

**British Astronomical
Association || Radio Astronomy
Section ||
SARA's Telescope in a Box and
improvements**

PABLO LEWIN (WA6RSV)

**BRITISH ASTRONOMICAL ASSOCIATION || RADIO ASTRONOMY
SECTION ||2021**

A little bit about me:

Active Ham radio
Operator WA6RSV since
1976

I work all bands, all
modes including, CW, FT-
8,Q65 ,WSPR 24/7

Working towards getting
EME operations active

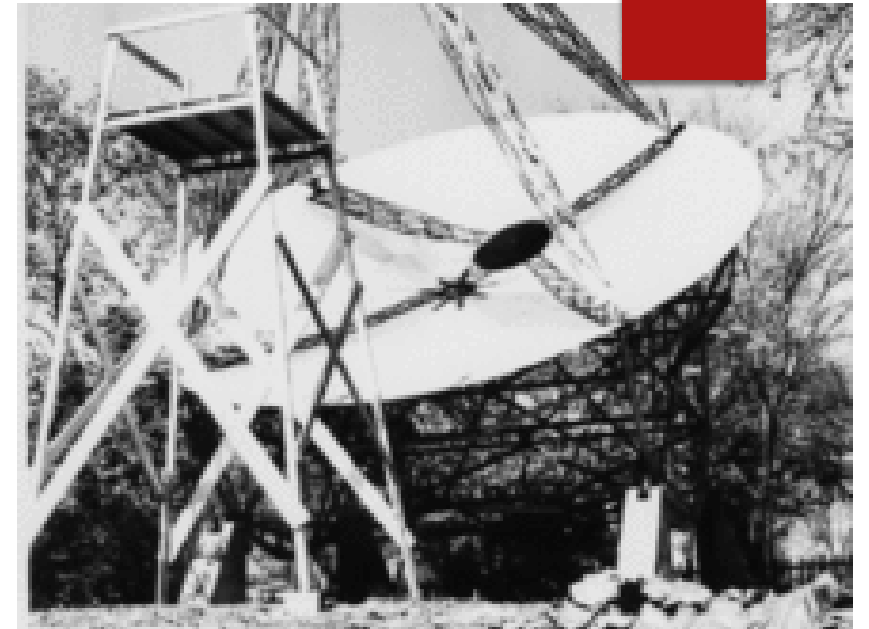
Active Citizen/Scientist
Astronomer member of
AAVSO,AAS,SARA and
NASA TESS Follow up
group 1. NASA Exoplanet
Watch, MPC U76

Own and operate private
research level backyard
observatory

Retired Airline Pilot

Briefly what's Radio Astronomy?

- ▶ 1) Radio astronomy is a subfield of astronomy that studies celestial objects at radio frequencies.
- ▶ 2) The first detection of radio waves from an astronomical object was in 1932, when Karl Jansky at Bell Telephone Laboratories observed radiation coming from the Milky Way.
- ▶ 3) Grote Reber W9GFZ (SK) (December 22, 1911 – December 20, 2002) was an American pioneer of radio astronomy, which combined his interests in amateur radio and amateur astronomy. He was instrumental in investigating and extending Karl Jansky's pioneering work and conducted the first sky survey in the radio frequencies. His 1937 radio antenna was the second ever to be used for astronomical purposes and the first parabolic reflecting antenna to be used as a radio telescope. For nearly a decade he was the world's only radio astronomer.



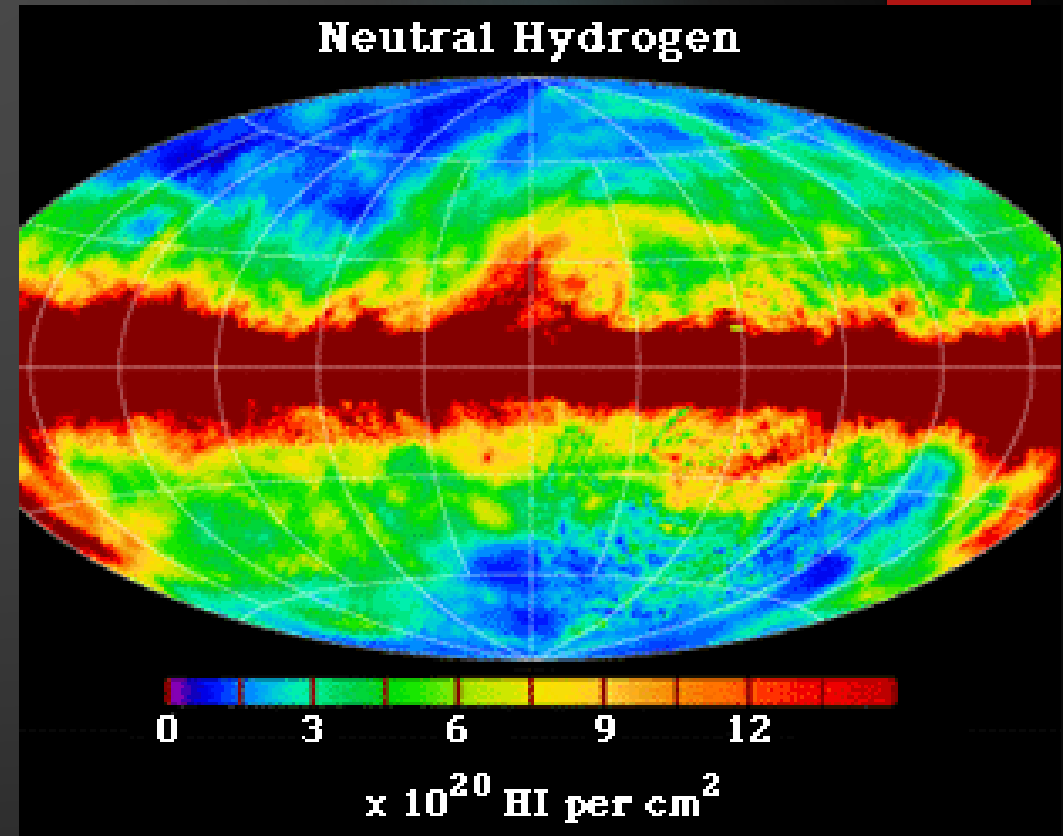
A Brief History of Radio Astronomy in UK

- ▶ The development of radar during the Second World War had two consequences for radio astronomy. Firstly, sources of radio interference which might confuse radar location had to be identified. Hey and his colleagues continued to improve the sensitivities of the receivers and discovered that the background radio emission from the Galaxy itself limited the sensitivity of the telescope system. At the end of hostilities, Hey and his colleagues began mapping the sky at 5m wavelength and in 1946 they discovered the first discrete source of radio emission, which lay in the constellation of Cygnus - the source became known as Cygnus A.
- ▶ At [Cambridge University](#), where ionospheric research had taken place during [World War II](#), [J.A. Ratcliffe](#) along with other members of the [Telecommunications Research Establishment](#) that had carried out wartime research into [radar](#), created a radio physics group at the university where radio wave emissions from the Sun were observed and studied. This early research soon branched out into the observation of other celestial radio sources and interferometry techniques were pioneered to isolate the angular source of the detected emissions. [Martin Ryle](#) and [Antony Hewish](#) at the [Cavendish Astrophysics Group](#) developed the technique of Earth-rotation [aperture synthesis](#). The radio astronomy group in Cambridge went on to found the [Mullard Radio Astronomy Observatory](#) near Cambridge in the 1950s. During the late 1960s and early 1970s, as computers (such as the [Titan](#)) became capable of handling the computationally intensive [Fourier transform](#) inversions required, they used aperture synthesis to create a 'One-Mile' and later a '5 km' effective aperture using the One-Mile and Ryle telescopes, respectively. They used the [Cambridge Interferometer](#) to map the radio sky, producing the [Second](#) (2C) and [Third](#) (3C) Cambridge Catalogues of Radio Sources

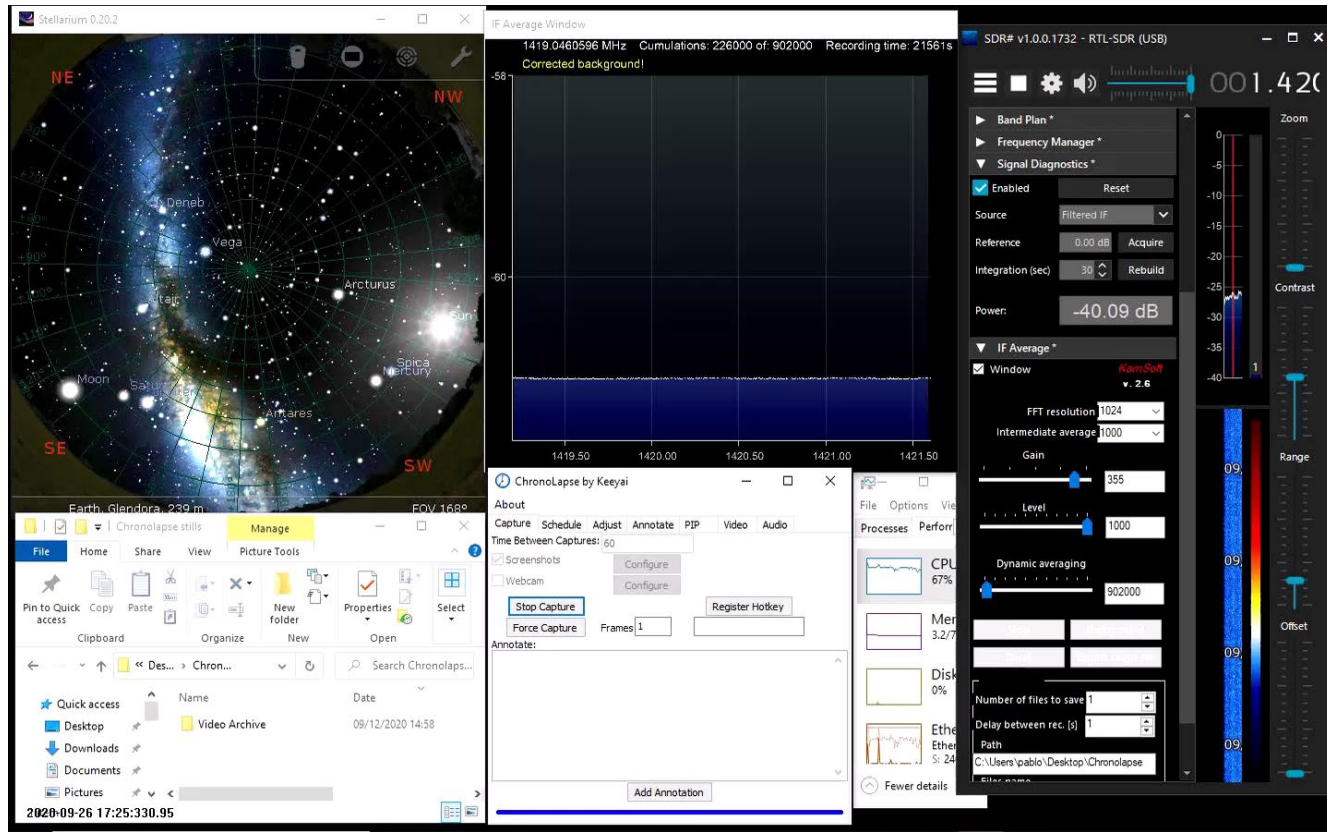


Just one more piece of theory then I'll get on with it, I promise!!

- ▶ If you don't know what the hydrogen line is, Here's a brief explanation. Hydrogen atoms randomly emit photons at a wavelength of 21 cm (1420.4058 MHz). Normally a single hydrogen atom will only very rarely emit a photon, but the galaxy and even empty space is filled with many hydrogen atoms, so the average effect is an observable RF power spike at ~ 1420.4058 MHz. By pointing a radio telescope at the night sky and averaging the RF power over time, a power spike indicating the hydrogen line can be observed in a frequency spectrum plot. This can be used for some interesting experiments, for example you could measure the size and shape of our galaxy. Thicker areas of the galaxy will have more hydrogen and thus a larger spike, whereas the spike will be significantly smaller when pointing at empty space. You can also measure the rotational speed of our galaxy by noting the frequency doppler shift..



Neutral Hydrogen ($\lambda=21$ cm), radio map of the Milky Way. From Dickey and Lockman 1990.



Enough intros and theory show me what this \$300 system do for me!
If a picture is worth a thousand words, then a video?..



Basic Scope in a Box

- ▶ Based on the RTL-SDR CHEAP AND EASY HYDROGEN LINE RADIO ASTRONOMY WITH AN RTL-SDR, WIFI PARABOLIC GRID DISH, LNA AND SDRSHARP ARTICLE

OFF THE SHELF 2.4GHZ DISH

OFF THE SHELF SDR-RTL (BIAS T)

OFF THE SHELF LNA (WITH 50 OHM)



DM

ware defined radio news and projects. Also featuring Airspy, F

[START GUIDE](#) [FEATURED ARTICLES](#) [SOFTWARE](#) [SIGNA](#)

HYDROGEN LINE RADIO ASTRONOMY WITH AN RTL-SDR, WIFI PARABOLIC GRID DISH, LNA AND S



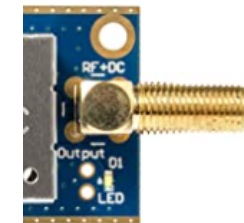
Nooelec SAWbird+ | Cascaded Ultra-Low Hydrogen Line (21cm) Frequency

Brand: NooElec
★★★★☆ 8 ratings

Best Seller

Price: \$37.95 ✓prime FREE On

Get \$10 bonus w



OK, to build this what do I need to buy and where are the plans??

RTL-SDR.COM

RTL-SDR (RTL2832U) and software defined radio news and projects. Also featuring Airspy, HackRF, FCD, SDRplay and more.

HOME ABOUT RTL-SDR QUICK START GUIDE FEATURED ARTICLES SOFTWARE SIGNAL ID WIKI FORUM RTL-SDR STORE

JANUARY 31, 2020

CHEAP AND EASY HYDROGEN LINE RADIO ASTRONOMY WITH AN RTL-SDR, WIFI PARABOLIC GRID DISH, LNA AND SDRSHARP



Roll over image to zoom in

RTL-SDR Blog R820T2 RTL2832U 1PPM TCXO SMA Software Defined Radio (Dongle Only)

Brand: RTL-SDR Blog
★★★★★ 1,305 ratings | 128 answered questions

11 Price Changes

Price: \$29.95 ✓prime & FREE Returns

Save up to 21% with business pricing. Sign up for free Amazon Business account

- Includes 1x RTL-SDR Blog brand R820T2 RTL2832U 1PPM TCXO HF Bias Tee SMA Dongle (V3) (Dongle Only)
- Great for many applications including general radio, air traffic control, public safety radio, ADSB, ACARS, trunked radio, P25 digital voice, POC/SAG, weather balloons, APRS, NOAA APT weather satellites, radio astronomy, meteor scatter monitoring, DAB, classroom learning, or for use as a low cost panadapter with a traditional ham radio.
- Several improvements over other brands including use of the R820T2 tuner, improved component tolerances, a 1 PPM temperature compensated oscillator (TCXO), SMA F connector, aluminium shielded case with thermal pad for passive cooling, activatable bias tee circuit and a much improved antenna set.
- Can tune from 500 kHz to 1.7 GHz and has up to 3.2 MHz of instantaneous bandwidth (2.4 MHz stable). (HF reception below 24 MHz in direct sampling mode with reduced performance). Please note RTL-SDR dongles are RX only.

Nooelec SAWbird+ H1 Barebones - Premium Saw Filter Cascaded Ultra-Low Noise Amplifier (LNA) Module for Hydrogen Line (21cm) Applications. 1420MHz Center Frequency

Brand: NooElec
★★★★☆ 8 ratings

Best Seller

Price: \$37.95 ✓prime FREE One-Day & FREE Returns

Get \$10 bonus when you reload \$100 or more to your gift card balance.

Dish Tripod with Level and Compass, 3 Feet Tall

Brand: NooElec
★★★★☆ 82 ratings | 9 answered questions

2 Price Changes

Price: \$44.99 ✓prime & FREE Returns

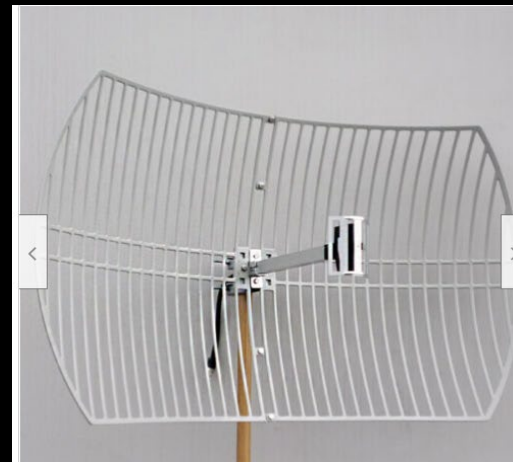
Get 5% back \$2.24 in rewards on the amount charged to your Amazon Prime Rewards Visa Signature Card.

- Portable design for temporary dish mounting. Ideal for 90% of Cassegrain.
- Compact pole & legs attach to base and can be easily removed.
- Works with small portable antennas or standard 18-inch satellite antennas. (Mount sold separately).
- Bubble Level & Compass for quick dish calibration. (Flat, mobile, heavy-duty disc base with convenient azimuth degree markings).
- 3ft Tall (1.66' O.D.) mast included.

Compare with similar items.

Report incorrect product information.

Desk Clamp Power Strip, Desktop Power Outlet Charging Mount with 2 USB Ports & AC Outlets...
\$23.49 ✓prime



2.4GHz 802.11bgn 24dBi WiFi Parabolic Grid Antenna N Female Mounting Kits

★★★★★ 10 product ratings

Condition: New

Bulk savings: Buy 1 \$85.99/ea Buy 2 \$81.69/ea

Quantity: 1 2 or more for \$81.69/ea

More than 10 available
346 sold / See feedback

Price: US \$85.99/ea

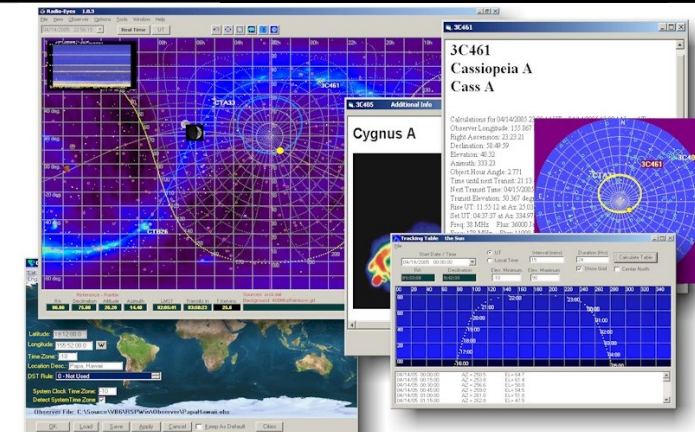
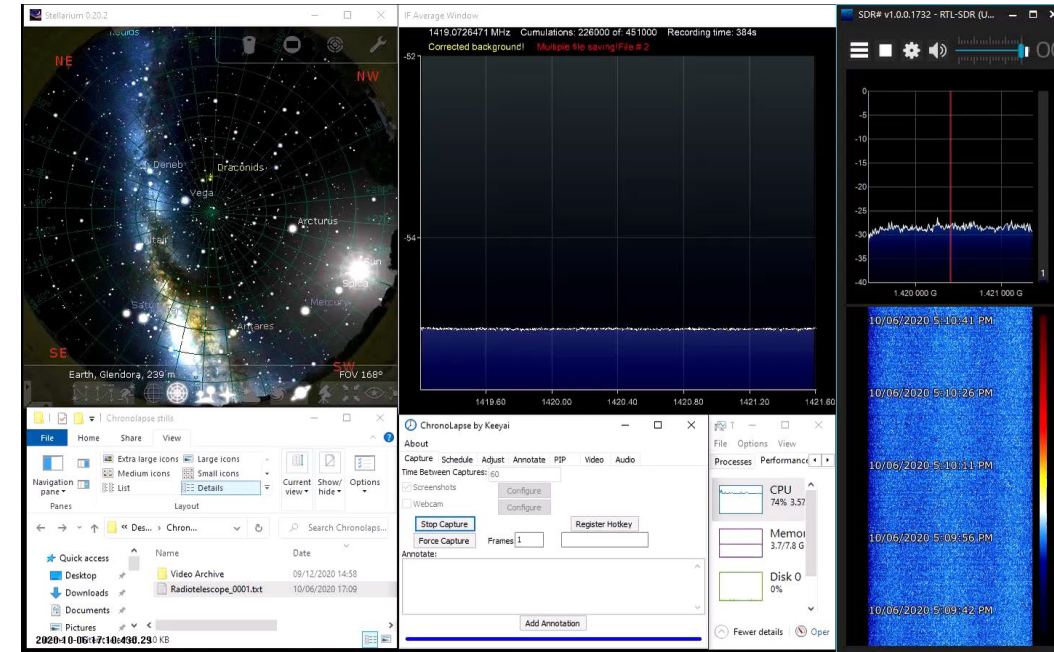
Buy It Now

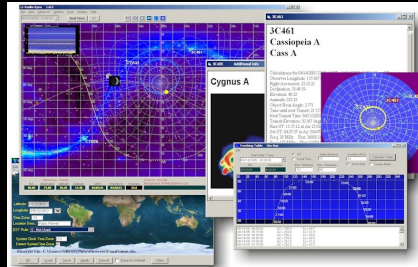
Add to cart

Add to Watchlist

Software for basic “Scope in a Box”

- 1) Stellarium (free) is a free and open-source planetarium, licensed under the terms of the GNU General
 - 2) SDR Sharp (free) In order to detect the hydrogen line we need to use software capable of integrating/averaging many FFT samples over time. Averaging the samples reduces the SDRs quantization noise, allowing the weak hydrogen line peak to be seen. Because the galaxy is moving fairly slowly in the sky, we can safely average for 5-10 minutes at a time.
 - 3) Chronolapse (free) for recording the event
 - 4) Radio Eyes (OPTIONAL AND NOT FREE). The Best!
- Radio Eyes is not just a typical sky viewer that has mappings for radio objects. It is a tool to help you plan and execute your radio observations.
- ▶ correction technique (50 ohm load or simply correct background with no Hydrogen signal)





IMPROVEMENTS TO THE SCOPE IN A BOX


Nooelec Lana Barebones - Ultra Low Module for RF & Software Defined R and Linear 20MHz-4000MHz Freque Tee & USB Power Options

Brand: NooElec
★★★★★ 67 ratings

Best Seller

Price: \$19.95 & FREE Returns

Get \$10 bonus when you reload \$100 or more



Heavy Duty 30" Linear Actuator Polarity Switch Inch Stroke 12v 200LBS Max Lift

Condition: New
Quantity: 1 Last one 23 sold / See feedback

Price: US \$75.95

[Buy another](#)
[Add to cart](#)
[Add to Watchlist](#)

100% buyer satisfaction 23 sold Free shipping and returns

Shipping: FREE Expedited Shipping | [See details](#)
Item location: Sarasota, Florida, United States
Ships to: United States and many other countries | [See details](#)

Delivery: Estimated between Mon, Feb. 9 and Tue, Feb. 9

Payments:

PayPal CREDIT
Special financing available. | [See terms and apply now](#)

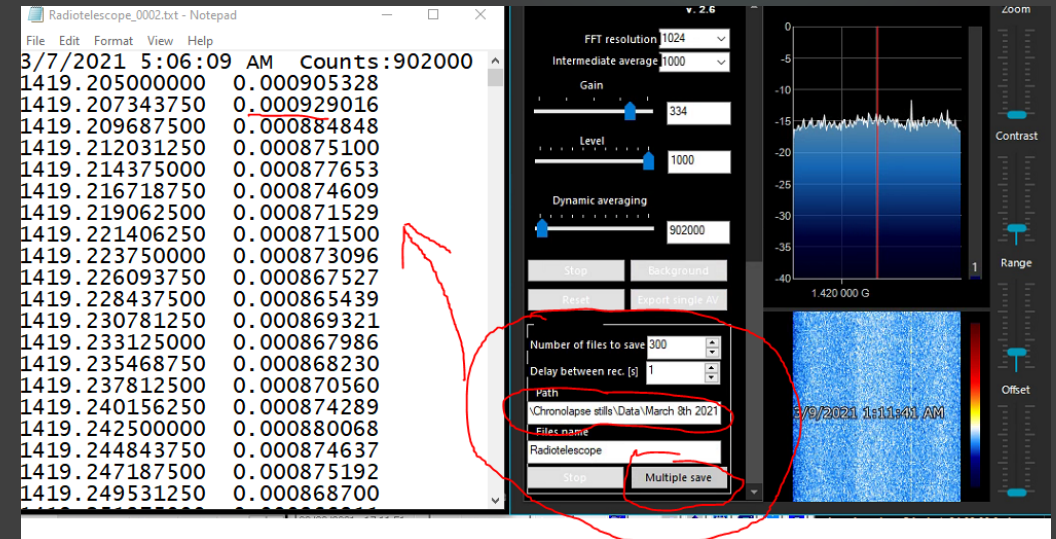
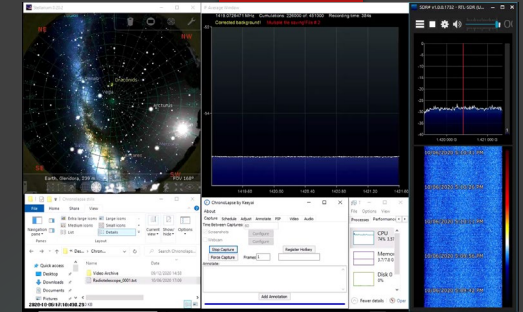
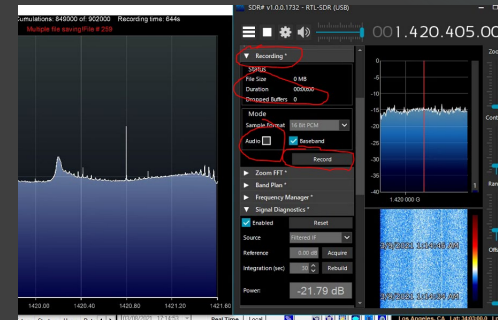
Earn up to 5x points when you use your eBay Mastercard®. [Learn more](#)

Returns: Free 30 day returns | [See details](#)

- ▶ Mesh (1/4 inch)
- ▶ Second LNA (Wideband)
- ▶ Radio Eyes software
- ▶ Elevation Actuator

Results that can be expected with the Scope in a Box

- ▶ Galactic H1 Line detection.
- ▶ Visual display
- ▶ Movie of results
- ▶ Raw Data collection
- ▶ Audio Collection



Computer strategies

- ▶ Types of computers
- ▶ No WiFi
- ▶ Improving Shielding
- ▶ USB Switch for LNA 50 ohm built in switch



VGA Dummy Plug, Headless Ghost, Headless-1920x1080@60hz


Brand: FUERAN
★★★★★ 65 ratings

Checking Prices...

Price: \$8.54 ✓prime & FREE Returns

Get \$10 bonus when you reload \$100 or more

- Solving problems such as stop working for no reason with Windows, OSX, Linux and just about everything else Ultra design Supporting Plug and Play, Hot Plug
- Requiring no driving forces, supporting all systems
- Allows for high resolution, GPU accelerated remote desktop
- Acts as a dummy plug for use with GPU tasks such as cry Desktop on Oculus Rift & HTC Vive (HDMI2K,4K,DVI,DP, THROUGH EDID PLEASE ENTER THE STORE TO PURCHASE



Lenovo ThinkCentre M92p Tiny Mini Business Desktop Computer, Intel Core i5-3470T up to 3.6Ghz, 8GB RAM, 500GB HDD, Intel HD Graphics, VGA, USB 3.0, Windows 10 Professional (Renewed)

Visit the Amazon Renewed Store
★★★★★ 201 ratings | 45 answered questions

Best Seller

Price: \$162.99

Pay \$27.17/month for 6 months, interest-free with your Amazon Prime Rewards Visa Card

Product works and looks like new. Backed by the 90-day Amazon Renewed Guarantee.

- This pre-owned product has been professionally inspected, tested and cleaned by Amazon-qualified suppliers.
- There will be no visible cosmetic imperfections when held at an arm's length.
- Products with batteries will exceed 80% capacity relative to new.
- Accessories may not be original, but will be compatible and fully functional. Product may come in generic box.

This product is eligible for a replacement or refund within 90 days of receipt if you are not satisfied.



SMAKN LCUS-1 type USB intelligent control switch

Brand: SMAKN
★★★★★ 25 ratings | 29 answered questions

Amazon's Choice for USB Cables by SMAKN

Best Seller

Price: \$15.60 ✓prime FREE One-Day & FREE Returns

Get \$10 bonus when you reload \$100 or more to your Amazon Prime account

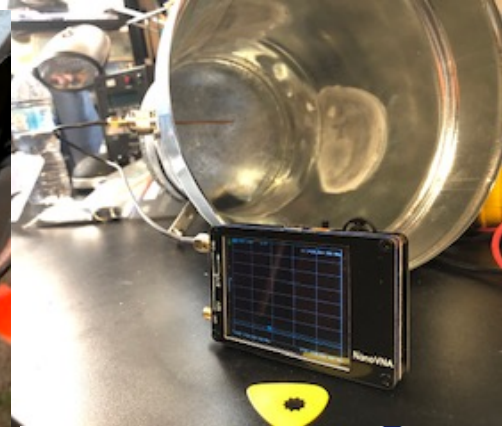
May be available at a lower price from other sellers without free Prime shipping.

- USB intelligent control switch.
- Onboard high-performance micro-controller
- Onboard 5V, 10A / 250VAC, 10A / 30VDC continuous pull 100,000 times.
- Relay modules with overcurrent protection

A Larger Dish

- ▶ Where to get cheap/free Dishes
Offerup, Craigslist, Freecycle, Nextdoor
- ▶ Building a feedhorn
- ▶ Soldering for the first time

OfferUp listing for a C-band 10 foot satellite dish with LNB. Price: \$25. The listing includes details about the dish's condition and location (Irvine, CA).

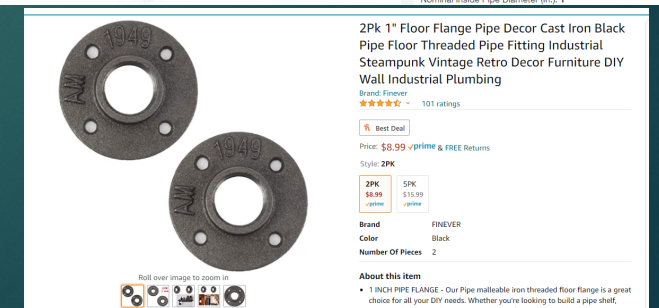
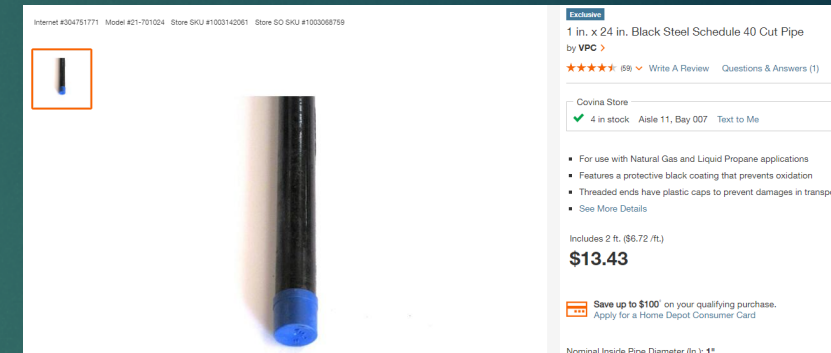
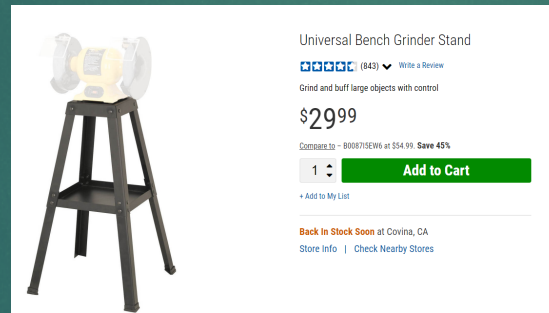
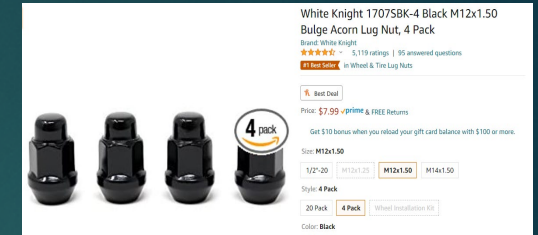
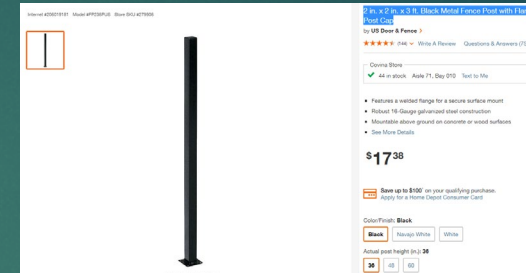
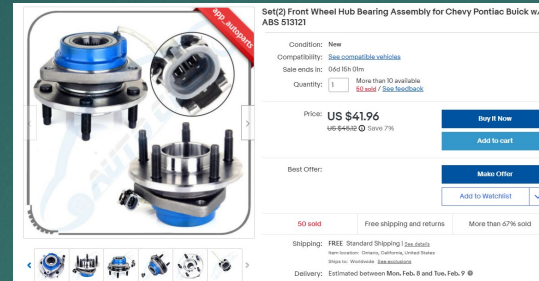


Amazon listing for Imperial 8-in Dia Galvanized Steel Round End Cap. Price: \$6.98. The listing includes a description and an 'Add to Cart' button.

Amazon listing for NanoVNA-H Vector Network Analyzer. Price: US \$52.68. The listing includes a description and an 'Add to Cart' button.

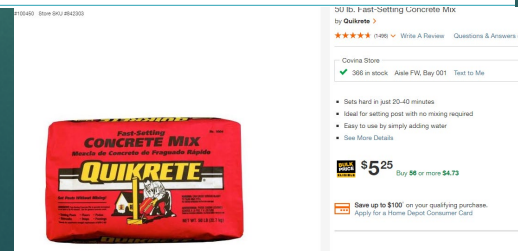
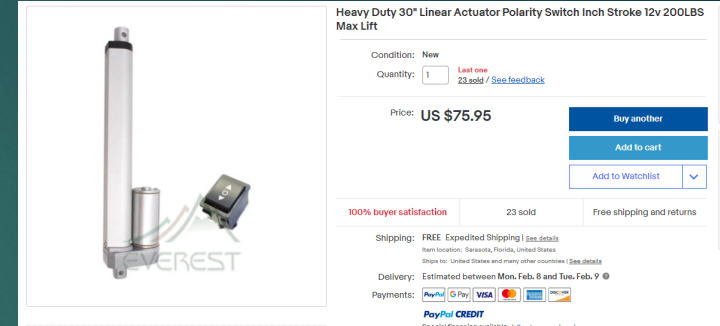
An Inexpensive, Sturdy Alt/Az mount

- ▶ The front wheel axle
- ▶ The Universal Bench grinder stand
- ▶ Fence Posts
- ▶ Black steels pipes
- ▶ Ubolts, floor flange and steel nipples




The Mount assembly and Elevation motor

- ▶ The Linear Actuator
- ▶ Elevation simple remote control
- ▶ Quikrete and Electric auger



The mount assembly and the Azimuth motor

- ▶ The sprockets
- ▶ The motor
- ▶ The chain



L-FASTER 9 Tooth Sprocket for Bike Motor MY1016Z Unitemotor MY1018 Original 9T Sprocket Scooter Engine Sprocket for 410
Brand: L-FASTER
★★★★☆ 58 ratings
Amazon's Choice

Best Deal

Price: **\$7.99** ✓prime & FREE Returns

Get \$10 bonus when you reload your gift card balance with \$100 or more.



JRL Wheel Sprocket 36T 36 Tooth Motorized Gas Cycle Bicycle 50cc 60cc 80cc
Brand: JRL
★★★★☆ 104 ratings | 12 answered questions

Best Deal

Price: **\$12.30** ✓prime & FREE Returns

Your cost could be \$2.30. Eligible customers get a \$10 bonus when reloading \$100.

May be available at a lower price from other sellers, potentially without free Prime shipping.

- Fit 49cc 50cc 66cc 80cc Motorized Bicycle Bike Moped
- Package Include: 1x sprocket
- USE FOR Rear-Sprocket Mount Mounting Plads Kits/ 9 Hole Sprocket Mount Kit USE FOR CNC 3 Holes Sprocket USE FOR Rear Hub Disc Brake Ball Bearing
- Purchase With Confidence - Buy our Motorparts Product knowing it's a perfect fit, excellent quality, built to last, and most importantly we stand behind our products.

See more product details

Compare with similar items

New (2) from \$11.99 & FREE Shipping

Report incorrect product information.



Bringsmart 12V 3rpm DC Worm Gear Motor 25kg.cm High Torque Mini Turbine Worm Reducer Motor Self-locking Micro Gear Motor Reversible (JGY-370 12V 3rpm)
Brand: Bringsmart
★★★★☆ 93 ratings

Best Deal



Price: **\$14.99** ✓prime & FREE Returns

Your cost could be \$4.99. Eligible customers get a \$10 bonus when reloading \$100.

Size: JGY-370 12V 3rpm

12V 6rpm	12V 18rpm	12V 23rpm	12V 30rpm	12V 40rpm
12V 66rpm	12V 90rpm	12V 160rpm	12V 210rpm	

JGY-370 12V 3rpm JGY-370 12V 10rpm Bracket



420 Motorcycle Chain - 420 Standard Roller Chain for 110cc 125cc Go kart Dirt Pit Bike ATV Quad Scooter Mini Bike, Total 132 Links, Free Chain Breaker Included
Brand: AOIT
★★★★☆ 39 ratings | 9 answered questions

Best Deal

Price: **\$18.99** ✓prime & FREE Returns

Save 5% on 2 select item(s). Shop items

Get \$10 bonus when you reload your gift card balance with \$100 or more.

- Made of alloy steel, this 420 roller chain is in premium quality, heavy duty, strong and durable
- Fit for 110cc 125cc go kart, dirt bike, pit bike, mini bike, scooter, ATV quad etc
- Chain total length 132 links, long enough for your use
- Come with a master link and chain breaker, you can cut the chain to required length and reconnect
- Package including 1pcs roller chain with a master link and 1pcs chain breaker

See more product details

Compare with similar items

Report incorrect product information.



Mount Computer Control and remote position feedback

- ▶ Simple Motor controllers
- ▶ Witmotion Sensor with cable
- ▶ Live demonstration of Radio Telescope Operation



【WT901C-TTL 9-Axis Vibration Inclinometer】 High-Performance Acceleration+Gyro+Angle (XY 0.05° Accuracy)+Digital Compass, Triaxial MPU9250 Tilt Sensor 【Kalman Filtering】 for Arduino, Raspberry Pi

Visit the WITMOTION Store
3 answered questions

Best Seller

Price: ~~\$33.90~~ ✓prime & FREE Returns

Extra Savings Promotion Available. 4 Applicable Promotion(s)

- 【 High Performance 】 Rock-solid data output: 3-axis XYZ (Pitch Roll Yaw) Acceleration+ Gyro+ Angle+ Magnetic field+Quaternion, measurement range and output rate (0.2-200Hz) selectable
- 【 Robust Design 】 X, Y-axis: 0.05° (Static) , X, Y-axis: 0.1° (Dynamic), Long term measurement, Premium casing, Small in Size
- 【 WITMOTION Advantage 】 8-year Professional Attitude Measuring Solution Provider, sensors integrated R&D dynamic fusion algorithm and Kalman Filtering ensuring stable data output and excellent bias stability.

returns
FREE delivery: Saturday, March 13
Order within 2 hrs and 28 mins
Details

Only 19 left in stock - order soon.

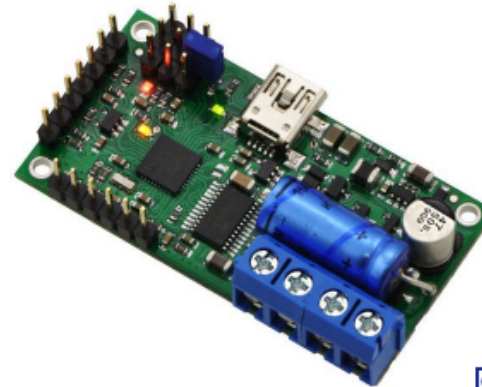
Qty: 1

Add to Cart

Buy Now

Secure transaction
Ships from Amazon

Motion Control Modules » Brushed DC Motor Controllers » Pololu Simple Motor Controllers » Pololu Simple Motor Controller 18v7 (Fully Assembled)



Pololu item #: 1372

31 in stock

Brand: Pololu

Status: Not Recommended for New Design

✓RoHS3

Price break Unit price (US\$)

1	41.95
5	38.59
25	35.51

Quantity: 1

Add to cart

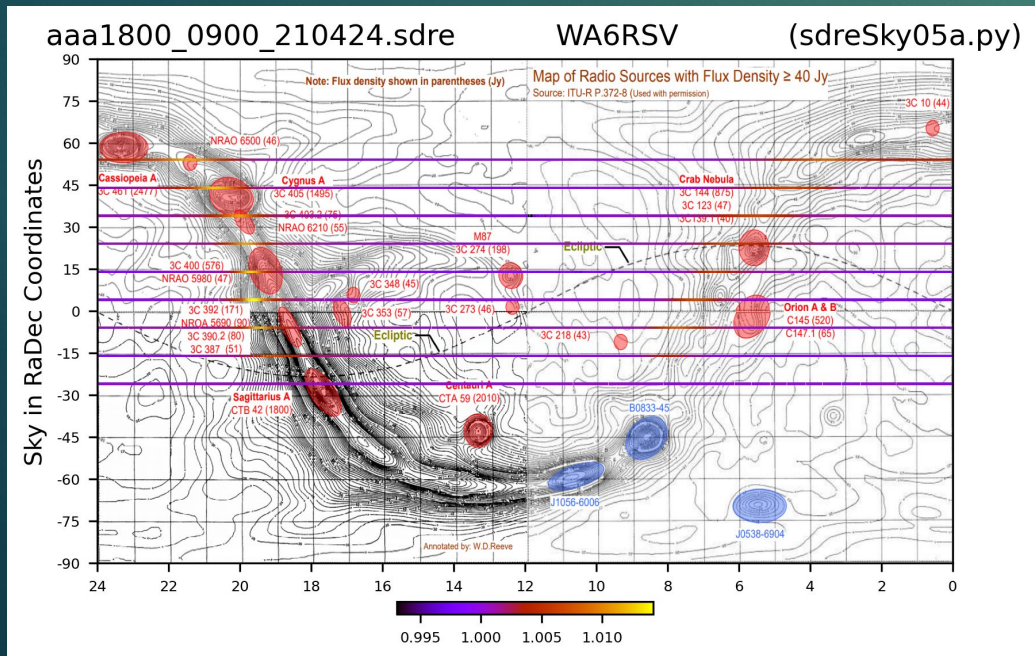
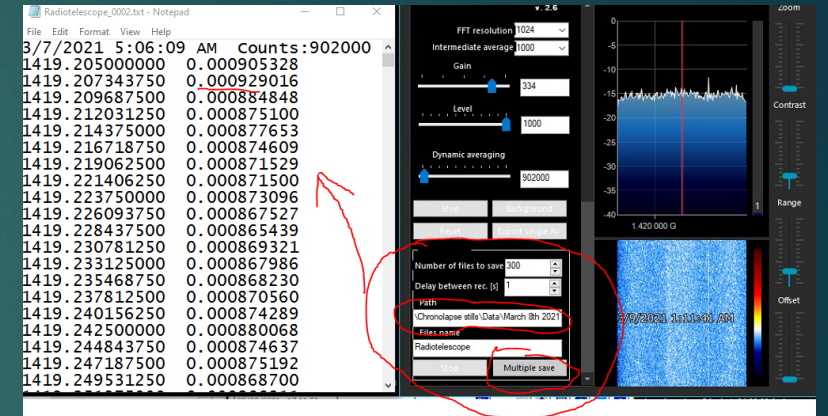
backorders allowed

Add to wish list



Possible Science applications IF Average

- ▶ Spectra: A spectrum is simply a chart or a graph that shows the intensity of light being emitted over a range of energies. ... Spectra can be produced for any energy of light, from low-energy radio waves to very high-energy gamma rays.



The sdrRA set of programs reveal information in the radio spectrum data files created by the popular SDR# Software Defined Radio program and an "IF Average Plugin", SARA member Ted Cline N0RQV

Society of amateur Radio Astronomers (SARA)


radio-astronomy.org

Search our store

MEETINGS MEMBERSHIP PROJECTS BOOKS SHIRTS AND LOGOS

HOME / PROJECTS / SCOPE IN A BOX

SCOPE IN A BOX



REQUIRED FOR AMAZON SHIPPING (Required)

\$295.00

0 Add to Basket

Product Information Specification

A ready made kit of parts and software to detect the Hydrogen line are now available through SARA.
The original design was from RTL-SDR.
<https://www.rtl-sdr.com/cheap-and-easy-hydrogen-line-radio-astronomy-wit...>

We had three different SARA members build the kit and refine the software.
When you order the kit, the parts will be drop shipped from Amazon. This saves about \$70 in shipping costs.
You will also receive an email with a DropBox download that will contain complete installation instructions and software.
Unfortunately sales are currently limited to addresses in the USA.

Society of Amateur Radio Astronomers

Home Education Administrative Forum Meetings Projects Links Photo Gallery Shop SARA Store Sections RASDR Contact Us

The Society of Amateur Radio Astronomers (SARA) Mission Statement

It shall be the Mission of the Society of Amateur Radio Astronomers (SARA) to:

- Facilitate the flow of information pertinent to the field of Radio Astronomy among our members.
- Promote members to mentor newcomers to our hobby, and share the excitement of radio astronomy with other interested persons and organizations.
- Promote individual and multi station observing programs.
- Encourage programs that enhance the technical abilities of our members to monitor cosmic radio signals, as well as to share and analyze such signals.
- Encourage educational programs within SARA and also educational outreach initiatives thru student and teacher grants for radio astronomy projects.
- The Society of Amateur Radio Astronomers, Inc. is a membership supported, non-profit [501(c) (3)], educational and scientific corporation.

What is The Society of Amateur Radio Astronomers (SARA)?

The Society of Amateur Radio Astronomers (SARA) is an international society of dedicated enthusiasts who teach, learn, trade technical information, and do their own observations of the radio sky.
This organization is a scientific, non-profit group founded for the sole purpose of supporting amateur radio astronomy. SARA was organized in 1981, and today has hundreds of members worldwide.
The group consists of optical astronomers, ham radio operators, engineers, teachers and non-technical persons. Many of our members are new to the field, and membership is extended to all who have an interest in radio astronomy.
Donate now to help SARA promote radio astronomy to students and teachers worldwide.

Join SARA!

SARA Annual Conference

- Conference info
- Keynote Speaker
- Paper Abstracts
- Conference registration

Articles on web

- York College students building local astronomers new, larger eye on the cosmos

PayPal Click Here To Donate



Q&A

- ▶ Thank you for watching!
- ▶ Thank you Paul Hearn and the British Astronomical Association.
- ▶ Go ahead, ask any questions you want, I'm still not going to get paid and if I don't know the answer, I'll either research it or make it up or both!
- ▶ My contacts are
 - ▶ pablotwa@earthlink.net
 - ▶ pablotwa1@gmail.com
 - ▶ [Facebook.com/pablotwa](https://www.facebook.com/pablotwa)