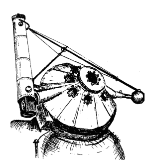
The Springfield Telescope Makers &
The Hartness House Inn
Presents

The Search for and Science of Exoplanets

Thursday July 20, 2017



Welcome to the 2017
Hartness House Workshop

Welcome to the 2017
Hartness House Workshop

The Search for and Science of Exoplanets

Exoplanets *are planets beyond our own solar system. Thousands have been discovered in the past two decades, mostly with NASA's Kepler space telescope. These worlds come in a huge variety of sizes and orbits. Some are gigantic planets hugging close to their parent stars; others are icy, some rocky.*

Chair, Dr. Thomas Spirock
Co-Chair & Registrar, Daniel Lorraine

Hartness House Workshop, July 20, 2017
The Search for and the Science of Exoplanets

8:30 – 8:55 **Registration and Coffee**

8:55 – 9:00 **Words of Welcome**
David Tabor, President, Springfield Telescope Makers

9:00 – 9:50 **Observing Exoplanet Transits with small telescopes – A practical guide**
Dr. Stella Kafka
We live in the century of exoplanet exploration: So far, more than 3000 planetary systems of all sizes have emerged around all types of stars, as a result of ground- and space-based missions. Some of the exoplanets are Earth-sized and occupy that niche we call the Goldilocks zone; we are close to identifying our Earth's twin. In this presentation, I will discuss the main exoplanet detection techniques which have already provided a zoo of exoplanets. I will also present contributions of small telescopes to exoplanet exploration, and how the AAVSO can help YOU to engage in and contribute to exoplanet studies with a small telescope.

9:50 – 10:40 **First Steps in Amateur Exoplanet Observing**
Brad Vietje
Exoplanets are a hot topic in Astronomy these days, especially since the discovery of the TRAPPIST-1 system a few months ago. Can motivated amateurs with access to nice equipment detect exoplanets and contribute to exoplanet science? The answer is a resounding YES! This session will help science-minded amateurs reduce the learning curve, and avoid some common pitfalls while getting started in exoplanet observations. We'll discuss the equipment, software, and techniques needed to record and analyze exoplanet transits with amateur sized instruments.

10:40 – 11:00 **Break**

11:00 – 11:50 **The Galactic Plane Exoplanet Survey (GPX) – an Amateur Designed Transiting Exoplanet Wide-Field Search**
Paul Benni
GPX is designed to search high density star fields where other surveys, such as WASP[1], HATNet[2], XO[3], and KELT[4] would find challenging due to blending of transit like events. Using readily available amateur equipment, a wide-field telescope (Celestron RASA, 279 mm f/2.2, based in Acton, MA) on a Losmandy G11 mount, and configured with a FLI ML16200 camera, surveys multiple image fields at a ~10 minute cadence per field. The resultant image resolution of GPX is about 2 arcsec/pixel compared to 13.7-23 arcsec/pixel of the aforementioned surveys and the future TESS space telescope exoplanet survey [5].
GPX evolved from the Kourovka Planet Search (KPS) prototype survey and uses K-pipe data reduction pipeline to search for periodic transit-like events in the photometric time-series [6]. K-pipe consists of several sequential scripts for astrometry (Astrometry.net [7]), photometry (IRAF[8]), and Box-fitting Least

Squares transit search [9], and runs on a Linux based laptop computer potentially operable by advanced amateurs.
One Hot Jupiter was discovered with the RASA telescope and validated by RV measurements from SOPHIE spectrograph [10] in the frames of KPS prototype survey (publication pending). Several GPX exoplanet candidate stars of magnitude 11-14 have been identified, showing achromatic depth transit events, a sign of a possible Hot Jupiter, and are now awaiting RV follow-up. This survey demonstrates that advanced amateurs can build & operate star survey equipment, and with professional help with follow-up and validation, expanded ground based surveys can be conducted in star fields that are challenging for other surveys.

11:50 – 1:20 **Lunch, Museum and Turret Telescope open house**

1:20 – 2:10 **Do Planets Leave Home When They Come of Age?**
Observational Constraints on Planetary Migration
Dr. Sam Quinn
In this talk I will review the mechanisms by which planets form (and migrate!) and present observations that constrain our knowledge of these processes. For example, while some giant planets likely form far from their host stars and migrate inward to become hot Jupiters, the method by which they do so will leave its imprint on the system; some mechanisms require the presence of additional planets or stars to drive changes via gravitational interactions, some will excite high orbital eccentricities, and some must occur within a few Myr of formation. Measuring the properties of hot Jupiters (their orbits, system architectures, ages, etc.) will therefore shed light on the processes by which they form. With this in mind, I present the results of a radial-velocity search for planets in adolescent open clusters and an imaging search for binary companions to hot Jupiter host stars. By analyzing hot Jupiter eccentricities and outer companions in these systems, I argue that high eccentricity migration mechanisms (those requiring the presence of an additional planet or star) play an important role in shaping planetary systems. Finally, while I focus mainly on giant planets, I will also describe some ways in which NASA's upcoming TESS mission will contribute to this field for planets of all sizes, which may ultimately help us assess the occurrence rate of habitable planets.

2:10 – 3:00 **High-Precision Photometry in the Search for Exoplanets**
Dr. Song-Hu Wang
Dr. Wang's talk will focus on the high-precision photometry for Exoplanets using the telescope all over the world.

3:00 – 3:20 **Break**

3:20 – 4:10 **Searching for planets with an automated telescope**
Dr. Jennifer Burt
The Automated Planet Finder (APF) is the newest facility at Lick Observatory, comprised of a 2.4m telescope coupled with the high-resolution Levy echelle spectrograph. Purpose built for exoplanet detection and characterization, 80% of the telescope's observing time is dedicated to these science goals. The APF has demonstrated 1 m/s radial velocity precision on bright, RV standard stars and performs with the same speed-on-sky as Keck/HIRES when observing M-dwarfs.

The telescope is now fully automated for RV observations, using a dynamic scheduler capable of monitoring moment to moment weather conditions and selecting targets based on availability, cadence requirement and scientific import, and has played a key role in the detection and characterization of numerous exoplanet systems over the past 3 years.

4:10 – 5:00 **Panel Review: Moderator Dan Lorraine**

5:00 – 5:30 **Break**

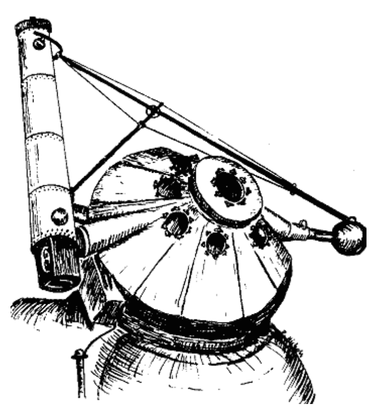
5:30 – 6:30 **Cocktail Hour**

6:30 – 7:30 **Banquet**

7:30 – 8:30 **The MEarth Project - Searching for Small Planets around the Smallest, Closest Stars to the Sun**

Dr. *Jason Dittmann*

Since the discovery of the first exoplanet around a Sun-like star, our understanding of exoplanets has been revolutionized. The next generation of space telescopes and ground based instrumentation may be capable of detecting the atmospheres of rocky, potentially habitable planets. However, these measurements will require large investments of observing time and therefore it is imperative to select the most promising targets for these studies. In this talk, I will discuss the MEarth Project and its search for the small planets whose atmospheres may be detectable with these instruments. MEarth consists of 2 arrays of 8 telescopes each, one in the Northern hemisphere at Mt. Hopkins, AZ and one in the Southern hemisphere at CTIO, Chile. MEarth is monitoring the stars with estimated radii less than 0.3 solar radii and estimated distances within 33 parsecs for transiting exoplanets. Recently, MEarth has identified a rocky super-Earth planet transiting the nearby small star LHS 1140. LHS 1140b resides in its star's habitable zone. In this talk, I will discuss how MEarth identified this object, what we have learned about this object to date, and its prospects for future studies, including the possibility of identifying atmospheric gases that may be indicative of ongoing biological processes.



Lick Observatory: Searching for Extrasolar Planets

In this webcam view of Lick Observatory, the dome of the Shane telescope is in the center. To its left is the Crocker dome, which houses a specialized telescope for finding exoplanets. Just to the right of the Shane dome is the Automated Planet Finder. Above the APF dome is the Katzman Automatic Imaging Telescope, which searches for supernovae.
Credit: Lick Observatory

Lick Observatory is an astronomical research facility in California that has been in operation since 1888. Astronomers at Lick are searching for planets outside the solar system, trying to understand how stars and galaxies came to be, and doing a survey of supernovae to learn about the universe's history.

The University of California owns and operates the observatory, and in 2013 initially announced that it would stop funding for Lick in 2018. In November 2014, however, the university reversed the decision and said it would continue to provide the $1.5 million annually that Lick requires for operations.

“There are enough funds in the projected budgets of UCO to run Lick Observatory for the next five years, albeit at a frugal level,” read a press release from Lick. “Ongoing fundraising efforts and potential partnerships currently being explored may provide additional funding for Lick.”

History
The facility sits at 4,200 feet (1,280 meters) atop Mount Hamilton, which is east of San Jose, California. Funding came from James Lick, who bought 37 tracts of land in San Francisco in 1848, just weeks before the gold rush, according to the observatory's website. Lick bequeathed funds before he died in 1876, desiring a telescope that was "superior to and more powerful" than others that came before it, states the observatory's website.

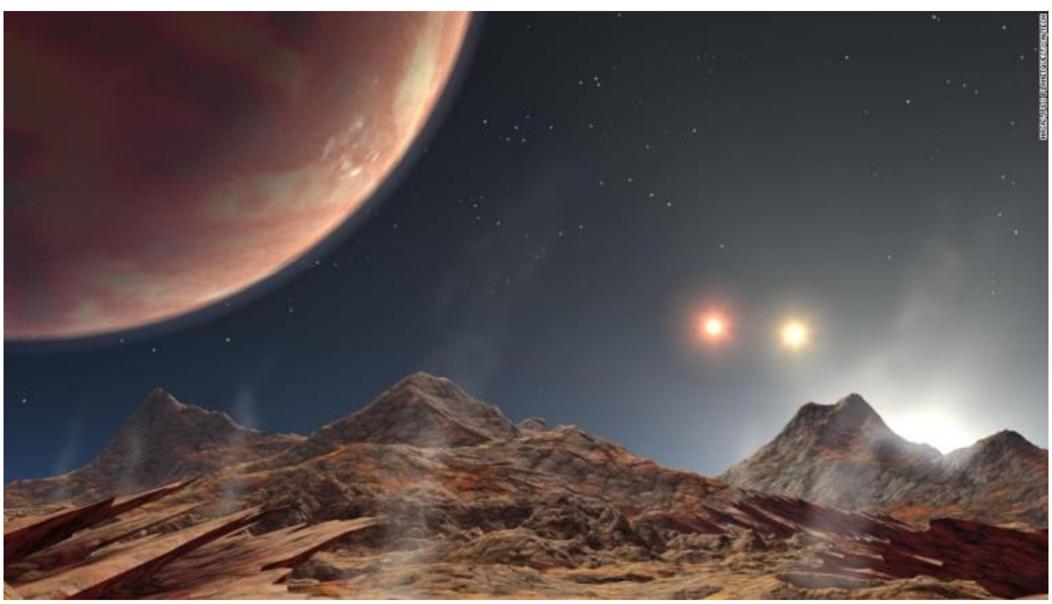
"Lick's deed of trust did not spell out the details of the new observatory, leaving the board of trust great latitude and a great burden of responsibility in carrying out his wishes," the website added.

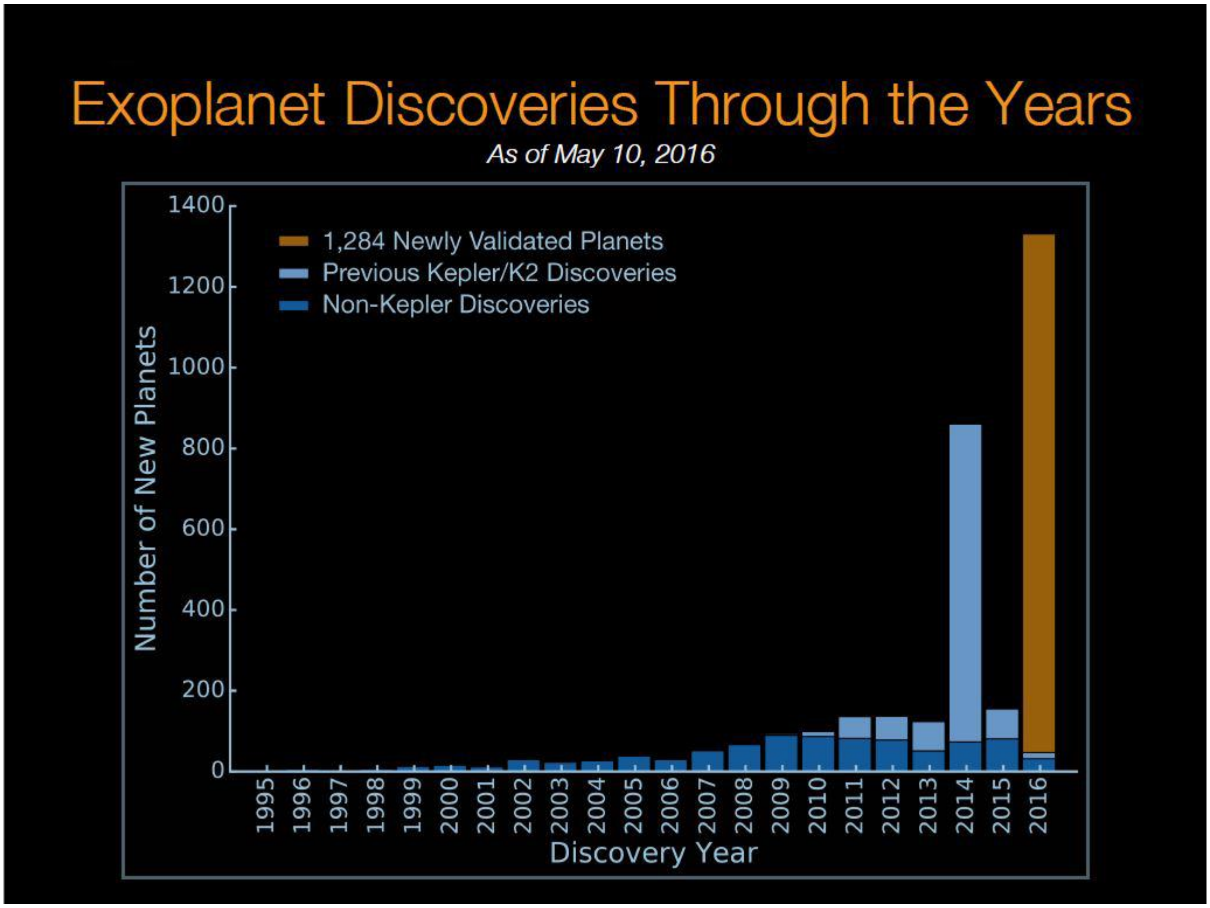
The board debated whether to use a refracting telescope (which focuses light with lenses) or a reflecting telescope (which uses mirrors instead), but at the time, reflectors were just coming on the scene. Officials elected to use a refractor at first (only adding a reflector in later years).
Most telescopes of the era were built in cities, but astronomers were rapidly meeting with disadvantages as light pollution became more prevalent. This led astronomers to choose a mountaintop site instead for the new observatory. Lick bills itself as the "first permanently occupied mountaintop observatory in the world," and currently houses several telescopes.

Current research
Lick's extrasolar planet search involves monitoring about 1,000 stars that are close to the sun's age, temperature and luminosity (intrinsic brightness), Lick states. This is done using the Shane reflector telescope and the Hamilton spectrograph, as well as a newly built Automated Planet Finder.
"Many Jupiter-size and Saturn-size planets have been discovered. As technology improves, smaller planets will be discovered more frequently. The ultimate goal of extrasolar planet search is to discover a solar system similar to our own, with Earth-like planets that may support life," the Lick site states.

Additionally, Lick astronomers are looking at stars to see how elements are created — particularly, how stars evolve to create metals and other elements. The scientists examine older stars that are at different phases in their evolution, looking for similarities and differences. Astronomers also look at high redshift galaxies, which are quite far away from Earth and are early in their evolution.
Another research direction is examining supernovae to see why stars explode and what types are more prone to exploding.

"The Katzman Automatic Imaging Telescope (KAIT) is programmed to search robotically for distant supernovae on every clear night of the year," Lick states. "If KAIT 'sees' differences in luminosity within a galaxy, indicating a possible supernova, it notifies astronomers, who investigate further using the Kast spectrograph."





Facts about Exoplanets

- The known exoplanets fall along a range of sizes, masses, and orbital positions. Sizes and masses range from smaller and less massive than Earth to super-Jupiter types of worlds. Orbital positions range from very close to the parent star to very distant.
- Astronomers are starting to find and measure atmospheres around distant exoplanets. This allows them to understand what gases exist in those gaseous envelopes.
- Among other characteristics, astronomers can measure the surface temperatures, orbits, magnetic fields, and colors of exoplanets. As detection methods improve, they will be able to find out more about distant worlds.
- At least one exoplanet has been found to have an exomoon, while another one is leaving behind a trail of material as it vaporizes while orbiting too close to its star.
- The region around a star where liquid water could exist on the surface of a solid planet is called the habitable zone. Worlds orbiting in that zone are considered to be prime candidates where life could be supported.
- More than 22 percent of Sun-like stars have Earth-sized planets in their habitable zones. These are important places to concentrate a search for possible life-bearing worlds.
- The Kepler Mission was launched to search out distant worlds. It continues its search today. Other missions that have found distant worlds include the Hubble Space Telescope, the CoROT mission from the European Space Agency, the WISE mission, and the Herschel spacecraft. Ground-based observatories continue to be an important part of the search for distant worlds.

Exoplanets - Amateur Detection

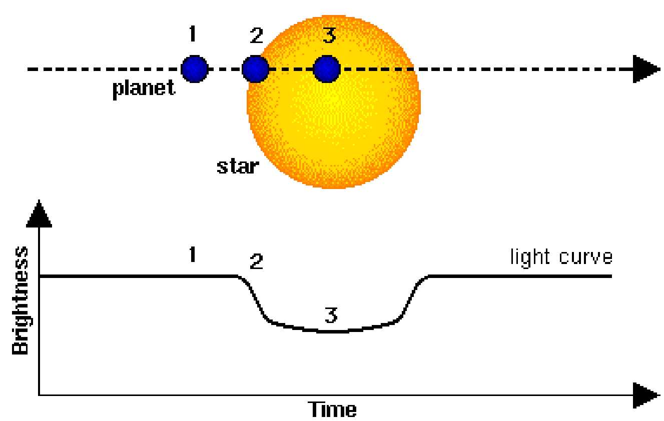
Amateur astronomers can detect exoplanets from their back yards! While finding new planets is probably not possible from a backyard telescope, the professionals have a list of known planets for us to examine.

This is important for two reasons:

- Professionals can discover new planets to add to a target list
- Amateurs can follow-up the target list with desired data for the professional since the professional will have difficulty securing telescope time for continual observation

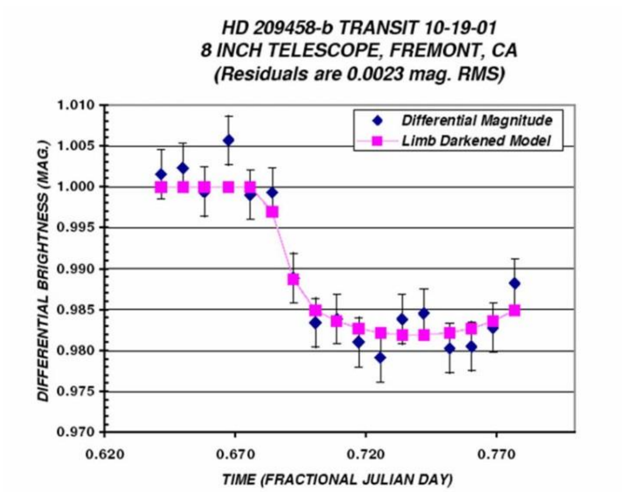
Organized searches like Transitsearch.org can provide interested amateurs with a list of targets for continual study. Best of all, this data is used by professional groups!

The most successful type of data collection by the amateur is through the photometric change in stellar brightness - or the transit method. Only a handful of stars will have a planet cross of the surface of the star, none-the-less continual data of these sources are needed - this frees up the professionals time to focus on the more obscure methods of detection.

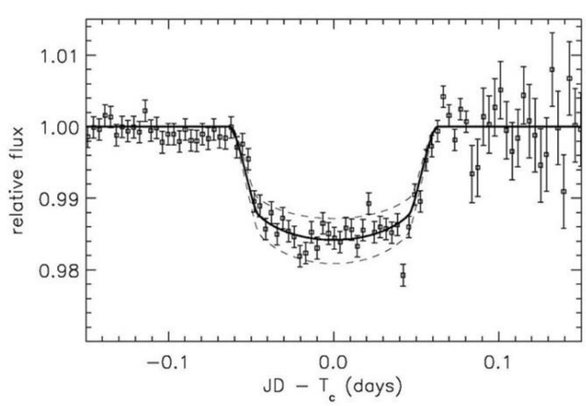


As a planet passes over the portion of the star facing us, the light curve of the star drops for a time. As the planet passes through, the light curve returns to normal. The image below shows a typical setup for an amateur to capture images of the transit:

That is an 8 inch Schmidt-Cassegrain telescope with a 765x510 pixel CCD camera - total cost is about $4000.00 - not bad! The light curve from this telescope is below:



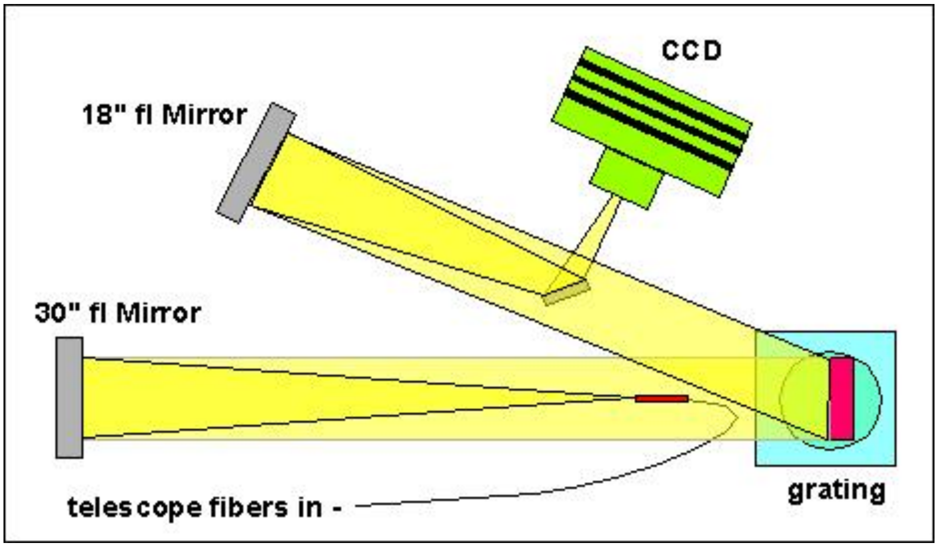
Compare that to a professional light curve:



In other words, the curve is identical.

A group from Spectrashift.com has taken the amateur detection to the next level. Using professional specifications for a home-built spectrometer attached to a 16 inch telescope, this group was able to detect the radial velocity from Tau Boo II, a star with a known planetary system.

The image above shows their 16 inch telescope with custom-made fiber optic cable (running along the ground to the left of the image). This fiber is connected to a large, table mounted spectrometer using this design:



A more detailed look at this spectrometer is available in Stephen F. Tonkin's book Practical Amateur Spectroscopy.

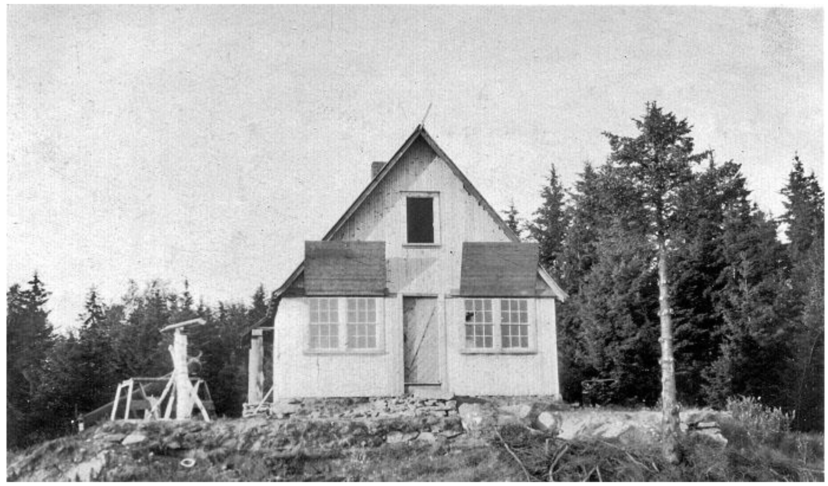
Enjoy the Stellafane Convention

HOME OF THE
SPRINGFIELD TELESCOPE MAKERS
SPRINGFIELD, VERMONT, U.S.A.

THE SPRINGFIELD
TELESCOPE MAKERS
invite you to
STELLAFANE
Springfield, Vt.
July 3rd and 4th, 1926

Talks Exhibits Demonstrations

A night with the stars at Stellafane
Supper by Redfield
Bring your work for inspection
If you have not begun your mirror
START NOW
Bring a fellow enthusiast
Good hotel at Springfield
Fine camping at Stellafane
Will You Come?
Write at once to
OSCAR S. MARSHALL, *Sec.*
135 Putnam Ave.



Thanks for supporting the Hartness House Workshop