The Evryscope and extrasolar planets

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http://evryscope.astro.unc.edu/

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The Evryscope: why build it?

-Most of surveys (transiting exoplanets and others) cover the sky by tile & revisit strategy in a few-days. So they are not sensitive to ~hrs/mins timescale events.

-Evryscope opens a new parameter space among operating sky surveys: it adds an order of magnitude in FoV and high data cadence (2mins).

Key capability: long-term, high-cadence monitoring of millions of targets simultaneously.

-A lot of people can benefit!
The Evryscope: Concept

- 24 x 61mm telescopes, 29MPix each
- 1.8m fiberglass dome
- German Equatorial mount
- Dome tracks sky

691 MPix
8,000 sq.deg. FoV
Total hardware cost $300K (funded by NSF/ATI 2014)
Key projects summary with Evryscope:

**Transiting exoplanets**
- Asteroid-sized planets around white dwarfs
- Confirmation of long-period TESS single-transit detections
- Habitable zone of M-dwarfs
- The nearest & brightest stars

**Nearby microlensing events**
- 2-minute cadence even before detection

**Eclipse/transit timing & measurement**
- Exoplanet detection
- Mass-radius relation measurement

**Young & active stars**
- Comprehensive measurement of stellar activity
- All stars $g<16$, every 2 minutes, 100-degree declination range

**Young Nearby Supernovae**
- Monitor the objects before they go off
- Shock breakout & pre-outbursts

**Gamma Ray Bursts**
- Optical observations of GRBs before gamma-ray detection
- Orphan afterglows across the sky

**Exotic transients**
- Post-facto localization of gravitational wave counterparts, millisecond radio transients, ...
The Evryscope: deployment

**When:** deployed May 2015 (4 months ahead of schedule).

**Where:** CTIO.

**Status:**
- as today it has already collected ~250,000 29MPx images (~15TB of raw data).
- fully robotic: system health, weather status monitoring & observations scheduling.
- wind-shake, tracking & image quality within requirements.
- reduction pipeline is providing astrometrically and photometrically-calibrated images.
The Evryscope: specifications

**FoV:** 8,000 sq.deg.

**Direct imaging:**
\[ g_{\text{lim}} \approx 16 \text{ every 2 minutes} \]
\[ g_{\text{lim}} \approx 18 \text{ every hour} \]

**Precision photometry:**
3 mmag on all \( g=12 \) stars every 16 minutes

**Data rates:** 97% survey efficiency (4sec dead time).

104 MBit/sec continuous raw data streaming.

35,000 photometric measurements/yr for 20 million stars (~100TB/yr).
8,000 sq. degrees instantaneous FoV vs. SDSS DR7 FoV
Ratchet back HA every 2hrs.
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~40% of the entire sky is covered in ~6.5h at 2 minutes cadence
90% of stars $b>15^\circ$ in 120s exposures with **uncrowded photometry**

Image quality: 1:1 zoom cutout of a single Evryscope exposure taken under typical sky conditions at CTIO. This image makes up about 0.03% of the Evryscope FoV.
First large-scale survey for habitable planets transiting White Dwarfs

- Planetary system evolution during red giant phase is a topic of active research.
- A few 100+ WDs with <10% precision and ~1000+ g<16 WDs each night are observed with 2mins cadence.
- >Ceres-size objects could be detectable (+dust clouds etc.).
- Even a null result for the transiting WD exoplanets would constrain the habitable planet fraction at the 30% level (Agol 2011).

The probability of detecting a transiting rocky planet around a white dwarf in one month of Evryscope data, based on detailed simulations of our detection efficiency, detection algorithms and correlated noise.

Mark Garlick
TESS-Evryscope Synergies

- Four 10.5cm lenses
- 2300 sq. deg. FOV, 21”/pixel
- ~200,000 nearby, bright stars ($m_I = 4-13$)

- Evryscope provides at least 2 years of target pre-imaging for TESS host characterization
- Observes fields for >20 times longer than TESS => greatly increases TESS long-period giant return
Nearby M-dwarfs transits

- ~5,000 M-dwarfs bright & small enough to find few-Earth-radii planets.
- 5-10 few-Earth-radii rocky planets likely detectable based on simulations.
- >30,000 M-dwarfs searchable for giant planets.

The probability of detecting a transiting rocky planet around an M-dwarf in 1 and 3 years of Evryscope data, based on detailed simulations of our detection efficiency, detection algorithms and correlated noise.
All-sky survey of rare microlensing events of nearby stars

Rocky planet in 2.6AU orbit around M-dwarf ($m_I=14.2$)
In 2 years Evryscope will perform a short-time exposures survey, which will be sensitive to long-term planets in the very bright end.

This survey will monitor 70,000 stars g<10 for increasing planets around very bright stars, which will be amenable to follow up atmospheric characterization.
Preliminary results

Photometric performance achieved by the Evryscope for 3 different nights for stars which are bright enough to be limited by scintillation and systematics. The photometric performance improves as expected for low levels of systematic noise.

Light curve of the RR-Lyr V*RS Oct imaged by the Evryscope during a single night sampled at 2mins, from our preliminary data analysis.
Thank you.

Questions?

Interested in collaborating?

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