they stripped away the atmosphere entirely? Is the far side permanently frozen, or do winds allow possible life there? Is the near side baked and barren, leaving only the 'ring' at the edge potentially habitable?

Proxima b is a vastly different world from Earth, and could range anywhere from actually inhabited to completely unsuitable for any form of life. As 30m-class telescopes and the next generation of space observatories come online, we just may find out!

Ethan Siegel

Image credit: An artist's conception of the exoplanet Kepler-452b (R), a possible candidate for Earth 2.0, as compared with Earth (L). Image credit: NASA/Ames/JPL-Caltech/T. Pyle.

