Progress in Developing the Fiber-link of 188 cm Telescope and HIDES

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with
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contents of my talk

• what is HIDES (+188 cm telescope+OAO)?
• purposes of HIDES fiber-feed project
• features & specifications of HE (high efficiency) fiber-link
• current status of the project
what is HIDES?

- high-resolution echelle spectrograph attached to 188 cm reflector
  the most favorite open-use instrument at OAO
  we just have the tenth year anniversary since its first-light on Apr 1999

Izumiura (1999)
- some specifications
  - wavelength region: 360 nm ~ 1000 nm
  - simultaneous wavelength coverage of about 375 nm (red cross disperser) thanks to the 3 mosaic CCDs since Dec 2007
    - R and $\phi$: R=69,000 (slit width of 200um; $\phi = 0.75$ arcsec)
    - maximum R ~ 100,000
  - overall efficiency (telescope + spectrograph): about 3 % @ 500 nm
    - but light loss at the entrance slit is quite large for typical seeing size of 1.5 arcsec at Okayama

- options
  - iodine cell (2000.10 ~):
    - current RV measurement accuracy ~ 2 m/s (over a few weeks)
    - 6 m/s (over years)

- image rotator
HIDES’s 3 mosaic CCD’s, dewar, and its Th-Ar lamp spectra

simultaneous wavelength coverage of about 375nm with red cross disperser

Photon counts (Procyon; per 30 expt; per R=200,000)

HIDES: 200um slit width

R \sim 69,000

night with good seeing size
HIDES has an iodine cell to measure stellar radial velocity very accurately. 

currently $2 \sim 3 \text{ m/s in best case}$

from telescope

entrance slit

iodine cell

purposes of HIDES fiber-feed project

• it is one of two major projects in “the HIDES upgrade plan”, which is started in FY2005, to keep its competitive power in astronomy

wider wavelength coverage $\Rightarrow$ 3 mosaic CCD

higher throughput and higher rv measurement accuracy $\Rightarrow$ HIDES fiber-feed

• we aim to improve the throughput of the system by one magnitude

we can monitor four times as many as target stars for exposure time limited observations

$(2.51^{0.5})^3 \sim 4!!$

example of sciences:

exoplanet search: monitor more than 1,000 targets

asteroseismology: more than one solar-type stars

erly-type nrp stars down to 7 or 8 mag. (enabling more collaborations )
• this project is the basic research for our future instrumentations

accumulation of know-how on fiber-feed spectrographs
fiber modal noise and throughput for higher SN
high-resolution spectra and also for higher rv measurement accuracy
building infrastructure at OAO
lab, low-cost test spectrograph, clean booth, etc.

features of HE (high efficiency) fiber-link

• to obtain higher throughput for typical seeing condition at OAO while maintaining high resolution, we carefully designed the optics of the fiber-link

link Cassegrain focus to coude focus by optical fiber
3rd mirror (0.8) x 4th mirror (0.8) x window (0.9) = 0.58  ➔ 0.9X
2.7 arcsec FOV and image slicer at the entrance of HIDES
slit efficiency 0.4 (0.75 arcsec, R ~ 69,000)
➔ 0.8X (FOV 2.7 arcsec/3 slices; R ~ 50,000)
(convert F from 18 to 3.3 by a microlens at the fiber input to suppress FRD)
there is a trade-off between resolution/number of slices and wavelength coverage
R \sim 50,000 \ (1 \text{ arcsec; 3 slices}) \text{ but for } \lambda > 450 \text{ nm (red cross disperser)}
no limitation for blue cross fiber

HE input (cassegrain focus)  \hspace{1cm}  HE output (coude focus)

image slicer and sliced image
• efficiency of fiber couplings, FRD, and modal noise property will be examined carefully by a low-cost test spectrograph and a star simulator
detailed optics, like star image slice or pupil slice, will be determined after tests at lab

• an iodine cell is installed for radial velocity measurement
  is independent RV fiber-link (+fiber scrambler) necessary?
examine effects of modal noise, complicated IP by the image slicer, & etc.
  important to setup next target of rv measurement accuracy

current status of the project

• FY2005: conceptual design phase

• FY2006: preliminary design phase
  preliminary design of fiber-link optics (referring to HARPS’s experience)
  choice and purchase of optical fibers
  re-designing of current GUI system, preparation of optical lab

• FY2007: start finalizing designing
  continuous study of fiber-link optics including image slicer, etc.
  final mechanical design of the Cassegrain unit
  design and order of a star simulator
  investigation of fiber-end polishing method and preparation of jigs, etc.

• FY2008: order of the Cassegrain unit (frame and optical components)
  design and order of the HE fiber input optics at Cassegrain focus
Cassegrain Unit (tentative)
showed last year at Jeju WS

Cassegrain focus (HE and RV fiber-links)

star/cal. lamp switching assem.
guider
fiber switching assem.
iodine cell

and after the Jeju WS …
design and order of HE optics at coude focus including image slicer
design and order of F-ratio convert optics for calibration lights
on Cassegrain unit
preparation for modification of the coude pre-optics for the fiber-links
design of a low cost test spectrograph and order its parts

• FY2009:
improvement of Cassegrain unit (balance weight, cover)
modification of coude pre-optics assembly (and installation of new WFV)
design, order parts of, and assemble of calibration source unit
design and manufacture of mechanical parts for fiber wiring
adding the fiber-link option to the control software (preliminary version)
at present: making fiber cables (polish and sheath of the bare optical fibers)
overall assembly and adjustment
to do: manufacture of iodine cell temperature control system
extensive tests of HE fiber-link, fiber agitator
etc.
Cassegrain unit

Cassegrain focus (mirror with a hole)

Bottom view

Top view

modified coude pre-slit optics

attachment to HE-output assembly

new WFV
calibration lamp unit

halogen lamp

Th-Ar

to telescope (Cassegrain unit)

control unit of calibration lamp source

F-ratio convert optics for calibration lights

500 um dia hole

view of the guider
with 5 um polishing sheet

with 0.3 um polishing sheet

with 1 um polishing sheet

*close to first light, maybe!*