MINERVA-Australis and SONG: Australia’s Robotic PRV Machines

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MINERVA-Australis: Partners

“From many, we are one”
• TESS will deliver hundreds of super-earths and mini-Neptunes orbiting bright stars.
• Precision radial velocity resources are limited and highly competitive. There are too many planets and not enough telescopes.
• Prime missions: Measure masses for TESS planets $2+ R_{\text{earth}}$, and longer-term monitoring for additional non-transiting planets.
• MINERVA-Australis at USQ is the world’s only fully dedicated TESS Southern follow-up facility.
MINERVA-Australis: Site

- 28° South: Northern targets observable to +40° dec
- Average 1.6” seeing, ~65% spectroscopic nights
- 30 minutes from Toowoomba campus: easily accessible for maintenance
- Remote operations NOW, Robotic ops “soonish”
MINERVA-Australis: Equipment

- Up to 6 Planewave 0.7m telescopes
- Individual telescopes can “break formation” to perform simultaneous photometry.
- Stabilised R>80,000 “Kiwispec” spectrograph purpose-built for precision velocity work.
- 4-telescope ops by mid-2019.
MINERVA-Australis: Technical

- Coverage 480-620 nm
- 20 mK thermal stability in the vacuum tank
- RVs obtained via simultaneous Th-Ar calibration fibre. Iodine cell optional.
- Internal calibration precision: 2 m/s
- Photometry: 2-4 mmag rms

Ask Duncan Wright for more details

Tau Ceti: 2.3 m/s rms
Minerva data (blue) for HD 1397 = TOI-120
Consistent with CORALIE data (black)
L.D. Nielsen et al., 2019 A&A 623, 100
MINERVA-Australis: Results

- HD 75289, known Hot Jupiter P=3.486 d
- V mag: 6.36    26 days of data
- Fit RMS = 5.3 m/s
MINERVA-Australis: Results
Our First TOIs

- V mag: 9.58
- 48 +/- 13 Mearth

- V mag: 9.12
- 60 +/- 20 Mearth
SONG: Stellar Observations Network Group

- Measuring the small movement of the stellar surface requires precise, high-cadence velocity observations.
- A single target must be observed continuously for days to weeks to capture the most important modes.
SONG: Tenerife node performance

Credit: Frank Grundahl
The Conductor

M.F. Andersen+ 2019, arXiv:1901.07560

Normal night

Credit: Mads Fredslund Andersen
The Conductor

M.F. Andersen+ 2019, arXiv:1901.07560

High winds

Credit: Mads Fredslund Andersen
SONG-Australia: Stellar Observations Network Group

- We built the MINERVA site to accommodate a SONG node.
- Extend longitude coverage.
- Overlaps significantly with Northern targets since we are at only 28 South.
SONG-Australia at Mount Kent

- Identical to MINERVA design: many 0.7m telescopes feed a single high-resolution spectrograph.
- Funded by Carlsberg Foundation, Aarhus University, Australian Research Council.
- Spectrograph being built now.
- Telescope 1 donated by local philanthropist.
Alexander wept when he heard Anaxarchus discourse about an infinite number of worlds, and when his friends inquired what ailed him, "Is it not worthy of tears," he said, "that, when the number of worlds is infinite, we have not yet become lords of a single one?"

- Plutarch, De Tranquillitate Animi

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• MINERVA-Australis at USQ is the world’s only fully dedicated TESS Southern follow-up facility.
• MINERVA and SONG will make USQ’s Mount Kent Observatory Australia’s premier robotic observatory.
EPRV 5
Great Barrier Reef