Introduction

Speckle imaging allows telescopes to achieve diffraction limited imaging performance. The technique requires cameras capable of reading out frames at a very fast rate, effectively freezing out atmospheric seeing. The resulting speckles can be correlated and images reconstructed that are at the diffraction limit of the telescope. These new instruments are based on the successful performance and design of the Differential Speckle Survey Instrument (DSSI) [2, 1].

The instruments are being built for the Gemini-N and WIYN telescopes and will be made available to the community via the peer review proposal process. We envision their primary use to be validation and characterization of exoplanet targets from the NASA K2 and TESS missions and RV discovered exoplanets. Such targets will provide excellent follow-up candidates for both the WIYN and Gemini telescopes [3]. Examples of DSSI data are shown in the figures below. We expect similar data quality in speckle imaging mode with the new instruments.

Additionally, both cameras will have a wide-field mode and standard SDSS filters. They will be highly versatile instruments and it is likely many other science programs will request time on the cameras. The limiting magnitude for speckle observations, will remain around 13-14th at WIYN and 16-17th at Gemini, while wide-field, normal CCD imaging operation and it is likely many other science programs will request time on the cameras. The instrument support will be provided, including a software pipeline that takes raw speckle data to fully reconstructed images.

Gemini North

Telescope f/# 16.0
Plate scale 1.592 ″/mm

GemSpeck - Speckle mode
Focal Lengths
L1 35 mm
L2 75 mm

Detector Image Plane
Magnification 2.14x
Pixel Scale 0.0006 ″/pxl
Unregnetted Circle Dia 6.7 ″
Detector FoV 9.0 x 9.0 ″

GemSpeck - Wide-Field mode
Focal Lengths
L1 75 mm
L2 -100 mm
L3 50 mm

Detector Image Plane
Magnification 0.286x
Pixel Scale 0.0075 ″/pxl
Unregnetted Circle Dia 60 ″
Detector FoV 74 x 74 ″

Dichroic Edge
685 nm

This allows the blue (447nm) and green (562nm) filters in the reflective channel and the red (692nm) and infrared (880 nm) filters in the transmissive channel.

Filter Wheel A
<table>
<thead>
<tr>
<th>SDSS/g</th>
<th>central λ, bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>460 nm, 140 nm</td>
<td></td>
</tr>
<tr>
<td>625 nm, 140 nm</td>
<td></td>
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<tr>
<td>466 nm, 40 nm</td>
<td></td>
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<tr>
<td>562 nm, 40 nm</td>
<td></td>
</tr>
</tbody>
</table>

Filter Wheel B
<table>
<thead>
<tr>
<th>SDSS/i</th>
<th>center λ, bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>770 nm, 150 nm</td>
<td></td>
</tr>
<tr>
<td>910 nm, 120 nm</td>
<td></td>
</tr>
<tr>
<td>692 nm, 40 nm</td>
<td></td>
</tr>
<tr>
<td>832 nm, 40 nm</td>
<td></td>
</tr>
</tbody>
</table>

Detectors

The instrument will use two identical Andor iXon Ultra 888 EMCCD cameras.

- 1024 x 1024 with 13 ″ square pixels
- Capable of 26 fps reading out the full chip, higher for subarray readout (speckle mode)
- EX coating, >90% quantum efficiency from 420 to 700 nm, >90% QE between 550 and 720 nm.
- Thermoelectrically cooled, require no consumables.
- Data is transferred to the control computer via USB3, no internal cards
- Control computer can be quite small with heat dissipation being minimal.

Maximum Resolution

Gemini 0.015 ″ FWHM @ 500 nm
0.05 ″ FWHM @ 800 nm

Discussion

Possible Exoplanet Applications

- Simultaneous two color transit photometry yields instant verification (same depth in both channels).
- Standard imaging provides host star photometry
- Speckle imaging assesses binarity and yielding correct exoplanet radius

Future Expansion

The filter wheels each have two remaining empty slots, we are currently exploring possible uses for these including the addition of:

- Transmission Grating - Grism
- Aperture Mask

Possible science application include: exoplanet transit spectroscopy, exoplanet atmosphere detection, transient object classification and characterization.

An aperture mask would allow spatial resolution beyond the diffraction limit. Achieving true interferometric resolution (2.44x the diffraction limit). This could be especially interesting if used on next-generation ELTs.

Acknowledgments

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Notes

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References