Scientific Capabilities

Jon Morse
(CU-CASA)

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• **Wavelength range:** 0.85 to 2.5 µm

• **Pixel Scale and Field of View:** single image scale
  – Pixel scale of 0.28 ±0.02 arcsec/pixel for Hawaii 1 1024×1024 HgCdTe detector with 18.5µm pixel pitch
  – Field of View of 4.8′×4.8′ (6.75′ across diagonal)
  – Minimized and well-characterized image distortion to allow accurate astrometry
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Filters

- Two 10-slot filter wheels provide 16-18 slots for science filters
- Nominal filter size 65 mm diam. × 5 mm thick, 5° tilt

<table>
<thead>
<tr>
<th>Core Filters</th>
<th>Central</th>
<th>Cut-on</th>
<th>Cut-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>MKO J</td>
<td>1.25</td>
<td>1.17</td>
<td>1.33</td>
</tr>
<tr>
<td>MKO H</td>
<td>1.63</td>
<td>1.49</td>
<td>1.78</td>
</tr>
<tr>
<td>MKO Ks</td>
<td>2.15</td>
<td>1.99</td>
<td>2.31</td>
</tr>
<tr>
<td>[Fe II]</td>
<td>1.644</td>
<td>1.639</td>
<td>1.649</td>
</tr>
<tr>
<td>H₂ 1-0 S(1)</td>
<td>2.122</td>
<td>2.117</td>
<td>2.127</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hi-pri Filters</th>
<th>Central</th>
<th>Cut-on</th>
<th>Cut-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>z</td>
<td>1.01</td>
<td>0.90</td>
<td>1.12</td>
</tr>
<tr>
<td>MKO K</td>
<td>2.20</td>
<td>2.03</td>
<td>2.37</td>
</tr>
<tr>
<td>[Fe II] red/cont.</td>
<td>1.652</td>
<td>1.647</td>
<td>1.657</td>
</tr>
<tr>
<td>H₂ red/cont.</td>
<td>2.13</td>
<td>2.125</td>
<td>2.135</td>
</tr>
</tbody>
</table>
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- MKO Broad-band Filter Set
- Compatible photometric system
- 65 mm diameter also used at CTIO and elsewhere
Filters (cont.)

- Additional filters sought by ARC community
- Most requests desire duplication of GRIM II filters, some requests for new filters
- Wish-list includes:
  - [S III]λ0.953; [C I]λ0.985; [S II] λ1.03; He I λ1.08; Pa γ λ1.09;
  - H$_2$ S(1) lines at λ1.233, λ1.311, λ2.248; Pa β λ1.28 + redshifted/cont.;
  - H$_2$O/CH$_4$ + cont. at λ1.27, λ1.385; CH$_4$ + cont. at λ1.58, λ1.70;
  - H$_2$O/NH$_3$ at λ1.53; Br γ λ2.16 + redshifted/cont.; K$’$; K$_{long}$; CO$_2$ λ2.3;
  - H$_2$ Q-br λ2.43; etc.
## Detection Limits

Estimated 5-sigma detection limits over a 4x4 pixel aperture

<table>
<thead>
<tr>
<th>Band</th>
<th>1 minute</th>
<th>1 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>z</td>
<td>20.7</td>
<td>22.9</td>
</tr>
<tr>
<td>J</td>
<td>20.0</td>
<td>22.2</td>
</tr>
<tr>
<td>H</td>
<td>18.7</td>
<td>20.9</td>
</tr>
<tr>
<td>K</td>
<td>18.0</td>
<td>20.2</td>
</tr>
</tbody>
</table>

- Estimates are for time on target only, and do not include overhead due to readouts or sky subtraction.
- Estimated sky saturation times for J, H, K bands are 55, 5.5 and 6 seconds, respectively.
- Dark current 0.5 e/pixel/s, Readnoise 10 e/pixel rms, System Throughput 0.33.
- Sky Brightnesses for z, J, H, and K bands are 19, 17, 15, are 13 mag arcsec$^{-2}$, respectively.
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Galaxy Clusters

- Cluster morphology and evolution
- Spheroidal population evolution
- Cluster core radius of $1 \, h^{-1} \text{Mpc}$ corresponds to $\sim 4 \text{arcmin}$ at $z = 0.5$

Example:
- X-ray selected galaxy cluster from Lewis et al. (2002)
- KPNO 2.1 m 1800s Gunn r exposure
- T1KA with 0.305”/pix
- Cluster at redshift $z \sim 0.45$
- Circle is $0.5 \, h^{-1} \text{Mpc}$ radius centered on BCG
- Note arcuate lensed galaxies
Galactic Nebulae

- H II regions, protostellar jets/outflows, PNe, LBVs, SNRs, nova shells, etc.
- Morphologies, kinematics; radiative shocks, photoionized gas, dust
- 6 pc subtends ~4 arcmin at D = 5 kpc

Example:
- Cas A supernova remnant
- SN ~1680, D ~ 3.4 kpc
- Main shell diameter ~4 arcmin
- High-extinction sight-line
- Probe Fe distribution and kinematics plus other tracers of nucleosynthesis
- Forward/reverse shock physics

Fesen et al. (2001)
Uniqueness of cryogenic Fabry-Perot capability

- Value of full-field kinematics and fluxes
- Can be used to probe line emission or absorption
- Mature data reduction software and ample computing power/disk storage available

Example:
Optical F-P observations of young SNR N132D in the LMC (Morse et al. 1995)
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N132D

30''
7.3 pc

[O III] λ5007  Continuum

• Very narrow bandpass allows for high-S/N images with excellent continuum subtraction.
Full-field kinematics distinguish fast-moving, O-rich ejecta from shocked ISM gas.
• These views show the data cube from the top and the side.
• For simple inertial expansion, velocity can be converted to third spatial dimension for full 3-D structure.
• Note: This data cube has been Phase Corrected for velocity curvature in raw images - ie., the ambient line emission at $\lambda 5007$ has been straightened and the variable sky level from each separate image is now curved. Data were obtained over multiple nights as qtr Moon set.
• Individual raw images showing stationary nature of diffuse emission.
• Emission in bright shocked filaments has broad velocity dispersion and appears at multiple etalon settings.
• Unresolved HeNeAr line (He I λ5015) is shown for comparison at lower-right.
Example:
- NGC 5252 from Morse et al. (1998).
- Seyfert 2 nucleus with ionization cones embedded in S0 galaxy.
- HST images show fine detail in gaseous filaments.
- Ionization cones extended $\pm 1$ arcmin ($\pm 25$ kpc) from nucleus.
Full-field kinematics reveal two separate gaseous disks rotating at large projected angles from each other (and from the stellar disk).

System appears to be the result of a merger with a mostly gaseous companion.
Example: The value of the near-IR

- HH 1 protostellar jet can be traced much closer to the source in [Fe II]λ1.64 microns than in optical lines such as Hα or [S II].
- H₂ traces interactions with ambient molecular cloud material (or may even be present in high-velocity jet).
Example: Cepheus A star forming region with large bipolar outflow.  

Hartigan et al. 2001
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- CFHT cryo-echelle long-slit spectrograms of Ceph A knots and filaments in H$_2$ emission.
- R $\sim$ 10,000 spectral resolution needed to decipher H$_2$ flows.
- IR F-P imaging will reveal full field kinematics more efficiently than stepping a long slit, and with seeing-limited angular resolution.