Procedural guide in the tutorial session

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1. Sample data

The data was obtained by near-infrared multi-object spectroscopic observations for high-redshift star-forming galaxies, which is conducted with MOIRCS on the Subaru Telescope (Yoshikawa, T., et al. 2010, ApJ, 718, 112).

2. Procedure

09:30-12:30 Practice of data analysis
12:30-13:30 Lunch
13:30-17:00 Practice of data analysis
18:00- Banquet

If you understand the yesterday's lecture well, begin and proceed an exercise (from chapter 4.1) according to the handbook of data reduction school. If you do not, first read the chapter 2 of the handbook.

In each process, **be sure to verify the processed images on ds9** and take care to check the difference between before/after images. For interpolation of cosmic ray, a significant difference would not be found.

3. Points to be checked

If you achieve the following goals, get it looked at by lecturers and then go to the next step after the pass.

- Extraction of a slit from reduced spectra images (section 4.3)
- Combine of spectra (section 4.5)
- Reduction of a standard star spectrum (section 4.6)
- Measurement of redshift (section 5.1)

After you complete the all tasks, continuously analyze other slits.

4. Command log

At first, **you should try to do the data reduction without following helps**. When you have a trouble doing, the following logs would be useful for you.

```
# 4.1 Preparation of the data

cd /home/subaru_tutor02/scratch/
mkdir username
cd username
tar jxf /home/subaru_tutor02/scratch/subaru_sample_data/
MCSMDP_sample.tbz
cp MCSMDP_sample/*.* .
```

```
subaru_setup
ds9 &
mcsmdp
mcsmdp

hselect MCSA*.fits $I,OBS-MOD,DATA-TYP,OBJECT,DISPERSR yes

hselect MCSA*.fits $I "OBJECT = 'DOMEFLAT' & @'DET-ID' = 1" > flat1.lst
hselect MCSA*.fits $I "OBJECT = 'DOMEFLAT' & @'DET-ID' = 2" > flat2.lst

hselect MCSA*.fits $I "OBJECT = 'CDFN_MASK02' & @'DET-ID' = 1 &
K_DITCNT = 1" > obj1a.lst
hselect MCSA*.fits $I "OBJECT = 'CDFN_MASK02' & @'DET-ID' = 1 &
K_DITCNT = 2" > obj1b.lst
hselect MCSA*.fits $I "OBJECT = 'CDFN_MASK02' & @'DET-ID' = 2 &
K_DITCNT = 1" > obj2a.lst
hselect MCSA*.fits $I "OBJECT = 'CDFN_MASK02' & @'DET-ID' = 2 &
K_DITCNT = 1" > obj2b.lst

# 4.2.1 Making the dome flat and the flat fielding

imcombine @flat1.lst HK500_CDFN2_Domeflat1.fits combine=median
reject=sigclip scale=exposure expname=EXPTIME
imcombine @flat2.lst HK500_CDFN2_Domeflat2.fits combine=median
reject=sigclip scale=exposure expname=EXPTIME

imarith HK500_CDFN2_Domeflat1.fits / 10000. HK500_CDFN2_Domeflat1.fits
imarith HK500_CDFN2_Domeflat2.fits / 10000. HK500_CDFN2_Domeflat2.fits

!sed 's/\(.*\)/fl\1/' obj1a.lst > flobj1a.lst
imarith @obj1a.lst / HK500_CDFN2_Domeflat1.fits @flobj1a.lst
!sed 's/\(.*\)/fl\1/' obj1b.lst > flobj1b.lst
imarith @obj1b.lst / HK500_CDFN2_Domeflat1.fits @flobj1b.lst

# 4.2.2 Bad pixels and cosmic rays detection/interpolation

!sed 's/\(.*\)\.fits/BPM\/\1\.pl/' obj1a.lst > bpm1a.lst
!sed 's/\(.*\)\.fits/BPM\/\1\.pl/' obj1b.lst > bpm1b.lst
mkdir BPM

imcopy mdpdb$bpm/nlbpm1_FF64r.fits,mdpdb$bpm/nlbpm1_FF64r.fits,mdpdb
$bpm/nlbpm1_FF64r.fits,mdpdb$bpm/nlbpm1_FF64r.fits @bpm1a.lst
imcopy mdpdb$bpm/nlbpm1_FF64r.fits,mdpdb$bpm/nlbpm1_FF64r.fits,mdpdb
$bpm/nlbpm1_FF64r.fits,mdpdb$bpm/nlbpm1_FF64r.fits @bpm1b.lst

craverage @flobj1a.lst "" crmask=@bpm1a.lst average="" sigma="" navg=5
nrej=30 nsig=10 lcrsig=100 hcrsig=10
```

```
craverage @flobj1b.lst "" crmask=@bpm1b.lst average="" sigma="" navg=5
nrej=30 nsig=10 lcrsig=100 hcrsig=10

!sed 's/\(.*\)/cr\1/' flobj1a.lst > crobj1a.lst
!sed 's/\(.*\)/cr\1/' flobj1b.lst > crobj1b.lst
imcopy @flobj1a.lst @crobj1a.lst
imcopy @flobj1b.lst @crobj1b.lst
fixpix @crobj1a.lst @bpm1a.lst cinterp=1
fixpix @crobj1b.lst @bpm1b.lst cinterp=1

# (cosmic rays detection/interpolation)
# !sed 's/\(.*\)/cr2\1/' flobj1a.lst > cr2obj1a.lst
# !sed 's/\(.*\)/cr2\1/' flobj1b.lst > cr2obj1b.lst
# crrejection @flobj1a.lst @flobj1b.lst @cr2obj1a.lst @cr2obj1b.lst mdpdb
$bpm/nlbpm1_FF64r.fits bpmdir="BPM2" navg=15 nrej=100 nsig=10
lcrsig=100 hcrsig=10

# 4.2.3 Sky subtraction

!sed 's/\(.*\)/ab\1/' crobj1a.lst > abobj1a.lst
imarith @crobj1a.lst - @crobj1b.lst  @abobj1a.lst

# 4.2.4 Distortion correction

!sed 's/\(.*\)/gc\1/' abobj1a.lst > gcobj1a.lst
geotran @abobj1a.lst @gcobj1a.lst mdpdb$geomap/mcsdistcrr1_feb07new.dbs
mcsdistcrr1_feb07new.gmp boundary=constant

# 4.3 Extraction of slit

maskplot CDFN_MASK02.mdp image=gcabcrflMCSA00057147.fits raw+

!sed 's/\(.*\)\.fits/\1_MODS11-0390\.fits/' gcobj1a.lst > gcMODS11-0390.lst
!sed 's/\(.*\)/\1[*,1755:1840]/' gcobj1a.lst > cut.lst
imcopy @cut.lst @gcMODS11-0390.lst

# 4.4 Individual processing
# 4.4.1 Wavelength calibration

!sed 's/\(.*\)/gcsky\1/' crobj1a.lst > gcsky1a.lst
geotran @crobj1a.lst @gcsky1a.lst mdpdb$geomap/mcsdistcrr1_feb07new.dbs
mcsdistcrr1_feb07new.gmp boundary=constant
!sed 's/\(.*\)\.fits/\1_MODS11-0390\.fits/' gcsky1a.lst >
gcskyMODS11-0390.lst
!sed 's/\(.*\)/\1[*,1755:1840]/' gcsky1a.lst > cut.lst
imcopy @cut.lst @gcskyMODS11-0390.lst
```

```
identify gcskycrflMCSA00057147_MODS11-0390.fits coordlist=mdpdb$ohlist/
list_NS_HK500 nsum=20 fwidth=8.0 function=chebyshev order=4 niterate=10

reidentify gcskycrflMCSA00057147_MODS11-0390.fits
gcskycrflMCSA00057147_MODS11-0390.fits override=yes step=20 nsum=20
nlost=10 coordlist=mdpdb$ohlist/list_NS_HK500 verbose=yes

fitcoords gcskycrflMCSA00057147_MODS11-0390 xorder=4 yorder=3

!sed 's/\(.*\)/tr\1/' gcMODS11-0390.lst > trMODS11-0390.lst
transform @gcMODS11-0390.lst @trMODS11-0390.lst
gcskycrflMCSA00057147_MODS11-0390 interptype=linear

# 4.4.2 Removal of residual sky emission

!sed 's/\(.*\)/bg\1/' trMODS11-0390.lst > bgMODS11-0390.lst
background @trMODS11-0390.lst @bgMODS11-0390.lst axis=2 order=3
low_reject=3 high_reject=3 niterate=3

# 4.5 Combine of the spectra

hselect @bgMODS11-0390.lst "$I,K_DITWID" yes
!sed 's/\(.*\)/sh\1/' bgMODS11-0390.lst > shMODS11-0390.lst
imshift @bgMODS11-0390.lst @shMODS11-0390.lst 0 26
!sed 's/\(.*\)/ng\1/' shMODS11-0390.lst > ngMODS11-0390.lst
imarith @shMODS11-0390.lst * -1  @ngMODS11-0390.lst
imcombine @bgMODS11-0390.lst,@ngMODS11-0390.lst
HK500_MODS11-0390 combine=median reject=sigclip scale=exposure
weight=exposure expname=EXPTIME

# 4.6 Flux calibration and telluric correction

hselect MCSA*.fits $I "OBJECT = 'M53735(A0V:J8.9:H8.9:K8.9)'"

imarith MCSA00057114.fits / HK500_CDFN2_Domeflat2.fits
flMCSA00057114.fits
imarith MCSA00057116.fits / HK500_CDFN2_Domeflat2.fits
flMCSA00057116.fits

imcopy mdpdb$bpm/nlbpm2_FF64r.fits BPM/MCSA00057114.pl
imcopy mdpdb$bpm/nlbpm2_FF64r.fits BPM/MCSA00057116.pl
craverage flMCSA00057114.fits "" crmask=BPM/MCSA00057114.pl average=""
sigma="" navg=5 nrej=30 nsig=10 lcrsig=100 hcrsig=10
craverage flMCSA00057116.fits "" crmask=BPM/MCSA00057116.pl average=""
sigma="" navg=5 nrej=30 nsig=10 lcrsig=100 hcrsig=10
imcopy flMCSA00057114.fits crflMCSA00057114.fits
imcopy flMCSA00057116.fits crflMCSA00057116.fits
fixpix crflMCSA00057114.fits BPM/MCSA00057114.pl cinterp=1
```

fixpix crflMCSA00057116.fits BPM/MCSA00057116.pl cinterp=1

imarith crflMCSA00057114.fits - crflMCSA00057116.fits
abcrflMCSA00057114.fits
geotran abcrflMCSA00057114.fits gcabcrflMCSA00057114.fits mdpdb$geomap/
mcsdistcrr2_feb07new.dbs mcsdistcrr2_feb07new.gmp boundary=constant
imcopy gcabcrflMCSA00057114.fits[*,902:1022]
gcabcrflMCSA00057114_M53735.fits
geotran crflMCSA00057114.fits gcskycrflMCSA00057114.fits mdpdb$geomap/
mcsdistcrr1_feb07new.dbs mcsdistcrr1_feb07new.gmp boundary=constant
imcopy gcskycrflMCSA00057114.fits[*,902:1022]
gcskycrflMCSA00057114_M53735.fits

identify gcskycrflMCSA00057114_M53735.fits coordlist=mdpdb$ohlist/
list_NS_HK500 nsum=20 fwidth=8.0 function=chebyshev order=4 niterate=10

reidentify gcskycrflMCSA00057114_M53735.fits
gcskycrflMCSA00057114_M53735.fits override=yes step=20 nsum=20
nlost=20 coordlist=mdpdb$ohlist/list_NS_HK500 verbose=yes

fitcoords gcskycrflMCSA00057114_M53735 xorder=4 yorder=3
transform gcabcrflMCSA00057114_M53735.fits
trgcabcrflMCSA00057114_M53735.fits gcskycrflMCSA00057114_M53735
interptype=linear

background trgcabcrflMCSA00057114_M53735.fits
bgtrgcabcrflMCSA00057114_M53735.fits axis=2 order=3 low_reject=3
high_reject=3 niterate=3

hselect bgtrgcabcrflMCSA00057114_M53735.fits "$I,K_DITWID" yes

imshift bgtrgcabcrflMCSA00057114_M53735.fits
shbgtrgcabcrflMCSA00057114_M53735.fits 0 43
imarith shbgtrgcabcrflMCSA00057114_M53735.fits * -1
ngshbgtrgcabcrflMCSA00057114_M53735.fits
imcombine
bgtrgcabcrflMCSA00057114_M53735.fits,ngshbgtrgcabcrflMCSA00057114_M53
735.fits HK500_M53735 combine=median reject=sigclip scale=exposure
weight=exposure expname=EXPTIME

apall HK500_M53735.fits

rescurve HK500_M53735.ms.fits 8.856 resc_CDFN2_HK500.fits

mdpfcalib HK500_MODS11-0390.fits resc_CDFN2_HK500.fits
HK500_MODS11-0390fl.fits

5.1 Measurement of redshift

splot HK500_MODS11-0390fl.fits 41