Monitoring nearly 4000 nearby stellar systems for extrasolar space weather with the OVRO-LWA

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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
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.
And understanding how CME mass, morphology, and velocity scale with magnetic field strength and topology.
Low frequency (< 100 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
Low frequency (< 100 MHz)

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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
- 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
The Owens Valley Radio Observatory
Long Wavelength Array (OVRO-LWA)
Stage I of the array was completed in 2014

- 256 crossed-dipoles
- Spread out across a 200-m diameter core
Stage II (and current status) of the array was completed in 2016

1. 256 crossed-dipoles
   - Spread out across 200-m diameter core

2. Added 32 additional dipoles
   - Increased maximum baseline out to ~1.5-km
(The final) Stage III of the array will add an additional 64 antennas on long baselines, and vastly increase the capabilities of the existing OVRO-LWA.

1. 256 crossed-dipoles
   - Spread out across 200-m diameter core
2. Added 32 additional dipoles
   - Increased maximum baseline out to ~1.5-km
3. Final array of 352 antennas
   - New correlator for 704 inputs
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 **28-hour** dataset monitoring 4000 objects out to 25 pc.

- **27-84 MHz** with 24 kHz resolution

- **13-second** integrations

Image credit: G. Hallinan
Initial results from a sample subset of flare stars.

~400 mJy Stokes I

~330 mJy Stokes V

Averaging down for 2 minutes in Stokes V - ~100 mJy.
OVRO-LWA light curves for the usual flare star suspects.

A Wolf 424-like flare would be >10 σ detection!
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 5 years of targeted observation
Sensitivities achieved for all objects in the 28-hour survey.
Scientific goals of the OVRO-LWA

- 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.