SPECTRE: A Wide Bandwidth High Throughput Spectrograph Concept

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Challenge: Better than SpeX

- What is the best thing we could build to characterize asteroids?
- Can something be sufficiently better than SpeX to be worth building?
- Magic SpeX/prism: $\Delta J=1.6$, $\Delta H=0.7$, $\Delta K=0.6$
- Need to optimize:  
  - Throughput  
  - Read noise  
  - Bandwidth  
  - Field of view
SPECTRE Design Study

- Science goals: Quickly characterize asteroids (especially NEAs) and astrophysical transients
- Low resolution prism spectrograph: $R \sim 100$
- High throughput: $\sim 70\%$
- Wide bandwidth: 0.36 $\mu$m to 4 $\mu$m simultaneous
- Uses one image slicer IFU with 7” x 7” FOV
  - No slit losses
  - No image rotator
- Dichroic splits the optical (0.36 to 0.85 $\mu$m) and IR channels (0.85 to 4 $\mu$m)
  - May need to split between near-IR and thermal-IR to mitigate scattered light
- Each detector will have a 3x13 grid of spectra
- 1 K detectors (SAPHIRA for near-IR)
The two channels together

39 image slicer mirrors

Three tiers of sub-pupil mirrors

Refractive 3’ FOV acquisition camera
SPECTRE: How Will It Work?

- No moving optics. Compact and rigid.
  - No flats or arcs during the night → more time on science target.

- Detectors: 1K CCD and 1K HAWAII/SAPHIRA array
  - 1K arrays reduce cost
  - 1K SAPHIRA: No read noise, can bin down spectra without losses

- 7” IFU
  - No slit losses
  - Enables ‘point-and-shoot’ observing
  - Map a planet much faster than slit scanning

- 3’ FOV visible light acquisition and guide camera
  - Rapid target acquisition: enough stars to platesolve
  - Guiding on field stars for moving or static targets
  - Similar to MORIS, w/ 1K CCD
SPECTRE: How Will It Work?

- High dynamic range in the IR
  - IR Array gets reset more frequently in the thermal region while allowed to integrate in the read noise limited region

- On target guiding for fast moving targets
  - Real-time image cube reconstruction in a moving window on the data stream from the IR detector to allow on-target guiding for rapidly moving targets

- Software
  - Need real time data reduction pipeline for first light, and for on-target guiding. Probably hardest part of project.
Comparison with SpeX

- Coverage in the optical
- 0.5 magnitudes at JHK
- 0.8 magnitudes at L
- Higher observing efficiency
  - Open shutter time on SpeX: 60%

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<td>L</td>
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Magnitudes for S/N=100 in 1 hr
What Would You Use It For?

• Rapid characterization of survey targets
  – Asteroids
  – Kuiper Belt Objects
  – Brown Dwarfs
  – Transients
    • SN type characterization
• Survey of hydrated minerals in asteroids
• Spectroscopic variability of young stars or AGN
• Resolution R~100
• Simultaneous coverage from 0.36 to 4 μm
• Throughput ~70 %
• Low (zero) noise detectors
• 7” x 7” Field of View
• 3’ acquisition/guide field
• Guiding for fast moving targets
• No moving optics
Multi-color Imager

- Lower resolution, wider field of view
- Project many images onto one detector
- No dichroics, higher throughput
- 3 detectors, 9 or 16 channels each
- R~10-15