IRCS-HRU

Subaru IRCS High Resolution Unit

Hiroshi TERADA
(NAOJ, Hawaii)
Project

『 Man-power 』
Terada (NAOJ) : PI
Pyo (NAOJ): IRCS-related work
Colley, Lamos, Weber (NAOJ) : Electronics, and software
Kobayashi (U-tokyo), Ikeda (Kyoto-SU) :
  Immersion grating, and instrument overall
Hayashi, Usuda, Tamura (NAOJ), Kawakita (Kyoto-SU),
  Matsunaga (U-Tokyo), Sato (TITech) … : Science
Tokunaga, Rayner (IfA) : Array Electronics, and instrument calibration
Seifahrt (UCD) : Infrared Gas Cell

『 Budget 』
Si immersion grating development : $ 240K
  FY18-21 Research promotion budget (PI: Terada)
IRCS-HRU development : $ 300K
  FY21-24 Kakenhi (Kiban(A); PI: Hayashi)
Subaru IRCS: Current Status

Future Instrument Project at Subaru: NAOJ, Hawaii on 2010/04/26

Hiroshi TERADA (Subaru Telescope)
**Subaru IRCS: Toward Higher Resolution**

- **New feature**
  
  - Echelle Spectroscopy
  - 0.9-5.5\(\mu\)m; R=5,000-20,000 (32mas, 54mas/pix)

- Grism/Prism Spectroscopy
  - 0.9-5.5\(\mu\)m; R=50-2,000 (12mas, 20mas, 52mas/pix)

- Imaging
  - 0.9-5.5\(\mu\)m; NBF & BBF
  - (12mas, 20mas, 52mas/pix)
Infrared High Resolution Spectroscopy: Merits

- Narrow Emission/Absorption
- Detailed structure of Velocity component

Science Cases
- Terrestrial Planet Search
- Interstellar Medium
- Absorption toward QSOs
- Chemistry in Prolyds
- Jet/Outflow from YSOs

Benefit for wide variety of astronomy fields

Infrared High Resolution Spectroscopy: Planet Detection

**Lower Mass Stars ⇒ Lower Mass Planet Detection**

$$K = 28.4 \left( \frac{P}{1 \text{ year}} \right)^{-1/3} \left( \frac{M_p \sin i}{M_3} \right) \left( \frac{M_*}{M_\odot} \right)^{-2/3} \text{ m s}^{-1}$$

"Doppler search" <10 m/s
Terrestrial Planet Detection around M,L-type stars (0.05--0.25 M\_solar)

M,L-type stars: Faint in Optical, but Bright in IR

IR High Resolution (R~70,000) Spectroscopy Essential for Terrestrial Planet Detection

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IR High Resolution Spectroscopy at 8-10m class telescopes

- **First** in northern hemisphere
- **Only one** with LGS function

*IR High Resolution Spectrograph*
At Large telescope / High sensitivity

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Our Approach:
Si Immersion Grating

Resolution $\propto$ Refractive index: $(n \sim 3.4)$

Significantly reduce
Optics (dewar) size
by $1/n$ (1/3.4)

Si Immersion Grating
10mm x 20mm Test Groove

Efficiency 94% @ 1.5 $\mu$m

Simulation

Achieved the best efficiency
in the world

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Hiroshi TERADA (Subaru Telescope)
Si Immersion Grooving on large area (~40mmx~70mm)

- Si optical contact
  - T ~ 90%
- Au coating
  - on reflective surface
  - R > 90% (1.4-5.5um)

Good total performance as a grating

Fabricated by NTT-AT N

Good quality also for large area groove

Detailed evaluation ongoing.

Future Instrument Project at Subaru: NAOJ, Hawaii on 2010/04/26

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IRCS-HRU Layout

Compact (~500mm)

Cross-disperser(s)

Slit (IRCS Offner Focus)

Collimator Lenses

Camera Lenses

Orion 2kx2k InSb

Si immersion grating

Attach onto IRCS -> Prompt commissioning / Minimum impact on current IRCS

Future Instrument Project at Subaru: NAOJ, Hawaii on 2010/04/26

Hiroshi TERADA (Subaru Telescope)
Instrument Specification

<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
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<tbody>
<tr>
<td>Wavelength coverage</td>
<td>1.4—5.5μm</td>
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<tr>
<td>Resolving power</td>
<td>72,500 @ 2.2μm</td>
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<tr>
<td>Pixel scale</td>
<td>66—72mas/pixel</td>
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<tr>
<td>Image Quality</td>
<td>Strehl ratio &gt; 0.8 @ 2.2μm</td>
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<tr>
<td>System Throughput</td>
<td>&gt; 15%</td>
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<tr>
<td>Sensitivity</td>
<td>15.3mag (@K, 1hr exposure, S/N=5)</td>
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<tr>
<td>Velocity accuracy</td>
<td>&lt;10m/s</td>
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</tbody>
</table>

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X-disperser Efficiency

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## Echelle format

### Number of format

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<th>BAND</th>
<th>ECHELLE</th>
<th>CROSS-DISPERSER</th>
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Calibration

1. Infrared Gas Cell (attached at AO188)

NH3 gas cell (IRCS; K-band)  Seifahrt et al.

2. Atmospheric absorption lines
   ✓ Under testing w/ Velocity standard stars (IRCS; H-band)