Monitoring nearly 4000 nearby stellar systems with the OVRO-LWA in search of radio exoplanets

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Understanding how CMEs scale with flare energy and frequency is critical to diagnosing habitable environments around magnetically active stars.

We need to characterize both planetary magnetic fields and stellar transient mass loss.
Characterizing stellar magnetic activity, planetary magnetic fields, and their interaction for a wide range of host mass and age.

How can we optimize the search for extrasolar space weather, and begin detecting and characterizing systems en masse?

- Low frequency ( < 100 MHz )
- Large-FoV instruments
- Capitalize on characteristics of emission mechanisms (Stokes V)

Image credit: C. Carter & G. Hallinan
Low frequency (< 100 MHz)

![Graph showing incident kinetic power (W) versus radio power (W) and incident magnetic power (W) for both Hot Jupiter population and Solar System bodies.](image)

- Zarka 2001
- OVRO-LWA
Low frequency (\(<\ 100\ \text{MHz}\))

- Extrapolation from our own SS suggests it is necessary to go below 100 MHz to directly detect exoplanetary radio emission.
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- Solar Type II radio bursts are associated with CMEs, and frequently occur in the sub-100 MHz regime.

Kouloumvakos et al. 2014
Figure c/o J. Villadsen
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- Solar Type II radio bursts are frequently associated with CMEs, and peak in the sub-100 MHz regime.

- Previous detections of flare star radio emission indicate flux increases at low frequencies.

Spangler & Moffett 1976
Large-FoV Instruments

- Capture a large fraction of sky in order to monitor a large sample of objects.

- Sensitive to rare events associated with extreme flares / CMEs that may induce significant increase in exoplanetary radio power.

Gallagher and D’Angelo 1981

Earth’s Auroral Emission

Solar wind speed [km/s] vs. Radio Power

1000x increase during Solar CME!
Current mode of operation with the Stage 2 OVRO-LWA

- Continuously observing as of November 2016, in order to respond to external event triggers (including GW events from aLIGO, X-ray flares from Swift).

  - Initial 24-hour dataset monitoring 4000 objects out to 25 pc.
  - 27-84 MHz with 24 kHz resolution
  - 13-second integrations

Image credit: G. Hallinan
Simultaneous optical monitoring with Evryscope

- Evryscope is an 8,600 sq. deg. FoV telescope at CTIO, that has 1.5 year-long coverage at $g > 16.5$.
- 45% FoV overlap between Evryscope and OVRO-LWA.
- Can begin to establish how flare frequency correlates with CME occurrence-rate for large range of spectral type and age.

EvryFlare: Flare rates and intensities for every $10 < g' < 15$ solar-type and red dwarf star in the Southern sky.
Initial results from a sample subset of flare stars.

~400 mJy

Stokes V

Integrating down in Stokes V, we can get down to 100 mJy.
OVRO-LWA light curves for the usual flare star suspects.

5 Jy at 196 MHz
2.0 Jy
0.25 Jy

500 mJy at 318 MHz

Spangler & Moffett 1976

<100 MHz

Optical Evryscope observations of UV Ceti

UV Ceti
Searching for signatures of magnetic activity in a volume-limited sample of systems.

Simultaneous monitoring of nearly 4000 objects, out to 25 pc

- Equivalent to >5000 hours of targeted observation
- Increases to 5 years with the full 24-hour dataset
The completed stage-III OVRO-LWA, in coordination with Evryscope-North...

- ...will provide unprecedented statistics on flare and CME activity
- ...with nearly 100% overlap in sky coverage
- Planned 1000-hour survey
  - with few-seconds cadence and ~100 mJy snapshot sensitivity with OVRO-LWA
  - and 2-minute cadence for every star down to 16.5 mag with Evryscope-N
Establish flare and CME rates across a wide range of mass and age.

Investigate the relationship between flare energy and CME kinetic energies for low mass stars.

Inform the community of extreme events.

Receive triggers for highest energy events (e.g. *Swift* super-flares)

Provide the most meaningful constraints (or detections) of radio exoplanets!